EVERYDAY PRACTICAL ELECTRONICS

FEBRUARY 1996

£2.25

Cut Your Electricity Bill!

PIC Electric

Shows the cost of running home appliances

Analogue Frequency Meter

Easy to build and use, reads up to 1MHz

Vari-Speed Dice

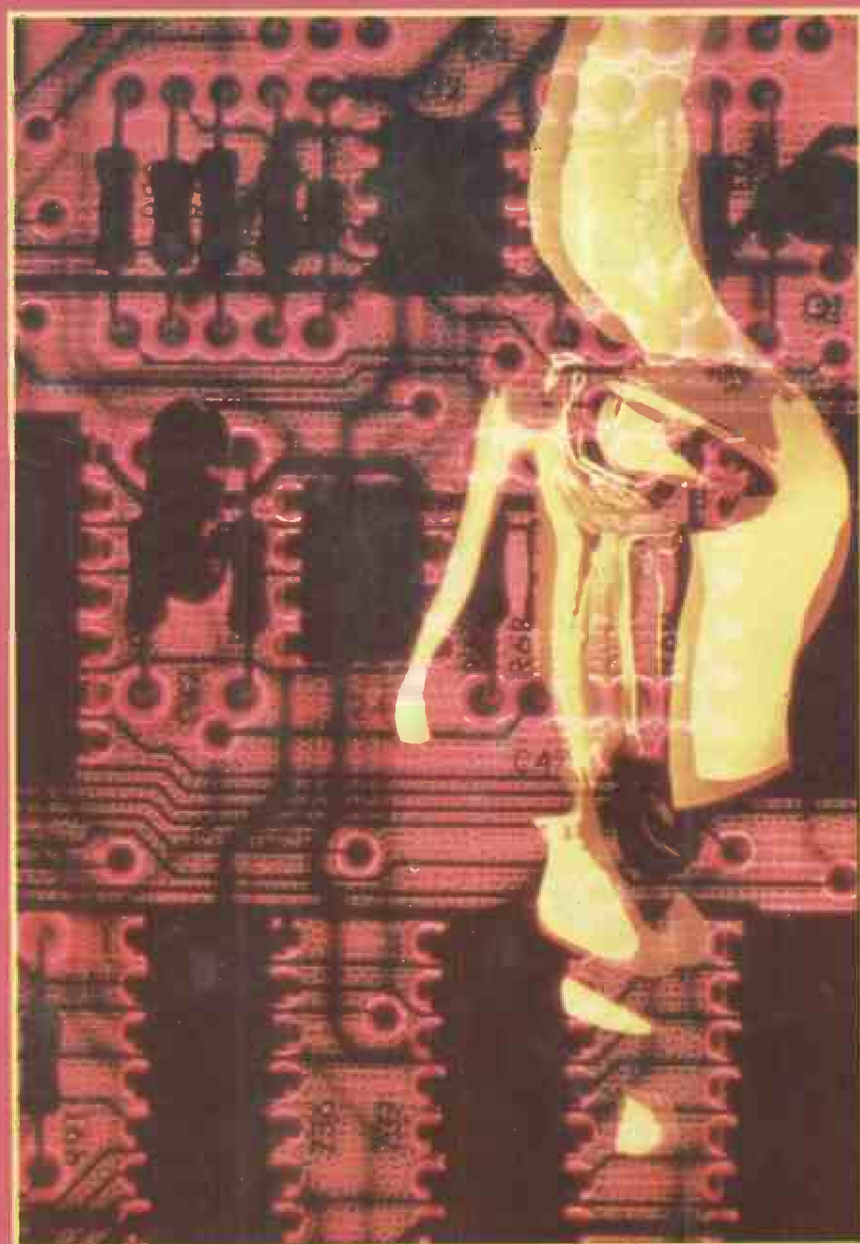
A Teach-In '96 project

Simple PIC Programmer

Get started simply with minimum expense

P.C.B. Making On A Budget

A practical approach



The No. 1 Independent Magazine For Electronics Technology & Computer Projects

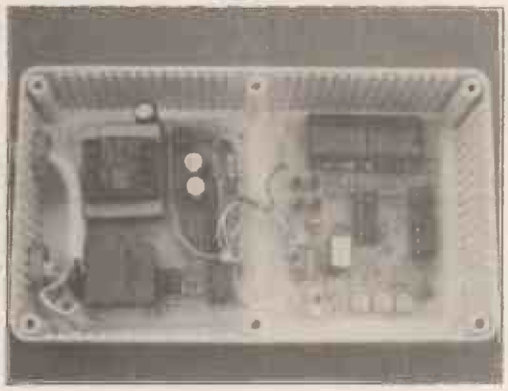
02
9 770262 361065

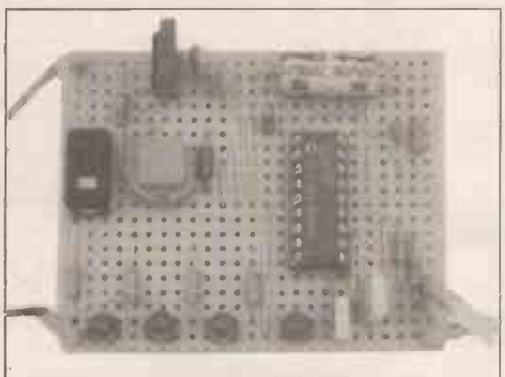
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

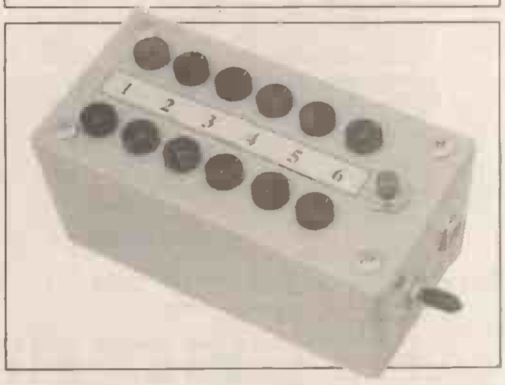
VOL. 25 No. 2 FEBRUARY 1996

EVERYDAY PRACTICAL ELECTRONICS

The No. 1 Independent Magazine for Electronics, Technology and Computer Projects







Our March '96 Issue will be published on Friday, 2nd February 1996. See page 91 for details.

Projects

Series

Features

NEXT MONTH

STEREO HEADPHONES

with all UK copies

Suitable for your personal hifi, radio, TV, audio, video or disco monitoring, mind entrainment, equipment testing etc.

PLUS A free Greenweld Catalogue with all copies

DON'T MISS OUT – PLACE AN ORDER NOW!

MIND MACHINE MkIII

Andy Flind's mind entrainment projects have been highly popular over many years. This completely updated unit is easier and cheaper to build than previous designs and the add-on programmer can easily store various sequences.

Learn to relax with this entrainment unit.

MULTI PURPOSE MINI AMP

Designed to be used with the FREE Stereo Headphones, this amplifier can be employed as a test amplifier for projects, for fault finding on audio equipment or simply as a general purpose amp. with any audio/radio/video/disco/noise/etc. equipment.

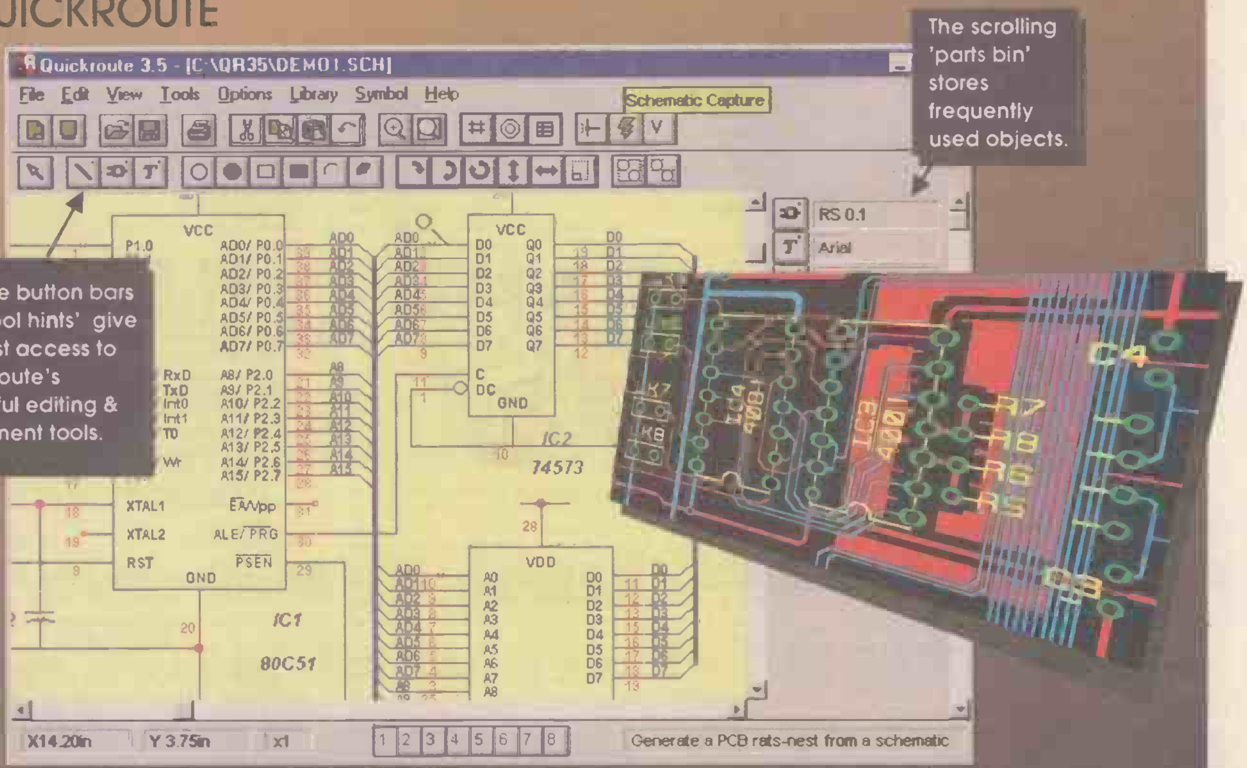
EVERYDAY PRACTICAL ELECTRONICS

MARCH ISSUE ON SALE FRIDAY, FEBRUARY 2

New Version 3.5

QUICKROUTE

Integrated PCB & Schematic Design System for Windows



"..of all the products included here, this is my personal favourite... Really, thats all I have to say about Quickroute - it certainly gets my vote!" Review of QR 3.0 & other products Computer Shopper Nov 95

EASY TO USE
Quickroute 3.5 is a powerful, affordable and easy to use integrated schematic & PCB design system for Windows. With its multiple button bars, 'tool hints' and 'parts bin', Quickroute helps you to design quickly and efficiently

POWERFUL
There are four different versions of Quickroute giving you a choice of features & price. Quickroute is available with multi-sheet schematic capture, auto-routing, 'engineering change' (modification of a PCB from a schematic), copper fill, and a range of file import/export options. See the table for a selection of features.

AFFORDABLE
Prices are Designer (£149), PRO (£249) and PRO+ (£399). The Personal edition is available for just £68, but has the manual provided on disk as on-line help. Post & Packing is £5 (UK), £8 (EC), £12 (World). VAT must be added to the total price.

	Personal	Designer	PRO	PRO+
PCB & Schematic Design	✓	✓	✓	✓
Schematic Capture		✓	✓	✓
Auto router			✓	✓
Design Rule Checking			✓	✓
Export WMF & Tango			✓	✓
Export Gerber/NC-Drill			✓	✓
Extended Libraries			✓	✓
Tango + Gerber Import				✓
Update PCB from schematic				✓
DXF & SPICE Export				✓
Copper Fill				✓

QUICKROUTE SYSTEMS

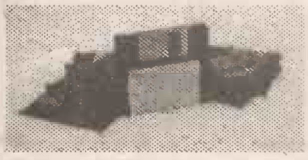
Tel/Fax 0161 449 7101

Quickroute Systems Ltd., 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD, U.K.
email info@quicksys.demon.co.uk

SWITCH

Phone now for more information

GREENWELD



UNBRANDED DISKS
High quality unformatted disks. 100% error free. Complete with sleeves and write protect tabs (5.25") and labels (3.5" & 5.25")

A637	3.5"	DSDD	1MB	**10 for £3.95**
A638	3.5"	DSHD	2MB	**10 for £6.95**
A657	5.25"	DSHD	1.6MB	**10 for £4.00**

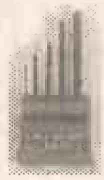
LOCKABLE STORAGE CASES
DD100L Holds 100 5¼" disks. Cream with transparent lid. **Reduced to £3.95**
DD50L As above but holds 50 disks. **Reduced to £3.45**
DD80L Holds 80 3½" disks in two banks. Cream with transparent lid. **Reduced to £3.95**
DD40L As above but holds 40 disks. **Reduced to £3.45**

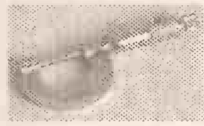
GLUE GUN T216 A hot melt glue gun suitable for home and industry. A smooth flow of adhesive is controlled by the trigger feed. Suitable for a wide range of materials including most metals, PVC and concrete. Supplied with two free glue sticks. **£9.95**

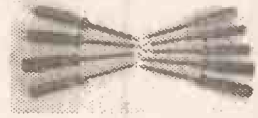
SET OF TWIST DRILLS X3372 1.5, 2.5, 3, 4 and 5mm drills in flip open case. **£2.00**

MICROMETER EX102 0-25mm supplied in wooden case. **£8.95**

TORX SET X6309 These screwdrivers are becoming an essential as more manufacturers resort to tamperproof screws. Full set of nine. **£9.95**

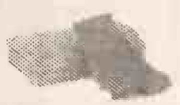






INSTRUMENT CASE X6147 Versatile soft padded instrument case measuring 250 x 250 x 80mm, with expanding side pocket 175 x 80 x 90mm. Both have velcro fasteners. On one side are two apertures, one 15 x 15mm and the other 80 x 40mm covered by a leatherette flap. Strong carrying handle. Grey material with black edging. Stacks of uses. **£2.95**

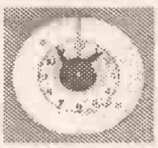
MOTOR Z9275 An excellent opportunity to purchase a high quality 45 watt multi-speed mains (250V ac) motor. Measuring 87mm long x 98mm dia, it has a 10mm spindle with flat 44mm long. There are 4 taps giving the following speeds: 1300, 1030, 900 or 650RPM, offering a maximum torque of 1.4kg/cm. A 1.5µF 500V running capacitor is supplied. weight 2.1kg. **£12.95**



SILPHEED GAME X6294 Super piece of software for the PC set in the year 3032. On two 3.5" disks. **£3.95**

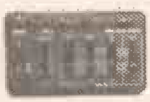
TIE IN A TIN Z5820 Now here's an unusual offer! They were going to be sent to Metal Box shareholders to stave off a bid. However, before they could be posted, a takeover was announced - so now we've got them. The box measures 200 x 135 x 45mm and is finished in a blue and gold pattern. The tie is pure silk with a discreet 'MB' logo. **£3.95**

GEAR SET Z5789 Comprises 7 items: 3 various steel with boss, rack and pinion and plastic bevel gears giving right angle drive. **£3.95**



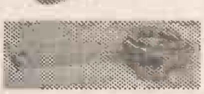
CLOCK X3364 17 jewel Swiss movement. Case is 37mm dia x 5mm thick. **£3.50**

ELECTRONIC ANTI-DAZZLE MIRROR Z5693 The mirror that dips by itself! Reduces eyestrain/tiredness and removes headlight dazzle from behind. Automatic operation. Complete with accessories. **£7.95**

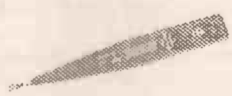


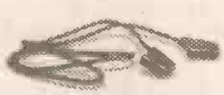
STEREO VIDEO MIXER VM516 Desk type with enhancer. Allows separate adjustment and mixing of original video sound with 3 external sources (mic, cassette, etc). Master output control. Continuously adjustable slider corrects video signal when copying. Supplied with 12V mains adaptor. **£29.95**

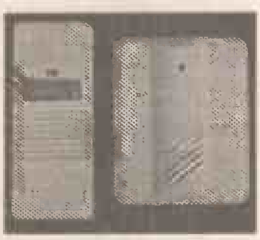
METER Y122F Input impedance 10MΩ, 3½ digit 15mm LCD display. 32 ranges including 20A ac/dc. Transistor and diode test. Continuity test with buzzer and LED. Rugged yellow case. Test leads with shrouded 4mm plugs. Carrying case. Fuse protection. Automatic polarity and zero. Battery and instruction manual included. **£29.95**



4 WAY MAINS BLOCK P3525 Four way trailing socket with 2m cable and fused 13A plug. **£6.95**





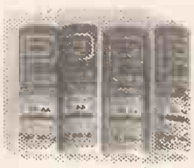


VOLTAGE TESTER Y023BA Dual function screwdriver type circuit tester. Used as an inductance tester it will detect buried live cables, breaks in cables, etc. Touching a live part with the tip will indicate the voltage level on the LCD screen. AC or DC up to 250V max. **£3.95**

SCART LEADS
P2940 Scart plug to scart plug. 1.5m long. All pins connected. **£2.60**
P2950 Scart plug to 6 x RCA phono plugs. Video in/out and Audio in/out (left and right). 1.5m long. **£3.50**

WIRELESS DOORBELL T071D Two part wireless doorbell. The transmitter is mounted by the front door and the receiver can be mounted or carried up to 16m (50 feet) away. Provided with self adhesive pads and screws for mounting (if required). Transmitter requires a PP3 battery, receiver requires two AA batteries. **£8.95**

MINI DIGITAL MULTIMETER Y123BD A compact yet reliable multimeter that is ideal for engineers or hobbyists. It offers 9 testing ranges and 5 functions, all easily selectable with just one switch. **£10.95**



NI-CAD BATTERIES
X132 Four AA Ni-Cad batteries. **£4.80**

GREENWELD ELECTRONIC COMPONENTS
27D Park Road · Southampton · SO15 3UQ
TELEPHONE: 01703 236363 · FAX: 01703 236307
INTERNET: http://www.herald.co.uk/clients/G/Greenweld/greenweld.html.
EMAIL via Compuserve 100014, 1463

Our stores (over 10,000 sq. ft.) have enormous stocks. We are open 8.00am - 5.30pm Monday to Saturday. Come and see us!

ACCESS VISA SWITCH

Minimum credit card order £12.00. Official orders welcome from Education - minimum invoice charge £15.00. Payment accepted by cheque, P.O., cash, book tokens, Switch, Access, Visa, Connect

1996 CATALOGUE NOW AVAILABLE!

Only £2.00 UK/BFPO - Overseas £4.00

196 pages of bargains - from craft accessories to power supplies, electronic components to toolkits....and much more in between!

For The Best Bargains Become A Subscriber...

GOLD Service
For just £12.00 a year, the **GOLD S**ubscriber category offers the following advantages:
- **The Greenweld Guardian** and latest **Bargain List** every month, together with any brochures or fliers from our suppliers
- A first class **Reply Paid Envelope**
- **A REDUCED POSTAGE RATE** of just £1.50 for all orders (UK only)
- **5% DISCOUNT** on all regular Catalogue and Bargain List items
- **FREE 1997 Catalogue** on publication in October.

So with just 4 orders per year you save £6.00 postage, £2.00 for a catalogue and 5% on everything you buy! *(Does not apply to qty. prices or sale goods. Min. order value £20.00)*

Standard Service
For just £6.00 a year UK/BFPO (£10.00 overseas), we'll send you The Greenweld Guardian every month. With this newsletter comes our latest Bargain List giving details of our new lines being stocked. Each issue is supplied with a personalised reply paid Order Form and details of exclusive offers available to Subscribers only.

MAGENTA ELECTRONICS LTD

135 Hunter Street
Burton-on-Trent
Staffs. DE14 2ST
Tel 01283 565435 Fax 546932

EE164

All Prices include V.A.T. Add £3.00 per order p &p

SHOP OPEN 9-5 MON-FRI. CLOSED SAT --- OFFICIAL ORDERS WELCOME

EPE MICROCONTROLLER P.I. TREASURE HUNTER

The latest MAGENTA DESIGN – highly stable & sensitive – with µC control of all timing functions and advanced pulse separation techniques.

- New circuit design 1994
- High stability drift cancelling
- Easy to build & use
- No ground effect, works in seawater
- Detects gold, silver, ferrous & non-ferrous metals
- Efficient quartz controlled microcontroller pulse generation.
- Full kit with headphones & all hardware

KIT 847......................£63.95

WINDICATOR

A novel wind speed indicator with LED read-out. Kit comes complete with sensor cups, and weatherproof sensing head. Mainspower unit £5.99 extra.

KIT 856...£28.00

BAT DETECTOR

An excellent circuit which reduces ultrasound frequencies between 20 and 100 kHz to the normal (human) audible range. Operating rather like a radio receiver the circuit allows the listner to tune-in to the ultrasonic frequencies of interest. Listening to Bats is fascinating, and it is possible to identify various different types using this project. Other uses have been found in industry for vibration monitoring etc.

KIT 814...£21.44

1000V & 500V INSULATION TESTER

Superb new design. Regulated output, efficient circuit. Dual-scale meter, compact case. Reads up to 200 Megohms.
Kit includes wound coil, cut-out case, meter scale, PCB & ALL components.

KIT 848...................£32.95

SPACEWRITER

An innovative and exciting project. Wave the wand through the air and your message appears. Programmable to hold any message up to 16 digits long. Comes pre-loaded with "MERRY XMAS". Kit includes PCB, all components & tube + instructions for message loading.

KIT 849.......................£16.99

12V EPROM ERASER

A safe low cost eraser for up to 4 EPROMS at a time in less than 20 minutes. Operates from a 12V supply (400mA). Used extensively for mobile work - updating equipment in the field etc. Also in educational situations where mains supplies are not allowed. Safety interlock prevents contact with UV.

KIT 790.........................£28.51

MOSFET 25V 2.5A POWER SUPPLY

High performance design has made this one of our classic kits. Two panel meters indicate Volts and Amps. Variable from 0-25 Volts and current limit control from 0-2·5A. Rugged power MOSFET output stage. Toroidal mains transformer.

KIT 769.........................£56.82

DIGITAL LCD THERMOSTAT

A versatile thermostat using a thermistor probe and having an l.c.d. display. MIN/MAX memories, -10 to 110 degrees celsius, or can be set to read in Fahrenheit. Individually settable upper and lower switching temperatures allow close control, or alternatively allow a wide 'dead band' to be set which can result in substantial energy savings when used with domestic hot water systems. Ideal for greenhouse ventilation or heating control, aquaria, home brewing, etc. Mains powered, 10A SPCO relay output. Punched and printed case.

KIT 841..........................£29.95

MOSFET MkII VARIABLE BENCH POWER SUPPLY 0-25V 2·5A.

Based on our MkI design and preserving all the features, but now with switching pre-regulator for much higher efficiency. Panel meters indicate Volts and Amps. Fully variable down to zero. Toroidal mains transformer. Kit includes punched and printed case and all parts. As featured in April 1994 *EPE*. An essential piece of equipment.

KIT 845............£64.95

INSULATION TESTER

A reliable and neat electronic tester which checks insulation resistance of wiring and appliances etc., at 500 Volts. The unit is battery powered, simple and safe to operate. Leakage resistance of up to 100 Megohms can be read easily. A very popular college project.

KIT 444.........................£22.37

DIGITAL COMBINATION LOCK

Digital lock with 12 key keypad. Entering a four digit code operates a 250V 16A relay. A special anti-tamper circuit permits the relay board to be mounted remotely. Ideal car immobiliser, operates from 12V. Drilled case, brushed aluminium keypad.

KIT 840..........................£19.86

PORTABLE ULTRASONIC PEsT SCARER

A powerful 23kHz ultrasound generator in a compact hand-held case. MOSFET output drives a special sealed transducer with intense pulses via a special tuned transformer. Sweeping frequency output is designed to give maximum output without any special setting up.

KIT 842..........................£22.56

ULTRASONIC PEsT SCARER

Keep pets/pests away from newly sown areas, fruit, vegetable and flower beds, children's play areas, patios etc. This project produces intense pulses of ultrasound which deter visiting animals.

- KIT INCLUDES ALL COMPONENTS, PCB & CASE
- EFFICIENT 100V TRANSDUCER OUTPUT
- COMPLETELY INAUDIBLE TO HUMANS
- UP TO 4 METRES RANGE
- LOW CURRENT DRAIN

KIT Ref. 812...£14.81

E.E. TREASURE HUNTER P.I. METAL DETECTOR MKI

Magenta's highly developed & acclaimed design. Quartz crystal controlled circuit MOSFET coil drive. D.C. coupled amplification. Full kit includes PCB, handle, case & search coil.

- KIT INC. HEADPHONES
- EFFICIENT CMOS DESIGN
- POWERFUL COIL DRIVE
- DETECTS FERROUS AND NON-FERROUS METAL – GOLD, SILVER, COPPER ETC.
- 190mm SEARCH COIL
- NO 'GROUND EFFECT'

KIT 815..........................£45.95

DIGITAL CAPACITANCE METER

A really professional looking project. Kit is supplied with a punched and printed front panel, case, p.c.b. and all components. Quartz controlled accuracy of 1%. Large clear 5 digit display and high speed operation. Ideal for beginners – as the µF, hF and pF ranges give clear unambiguous read out of marked and unmarked capacitors from a few pF up to thousands of µF.

KIT 493..........................£39.95

ACOUSTIC PROBE

A very popular project which picks up vibrations by means of a contact probe and passes them on to a pair of headphones or an amplifier. Sounds from engines, watches, and speech travelling through walls can be amplified and heard clearly. Useful for mechanics, instrument engineers, and nosey parkers!

KIT 740..........................£19.98

'COMSTEP' P.C. COMPUTER STEPPING MOTOR INTERFACE

An exciting project supplied with two 200 step motors, interface board, and easy to use P.C. software.
Allows independent control of both motors – speed, direction, number of steps, and half/full step mode. Connects to computer parallel port. Requires 12V 1A D.C. supply and printer lead.

KIT 846 (with 2 motors) ....£67.00 (Printer lead £5.00)

HAMEG HM303 30 MHz DUAL TRACE OSCILLOSCOPE & COMPONENT CHECKER

Western Europe's best selling oscilloscope - now improved. It now features 30MHz bandwidth, triggering to 100MHz and 2mV/div sensitivity.
Sharp bright display on 8 x 10cm screen with internal graticule. Special component tester built in – allows capacitors, resistors, transistors, diode, and many other components to be checked at a glance.
As with its predecessor, the QUALITY OF THIS INSTRUMENT IS OUTSTANDING. It is supported with a two year warranty covering parts and labour. If you are buying an oscilloscope, this is the one. It costs a fraction more than some others, but it is far far superior. Supplied with test probes, mains lead, and manual.

£392.00 + £68.60 VAT Includes FREE Next-day delivery
(Cheques must be cleared)

EDUCATIONAL BOOKS & PACKS

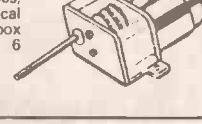
ADVENTURES WITH ELECTRONICS
The classic book by Tom Duncan used throughout schools. Very well illustrated, ideal first book for age 10 on. No soldering. Uses an S.DEC breadboard.
Book &Components £28.95, Book only £7.25

FUN WITH ELECTRONICS
An Usborne book, wonderfully illustrated in colour. Component pack allows 6 projects to be built and kept. Soldering is necessary. Age 12 on, or younger with adult help. Book & Components £20.88, Book only £2.95

30 SOLDERLESS BREADBOARD PROJECTS
A more advanced book to follow the others. No soldering. Circuits cover a wide range of interests.
Book & Components £30.69, Book only £2.95

DC MOTOR/GEARBOXES

Ideal for robots, buggies, and many other mechanical projects. Min. plastic gearbox with 1.5-4.5V DC motor. 6 ratios can be set up.



Small type MGS....£4.77

STEPPING MOTORS

For computer control via standard 4 pole unipolar drivers.

MD38 - miniature 48 steps per rev...............£9.15
MD35¼ - standard 48 steps per rev............£12.99

Tel (0191) 251 4363
Fax (0191) 252 2296
ESR
ELECTRONIC COMPONENTS
Station Road, Cullercoats,
Tyne & Wear
NE30 4PQ
U.K.

296

4000 Series

4000	£0.17
4001	£0.20
4002	£0.17
4006	£0.40
4007	£0.18
4008	£0.31
4009	£0.19
4010	£0.23
4011	£0.21
4012	£0.16
4013	£0.24
4014	£0.30
4015	£0.24
4016	£0.30
4017	£0.31
4018	£0.27
4019	£0.48
4020	£0.31
4021	£0.31
4022	£0.32
4023	£0.16
4024	£0.32
4025	£0.15
4026	£0.78
4027	£0.26
4028	£0.22
4029	£0.40
4030	£0.17
4031	£0.70
4033	£0.56
4034	£1.24
4035	£0.31
4040	£0.38
4041	£0.31
4042	£0.22
4043	£0.28
4044	£0.35
4046	£0.52
4047	£0.48
4048	£0.28
4049	£0.22
4050	£0.26
4051	£0.43
4052	£0.32
4053	£0.40
4054	£0.56
4055	£0.34
4060	£0.48
4063	£0.29
4066	£0.22
4067	£1.96
4068	£0.16
4069	£0.20
4070	£0.17
4071	£0.22
4072	£0.17
4073	£0.17
4075	£0.17
4076	£0.30
4077	£0.28
4078	£0.20
4081	£0.23
4082	£0.21
4085	£0.28
4086	£0.26
4089	£0.55
4093	£0.22
4094	£0.31
4095	£0.56
4097	£1.20
4098	£0.48
4099	£0.38
4502	£0.38
4503	£0.40
4508	£1.40
4510	£0.36
4511	£0.56
4512	£0.32
4514	£0.77
4515	£0.99
4516	£0.31
4518	£0.44
4520	£0.43
4521	£0.62
4526	£0.40
4527	£0.40
4528	£0.40
4529	£0.44
4532	£0.32
4534	£2.48
4536	£1.00
4538	£0.37
4541	£0.33
4543	£0.46
4555	£0.34
4556	£0.40
4560	£1.18
4566	£1.96
4572	£0.25
4584	£0.24
4585	£0.47
4724	£0.70
40106	£0.37
40109	£0.58
40163	£0.46
40174	£0.34
40175	£0.36
40193	£0.60

74HC Series

74HC00	£0.16
74HC02	£0.21
74HC03	£0.21
74HC04	£0.21
74HC08	£0.21
74HC10	£0.16
74HC11	£0.20
74HC14	£0.22
74HC20	£0.28
74HC27	£0.16
74HC30	£0.22
74HC32	£0.21
74HC42	£0.25
74HC73	£0.22
74HC74	£0.23
74HC75	£0.22
74HC76	£0.20
74HC85	£0.24
74HC86	£0.22
74HC107	£0.40
74HC123	£0.33
74HC125	£0.24
74HC126	£0.46
74HC132	£0.37
74HC133	£0.29
74HC138	£0.25
74HC139	£0.31
74HC151	£0.33
74HC153	£0.27
74HC154	£0.85
74HC157	£0.40
74HC158	£0.25
74HC160	£0.32
74HC161	£0.28
74HC162	£0.45
74HC163	£0.27
74HC164	£0.35
74HC165	£0.35
74HC173	£0.32
74HC174	£0.27
74HC175	£0.27
74HC192	£0.45
74HC195	£0.32
74HC240	£0.37
74HC241	£0.37
74HC243	£0.48
74HC244	£0.42
74HC245	£0.46
74HC251	£0.25
74HC253	£0.25
74HC257	£0.25
74HC259	£0.57
74HC273	£0.35
74HC299	£0.64
74HC356	£0.45
74HC365	£0.34
74HC367	£0.25
74HC368	£0.25
74HC373	£0.35
74HC374	£0.40
74HC390	£0.52
74HC393	£0.38
74HC423	£0.37
74HC553	£0.42
74HC563	£0.48
74HC564	£0.48
74HC573	£0.45
74HC574	£0.45
74HC640	£0.73
74HC688	£0.64
74HC4002	£0.16
74HC4017	£0.64
74HC4020	£0.36
74HC4040	£0.45
74HC4049	£0.25
74HC4050	£0.25
74HC4060	£0.44
74HC4075	£0.27
74HC4078	£0.32
74HC4511	£0.64
74HC4514	£0.84
74HC4538	£0.41
74HC4543	£0.90

74LS Series

74LS00	£0.20
74LS01	£0.14
74LS02	£0.29
74LS03	£0.29
74LS04	£0.17
74LS05	£0.14
74LS07	£0.32
74LS08	£0.23
74LS09	£0.14
74LS10	£0.14
74LS11	£0.17
74LS12	£0.14
74LS13	£0.14
74LS14	£0.21
74LS15	£0.14
74LS20	£0.14
74LS21	£0.14
74LS22	£0.14
74LS26	£0.14
74LS27	£0.14
74LS30	£0.20
74LS32	£0.21
74LS37	£0.14
74LS38	£0.19
74LS40	£0.14
74LS42	£0.25
74LS47	£0.72
74LS51	£0.24
74LS73	£0.40
74LS74	£0.25
74LS75	£0.19
74LS76	£0.25
74LS83	£0.31
74LS85	£0.35
74LS86	£0.20
74LS90	£0.44
74LS92	£0.35
74LS93	£0.42
74LS107	£0.23
74LS109	£0.21
74LS112	£0.24
74LS113	£0.21
74LS114	£0.21
74LS122	£0.31
74LS123	£0.31
74LS125	£0.27
74LS126	£0.25
74LS132	£0.21
74LS133	£0.36
74LS136	£0.16
74LS138	£0.40
74LS139	£0.25
74LS145	£0.56
74LS147	£1.26
74LS148	£0.70
74LS151	£0.25
74LS153	£0.25
74LS154	£0.70
74LS155	£0.25
74LS156	£0.36
74LS157	£0.22
74LS158	£0.21
74LS160	£0.48
74LS161	£0.32
74LS162	£0.44
74LS163	£0.32
74LS164	£0.24
74LS165	£0.48
74LS170	£0.30
74LS173	£0.24
74LS174	£0.24
74LS175	£0.24
74LS190	£0.60
74LS191	£0.24
74LS192	£0.60
74LS193	£0.24
74LS195	£0.24
74LS196	£0.24
74LS197	£0.24
74LS221	£0.40
74LS240	£0.32
74LS241	£0.32
74LS242	£0.32
74LS243	£0.30
74LS244	£0.32
74LS245	£0.60
74LS247	£0.32
74LS251	£0.24
74LS257	£0.24
74LS258	£0.24
74LS266	£0.14
74LS273	£0.32
74LS279	£0.25
74LS365	£0.21
74LS367	£0.21
74LS368	£0.21
74LS373	£0.33
74LS374	£0.34
74LS375	£0.34
74LS377	£0.32
74LS378	£0.62
74LS390	£0.25
74LS393	£0.24
74LS395	£0.26
74LS399	£0.62
74LS670	£0.69

Linear ICs

AD524AD	£23.04
AD548JN	£1.62
AD590JH	£5.40
AD592AN	£4.52
AD595AQ	£14.64
AD620AN	£9.88
AD625JN	£16.20
AD633JN	£8.25
AD648JN	£2.57
AD652AQ	£14.88
AD654JN	£7.25
AD698AP	£23.28
AD707JN	£2.36
AD708JN	£5.69
AD711JN	£1.51
AD712JN	£2.38
AD736JN	£8.75
AD795JN	£5.94
AD797AN	£8.69
AD811N	£6.73
AD812AN	£6.32
AD813AN	£8.81
AD817AN	£3.85
AD820AN	£3.24
AD822AN	£5.20
AD826AN	£5.33
AD829JN	£6.41
AD830AN	£6.14
AD847JN	£6.50
AD9696KN	£7.73
ADEL2020AN	£5.06
ADM222AH	£3.55
ADM232AAN	£3.55
ADM485JN	£2.97
ADM690AN	£5.13
ADM691AN	£6.48
ADM695AN	£6.48
ADM699AN	£3.58
AMP04FP	£10.94
BUF04GP	£8.56
CA741CE	£0.26
CA747CE	£0.39
CA3046	£0.37
CA3059	£1.16
CA3080E	£0.72
CA3130E	£0.98
CA3140E	£0.56
CA3189E	£1.22
CA3240E	£1.12
DG211CJ	£1.55
DG212CJ	£1.55
DG411DJ	£3.11
DG412DJ	£4.19
EL2020CN	£4.99
EL2030CN	£5.67
ICL7106	£2.80
ICL7611DCPA	£1.06
ICL7621	£1.70
ICL8038	£5.25
ICM7555	£0.36
ICM7556	£0.98
L165V	£2.63
L272M	£1.89
L297	£6.37
L298	£6.99
LF347N	£0.86
LF351N	£0.43
LF353N	£0.42
LF356	£0.84
LM301A	£0.25
LM308N	£0.42
LM311N-8	£0.32
LM318	£1.28
LM319N-14	£0.96
LM324	£0.30
LM335Z	£1.52
LM339N	£0.24
LM348N	£0.31
LM358N	£0.27
LM377	£2.57
LM380N-14	£1.12
LM381N	£2.64
LM382	£2.30
LM386	£0.79
LM387	£1.60
LM392N	£0.79
LM393N	£0.21
LM709T	£0.79
LM733	£1.04
LM748CN-8	£0.31
LM579CP	£3.38
LM1458	£0.37
LM1881	£5.22
LM2917N8	£3.20
LM3900N	£0.72
LM3909N	£1.76
LM3911	£2.56
LM3914	£2.70
LM3915	£2.70
LM13600	£1.82
LMC660CN	£2.16
LMC6032IN	£1.55
LMC6042IN	£1.82
LP311N	£0.74
LP324N	£0.74
LP339N	£0.73
MAX202CPE	£2.97
MAX208CNG	£6.99
MAX220CPE	£5.06
MAX222CPE	£5.06
MAX232CPE	£2.16
MAX238CNG	£6.88
MAX242CPE	£5.51
MAX631ACP	£4.99
MAX635ACP	£4.99
MC1488	£0.39
MC1489	£0.39
MC3302	£0.56
MC3340P	£1.60
MC4558P	£0.36
MV500DP	£2.63
MV601DP	£2.97
NE531	£1.47
NE555N	£0.25
NE556N	£0.36
NE565	£1.84
NE566N	£0.90
NE567N	£0.39
NE571N	£2.47
NE592	£0.62
NE5532N	£0.80
NE5534N	£0.64
OP07CN	£1.42
OP27CN	£2.90
OP77GP	£2.36
OP90GP	£3.11
OP97FP	£2.43
OP113GP	£3.44
OP176GP	£2.09
OP177GP	£1.89
OP183GP	£3.44
OP200GP	£5.60
OP213FP	£5.20
OP275GP	£2.57
OP282GP	£2.27
OP283GP	£5.20
OP290GP	£5.40
OP295GP	£4.73
OP297GP	£5.74
OP400GP	£11.81
OP467GP	£13.74
OP495GP	£8.69
PM1012GP	£5.20
RC4136	£1.00
SAA1027	£4.46
SG3524N	£1.08
SG3543	£6.88
SL486	£4.12
SL490	£4.05
SSM2017P	£3.38
SSM2131P	£4.19
SSM2141P	£4.21
SSM2142P	£6.40
SSM2143P	£3.78
TBA120S	£0.90
TBA800	£0.70
TBA810S	£0.68
TBA820M	£0.39
TDA1024	£1.49
TDA1170S	£1.83
TDA2002	£1.04
TDA2004	£3.11
TDA2030	£1.18
TDA2050V	£3.98
TEA5115	£3.11
TL061CP	£0.35
TL062CP	£0.60
TL064CN	£0.72
TL071CP	£0.48
TL072CP	£0.50
TL074CN	£0.58
TL081	£0.33
TL082CP	£0.54
TL084CN	£0.63
TL494CN	£1.49
TL7705ACP	£1.62
TLC271	£0.54
TLC272	£0.88
TMP01FP	£5.60
UA2240CN	£2.30
ULN2003	£0.52
ULN2004A	£0.48
ULN2608	£1.20
ULN2803	£0.90
ZN409CE	£1.89
ZN414Z	£1.16
ZN416E	£1.99
ZN1034E	£3.11

EPROM's

2716	£4.46
2732	£4.84
2764-25	£4.20
27C64-25	£3.44
27C010	£5.74
27128-20	£4.08
27C128-20	£4.08
27256-20	£4.85
27C256-20	£3.68
27C512	£3.42

RAM

4164-15	£1.78
6116-10	£1.53
6264-10	£3.16
41256-10	£2.80
62256-10	£5.35
511000-8	£8.54
514256-8	£6.88

A/D Converters Data Acquisition

AD420AN	£25.38
AD557JN	£8.75
AD574AJN	£18.48
AD767JN	£20.88
AD775JN	£18.48
AD7226KN	£25.69
AD7528JN	£8.63
AD7545AKN	£14.04
AD7581JN	£25.80
AD7828KN	£20.33
AD7845JN	£14.04
ICL7109CPL	£7.75
TLC549IP	£3.51
ZN425E	£5.94
ZN426E	£3.13
ZN427E	£8.78
ZN428E	£5.94
ZN439E8	£7.13
ZN448E	£7.02

Voltage Regulators

7805	£0.44
7808	£0.50
7812	£0.43
7815	£0.38
7905	£0.31
7912	£0.38
7915	£0.38
7924	£0.38
78L05	£0.27
78L08	£0.23
78L12	£0.23
78L15	£0.24
78L24	£0.39
79L05	£0.28
79L08	£0.28
79L12	£0.28
79L15	£0.28
79L24	£0.30
ADM666AN	£3.44
L200CV	£1.24
L296	£8.13
L387A	£3.24
LM2904CT	£2.30
LM317T	£0.58
LM323K	£2.84
LM334Z	£1.35
LM338K	£5.52
LM723	£0.29
LP2950CZ	£2.97
REF01CP	£3.44
REF02CP	£4.66
REF12Z	£1.28
REF195GP	£4.72
REF25Z	£1.24
REF50Z	£1.22
TL431CP	£0.45
ZN423	£1.55
ZN458B	£1.8

Diodes

1N914	£0.0
1N916	£0.06
1N4001	£0.06
1N4002	£0.07
1N4003	£0.07
1N4004	£0.07
1N4005	£0.07
1N4006	£0.08
1N4007	£0.08
1N4148	£0.05
1N4149	£0.06
1N5400	£0.09
1N5401	£0.09
1N5402	£0.10
1N5404	£0.11
1N5406	£0.12
1N5407	£0.14
1N5408	£0.15
BA157	£0.10
BA158	£0.10
BA159	£0.10
BY126	£0.13
BY127	£0.11
BY133	£0.10
OA47	£0.28
OA90	£0.07
OA91	£0.10
OA200	£0.10
OA202	£0.29

Zeners 2.7 to 33V

400mW	£0.08
1.3W	£0.14

Bridge Rectifiers

W005 1.5A 50V	£0.19
W02 1.5A 200V	£0.20
W04 1.5A 400V	£0.22
W06 1.5A 600V	£0.22
W08 1.5A 800V	£0.27
W010 1.5A 1kV	£0.24
BR32 3A 200V	£0.36
BR34 3A 400V	£0.40
BR36 3A 600V	£0.33
BR62 6A 200V	£0.70
BR68 6A 800V	£0.59
1004 10A 400V	£1.39
2502 25A 200V	£1.68
2506 25A 600V	£1.75

Thyristors

PO102AA	£0.30
TIC106D	£0.36
TIC116D	£0.66
TIC126D	£0.77

Triacs

ZO105DA	£0.42
TIC206D	£0.65
TIC226D	£0.73
BTA08-600B	£0.99
TIC236D	£0.96

Diac, Si. Switch

DB3, 32V	£0.20
BRY39	£1.30

Transistors

2N1613	£0.31
2N1711	£0.26
2N1893	£0.29
2N2218A	£0.28
2N2219A	£0.25
2N2222A	£0.18
2N2646	£0.86
2N2904A	£0.25
2N2905A	£0.25
2N2907	£0.20
2N2907A	£0.20
2N2926	£0.16
2N3053	£0.27
2N3054	£0.85
2N3055	£0.62
2N3439	£0.62
2N3440	£0.50
2N3702	£0.09
2N3703	£0.10
2N3704	£0.10
2N3705	£0.10
2N3706	£0.10
2N3771	£1.44
2N3772	£1.51
2N3773	£1.70
2N3819	£0.33
2N3820	£0.66
2N3904	£0.10
2N3905	£0.10
2N3906	£0.10
2N4036	£0.34
2N5245	£0.80
2N5296	£0.57
2N5321	£0.57
2N5322	£0.57
2N5401	£0.11
2N5551	£0.11
2N6107	£0.60
2N6491	£1.58
2SB548	£0.30
2SD1730	£1.44
AC126	£0.44
AC127	£0.50
AC128	£0.40
AC187	£0.48
AC188	£0.48
ACY17	£3.84
AD149	£1.67
AD161	£0.92
AD162	£0.92
BC107	£0.16
BC107B	£0.17
BC108	£0.14
BC108A	£0.14
BC108C	£0.16
BC109	£0.17
BC109C	£0.18
BC114	£0.41
BC115	£0.41
BC116	£0.41
BC118	£0.41
BC132	£0.36
BC134	£0.36
BC135	£0.36
BC140	£0.25
BC141	£0.27
BC142	£0.31
BC143	£0.34
BC149	£0.21
BC154	£0.36
BC157	£0.12
BC159	£0.12
BC160	£0.28
BC170	£0.16
BC170B	£0.16
BC171	£0.11
BC171B	£0.16
BC172	£0.13
BC172B	£0.13
BC177	£0.18
BC178	£0.18
BC179	£0.18
BC179A	£0.17
BC182	£0.11
BC182A	£0.11
BC182B	£0.12
BC182L	£0.08
BC182LB	£0.08
BC183	£0.08
BC183L	£0.08
BC183LB	£0.08
BC184	£0.08
BC184L	£0.08
BC186	£0.33
BC204C	£0.72
BC206B	£0.72
BC207B	£0.74
BC208	£0.72
BC209A	£0.72
BC212	£0.08
BC212L	£0.08
BC212LB	£0.08
BC213	£0.08
BC213B	£0.08
BC213LC	£0.08
BC214	£0.08
BC214L	£0.08
BC225	£0.15
BC237B	£0.09
BC238B	£0.09
BC238C	£0.09
BC239C	£0.10
BC250A	£0.15
BC251	£0.13
BC252	£0.13
BC261B	£0.34
BC262B	£0.24
BC267B	£0.30
BC307	£0.10
BC308	£0.10
BC319C	£0.13
BC327	£0.10
BC327-16	£0.10
BC328	£0.10
BC328-16	£0.10
BC337	£0.10
BC337-25	£0.12
BC338	£0.10
BC338-25	£0.10
BC348B	£0.14
BC357	£0.25
BC393	£0.73
BC414C	£0.13
BC441	£0.40
BC461	£0.40
BC463	£0.29
BC478	£0.32
BC479	£0.32
BC490	£0.24
BC516	£0.22
BC517	£0.20
BC527	£0.20
BC528	£0.20
BC537	£0.20
BC546B	£0.08
BC546C	£0.08
BC547B	£0.09
BC547C	£0.09
BC548C	£0.08
BC549C	£0.10
BC550C	£0.10
BC556A	£0.08
BC557B	£0.08
BC557C	£0.08
BC558C	£0.08
BC559C	£0.08
BC560A	£0.09
BC560B	£0.09
BC637	£0.21
BC638	£0.21
BC639	£0.21
BC640	£0.21
BCY70	£0.21
BCY71	£0.20
BCY72	£0.20
BD124P	£6.86
BD135	£0.21
BD136	£0.21
BD137	£0.23
BD138	£0.22
BD139	£0.26
BD140	£0.25
BD150C	£0.82
BD165	£0.42
BD166	£0.35
BD187	£0.39
BD201	£0.40
BD202	£0.40
BD203	£0.40
BD204	£0.40
BD222	£0.58
BD225	£0.42
BD232	£0.50
BD237	£0.32
BD238	£0.32
BD240C	£0.37
BD243B	£0.50
BD244A	£0.53
BD244C	£0.53
BD245C	£1.18
BD246	£1.18
BD246C	£1.18
BD283	£0.61
BD284	£0.61
BD400	£0.79
BD441	£0.41
BD442	£0.37
BD534	£0.47
BD535	£0.50
BD536	£0.65
BD581	£0.62
BD597	£0.92
BD646	£0.52
BD648	£0.52
BD650	£0.53
BD707	£0.42
BD708	£1.04
BD807	£0.80
BDX32	£1.78
BDX33C	£0.49
BDX34C	£0.50
BDX53C	£0.47
BDX54C	£0.50
BF180	£0.31
BF182	£0.31
BF185	£0.31
BF194	£0.31
BF194B	£0.19
BF195	£0.19
BF244	£0.35
BF244B	£0.35
BF244C	£0.35
BF257	£0.33
BF259	£0.33
BF337	£0.40
BF355	£0.38
BF423	£0.13
BF451	£0.19
BF459	£0.33
BF469	£0.36
BFX29	£0.29
BFX84	£0.31
BFX85	£0.32
BFY50	£0.29
BFY51	£0.25
BFY52	£0.28
BS107	£0.21
BS170	£0.21
BSW66	£1.35
BU126	£1.32
BU205	£1.41
BU208A	£1.24
BU326A	£1.40
BU500	£1.54
BU508A	£1.42
BU508D	£1.44
BU526	£1.74
BU806	£1.06
BUT11A	£1.30
BUT11AF	£1.30
BUX84	£0.78
IRF540	£1.60
IRF740	£1.80
MJ2501	£1.60
MJ3001	£1.80
MJ11015	£2.11
MJ11016	£2.56
MJE340	£0.40
MJE350	£0.48
MPSA05	£0.14
MPSA06	£0.12
MPSA13	£0.12
MPSA42	£0.17
MRF475	£7.28
TIP29C	£0.31
TIP30C	£0.31
TIP31C	£0.41
TIP32C	£0.41
TIP33C	£0.72
TIP41A	£0.48
TIP42C	£0.52
TIP47	£0.48
TIP48	£0.62
TIP50	£0.53
TIP121	£0.35
TIP122	£0.48
TIP125	£0.46
TIP127	£0.40
TIP132	£0.46
TIP137	£0.56
TIP142	£1.08
TIP147	£1.12
TIP2955	£0.97
TIP3055	£0.63
VN10KM	£0.48
VN66AFD	£1.50
ZTX300	£0.16
ZTX500	£0.16

SAMEDAY DESPATCH

No Minimum Order Value

Electrolytic Radial Capacitors

µF	16v	25v	63v	100v	450v
0.47	---	---	£0.05	£0.07	---
1.0	---	---	£0.05	£0.06	£0.23
2.2	---	---	£0.05	£0.06	£0.31
4.7	---	---	£0.05	£0.08	£0.39
10	£0.05	£0.05	£0.06	£0.08	£0.44
22	£0.05	£0.05	£0.09	---	£0.85
47	£0.06	£0.06	£0.11	---	£0.98
100	£0.06	£0.09	£0.11	---	---
220	£0.09	£0.12	£0.31	---	---
470	£0.15	£0.19	£0.57	---	---
1000	£0.22	£0.29	---	---	---
2200	£0.37	£0.57	---	---	---
4700	---	£1.11	---	---	---

Electrolytic Axial Capacitors

µF	16v	25v	63v	100v	450v
0.47	---	---	---	£0.15	---
1.0	---	---	£0.11	£0.10	£0.19
2.2	---	---	£0.10	£0.10	£0.22
4.7	---	---	£0.10	£0.10	---
10	---	---	£0.12	£0.12	£0.57
22	---	£0.12	£0.13	£0.17	£1.06
47	£0.10	£0.11	£0.16	£0.20	---
100	£0.10	£0.14	£0.21	---	---
220	£0.13	£0.18	£0.42	---	---
470	£0.21	£0.24	£0.69	---	---
1000	£0.33	£0.40	£1.05	---	---
2200	£0.52	£0.64	---	---	---
4700	£0.90	---	---	---	---

Resistors

¼W Carbon Film 5% E12 Series 1Ω-10M	£0.02 Each, £0.60 per 100
½W Carbon Film 5% E12 Series 1Ω-10M	£0.02 Each, £0.95 per 100
¼W Metal Film 1% E24 Series 10Ω-1M	£0.04 Each, £1.72 per 100
Enclosed Presets, Horz / Vert. 100Ω - 1M0 0.15W	£0.15 Each
Skeleton Presets Horz / Vert. 100Ω - 1M0 0.1W	£0.11 Each
POTS ¼" Shaft 25mm Dia 470Ω - 2M2 Lin or Log	£0.42 Each

per 100 of one value only

Please State Value(s) Required

DIL Sockets

8 Pin	£0.07	14 Pin	£0.11	16 Pin	£0.15	18 Pin	£0.15
20 Pin	£0.16	24 Pin	£0.19	28 Pin	£0.22	40 Pin	£0.25

Out Now

New 1996 PCB Production Catalogue

A Fully illustrated catalogue covering everthing you require to Prototype & Design circuits and Manufacture Printed Circuit Boards. From simple Stripboard or Breadboard Development to Artwork Design, PCB Materials, Chemicals, Equipment and Tools.

Many New Products and all at LOW Prices

FREE .... with any order over £7.50 when requested.
(Please quote Order Code 000-120 to recieve a copy)
or .... send a S.A.E (A4 & stamps to the value of 47p)

ORDERING INFORMATION - All Prices Exclude Vat (17½%), Add £1.25 carriage & Vat to all orders. Send Payment with Order. PO / Cheques payable to ESR Electronic Components. Credit Card Orders Accepted. NO Credit Card Surcharges. Trade discount for Schools & Colleges.

EVERYDAY PRACTICAL ELECTRONICS

VOL. 25 No. 2 FEBRUARY '96

Editorial Offices:
EVERYDAY PRACTICAL ELECTRONICS EDITORIAL
ALLEN HOUSE, EAST BOROUGH, WIMBORNE
DORSET BH21 1PF
Phone: Wimborne (01202) 881749
Fax: (01202) 841692. DX: Wimborne 45314
Due to the cost we cannot reply to orders or queries by Fax.
See notes on **Readers' Enquiries** below – we regret lengthy technical enquiries cannot be answered over the telephone.

Advertisement Offices:
EVERYDAY PRACTICAL ELECTRONICS ADVERTISEMENTS
HOLLAND WOOD HOUSE, CHURCH LANE
GREAT HOLLAND, ESSEX CO13 0JS
Phone/Fax: (01255) 850596

OOPS!

First of all our rather belated Seasons Greetings and Best Wishes for the New Year. Why are we late? Well, when I sat down to write last month's Editorial it was the beginning of November and Christmas seemed an age away. The fact that the Editorial was for the January 1996 issue, when we were still well inside 1995, was also not conducive to getting the seasonal feeling of bonhomie. Sorry – but better late than never!

PROMOTIONS

Whilst our pages are put together a few weeks before publication, articles are planned up to nine months in advance and some promotions even further ahead. In this way we can keep the editorial balance – although occasionally this is upset, as it has been this month, by articles running out much longer than anticipated. We have had to split the *PIC-Electric Meter* article in two because it simply became too long to fit into the available pages and it is too good a project to try to cut back (aren't they all!).

Next month's issue will be promoted in the UK with a set of **Free Stereo Headphones** plus a Greenweld Catalogue bagged with your issue – demand will be very high so make sure of your copy by placing an order for it *now*. This promotion has been planned for about three months but the following issue promotion was sorted out over a year ago!

The issue also carries part one of a new Mind Machine from Andy Flind and a specially designed test and general purpose amplifier project, both of which can use the free headphones. Even if you don't build a project that will use the headphones we are sure you will find them valuable – they will provide astonishingly good output from your personal stereo, hi-fi, TV, video, etc.

PRO LOGIC

Following the Free Stereo Headphones and catalogue with the March issue, the April issue will come bagged with a 64 page booklet fully describing the operation of the Dolby Pro Logic surround sound system and giving full constructional details of a Dolby Pro Logic Decoder which you can build for under £100. This is the only kit available for Dolby Pro Logic at present and was developed in Australia and licensed by Dolby Laboratories in the USA.

If you have experienced Dolby Pro Logic on videos or TV films you will know just how good it is. In fact it is so good that you will never get the same excitement from watching a video without this system once you have experienced it. Again make sure of your copy as demand is bound to be high. **You have been warned!**

SUBSCRIPTIONS

Annual Subscriptions for delivery direct to any address in the UK: £24. Overseas: £30 (£47.50 airmail). Cheques or bank drafts (**in £ sterling only**) payable to *Everyday Practical Electronics* and sent to EPE Subscriptions Dept., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749. Subscriptions start with the next available issue. We accept Access (MasterCard) or Visa.

BINDERS

Binders to hold one volume (12 issues) are available from the above address. These are finished in blue p.v.c., printed with the magazine logo in gold on the spine. Price £5.95 plus £3.50 post and packing (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery – more for overseas orders.*

Payment in £ sterling only please. Visa and Access (MasterCard) accepted, minimum credit card order £5. Send or phone your card number and card expiry date with your name, address etc.

Editor: MIKE KENWARD
Secretary: PAM BROWN
Deputy Editor: DAVID BARRINGTON
Technical Editor: JOHN BECKER
Business Manager: DAVID J. LEAVER
Subscriptions: MARILYN GOLDBERG
Editorial: Wimborne (01202) 881749
Advertisement Manager:
PETER J. MEW, Frinton (01255) 850596
Advertisement Copy Controller:
DEREK NEW, Wimborne (01202) 882299

READERS' ENQUIRIES

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply *must* be accompanied by **a stamped self-addressed envelope or a self-addressed envelope and international reply coupons. Due to the cost we cannot reply to queries by Fax.**

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

We regret that we **cannot provide data, or answer queries, on projects that are more than five years old.**

ADVERTISEMENTS

Although the proprietors and staff of EVERYDAY PRACTICAL ELECTRONICS take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are *bona fide*, the magazine and its Publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or in inserts.

The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture. Legal remedies are available in respect of some of these circumstances, and readers who have complaints should first address them to the advertiser.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before buying any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use or ownership. The laws vary from country to country; overseas readers should check local laws.

Constructional Project

SIMPLE PIC16C84 PROGRAMMER

DERREN CROME

Serial programming the EEPROM version of the PIC microcontroller family is easily done from your PC.

DESCRIBED here are the circuit and software which enable an IBM PC-compatible computer to program the PIC16C84 microcontroller with a minimal amount of extra hardware.

Unlike other members of the PIC microcontroller family, the PIC16C84 is manufactured around EEPROM (electrically erasable programmable read-only memory) technology. Consequently, it can be repeatedly reprogrammed without the need for ultraviolet erasing. It is thus ideal for use in situations where programs are being developed stage by stage, or where some data parameters need to be periodically updated.

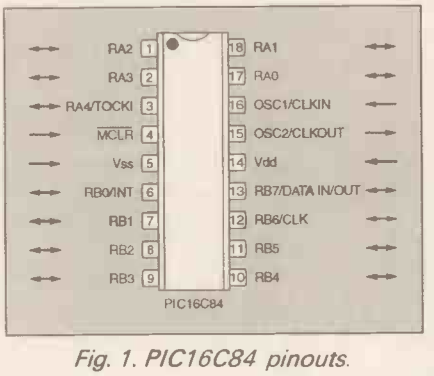


Fig. 1. PIC16C84 pinouts.

PIC16C84 SPECIFICATIONS

The PIC16C84 is a high performance, low cost, CMOS microcontroller having 1K × 14-bit EEPROM program memory and 64 × 8-bit EEPROM data memory. It also has 36 × 8-bit SRAM (static random access memory) general purpose registers and 15 special function hardware registers. The pinouts are shown in Fig. 1.

There are four interrupt sources available: external INT pin, TMRO timer overflow, PORTB <7:4> interrupt on change, and data EEPROM write completion. Typically, the device can accept around one million erase/write cycles. Data retention is in excess of 40 years.

In-built peripheral features include: 13 I/O (input/output) pins with individual direction control, 25mA current sinking per pin, 20mA current sourcing per pin, and 8-bit real time clock/counter (TMRO) with 8-bit programmable prescaler.

Special microcontroller features include: power-on reset, power-up timer, oscillator start-up timer, watchdog timer (WDT) with its own on-chip RC (resistor-capacitor) oscillator, security EEPROM fuse for code protection, power-saving Sleep-mode, plus serial in-system programming (ISP) of EEPROM program and data memory using only two pins.

There are also four user-selectable oscillator options: RC oscillator (RC), crystal/resonator (XT), high-speed crystal/resonator (HS – up to 10MHz), and power-saving low-frequency crystal (LP).

INSTRUCTION SET

The PIC16C84 instruction set is shown in Table 1. However, it is beyond the scope of this article to describe the way in which the instructions are used, and readers are recommended to obtain the manufacturer's data book, which covers them at length.

The book also comprehensively covers all other members of the PIC microcontroller family and should be regarded as an *absolute must* by anyone intending to program these devices. Details on how to obtain the book are given at the end of the article.

SERIAL PROGRAMMING

Although the PIC16C84 can be programmed in either parallel or serial mode, the programming technique described here is for serial mode. The circuit diagram for this technique is shown in Fig. 2.

For the moment, ignore the l.e.d.s D2 to D5 and their resistors R3 to R6. They are not part of the programming circuit but are used in connection with an example program discussed later.

The advantage of the serial technique is that only three wires are needed to connect between the computer and the microcontroller, IC1. The three wires carry the clock and data signals, and provide the ground (0V) connection.

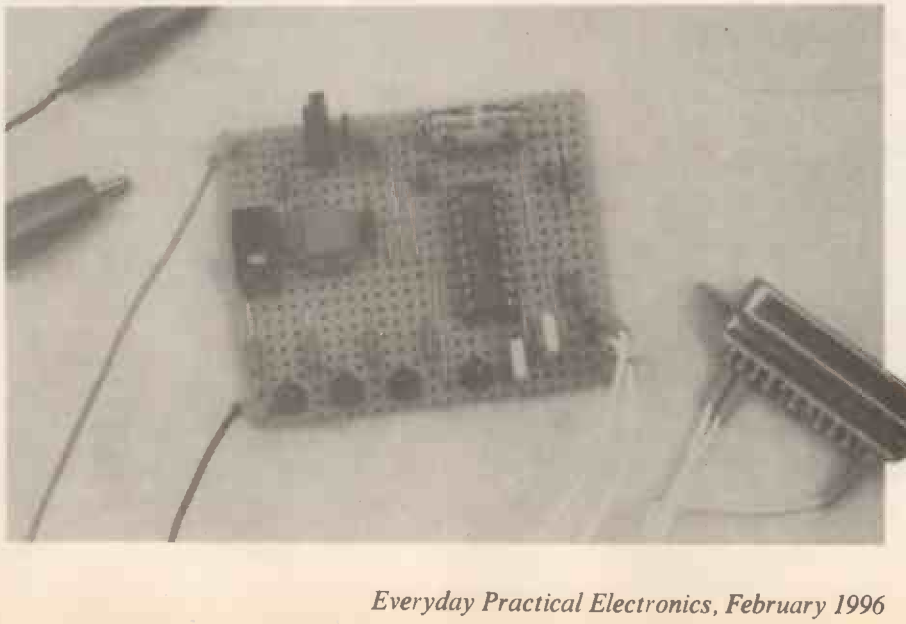


TABLE 1. PIC16C84 instruction set

MNEMONIC	OPERANDS	DESCRIPTION	STATUS AFFECTED
BYTE-ORIENTATED FILE REGISTER OPERATIONS			
ADDWF	F, D	Add W and F	C, DC, Z
ANDWF	F, D	AND W and F	Z
CLRF	F	Clear F	Z
CLRW	–	Clear W	Z
COMF	F, D	Complement F	Z
DECF	F, D	Decrement F	Z
DECFSZ	F, D	Decrement F, Skip if Zero	–
INCF	F, D	Increment F	Z
INCFSZ	F, D	Increment F, Skip if Zero	–
IORWF	F, D	Inclusive OR W and F	Z
MOVF	F, D	Move F	Z
MOVWF	F	Move W to F	–
NOP	–	No Operation	–
RLF	F, D	Rotate Left F through carry	C
RRF	F, D	Rotate Right F through carry	C
SUBWF	F, D	Subtract W from F	C, DC, Z
SWAPF	F, D	Swap halves F	–
XORWF	F, D	Exclusive OR W and F	Z
BIT-ORIENTATED FILE REGISTER OPERATIONS			
BCF	F, B	Bit Clear F	–
BSF	F, B	Bit Set F	–
BTFSC	F, B	Bit Test F, Skip if Clear	–
BTFSS	F, B	Bit Test F, Skip if Set	–
LITERAL AND CONTROL OPERATIONS			
ADDLW	K	Add Literal to W	C, DC, Z
ANDLW	K	AND Literal to W	Z
CALL	K	Call subroutine K	–
CLRWDT	–	Clear Watchdog Timer	$\overline{TO}$, $\overline{PD}$
GOTO	K	Go to address K	–
IORLW	K	Inclusive OR Literal to W	Z
MOVLW	K	Move Literal to W	–
RETFIE	–	Return from Interrupt	–
RETLW	K	Return with Literal in W	–
RETURN	–	Return from subroutine	–
SLEEP	–	Go into standby mode	$\overline{TO}$, $\overline{PD}$
SUBLW	K	Subtract Literal from W	C, DC, Z
XORLW	K	Exclusive OR Literal to W	Z
OTHER INSTRUCTIONS (see notes)			
OPTION	–	Load OPTION register	–
TRIS	F	Load TRIS register	–

NOTES:

B = Bit address within 8-bit file register
C = Carry/$\overline{\text{borrow}}$ bit
D = Destination select: D = 0, store result in W; D = 1 store result in file register F. Default is D = 1
DC = Digit Carry/$\overline{\text{borrow}}$ bit
F = File register address
K = Literal field, constant data or label
$\overline{PD}$ = Power-down bit
$\overline{TO}$ = Time-out bit
W = Working register (accumulator)
Z = Zero bit

Usable static RAM locations range from 0C to 2F hex, inclusive.

The instructions OPTION and TRIS are only included for code compatibility with PIC16C5X products. To maintain upward compatibility with future PIC16CXX products, the use of these two commands is not recommended. However, since both registers are readable and writable, the user can directly address them.

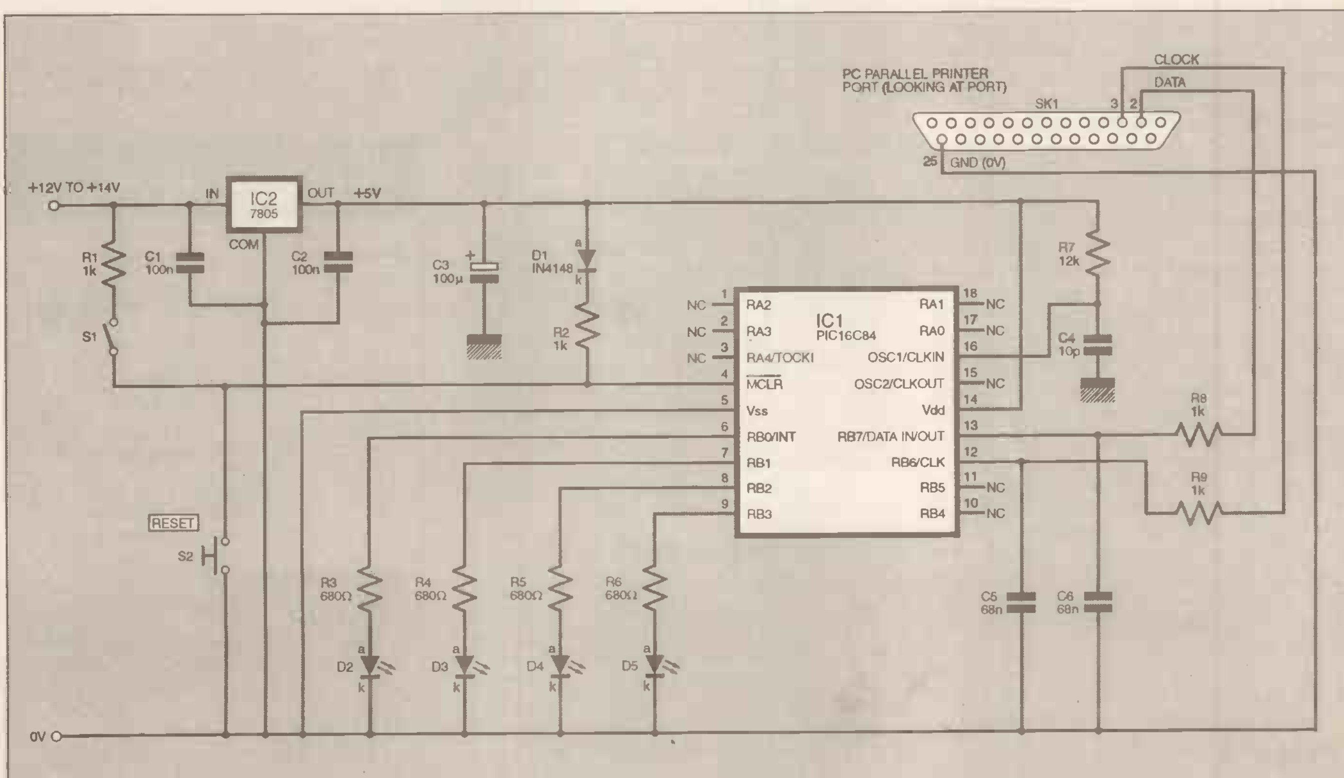


Fig. 2. Complete circuit diagram for the Simple PIC16C84 Programmer.

All three connections are made to the PC-compatible computer's parallel printer port via a 25-way male D-connector (SK1). Serial data is sent via SK1 pin 2 (data pin D0), and the clock signal is provided via SK1 pin 3 (data pin D1). The ground connection is provided via SK1 pin 25 (one of the several parallel port 0V lines available).

Current-limiting resistors R8 and R9 are included to protect the parallel port and IC1 in case of conflicting logic levels. Capacitors C5 and C6 prevent spurious noise signals from generating false data and clock pulses. As the data and clock inputs to IC1 have Schmitt trigger operation, the resulting slightly slower pulse rise/fall times should not cause problems.

(As illustrated in the PIC-Electric circuit elsewhere in this issue, the basic PIC16C84 programming components may be incorporated in the circuit of any design, allowing in-situ programming development. Ed.)

PROGRAMMING MODE

When in programming mode, the PIC16C84 requires a voltage of between +12V and +14V to be applied to its $\overline{MCLR}$ pin. However, the power supply across its V_{dd} and V_{ss} pins (pins 14 and 5) must be at no more than +5V. The circuit thus needs to be powered from a 12V to 14V d.c. regulated power supply, or a 12V battery. The input voltage is then regulated down to +5V by IC2. Capacitors C1 and C2 provide power line decoupling.

Resistor R7 and capacitor C4 form a CR time constant to set the PIC's clock frequency.

With programming switch S1 open, the $\overline{MCLR}$ pin is held high via diode D1 and resistor R2. In this mode, IC1 executes its stored program.

Pressing Reset switch S2 connects the $\overline{MCLR}$ pin to the 0V line, so resetting IC1 to the start of its stored program routine. In this mode, program execution ceases and all I/O pins go into a high impedance state. On releasing S2, the program restarts from address 0000 hex.

To set the PIC into program/verify mode, which is required when downloading a program or configuration data, switch S1 is closed, connecting the full programming voltage via resistor R1 to the $\overline{MCLR}$ pin. Diode D1 prevents this voltage from affecting the regulated +5V line.

Once S1 has been closed, S2 has to be pressed briefly to reset the microcontroller. Resistors R1 and R2 prevent either of the power lines from being shorted to ground when S2 is pressed.

With S1 closed and S2 open, the PIC is now in program/verify mode and waits for the first serial data command to arrive from the computer. It will remain in this mode until S1 is opened.

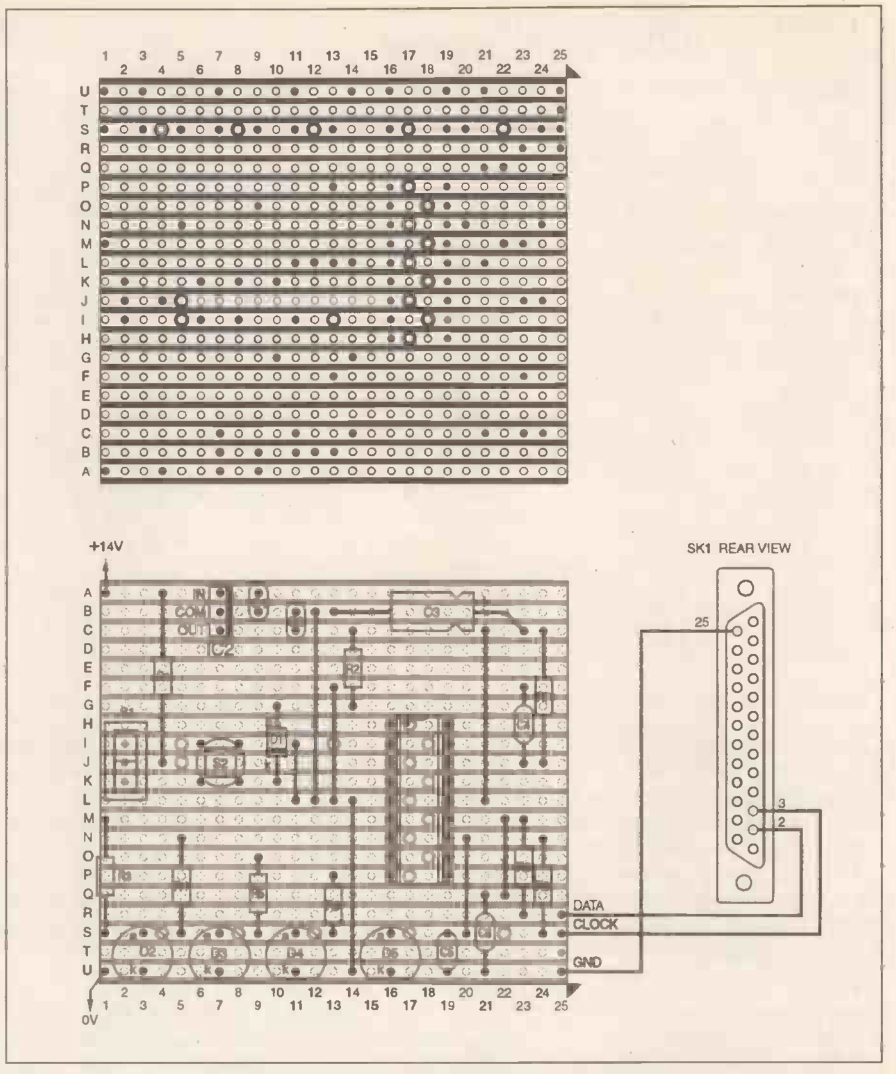


Fig. 3. Suggested stripboard layout details.

CONSTRUCTION

A suggested stripboard layout for the full circuit of Fig. 2 is shown in Fig. 3. The optional l.e.d.s D2 to D5 and their resistors R3 to R6 may be omitted if preferred.

The layout is designed for use with a standard 18-pin d.i.l. (dual-in-line) socket into which the PIC to be programmed is inserted. After programming, the PIC is removed using an i.c. extractor tool, or gently prised out using a screwdriver. Experienced constructors who intend to do a lot of PIC programming may prefer to change the layout so that a ZIF (zero insertion force) socket can be used instead.

Start off construction by soldering in the 18-pin d.i.l. socket. Then solder in the link wires and remaining components in any order you feel comfortable with. Ensure that the polarities of diode D1, regulator IC2 and capacitor C3 are correctly observed. Then connect wires for the power supply and socket SK1.

Make sure that all the track cuts are made as shown, and that you check everything thoroughly before using the board.

DATA TRANSMISSION

When the circuit is in program/verify mode, data present on pin 13 (RB7/Data In/Out) is clocked into IC1 on the rising edge of the clock signal applied to pin 12 (RB6/CLK). The serial data transfer protocol is as follows:

First, the binary code 000010 is sent. This instructs the PIC that the next 16 bits are program data. Next a 0 is sent, followed by the 14 data bits which make up a single program instruction, the most significant byte (MSB) being sent first. Finally, another 0 is sent.

At this point, the 14-bit data is stored in the PIC's internal buffer. To store the data in the EEPROM memory, the "begin programming" command 001000 is sent. There must be a 10ms delay between issuing this command and sending the next one, which is 000110. This instructs the PIC to increment its internal program counter, so that the next instruction will be stored in the next consecutive memory location.

The cycle is then repeated for every instruction in the program.

SOFTWARE

The software needed to program PIC16C84 microcontrollers using the circuit in Fig. 2 consists of three programs: a Text Editor (word-processing program) on which to write the instructions in mnemonic form, a Cross-Assembler, and the Send program which actually sends the data according to the above protocol.

Any standard text editor may be used to write the mnemonic instructions, providing it is capable of generating an ASCII file without additional layout formatting and printer control commands.

A cross-assembler is a program which converts the ASCII mnemonic text file into the binary code required by the PIC microcontroller. The cross-assembler required for this programmer is the Shareware software program TASM.

COMPONENTS

See SHOP TALK Page

Resistors

R1, R2, R8, R9 1k (4 off)
R3 to R6 680Ω (4 off) (see text)
R7 12k
All 0.25W 5% carbon film or better

Capacitors

C1, C2 100n min. ceramic disc (2 off)
C3 100µ elect. radial, 25V
C4 10p min. ceramic disc
C5, C6 68n min. polyester (2 off)

Semiconductors

D1 1N4148 silicon diode
D2 to D5 red l.e.d. (4 off) (see text)
IC1 PIC16C84 microcontroller
IC2 7805 1A +5V regulator

Miscellaneous

S1 s.p. min. slide switch, p.c.b. mounting
S2 min. push-to-make switch, p.c.b. mounting

Stripboard 25 holes × 21 strips, 0·1 pitch; 18-pin d.i.l. socket (see text); 25-way D-connector; connecting wire; solder, etc.

Approx cost guidance only **£12**

LISTING 1. Part of the translation table

```
.MSFIRST
.WORDADDRS

ADDWF  *,*  0700  2  TDMA  1  7  0080
ANDWF  *,*  0500  2  TDMA  1  7  0080
CLRF   *    0180  2  TDMA  1  0  007F
CLRW   ""   0100  2  NOTOUCH 1
```

Shareware software is copyrighted, but the authors of such software have given permission for it to be freely copied. However, if *regular* use of Shareware software is intended, then the copy must be registered by means of making a nominal payment to the author.

If you only wish to evaluate the Shareware software and then find that it is not suited to your needs, no registration payment needs to be made.

To enable TASM to assemble programming data for the PIC16C84, a translation table has been specially written for *EPE* readers. This is simply a text file which defines all the PIC16C84 instructions, as partly shown in Listing 1.

Also specially written for *EPE* is a program which sends the assembled data codes to the chip. Users of the translation table and the Sending program may freely do so without any registration payment being required.

Details about how to obtain all the software for this project are given later.

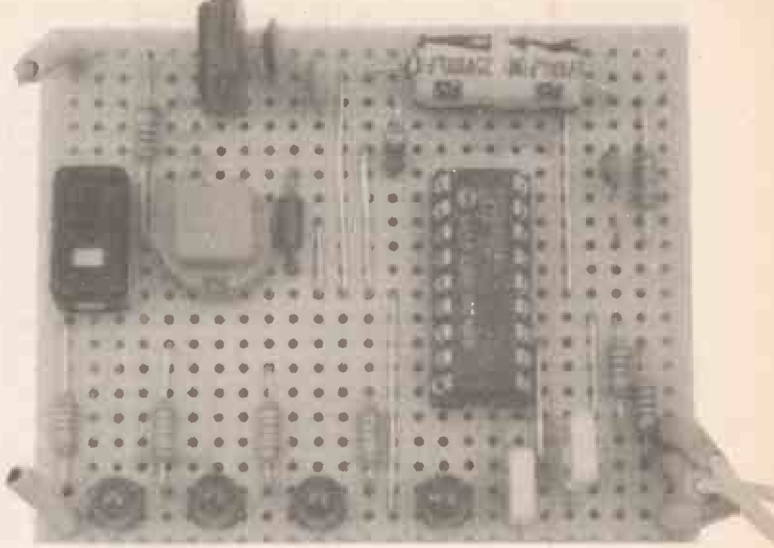
Having obtained the software, it recommended that it is copied from the disk supplied onto the hard disk of drive C, into its own directory for which a name of *PIC* is suggested (other names can be given if preferred).

This can be done as follows, typing each of the commands on the DOS prompt (>), followed by <ENTER>:

```
C:
CD\
MD PIC
CD\PIC
COPY B:*.*
```

(or, depending on your second disk drive, type COPY A:*.*).

Then come out of the PIC directory (CD\) and load your text editor program.



TABLE

Every PIC instruction the user types in via their text editor consists of a mnemonic plus up to two operands.

For example, take the single instruction ADDWF $13,1. The mnemonic is ADDWF, the first operand is $13 and the second operand is 1. The $ (dollar) symbol indicates to TASM that the value is in hexadecimal. If the $ symbol is omitted, TASM will take the value as being in decimal. Binary values may be entered by prefixing them with the % (percentage) symbol, e.g. %00010011.

When TASM is assembling a program, it "looks" at each line in turn and produces the code for it. When it comes across a command mnemonic, such as ADDWF for example, it refers to the translation table to find out which op-code is associated with that particular command.

The operands are then combined with the op-code to produce a 16-bit word. Since the PIC16C84 only needs 14-bit commands, the left-hand two bits are not used and are always set to zero.

Referring to the partial extract of the translation table in Listing 1 (from disk file TASM1684.TAB), first there are two assembler directive lines. The first one, .MSFIRST, instructs TASM to produce the most significant byte first, followed by the least significant byte. The next line, .WORDADDRS, instructs TASM to produce 2-byte addresses.

Following these lines is the table itself. The first command defined is ADDWF, which means add the contents of the working register to the contents of a file register. The ADDWF command expects two operands to be specified. The first is the address of the actual register file to which you wish to add. The second operand can only be a 0 or a 1. If a 0 is specified, the PIC

LISTING 2. Example program for PIC16C84

```
;EXAMPLE.ASM
;Lights l.e.d.s connected to PORT B bits 0 to 3 (IC1 pins 6 to 9) in
turn

#DEFINE PAGE0 BCF $03,5
#DEFINE PAGE1 BSF $03,5
          .AVSYM
STATUS:   .EQU $03      ;Located in page 0 & 1
PCL:      .EQU $02      ;0 & 1
TMR0:     .EQU $01      ;0
PORTA:    .EQU $05      ;0
PORTB:    .EQU $06      ;0
TRISA:    .EQU $05      ;1
TRISB:    .EQU $06      ;1
OPTION:   .EQU $01      ;1
INTCON:   .EQU $0B      ;0 & 1
EEDATA:   .EQU $08      ;0
EEADR:    .EQU $09      ;0
EECON:    .EQU $08      ;1
PCLATH:   .EQU $0A      ;0 & 1

W:        .EQU 0        ;Result to go into working register
                        (accumulator)
F:        .EQU 1        ;Result to go into a file register.
C:        .EQU 0        ;Carry flag (located in STATUS
                        register)
DC:       .EQU 1        ;Digit carry (located in STATUS
                        register)
Z:        .EQU 2        ;Zero flag (located in STATUS
                        register)
PD:       .EQU 3        ;Power Down bit (located in
                        STATUS register)
TO:       .EQU 4        ;Time-out bit (located in STATUS
                        register)
          .ORG $0004    ;Interrupt vector address
          GOTO INTRPT   ;Jump to interrupt routine on
                        interrupt
          .ORG $0005    ;Start of program memory
          ;Above lines must always be present.

          PAGE1         ;Defined above.
          MOVLW $00     ;Load working register
                        (accumulator) with literal 0.
          MOVWF TRISB   ;Configure all port B lines as
                        output
          CLRWDT        ;Clear watchdog timer
          MOVLW %00000111 ;Configure timer options
          MOVWF OPTION
          PAGE0
          MOVLW $08
          MOVWF PORTB   ;Set bit 3 on port B
          MOVLW %10100000
          MOVWF INTCON  ;Enable timer interrupt

START:    NOP           ;Dummy main program, loops
                        endlessly
          GOTO START    ;waiting for a timer interrupt to
                        occur

;Interrupt routine
INTRPT:   RRF PORTB,F   ;Set next bit of port B
          MOVF PORTB,F  ;Affect Z status bit
          BTFSS STATUS,Z ;Test to see if port B's value=0
          GOTO FIN      ;Its value is not 0
          MOVLW $08     ;Its value is zero, Set bit 3 of port B

          MOVWF PORTB
FIN:      BCF INTCON,2  ;Clear timer overflow interrupt
flag
          RETFIE        ;Return from interrupt
          .END          ;This command MUST be placed at
                        end of program
```

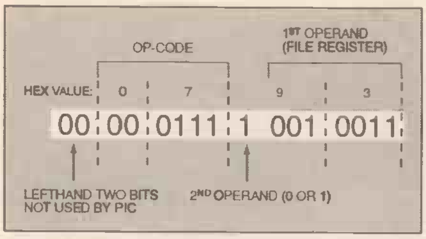


Fig. 4. Typical 14-bit pattern for program data code.

is instructed to place the result of the addition into the working register. If a 1 is specified, the result is placed back into the named file register.

For example, take the instruction:

ADDWF $13,1

For the PIC to perform this command, the 14-bit pattern held in its program memory must be as shown in Fig. 4 (ignoring the lefthand two bits).

To produce this required bit pattern, the translation table contains the following line:

ADDWF *,* 0700 2 TDMA 1 7 0080

The first part of the line, ADDWF *,*, instructs TASM to expect two operands after the ADDWF mnemonic, separated by a comma. As specified in the manufacturer's data book, 0700 is the actual hex value of the op-code. The following decimal 2 indicates that two bytes (16 bits) are to be produced for this command, i.e., binary 00000111 00000000 (07 hex and 00 hex)

Next, TDMA is a command to inform TASM what to do with the operand(s). What TASM actually does is to logically OR the 0700 hex with the first operand, which in this case is the $13 hex (00010011 binary) in the original command line. This results in 0713 hex (00000111 00010011 binary).

The second operand is decimal 1, indicating that the result of the instruction is to be placed back in the file register. The decimal 7 in the table line tells TASM to shift the bit pattern of this operand seven bits to the left. This intermediate result is ANDed with 0080 hex, producing 10000000 binary, which is then ORed with 0713 hex, resulting in 0793 hex (00000111 10010011 binary).

The table continues in a similar fashion for all the PIC16C84 commands. It will be seen that other commands occur in the table lines, such as TI and NOTOUCH. A full description of the translation table, including these commands, is given the additional text file TASMTABS.DOC which is supplied with the software.

Readers will be interested to know that the Shareware software also contains translation tables for processors other than the PIC16C84, including 6502, 6805, 68xx, 8048, 8051, 8085 and Z80 (but not 8086).

EXAMPLE PROGRAM

Once constructed, the programming circuit can be checked out using an example program (EXAMPLE.ASM) included with the software supplied. The program file can be loaded into your text editor for examination. When the assembled program code is loaded into the PIC, it causes four l.e.d.s (D2 to D5) to light in sequence and has its listing shown in Listing 2.

It will be seen in the listing that lines three and four use the #DEFINE command. This command allows alias string names to be defined. For example, line three states:

#DEFINE PAGE0 BCF $03,5

This simply tells the TASM assembler that when it is assembling the object code file, each time it comes across the statement PAGE0, it is to replace it with the statement BCF $03,5. Any desired aliases can be defined in this way. (The use of PAGE0 and PAGE1 is covered in the data manual.)

After aliases have been defined, the statement .AVSYM must be included.

Next, string names can be defined and allocated to specific values. For example, the manufacturer's data for the PIC16C84 states that the STATUS register is located at $03. Thus the line:

STATUS: .EQU $03

tells TASM that each time the name STATUS occurs in the text file it is to be replaced by the hex value $03.

The idea of equating values to string names is that it makes programs more readable and therefore easier to debug, and easier for other people to understand. Furthermore, it is also easier for programmers to remember names rather than numbers.

As will be seen, not only can byte locations be defined in this way, but also specific flag bits within bytes, e.g. the zero status flag, which is bit 2 of the STATUS register, is defined by:

Z: .EQU 2

Thus, if the command BTFSS STATUS,Z is encountered, the assembler will take this line to mean BTFSS STATUS,2, i.e. to tell the program to test the status of bit 2 in the STATUS register and branch accordingly.

Comments may be included anywhere in the text file but they must always be prefixed by a semi-colon (;).

Following the definition of names and their values come three further instruction lines to the assembler software:

```
.ORG $0004
GOTO INTRPT
.ORG $0005
```

The .ORG $0004 command followed by the command GOTO INTRPT puts the address of the interrupt routine into address $0004 in the PIC. If interrupts are not required in a program, this line should still be included, but a dummy interrupt routine should be defined, e.g.:

INTRPT: RETFIE

In this situation, if an interrupt mistakenly occurs in the program, instead of crashing, the program will jump to this dummy interrupt routine and jump straight back to where it left off in the main program (as instructed by the RETFIE command – return from interrupt).

The next line, .ORG $0005, instructs the assembler to assemble the program starting at address $0005. This is the address from which the PIC16C84 will start executing the program at switch on, or when reset by taking the $\overline{MCLR}$ pin low.

Next come various other "housekeeping" operations in which the input/output configurations of the ports are defined and the watchdog timer operation is specified.

Now come the first two lines of the program itself:

```
START:  NOP
        GOTO START
```

The word START: is used as a label. A label allows the programmer to specify jumps or calls to various parts of the program without actually specifying the actual addresses to which they are made. The assembler program automatically calculates the required address each time it comes across the label. Labels must be suffixed by a colon (:) when used in the left hand column.

In the above two program lines, the program repeatedly loops through the commands until an interrupt occurs, in this case until the watchdog timer count reaches zero.

When the interrupt occurs, the program jumps out of the loop and to the interrupt routine whose label was specified earlier on in the program (.ORG $0004 – GOTO INTRPT).

All the commands associated with the interrupt routine are then performed until the command RETFIE is encountered, whereupon the program jumps back to the START: loop at the point from which it had exited. The loop then continues to cycle until the next interrupt occurs.

The actions taken within the example interrupt routine here are all associated with incrementing a count value output to PORTB, resulting in the respective l.e.d.s being turned on or off as dictated by the count value. A high output on any of the four PORTB pins turns on the respective l.e.d.

Finally, at the end of the program listing is the command .END. This must be included so that the assembler knows when it has reached the end of the program it has to assemble.

ASSEMBLING CODE

When the program instructions have been written as mnemonic text, the text must be saved to disk. It is recommended that it is saved as two files if it has been written on a text editor which does not automatically save the file as an ASCII file.

First save it as an ordinary file which includes all the non-ASCII commands normally associated with the editor, using an easily recognisable extension code, such as .PIC. For example, the above listing could be saved as EXAMPLE.PIC.

Then select the text editor's function which causes files to be saved as pure ASCII text files without any formatting or layout commands, using a different extension, e.g. EXAMPLE.ASM.

This technique allows files to be worked on according to the text editor's normal formatting requirements while still generating a file which will be correctly acted upon by the TASM assembler. Be aware that *ANY* non-ASCII text editor commands may cause the assembler to misinterpret the mnemonic code lines.

(Before this fact was recognised when testing the program at our offices, a non-ASCII file was somehow erased when TASM failed to recognise some command lines. This resulted in it having to be retyped. Ed.)

When the mnemonic text files have been saved, exit the text editor and change directories. For example, assuming that all the PIC16C84 programs have been installed in a directory named PIC, at the DOS prompt type:

CD\PIC

Now invoke the assembler, telling it which file it is to assemble, i.e.:

TASM -1684 -B <filename>

The command TASM invokes the assembler, -1684 instructs it to relate the file to the PIC16C84 translation table, -B instructions it to assemble the code as a binary file, and <filename> should be replaced by the full name of the file to be assembled, including its extension. Note the space between each of the four commands. (The command may be typed in capital or lower case letters.)

Thus to assemble the above example program, type:

TASM -1684 -B EXAMPLE.ASM

The assembler then creates three files, an object file (.OBJ), a listing file (.LST) and a symbol (.SYM) file, in this case:

EXAMPLE.OBJ
EXAMPLE.LST
EXAMPLE.SYM

The object file (.OBJ) is the file whose binary data (machine code data) will be sent to the chip being programmed. The listing file (.LST) is a text file which shows all the mnemonics, addresses and object codes. The .SYM file can be ignored.

Any errors which are encountered in the source code (in the .ASM file) will be reported on screen. They are also reported in the .LST file, which can be examined from the text editor.

If errors exist, note them down, return to the text editor and correct them in the .PIC file. Then resave, both as a .PIC file, and as a .ASM (ASCII) file, as discussed above. Having done so, re-assemble via TASM as before.

Note that TASM checks for basic syntax errors or operands that are out of range. However, it will not check the logic of the program or for correct programming functions, such as typing in the wrong memory locations or testing the wrong bits prior to jumping, for example.

Once the program is error free, its .OBJ file can be downloaded into the PIC.

From the .PIC directory, at the DOS prompt type:

SEND

A menu will be presented with three options:

1..... PIC16C84 configuration set-up
2..... Load object code and send to PIC
3..... Quit program
enter option 1, 2 or 3

Option 1 allows the PIC to be configured. This needs to be done first when using a new PIC16C84, or if a PIC's previous configurations are inappropriate to the new program about to be loaded.

When Option 1 is chosen, another menu is displayed:

Program to set configuration fuses
WARNING: Any program presently in the PIC16C84 will be erased

Please enter which type of oscillator you wish the PIC16C84 to use:

1... LP low power crystal oscillator (32kHz – 200kHz)
2... XT crystal oscillator (100kHz – 4MHz)
3... HS High speed crystal oscillator (4MHz – 10Mhz)
4... RC Resistor capacitor oscillator
Enter selection 1 to 4

As this menu shows, there is a choice of four oscillator types which can be selected to control the timing of the PIC16C84. For use with the programming circuit shown in Fig. 2, select Option 4, for RC.

Having selected the oscillator option, you are asked:

Enable watchdog timer?
enter Y or N

If the watchdog timer is not required, as it is not for this circuit, press N, otherwise press Y. Next you are asked:

Enable power-up timer?
enter Y or N

Usually it is beneficial to have the power-up timer enabled, so press Y.

You are then asked if you wish the configuration data to be sent to the PIC. If you happy with it, press Y. The following prompt then appears:

Make sure PIC16C84 is in program mode (12V-14V on pin 4)
then press a key to begin transfer.

This means that switch S1 should be switched on, and switch S2 (reset) should be briefly pressed and then released. Now press any key, whereupon the configuration data is sent to the chip, and the following statements displayed:

Configuration data sent
Now reset the PIC16C84 (pin 4 low briefly), press a key

To reset the PIC, simply press switch S2, but leave switch S1 turned on. Then, as instructed, press any key, which will cause the original three-option menu to be displayed again. Select Option 2 if you wish to send the program data to the chip.

Having selected Option 2, you are requested to enter the name of the object file that is to be downloaded. The .OBJ extension does not need to be entered since the program automatically assumes that the file is an object file (it does not matter, though, if the .OBJ extension is included).

When the file name has been entered, in this case as EXAMPLE, press <ENTER>. The file will be loaded, the screen displaying the hex value of the bytes involved, the total number received, and the amount of PIC memory which will be used by them, both as a word count and as a percentage of available space.

The procedure is now the same as for the configuration programming. Confirm that you want to send the program, ensure that S1 is switch on, briefly press reset switch S2, and then press any key. The program will be downloaded and confirmation displayed, followed by the instruction:

Return pin 4 of PIC to +5V then press reset to run program
Press a key to return to main menu

This means that you should turn off switch S1, then briefly press switch S2, after which press any key, causing the three-option menu to re-appear. Select Option 3 to quit the Send program.

Now observe the l.e.d.s being controlled by the example program, they should be correctly turning on and off as expected. The sequence may be restarted at any time by pressing Reset switch S2.

The same programming technique applies when other programs are to be downloaded into the PIC16C84, such as the program for the *PIC-Electric* circuit in this issue of *EPE*.

OBTAINING SOFTWARE

The TASM software and associated program files discussed above (but not including a text editor) are available on a 3.5in. disk from the *EPE* Editorial offices for £2.50 (overseas £3.10 surface, £4.10 air-mail) to cover administration costs. Also included on this disk is the software for the *PIC-Electric* project.

This is not a payment for the software itself, for which we make no charge. The current registration fee for the shareware TASM assembler software is $40 US. This fee is only payable if you intend to regularly use the software beyond a reasonable evaluation period.

Readers are strongly recommended to honour the registration payment request. Registered users receive the following benefits:

1. The most recent version of TASM
2. TASM source code, in C
3. Bound TASM manual
4. Telephone support
5. Knowledge that they are supporting the development of useful but inexpensive software.

The address of the organisation (in the USA) who administer the TASM registration payment is quoted on the software disk.

The Shareware library which supplied the original TASM programs to the author is: The Public Domain and Shareware Library, Dept *EPE*, Winscombe House, Beacon Road, Crowborough, Sussex, TN6 1UL. Tel: 01892 663298.

The PDSL have a great deal of shareware software available – it is well worth while asking them for their catalogue.

PIC DATA BOOKS

Arizona Microchip's *PIC16/17 Microcontroller Data Book 1995/1996* referred to earlier is a 1276-page overview of the PIC16Cxx and PIC17Cxx families of 8-bit RISC-based microcontrollers. It contains full product and programming specifications, development system and software support information for designers working on embedded control applications.

Also of interest is their *Embedded Control Handbook*, which has over 1000 pages full of programming examples for all PIC chips.

For more information about these books, and PIC chips in general, contact Arizona Microchip Technology Ltd, Dept. *EPE*, Unit 6, The Courtyard, Meadowbank, Furlong Road, Bourne End, Bucks, SL8 5AJ. Tel: 01628 851077.

FOX REPORT

by Barry Fox

Theremin Revival

Nice to see the Theremin revived as a construction project in the September 1995 issue. Leon Theremin invented his music synthesiser in 1920 while still in Russia. It had no keyboard, just two aerials which change the pitch and volume of a note with movement of the performer's hand.

The inventor moved to the USA in the thirties and licensed RCA to make a consumer model. Composer Joseph Schillinger (who later taught both Glenn Miller and Benny Goodman musical theory) wrote a Suite for RCA Theremin in 1929, to promote the instrument.

In the forties and fifties musicians toured, giving solo performances. Clara Rockwell was the leading exponent. Bob Moog, father of modern synthesisers, has always given full credit to Theremin's pioneering work.

In the years following World War II, young Moog made electronic gadgets with his father. In 1964 he built his first music synthesiser, demonstrating it to the Audio Engineering Society's exhibition in New York. In 1968 Walter Carlos, later Wendy Carlos, released a record of Bach's compositions, played on Moog's synthesiser. Carlos used the same instrument to record the music for Stanley Kubrick's movie, *A Clockwork Orange*.

In Japan, musician Tomita rearranged Gustave Holst's *Planets Suite* for performance on a synthesiser. Representatives of the Holst estate disliked the effect so much that they applied for, and won, an injunction to ban the record.

Sound Track

As the construction article explained, the Theremin was used on many early science fiction movies, such as *The Day The Earth Stood Still*. Its eerie sound, a cross between a soprano voice and violin, fitted the genre. A Theremin was used on the sound track of the recent feature movie about the world's worst sci-fi film-maker, Ed Wood. It is now out on video.

If you want to hear what the Theremin sounds like, rent the movie. Or you can hear one on on the Beach Boys' classic track, *Good Vibrations*. Better still look out for an LP record of Clara Rockwell which Moog produced twenty years ago.

Although there have been Japanese versions, which use transistors, the original RCA valve models have a characteristic sound. They are very rare and expensive. If you ever find one in a junk shop, grab it!

Not the First

The Theremin was not the first electronic musical instrument. In 1896 Thaddeus Cahill, of New York, filed a patent application (US 580 035) on the "art of and apparatus for generating and distributing music electrically".

Long before oscilloscopes could display the shape of waveforms, Cahill very clearly described how music is built from sine waves. He warned that pure tones on their own sound "colourless and insipid". But if the pure tone is mixed with harmonic overtones or "partials", which have a clearly defined mathematical relationship, the change is dramatic.

Some of the mathematical relationships make the sound pleasant, "like a good pianoforte". But other pairings make the sound "disagreeable".

Telharmonium

Cahill was patenting the idea of an enormous tone generator, which he later called a Dynamophone or Telharmonium. Literally dozens of shafts, like carpenters' lathes, carried "rheotomes". These were cylinders built from alternate strips of metal and insulating material.

A motor and pulley-belts turned the shafts while a dynamo fed current through electrical brushes to the rheotomes. Each rheotome produced a fluctuating electrical signal as its strips made and broke contact with the brushes.

The speed of the fluctuation, and the musical pitch of the signal, depended on the speed at which the rheotomes were turning, and the number of their conducting parts. Audible sound was produced by feeding the fluctuating signal to a telephone head-set.

Cahill suggested an instrument built from 84 rheotomes on twelve shafts, rotating at different speeds to mimic the 84 notes of a seven octave piano. Fine tuning was by physically filing the pulleys to precise size.

Wrong Number

In the early years of the 20th century, Cahill built three Telharmoniums, and teamed up with US telephone company AT&T to feed music signals down its telephone lines. While a musician played the Telharmonium keyboard, paying subscribers in the New York area could plug in their earpieces and listen to synthesised sound. The project failed commercially, largely because the signals from the Telharmonium drove up to one amp of current into each receiver. This produced a loud sound but was the system's undoing.

The piped music interfered with ordinary telephone calls which were running through wires in the same underground ducts. Business callers heard music instead of speech.

The piped synthesis service ended in 1914. No-one knows where the original instruments ended up. As they were nearly 20 metres long, made of steel and weighed some 200 tonnes, it is a safe bet that they were sold for scrap.

Sounds of Ondes and Ondioline

In 1928 Maurice Martenot built his Ondes Martenot in Paris. It used two oscillators working at around 80kHz. One was fixed and the other was variable by a few hundred Hertz, under the control of a keyboard. Mixing the two signals produced an audible difference tone at a few hundred Hertz.

The similar Ondioline was developed and built by Georges Jenny, in Paris during World War II. When hostilities ended Jenny sold his Ondioline in kit form, for home construction.

The device looked like a radio, with a keyboard attached to the top. It was demonstrated at the Atomium Building, during the Brussels World Fair in 1958.

Although the Ondioline used only a single oscillator pair, and could thus play only one note at a time, Jenny devised circuitry which generated an extraordinary range of overtones.

A row of switches at the front controlled a bank of electronic filters to shape the waveform. A rotary knob switched the circuit through seven octaves.

Physically moving the keyboard slightly side to side slightly changed the pitch to create vibrato. Pushing a lever under the keyboard controlled the volume.

Demonstration Record

An instruction sheet told users which switches to put up or down to imitate the sound of many different instruments. The Ondioline could do passable impersonations of the Hawaiian guitar and jazz bass, as well as all the instruments of a classical orchestra.

Jenny produced his own demonstration record, and sold it to prospective constructors for 4.95 francs. A few working Ondiolines still exist, and sell as musical antiques.

THE ELECTRONICS SERVICE MANUAL

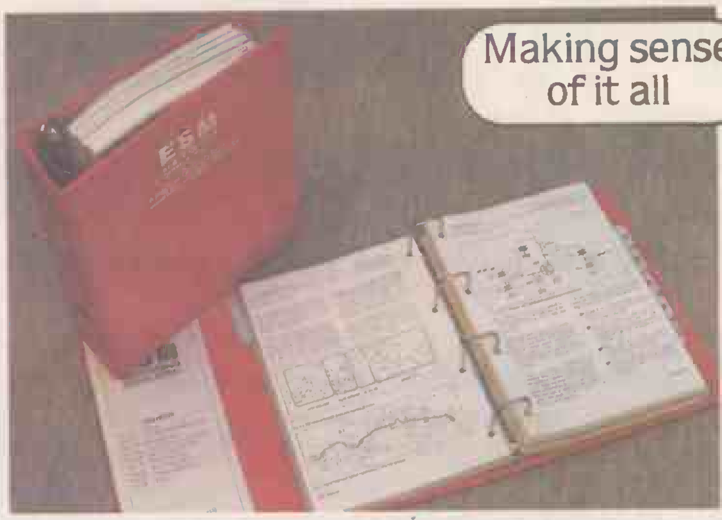
ESM ESM IS ABOUT ELECTRONICS AND ELECTRONIC EQUIPMENT, EXPLAINING:
- What it is • How it works • How to test it • How to take it apart
- How to find faults • How to fix it

OFFERING:
- Down to earth advice • Vital data • Facts to feast on
- Knowledge at your finger-tips

T TOPICS COVERED:
- TV • Audio • Video • Computers • Disk drives • Techniques
- Test gear • Workshops • Addresses • Pinouts • Symbols • Safety
- Logos • Tools • Data • etc

W WHO IT'S FOR:
- Across the board appeal !
- Ideal for: Technicians • Engineers • Students • Hobbyists

L LITERARY MERIT:
- Authoritatively written • Clearly presented • Highly readable
- A living library in words, drawings and photographs



S SUPPLEMENTS

Detailed technical servicing notes on various types of equipment are covered in the quarterly Supplements, plus additional valuable information for other sections of the Manual

F FREE

We will send you the latest Supplement FREE with your Manual

P PRICES

Manual only £39.95 plus P&P

Over 850 A4 pages edited by Mike Tooley. Supplied in robust ring binder. Latest Supplement included FREE. 24-hour despatch

Supplements £23.50 plus P&P

Approximately 160 pages of facts and data in each Supplement

G GUARANTEE

Our NO-QUIBBLE MONEY-BACK GUARANTEE gives you *complete peace of mind.* If you are not entirely happy with the Manual or its Supplements, for whatever reason, simply return to us in good condition (within 30 days for the Manual, 10 days for Supplements) and we will make a FULL REFUND of your payment. (Overseas buyers do have to pay the postage charge.)

H HOW TO OBTAIN ESM

Order now! – just fill in the order form.
Or, to find out more about ESM, ring, fax or write to:
Wimborne Publishing Ltd, Dept Y2
Allen House, East Borough, Wimborne
Dorset BH21 1PF
Tel: 01202 881749 Fax: 01202 841692

ELECTRONICS SERVICE MANUAL COVERAGE AND CONTENTS

A SAFETY
Safety practices, life-saving techniques, legal requirements

B UNDERPINNING KNOWLEDGE
Electronics theory, component theory & functions, circuit techniques, fault diagnosis, detailed equipment principles

C PRACTICAL SKILLS
Component identification, avoiding static, soldering & component replacement techniques

D TOOLS AND EQUIPMENT
Choosing tools & test gear, workshop practice, optimising test equipment

E SERVICING TECHNIQUES
The Supplements include detailed guidelines on how to service specific types of electronic equipment

F TECHNICAL NOTES
Detailed examination of how specific types of electronic equipment work

G REFERENCE DATA
Detailed tables of specifications for semiconductors, including pinouts

H USEFUL ADDRESSES
Manufacturers' & suppliers' addresses, including logos

I INDEX
Itemised key subjects in the Manual and individual Supplements

PRIORITY ORDER FORM

Full name:..
(BLOCK CAPITALS PLEASE):
Address: ....
....
....Post code:..........................
Telephone Number: ....

☐ I enclose cheque/PO payable to WIMBORNE PUBLISHING LTD
☐ Please charge my Access (Mastercard)/Visa card. Expiry date..........................

Card No: ....
(Please advise cardholder's address if different from above)

Please send me each new quarterly Supplement when it is published. I understand that these are billed separately and that they can be returned within 10 days or discontinued at any time.

I understand that should I decide not to keep the Manual I can return it to you within 30 days for a FULL REFUND (overseas customers must pay the postage).

Signature: ....

PLEASE URGENTLY SEND ME

Item	*Cost*	*Postage*	*Total*
ESM Manual	£39.95	£	£
One Supplement free with Manual	FREE	FREE	£0.00
Payment in £ Sterling only		Total	£

POSTAGE CHARGES

Manual

Postal Region	*Surface*	*Air*
UK	£5.50	–
Eire	–	£11
Europe (EEC)	–	£20
Europe (Non-EEC)	£20	£26
USA & Canada	£25	£32
Far East & Australia	£31	£33
Rest of World	£25	£44

NOTE: Surface mail can take over 10 weeks to some parts of the world. Each Manual weighs about 4kg when packed.

Please send this form (or a copy) to: **Wimborne Publishing Ltd, Dept. Y2, Allen House, East Borough, Wimborne, Dorset BH21 1PF**

Constructional Project

MAINS SIGNALLING UNIT

12V CAPACITIVE PSU
TWO-TONE SIREN ALARM

ANDY FLIND

Part 2

Adding a low cost power supply and alarm siren for the "through-the-mains" communications link.

Last month a simple system was described for using house mains wiring to transmit a signal. As this was originally intended to extend a doorbell, the Receiver module required the addition of a simple mains Power Supply Unit (PSU) and a Two-Tone Siren Alarm. Other applications for the system, such as a garage intruder alarm or relaying a smoke alarm from another floor, would need similar add-ons.

With a simple mains power supply and a low-current piezo sounder the entire Receiver system can be fitted into a small plastic box, creating a self-contained unit that can be plugged in anywhere in the house. This article describes the construction and use of these extra circuits.

Both simple circuits should find many other uses, especially the Two-Tone Siren Alarm Generator, though the Mains PSU is of the "capacitive dropper" type so circuits powered by it are ***hazardous and should NOT be touched.*** However, any circuits that are *totally enclosed and insulated* can use it, and experimenters wishing to try this type of supply in their own designs will find it a lot safer and more convenient to use one of these boards than normal bread-boarding techniques.

CAPACITIVE PSU

Beginning with the power supply, the full circuit diagram for the simple 12V Capacitive PSU is shown in Fig. 1. It uses resistor R1 and capacitor C1 in place of the more common transformer to reduce the mains a.c. voltage. A constant current flows through these, the value being determined by the capacitance and supply voltage values.

The circuit is a "half-wave" type. When the "live" is positive of "neutral", current from C1 flows through diode D2 and Zener diode D3.

The 12 volts that develops across D3 is stored in capacitor C2 which continues to supply the output during the negative half-cycle, whilst current returns to C1 through diode D1. VDR1 is a 230V mains transient suppressor, which clips any brief high-voltage spikes in the mains supply to protect C1.

Resistor R1 restricts the brief but heavy current inrush that would occur if the circuit was plugged in at the exact instant where the mains voltage was at a high point in the cycle. A rugged two watt component is used for this. Resistor R2, a high-voltage type, discharges capacitor C1 when the circuit is disconnected to eliminate the possibility of shocks to the user from the plug. The capacitor C1 is a special "IS" type intended for suppression applications, designed to withstand *continuous* connection across the 230V mains supply.

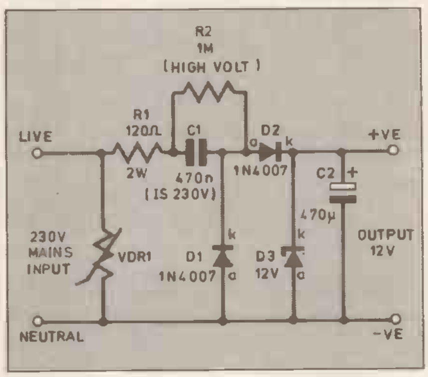
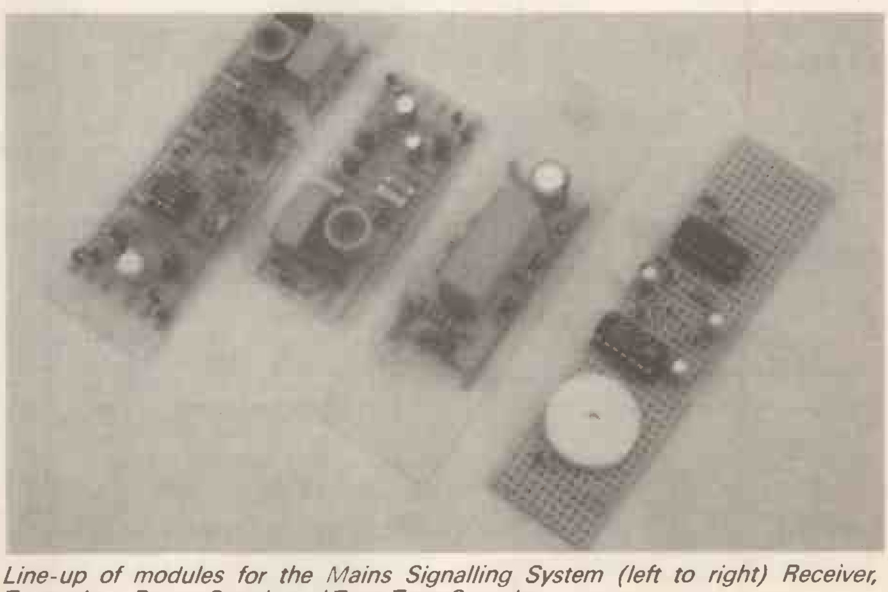


Fig. 1. Circuit diagram for the simple 12V Capacitive Power Supply.

The advantages of this circuit over a transformer are that it is smaller, lighter, cheaper, and does not generate any heat or noise. Transformers invariably warm up a little and can generate hum. The disadvantage is that circuits powered by it are in direct contact with the mains so they ***must be fully insulated.***

The maximum current available depends on the value of the capacitor C1 and in this case is about 10mA. Most of the current passing through the capacitor is "reactive", and does not appear on the electricity bill. Only the tiny part picked off by the resistive element of the circuit being supplied will register.

This type of circuit has obvious hazards and should only be built by constructors with sufficient experience to recognise and avoid them. Those in doubt should use a small transformer instead; the receiver circuit will operate happily from either supply source.



Line-up of modules for the Mains Signalling System (left to right) Receiver, Transmitter, Power Supply and Two-Tone Sounder.

COMPONENTS

Power Supply Board

Resistors
R1 120Ω 2W metal film
R2 1M high-voltage metal film

See **SHOP TALK** Page

Capacitors
C1 470n "IS" 230 volt suppression type
C2 470μ radial elect. 35V

Semiconductors
D1, D2 1N4007 1A 1000V rectifier diode (2 off)
D3 BZX61C12 12V 1·3W Zener diode

Miscellaneous
VDR1 250V mains transient suppressor

Printed circuit board available from *EPE PCB Service*, code 975; plastic case, size to choice; cable clamps to suit input and output wires; multistrand connecting wire; solder pins; solder etc.

Approx cost guidance only **£8** *excl. case*

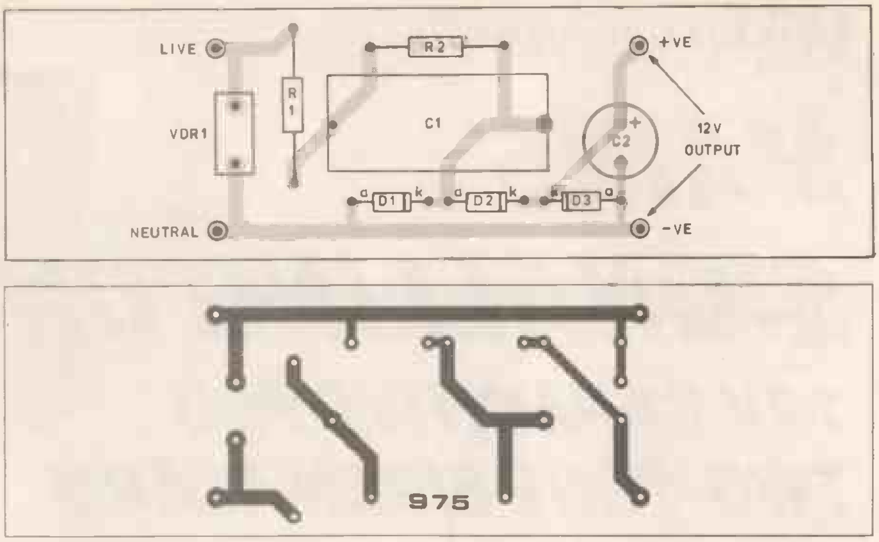


Fig. 2. Printed circuit board component layout and full size foil master for the 12V Capacitive PSU. The extra board space at each end allows it to safely slot into its case.

PSU CONSTRUCTION

For safety, the simple 12V Capacitive PSU is constructed on a small, robust printed circuit board (p.c.b.) with widely-spaced tracks. This board is available from the *EPE PCB Service*, code 975.

The components can all be fitted as shown in Fig. 2; working from the smallest component up to the large "continuous mains operation" IS capacitor C1. Take care with diode polarity, especially the Zener diode D3 which is the opposite way around to the other two.

Leads can now be fitted to the board for testing and a meter, set to the appropriate voltage range, connected to the output terminals *before* it is powered-up. The board *MUST* be connected to the mains supply through a suitable fuse – one with a rating of 3A or lower should always be used with this type of circuit.

At switch-on the "test" meter should read 12V, plus or minus about half-a-volt. If this is OK, construction and testing is complete.

It is perhaps worth mentioning that should a supply that is negative or "neutral" be required, this can be built by simply reversing the three diodes D1 to D3 and capacitor C2. This is sometimes useful in circuits where a triac is to be triggered with the low current available from a supply of this type as they tend to be more sensitive to negative gate current.

ALARM SOUND GENERATOR

For the alarm, a distinctive sound was required. The world these days is full of things that go "bleep", especially in an electronics workshop, so something instantly recognisable was needed.

The circuit diagram shown in Fig. 3. produces a two-tone sound a bit like a panic-stricken police siren, using an ICM 7556 dual timer to generate the signal and a CMOS 4093B quad Schmitt NAND gate i.c. for control and output buffering functions.

HOW IT WORKS

A positive input causes the output of IC1a to go low, discharging capacitor C1 through diode D1. When the input goes low, IC1a output returns high and recharges C1 through resistor R2.

Recharging of C1 takes four to five seconds so there is at least four seconds of positive output from IC1b. This was arranged so that brief presses of the Doorbell would result in substantial output from the remote repeater. If this feature is not required C1 can be omitted.

The output from IC1b powers IC2 which then generates the sound. This is a micropower version of the 556 dual timer and runs quite happily on the current available from the output of a single CMOS gate.

The two timers are connected as oscillators. The first, using resistor R3 and capacitor C3, runs at about 3Hz. The output of this, pin 5, is used to modulate the second by connection to its "control" input, pin 11, through resistor R4.

The centre frequency of this second oscillator is set to around 1·6kHz by resistor R5 and capacitor C4, but is modulated into a two-tone sound by the control voltage from the first. Its output, pin 9, is buffered and inverted by gates IC1c and IC1d to create a "bridge" output for the piezo sounder WD1, thereby obtaining maximum volume.

The output will be too loud for many applications so the resistor R6 can be added to reduce it. The value of 2·2 kilohms proved about right for the prototype but constructors can experiment with this.

ALARM CONSTRUCTION

Construction of the Alarm unit is carried out on a small piece of stripboard, with 11 strips of 45 holes, although only a length of 33 holes is taken up by the circuit. The

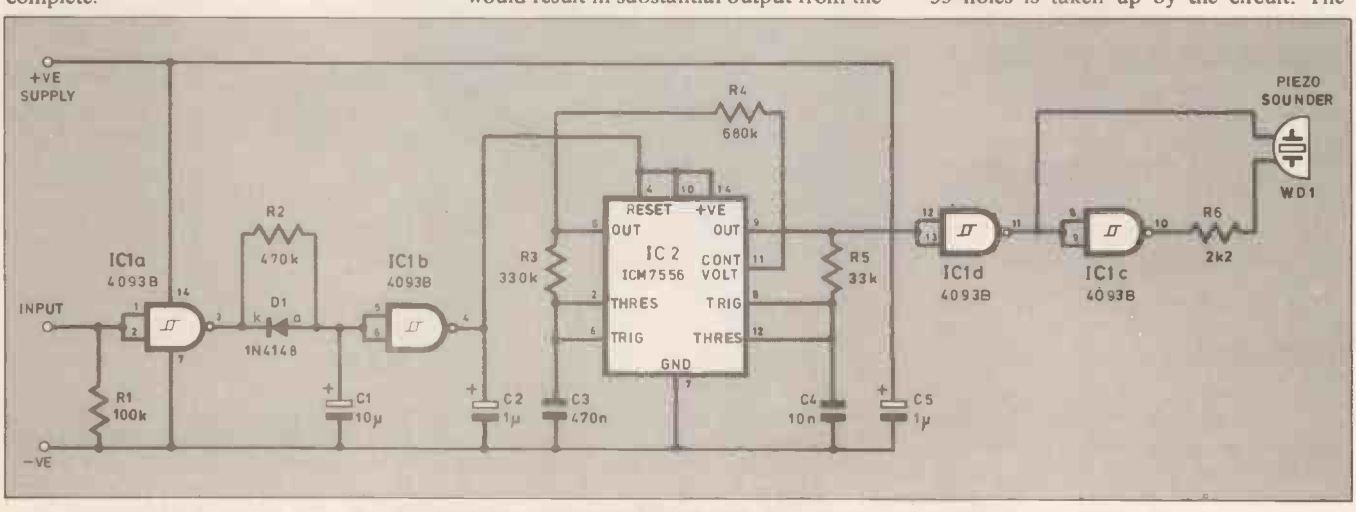


Fig. 3. Complete circuit diagram for the Two-Tone Siren Alarm.

COMPONENTS

Two-Tone Siren Alarm

Resistors

See **SHOP TALK** Page

R1	100k
R2	470k
R3	330k
R4	680k
R5	33k
R6	2k2 (see text)

All 0·6W 1% metal film

Capacitors

C1	10µ radial elect. 50V
C2, C5	1µ radial elect. 100V (2 off)
C3	470n resin-dipped ceramic
C4	10n resin-dipped ceramic

Semiconductors

D1	1N4148 signal diode
IC1	4093B CMOS quad Schmitt NAND gate
IC2	ICM7556 dual CMOS timer

Miscellaneous

WD1	3V to 24V d.c., p.c.b. mounting, piezoelectric sounder

Stripboard, 0·1in. matrix, 11 strips of 45 holes; case, ABS box 118mm x 98mm x 45mm; 14-pin d.i.l. socket (2 off); multistrand connecting wire; solder pins; solder etc.

Approx cost guidance only **£8**

reason for the extra length of both this and the PSU is that they fit neatly into the moulded slots in the specified case used.

Underside breaks in the copper strips and board topside component layout are shown in Fig. 4. Construction should start with the cutting of the 23 breaks as shown, after which the 17 wire links can be fitted.

Following this the components can be inserted, care being taken to insert diode D1 correctly. As shown, it should have the marked (cathode) end facing down towards the board. As mentioned earlier, if the timed operation feature is not needed capacitor C1 should be omitted.

It is recommended that d.i.l. sockets be used for the two i.c.s. When inserting the i.c.s care is recommended as both are CMOS types and IC2, the ICM7556, has proved to be a trifle more sensitive than most to static. The sounder is a p.c.b. mounting type and is soldered directly onto the board.

Testing consists of applying a suitable supply voltage, anywhere between 5V and 12V and touching the input to positive. The unit will normally sound immediately on power-up as capacitor C1 charges. Following this positive pulses to the input should trigger further operation. Current drain should be zero in the standby state, and about 2mA to 3mA when operating, though this may vary a little with supply voltage and the value of resistor R6 if fitted.

IN USE

The wide supply voltage range and zero standby current features of this unit should ensure that it finds plenty of applications beyond the simple doorbell repeater it was designed for. However, if it is used with the Receiver of the Mains Signalling Unit described last month, it can be connected as shown in Fig. 5, which shows complete interwiring for the Alarm together with the PSU board.

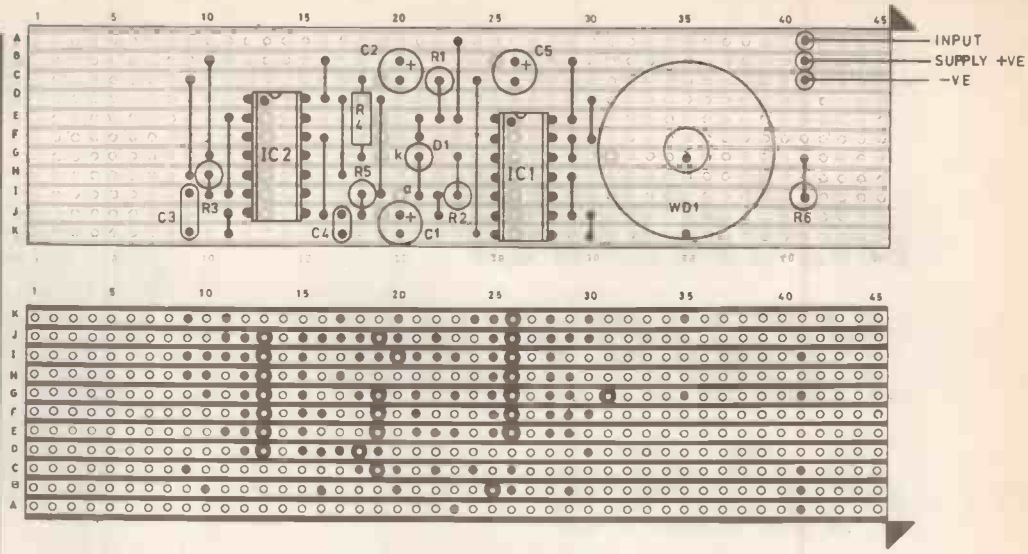


Fig. 4. Two-Tone Siren Alarm stripboard component layout and underside copper break details.

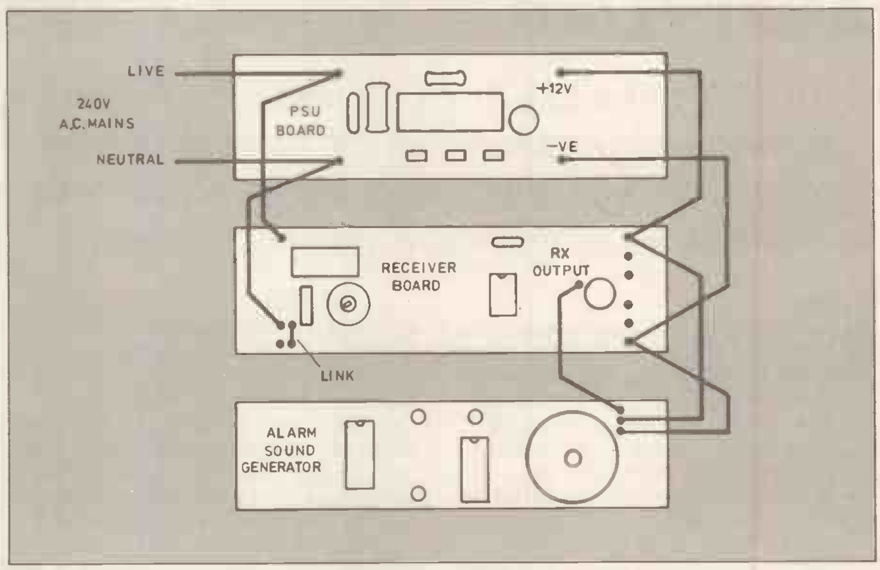


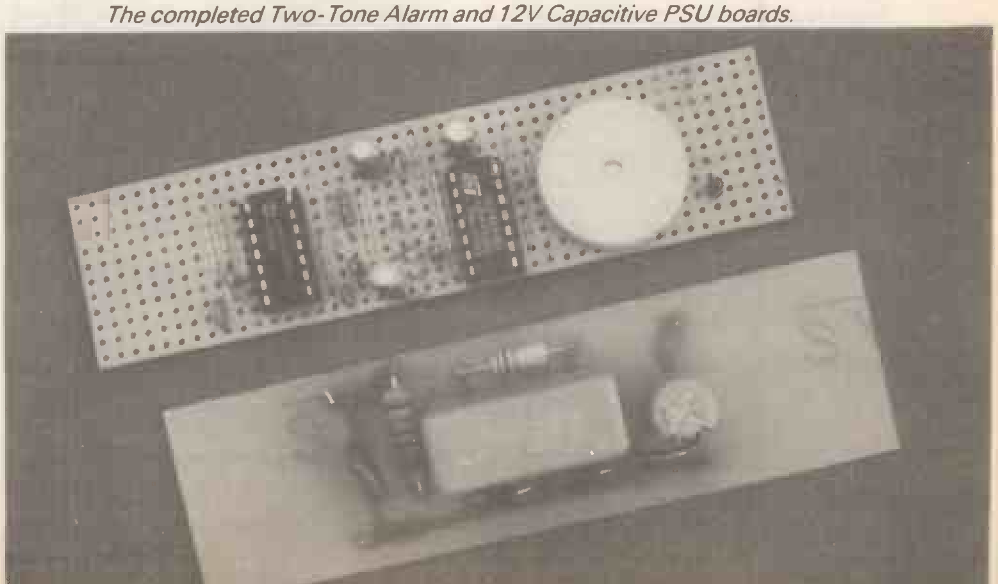
Fig. 5. Linking the two boards to last month's Receiver to produce a "through-the-mains" alarm repeater.

Constructors of the Mains Signalling System might be interested to know that the Receiver of the signalling project originally had a much shorter time constant in the section of the circuit following IC1a, but when used with the Alarm Sounder board, with its timed output feature, it proved susceptible to false triggering caused by noise in the mains supply. The time constant, set by resistor R14 and capacitor C9 on the Receiver board, was increased to the value shown last month and the problem disappeared.

This setting is inevitably something of a compromise. The longer the time constant the better the noise immunity, but if it is too long there will be a perceptible delay in operation. With the present values operation still has an "instant" feel to it.

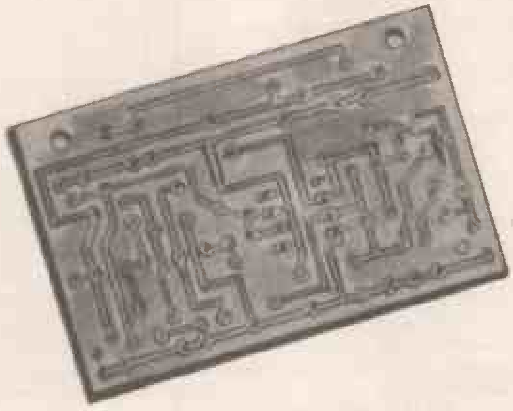
If any constructors do experience problems of this nature and are not able to cure them by adjustment of preset VR1 on the Receiver board, the value of capacitor C9 can be increased. At 470n there is a slight delay in response, but it should respond to most inputs satisfactorily. □

The completed Two-Tone Alarm and 12V Capacitive PSU boards.



Special Feature

MAKING YOUR OWN P.C.B.s



ANDY FLIND

Printed Circuit Board Making on a Budget
Unmasking some of the pitfalls that may be encountered when producing your own p.c.b.s.

SOONER or later, most serious electronics enthusiasts will want to make a printed circuit board, "p.c.b." for short, for themselves. Either a track pattern will be available but not the ready-made board, or it might be that a circuit has been designed from scratch and is considered worthy of a "proper" board rather than stripboard or tagstrip construction.

There are many ways to make a p.c.b. and over the years the author has tried most of them. As there are pitfalls for the unwary and often little advice on how to go about the task without expensive equipment, it seems worthwhile to pass on some of the experience gained.

Be Sensitive

Undoubtedly the best method for producing a p.c.b. is photographic, using a board coated with a photosensitive "resist" material. This is exposed to ultraviolet light shining through a track pattern on a transparent sheet, then developed and placed in etching fluid to dissolve away unwanted copper to leave the desired tracks. The resist is then removed and the board is drilled and trimmed to size ready for component assembly.

This method produces neat results, extra boards can be produced easily and, where necessary, minor layout alterations are usually simple to make.

At this point, readers may be wondering about the cost of a UV Lightbox and tanks for the chemicals, but in fact a lightbox can be built for a quite modest outlay and the chemistry can be carried out at the kitchen sink. There is definitely no need to shell out for a full production lab to produce the odd board for hobby use.

Making a Master

The first task in making a p.c.b. is to produce the transparent master. To do this by hand, a good method is to begin by drawing up a layout on 0·1 inch squared graph paper. This paper is difficult to find in pads and often expensive, but large sheets can be bought cheaply in W.H.Smith and cut into conveniently sized pieces.

A soft 0·5mm pencil and pencil-shaped eraser are recommended for initial layout work as these make alterations as simple as they would be on a computer. This part can be done in comfort in front of the TV!

Once the layout is finalised, a transparent "master" is required. Stationers and photocopying shops can provide clear acetate sheets, and one of these may be taped in place over the layout and the track pattern laid out using either transfers or adhesive tapes and symbols. Using adhesive tapes is much preferred where this method has to be used.

Computer Aided

Where a computer is available, life becomes much easier. Many professional printed circuit packages are available (*see advertisements in this issue*) offering various extras such as schematic capture, autorouting, design rule checking and so forth. Often these features are more suitable for rapid prototyping than really good finished designs but the basic layout routines will always produce *clean artwork* and this can be done rapidly from a layout drawn up on paper.

Computer Aided Design "CAD" type drawing packages can also produce track patterns. For this work the program should have "layers" and "symbol libraries", and, of course, must be able to draw lines of widely varying width.

Layers are useful for generating different views of the board, with components on one layer, pads on another, tracks on a third and so on. These views can be turned on or off as necessary for layout and printing purposes. Symbols can be designed to represent the components used, various sizes and shapes of pad, and patterns of pads for i.c.s etc.

If any readers have Acorn Archimedes computers, the "Vector" art package sold by "4-mation" is highly recommended. This is similar to Acorn's "Draw", but has many extra features including layers and symbol libraries. Prior to the acquisition of a PC the author used this software for several years.

Computer generated artwork will need conversion into a transparent master. It might be possible to print direct onto transparency at 1:1 scale, but the author's attempts to do this with an ink-jet have so far proved unsuccessful. A good quality printout is not an absolute essential, inexpensive inkjets can do an excellent job and even an 8-pin dot matrix may be used if the output is scaled up and then correspondingly reduced on a photocopier.

The printed copy can be reduced and transferred to acetate transparency in one go, usually at a cost of around 50p a sheet. Most copiers can reduce to 70 per cent in one go, so the author's usual practice is to print at the inverse of this, 1.49:1, and then ask for a 70 per cent reduction straight onto acetate at the copyshop. This easily handles detail such as tracks between i.c. pins.

Shortcomings

This is a good time to discuss some photocopier shortcomings. To start with, photocopies are not usually dense enough for direct use in a UV exposure process. When held up to a light the black areas usually appear slightly "porous".

This is often worse in large black areas, which is a good reason for avoiding these in the layout. However, two copies carefully taped together nearly always achieve adequate density.

Another photocopier problem is that they don't always achieve the exact print size expected. Usually, at least for small boards, this is not a problem, but it's worth taking along a 1:1 printout for checking. A similar problem is acetate copies turning out at slightly different sizes, the difference being tiny but sufficient to prevent the holes in the pads lining up when they are taped together.

The cause of this is probably expansion of the acetate sheet; by the time the second sheet passes through the copier will have warmed up so it will receive the image after being heated, and expanding, more than the first. A recent experiment was to ask for three copies instead of the usual two and, sure enough, two were a greatly improved match.

Right Exposure

Having produced the transparency, the next stage in the process is exposure. Pre-coated photosensitive board is available from most electronic suppliers and is easy to use. The instructions supplied by a major retailer used to suggest that exposure could be carried out with incandescent light.

Don't bother trying this! The author once did, using a 500-watt bulb and an exposure of about fifteen minutes. The results were very fuzzy, certainly not good enough to warrant any further use of this method.

Ultraviolet is essential for the exposure. However, it is certainly not necessary to shell out seventy quid or so for a lightbox as this can be constructed for little more than the cost of the tubes, starters and a choke. Currently the cheapest source of tubes is probably Electromail, who offer a kit consisting of two 8-watt replacement tubes with starters for their small lightbox at a very reasonable cost.

Constructors can design their own exposure unit using these, the essential dimensions are shown in Fig. 1. Connections for the components are shown in Fig. 2, where it will be seen that only one choke is required to supply both tubes. Glass can usually be cut very accurately to size for very little cost by a local glazier.

The exposure time required varies with different makes of board but is usually somewhere between two and six minutes. Since the board is fairly expensive, it's worth trying some small test pieces to determine the optimum time before committing a larger and more expensive bit.

Chemical Works

Once the board has been exposed, it's time to open the chemical works! This consists of developing the photosensitive coating so that the exposed portion dissolves away and the remainder is "fixed", remaining to protect the copper beneath it during etching.

It's possible to develop using dissolved caustic soda crystals, but this appears to be very temperature dependant so a proprietary developer is preferable for the job. This is cheap and re-useable, and gives much more consistent results. It's important to allow enough time for all the unwanted resist to dissolve, otherwise a thin film may be left which can hinder the etching.

Commercial tanks are available for developing and etching, especially the latter where the solution is often heated and agitated by bubbling air past the immersed board. Again, this is not essential, the processes can be carried out in literally any glass or plastic container that will hold the chemicals and the board. The lack of bubble agitation simply means the process will take slightly longer – but a cheap aquarium air pump could be used for the task.

As with developing, ferric crystals are available for making up etching fluid, but the preferred and most convenient method is to use ready-mixed fluid. This lasts for ages before having to be discarded, so the

UV LIGHTBOX CONSTRUCTION

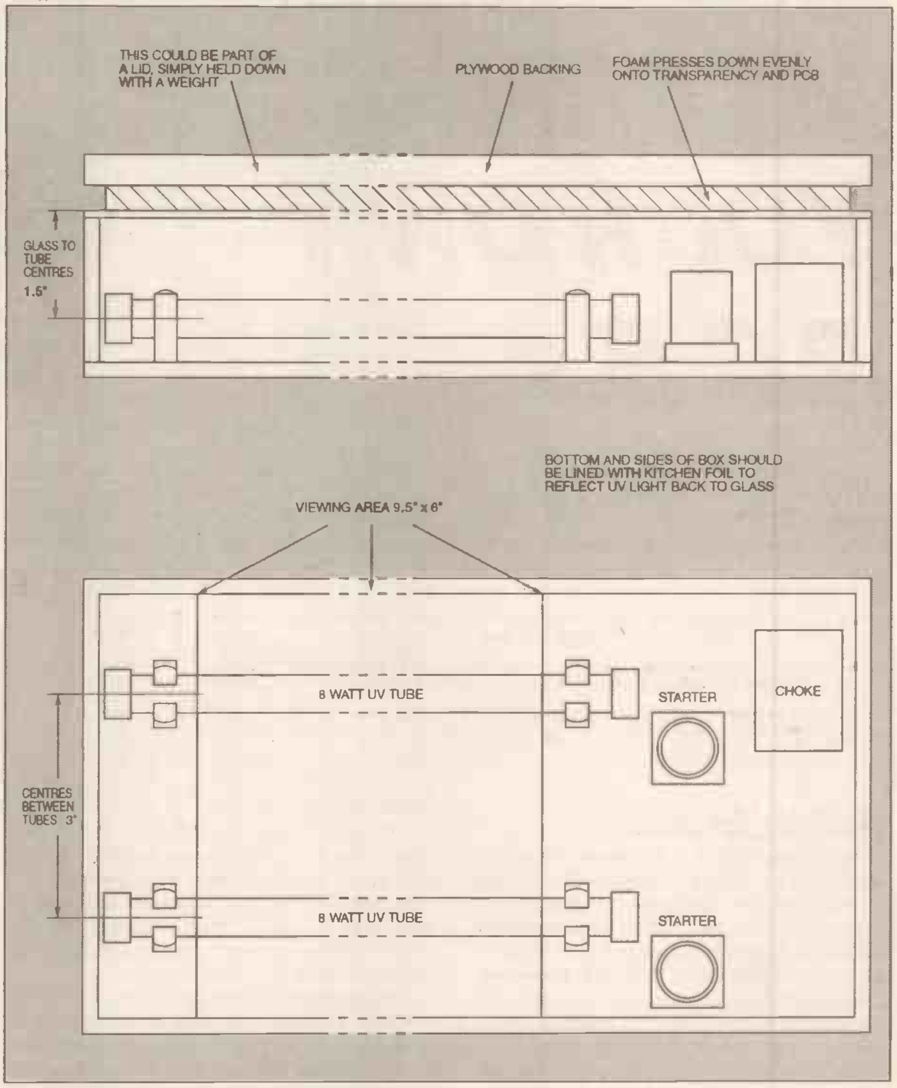


Fig. 1. Dimensions and layout suggestion for a two-tube UV Lightbox.

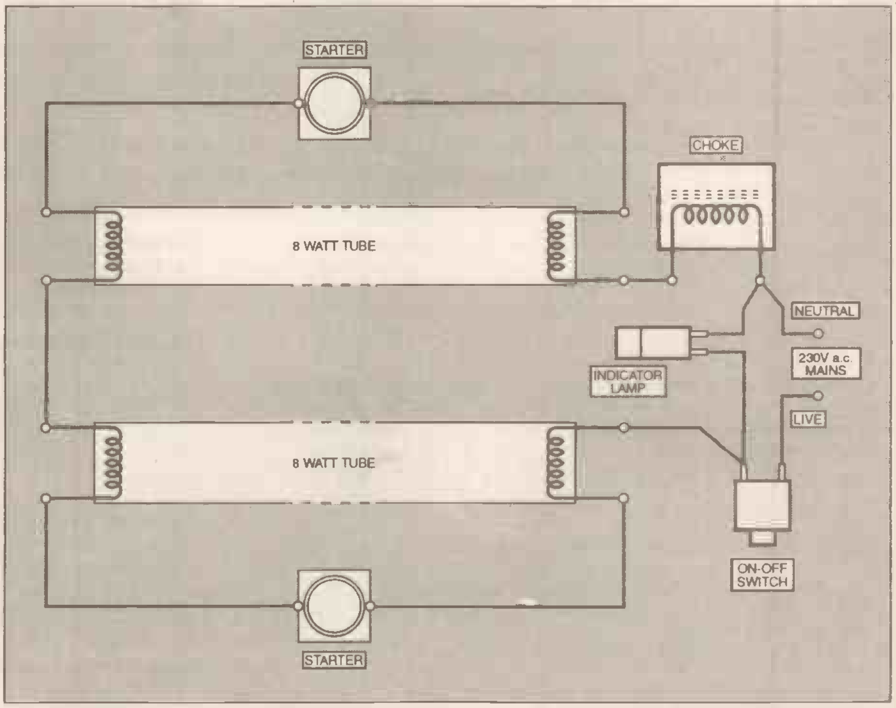


Fig. 2. Interwiring between tubes, starters, choke, mains switch and indicator lamp. ***Note that the unit should be wired with a switch that only allows the tubes to be turned on when the lid is closed. UV can damage eyes.***

small extra cost is not an important consideration.

In Suspension

During etching, the solution becomes heavier as copper dissolves into it so the board should be arranged to allow the fluid to fall away from it as this happens. Small boards can be stood on edge in a jar of fluid, larger ones can be supported face down in a flat tray.

The author's latest method is to make a support by twisting single-core plastic covered wire round the board as shown in Fig. 3, which holds it in the correct position and provides a convenient "handle" for removal. An extension of this would be to support the board vertically with a wire loop that would hook over the edge of a jar, keeping it just clear of the gunge that inevitably forms in the bottom of such a jar.

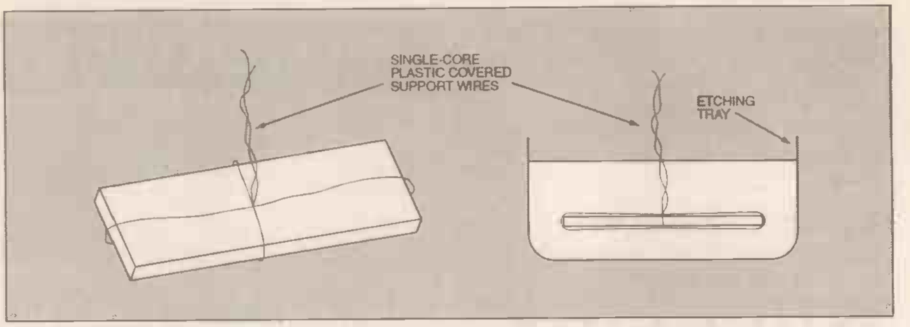


Fig. 3. Supporting a printed circuit board for etching.

Many domestic chemicals such as disinfectants, cleaners etc are now supplied in plastic bottles that are oval rather than round in section, the bottom half of one of these would make an ideal small etching tank.

Etching time depends on the state of the fluid and on temperature. Heat speeds the process considerably so it is worth placing the tray in a sink of hot water to warm it. Don't make the mistake once made by the author of placing a glass dish over a low gas flame though – the heat cracked the dish and the etching fluid did the cooker no good at all!

Polished Job

Following etching, the resist must be removed from the remaining copper tracks. Special chemicals are sold for this, but a wire-wool pad does the job just as well and imparts a wonderful polish to the copper beneath, leaving it in ideal condition for soldering. Thorough washing and rinsing is essential to remove every trace of etching fluid.

The chemicals used are not so much dangerous as unpleasant. The developer is caustic; if it comes into contact with the skin it will give a nasty "soapy" feel that persists even after thorough washing. ***Eye contact should be avoided at all cost.***

The etching fluid will permanently stain almost anything it comes into contact with and corrode just about any type of metal. It even appears capable of producing "rust" spots on stainless steel.

However, contact with the fingers seems to produce nasty staining rather than instant burns. The rule for handling both must be to wear rubber gloves and handle with great care to avoid splashes and spillage. Eye protection in case of splashes is also advisable.

Right Drill

Finally, some notes on drilling the board. In general it is very difficult to drill a p.c.b. using a hand-held drill. It certainly can't be done with the Black and Decker, though one of the mini-drills used for fine modelling work might do.

The ideal is a mini-drill with a suitable stand. They usually require an amp or two of d.c. supply, but check the junkbox for a suitable transformer before buying a custom power supply. If one is to hand, all that is needed with it is a bridge rectifier so again useful savings can be made.

Hole size for component leads is usually 0·8mm or 1mm. Occasionally larger components, or items such as presets, will require 1·3mm. The author usually drills all the holes to 1mm and opens up any that prove too small during construction, using the mini-drill.

If the board is Paxolin there will be no problem with drill bit type but glass-fibre board, preferred by many constructors, blunts ordinary steel drills rapidly. Solid carbide drills last much longer but are very fragile. They are also far more expensive so it is very frustrating when one breaks.

However, don't let anyone tell you they are for machine-controlled drills only. With suitable care a 1mm solid carbide bit can be used with a mini-drill in a stand, and will remain sharp enough to cut clean, accurate holes for far longer.

Have A Go

One final tip concerns preservation of the board after construction. Commercially-produced boards are normally roller-tinned. This prevents oxidation indefinitely, so the board always solders well and looks clean. The bare copper of a home-produced board does not have this advantage and will oxidise quite rapidly.

For easy soldering construction should be carried out fairly soon after cleaning, within say, a day or two. A coating with a spray-on p.c.b. varnish will then keep it looking good almost indefinitely, and will help to reduce other problems such as insulation breakdown between tracks.

Hopefully, these hints and tips will encourage many more enthusiasts to "have a go" at making their own p.c.b.s to near professional standards. Who knows, in time we might even see some of the results in the pages of *EPE*. □

Fault Finding

Here is a fault-finding guide to help locate any problems that might arise when producing boards using the ultra-violet technique.

Develops O.K. but excessive exposure time required.
Artwork drafting film is too opaque – use appropriate clear/translucent film.
Aerosol resist coating too thick: – increase exposure time or use spray more sparingly.
UV tubes need replacing.

Very long developing time, or resist does not develop fully or at all.
Resist is underexposed to UV light: – increase exposure period according (only areas which have been thoroughly exposed to UV light will be developed).
Resist may also be too thick or artwork film too opaque, and has not been thoroughly activated by the UV light – see above.
Developer cold, weak or exhausted. Renew.

Image is developed but then disappears.
PCB has been over-exposed. Reduce exposure time. (Applies especially to good quality sensitive pre-coated boards.)
Artwork layout is not opaque to UV light, permitting UV to pass through transfers etc.
Board has been left in developer for too long.

All of the etch-resist disappears when developing.
Developer could be too hot or concentrated.
The whole board has previously been exposed to UV light. (e.g. sunlight).

Unwanted copper is left on the p.c.b. when etching.
Unwanted etch-resist left on board, due to under-exposure or under-development. Try removing excess resist with a cotton-bud dipped in acetone, then re-immerse in etchant.

Excessive etching time.
Etchant may be exhausted: – dispose of safely and renew.

Narrower tracks are etched away.
Over-exposure to UV may affect very narrow etch-resist tracks which will be removed/reduced in width by etchant.
Developer or etchant may be too strong, undermining narrow sections.

Copper pads lift off when soldering.
Excessive heat applied during soldering.
Diameter of pads too small.
Diameter of the drilled hole too large!
If conductor is intact, repair by applying Super Glue Gel to the affected area, to encapsulate the lifted pad in resin.

Breaks in copper track.
Flaws in etch-resist coating or artwork.
Extremely thin conductors may be undermined by excessive etching time, resulting in the tracks being etched through.
Repair with silver-loaded paint or solder in a jumper wire.

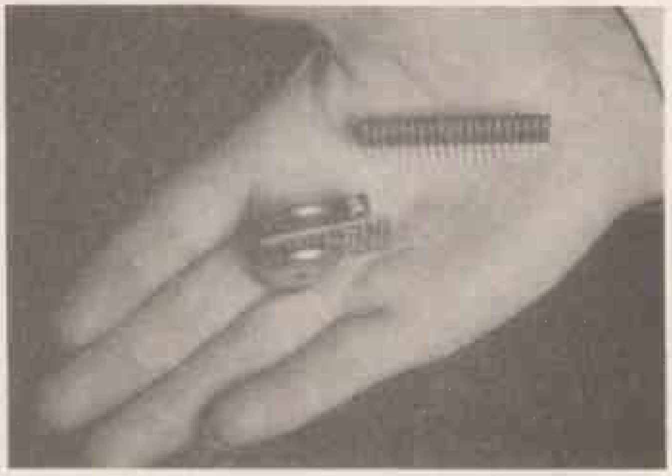
Innovations

A roundup of the latest Everyday News from the world of electronics

IN-CIRCUIT ALARM AIMS TO DETER COMPUTER THEFT

– by Hazel Cavendish

If you were one of the 775,000 British motorists who had your car radio stolen this year, relax. Better times are ahead. If it was your home PC or office computer that went missing, the news is even better. A happy collaboration between miniaturisation expert William Johnson and two top scientists from the University of Southampton has resulted in the development of a remarkable little alarm device which aims to protect all electronic equipment from theft in a way that has never before been achieved.



Prototype of Willy Johnson's ℰlarm, with a typical d.i.l. i.c. to show scale.

A-SIC Burglar

"ℰLARM" breaks new ground in being so miniscule that it can be built directly into an application specific integrated circuit (ASIC) of any computer, radio, TV or video – or, indeed, any electronic unit. The alarm has its own power source and is activated the moment the current is cut off – such as when the thief unplugs the equipment to escape with his loot. The owner possesses an ultrasonic key which switches it on and off (and his spouse can have one too).

What about power cuts? Those boys have thought of that. The machine can pick up the surge which always precedes a power cut, and the ℰlarm chip is programmed to be "intelligent" to that possibility and will ignore it.

Even an ever-sceptical Police force admits to being keenly interested in the new device. Chief constables countrywide are deeply concerned by the £600 million figure of computers stolen from offices over the last year, and Inspector Alan McInnes, Secretary to the Chief Police Officers' Crime Prevention Committee, says they are always ready to look at anything likely to prove effective in dealing with the problem of computer theft. He added that a great many electronic devices intended to protect had appeared on the market without marked success in achieving their aim.

"This new development could present a great advantage if its electronics form an integral part of a computer, or other electronic product, which is subsequently unable to be compromised by someone attacking it, or by a thief using a computer disk to access it," he said.

Human Reaction

The event which brought about such a profitable partnership at the University was just another street crime – hardly remarkable in the big city of Southampton – but in this case the thief who stole an expensive radio from a brand-new Audi chose the wrong man to rob, and did his fellow criminals no favours. The Dean of the Faculty of Engineering and Applied Sciences is a world expert on human reaction to noise, uniquely well placed to mastermind an alarmed device as he occupies the chair of Subjective Acoustics in the University's Institute of Sound and Vibration Research.

Professor Christopher Rice was still fuming when he telephoned Willy Johnson in Guernsey. "Let us get together and do something to beat these thieves," he said. "How about combining your inventive powers with the facilities offered by our Faculty to find an answer to the problem?" Johnson, never averse to a new challenge, agreed at once, but added "Stolen computers are being taken off by the lorry load, and if we find a way of alarming a car radio we should be able to extend that protection to the computer market."

Transducer

Dr Stephen Hughes, Director of the University's Institute of Transducer Technology, was invited to join the team as his department's main research subjects include transducer interfacing, ultrasonics and the design of electromagnetic transduction devices.

Eight months later the team's £100,000 project produced the first prototype of ℰlarm for demonstration at the private launch. It was half the size of a small matchbox and emitted a terrifying volume of noise when activated. The final device will be even smaller than the prototype. The electronic system which releases 110 decibels continues to sound for 10 minutes.

"Such a volume of noise at close quarters will be so startling that the reaction of a thief will usually be to get away from it as quickly as possible," said Professor Rice. "If he should attempt to stay to try and stop the noise he will not succeed, because the extremely robust device is embedded in the system. In the event of him attempting to escape with such an attention-grabbing item, it will restart immediately he tries to reconnect the equipment elsewhere.

ℰlarm will be codified, and every electronic unit of equipment containing it will carry a unique indelible sign. Johnson

Left to right, Dr Stephen Hughes, Willy Johnson and Prof. Christopher Rice, with the prototype alarm.

points out it should soon become known in criminal circles, and will result in thieves avoiding anything marked with the symbol as being altogether too troublesome, and impossible to "move on".

Certain misgivings about noise have been expressed by the Police. Inspector McInnes observed that the University team would need to pay regard to the 1993 Noise and Statutory Nuisance Act, while a Hampshire Crime Protection officer feared the sounding of the alarm in city streets, when attempts to steal radios set them off, would be likely to worry Environmental Health authorities. Johnson's riposte was that Ɛlarm would only sound for 10 minutes, whereas troublesome house and some car alarms went on all day.

Dr Hughes says "We are looking at a 5mm × 5mm cube. The limiting size of 5 × 5 is because of the acoustic requirement that one needs space to get sound out, but the actual electronics – the driver for the sound – will be very small. The other limitation on size is the battery, so we need to use the best quality and the highest power density that is re-chargeable."

Surprising is the low cost of building-in the new deterrent. Johnson believes their invention need only add a maximum of £5 to the cost of each electronic unit, with a slightly higher cost anticipated for one that is retro-fitted. A demand for the latter is anticipated, as many people in possession of valuable computers, or with expensive stereo equipment in their cars, may wish to avail themselves of the new deterrent.

Initial reaction to the new system is encouraging to the team. Fourteen multinational blue-chip companies and computer manufacturers have shown interest in the invention, which was launched hard on the heels of the Government's IT Security Survey focusing on the escalating wave of chip thefts throughout the country.

SOOP-ER TELGUARD

"Soop-er, smashin' lovvli - looook wot wi wun!!" So starts the latest Press Release from ComTel!

Back in our Jan '95 issue, we gave publicity to ComTel's excellent new security system, TelGuard. The company now tell us that this publicity has helped them to attain considerable business success through enquiries from readers. (We like the chatty style in which we have been told!)

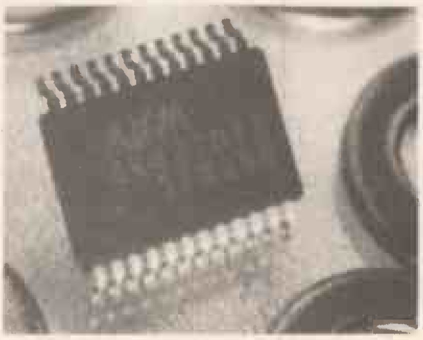
Just to recap, TelGuard is a Communications and Access Control System. Using the existing telephone network, it enables you to remain in control of your property from anywhere in the world. It is vandal resistant and weatherproof, and can be flush mounted in a brick pier or wall. Surface mounting can also be done, for example, by using a purpose built stand at a height and position convenient for drivers and pedestrians.

Natalie Earl, TelGuard's self-styled Marketing "Mangler" says that had it not been for readership response to the news item, she would not have been able to put forward TelGuard as a serious contender for the Innovation Award of the Surrey Business Awards 1995. Entry to this award required proven product marketing success and evidence of effective PR.

We are delighted to report that TelGuard won this award! Well done TelGuard, and Natty!

For further information, contact Natalie Earl, ComTel Ltd., P.O. Box 192, Dorking, Surrey, RH4 3YJ. Tel: 01306 877889.

ADVERTISERS!
WHY NOT send us details of your interesting new products for possible inclusion on these pages? They too could be winners! Drop us a line, with a picture if you've got one.



STEREO DAC

Audio-constructing enthusiasts will be interested to know about the new 16-bit stereo digital-to-analogue (DAC) chip recently introduced by DIP International.

The AK4310 operates at three sampling frequencies, 32·0kHz, 44·1kHz and 48·0kHz. Although designed principally for multimedia and portable audio equipment applications, it will undoubtedly find favour with those who delight in experimenting with the designing of digital audio circuits.

The device features high accuracy to clock jitter as it uses switched-capacitor filter (SCF) techniques, which in turn allow on-chip post filtering.

Total harmonic distortion/noise is quoted at −86dB. The device has a dynamic range of 92dB and a wide band of voltage operation from 3V to 5·5V. Packaged in a 24-pin surface mount format (SSOP) the AK4310 has a low power dissipation of 75mW at 5V and an operating temperature range from −10°C to +70°C.

For further information contact Simon Hilson, DIP International Ltd., Dept. EPE, Sheraton House, Castle Park, Cambridge, CB3 0AX. Tel: 01223 462244.

BULL AND THE SHARK

What an astonishing offer from Bull Electrical - they are offering a 60 million year old shark tooth with every order made from their latest newsletter! You will also be given information on where the tooth was found and the archeologist responsible.

Irrespective of incredible dental offers, Bull's newsletter is worth obtaining in its own right. There are numerous other offers and bargains on 16 A4 sides. How about a panoramic 35mm camera at £5.99, for example? Or electric peelers at £4.99? Or even Bargain Bottle Alarms at £3.99? The latter are like standard cycle bottles, but unclip the top, operate the keyswitch and the unit is armed. Perfect for protecting your bike against theft - it's activated by vibration.

There are masses of other fascinating devices available, both electronic and mechanical. Don't miss out on this great newsletter, request yours now, from:

Bull Electrical, 250 Portland Road, Hove, Sussex, BN3 5QT. Tel: 01273 203500.

TECHNICAL BOOKS

Have you used Mauritron Technical Services as a source for your technical books or service data sheets? If either subject interests you (and one of them must as you're reading *EPE*!), then do get hold of their latest catalogue, it lists masses of highly desirable printed data sources, and at very reasonable prices.

Subjects cover Satellite and TV, Computing, Video, Audio, Office, CB Radio, Semiconductors and much else. Also included is information about the expansion of their popular Monitor Circuits Compendium, which is now into its second volume.

For more information, contact Mauritron Technical Services, 8 Cherry Tree Road, Chinnor, Oxon, OX9 4QY. Tel: 01844 351694.

New Technology Update

Ian Poole asks "is this the comeback of bipolar transistors?" and also looks at the impact cell phone production is having on i.c. technology. Are manufacturers calling the tune?

CELLULAR phones are being produced in vast quantities these days. Manufacturers like Motorola, Nokia and many others are leading the way producing smaller and more complicated designs. This development is having a major impact on shaping many sections of the electronics industry.

In view of the enormous volumes involved, these manufacturers are able to call the tune with their requirements. New battery technologies are emerging to fill the requirement for longer operational times, and many new i.c.s have been designed specially for cell phones.

Many of the very specialised i.c.s have a very short production life. In view of the enormous volumes, some i.c.s may be designed for a specific manufacturer, or even for a particular phone and the production life of the chip may only be a year or two.

Despite the fact that manufacturers can lead the market where they want it to go there are still a number of areas where levels of integration are not as high as they might want. Radio frequency circuits is one particular area.

Monolithic microwave i.c.s (m.m.i.c.s) have been available for a number of years. These chips have virtually all the necessary circuit elements including inductors integrated onto a single chip. However, they are generally aimed at much higher frequencies than those used for cellular phones.

Although some m.m.i.c.s are available at reasonable cost, generally the ones with a wide range of printed components are very expensive, and well beyond the cost of anything which might be considered for cellular phones where price is a prime consideration.

Integrated Level

One of the keys to making mass produced equipment cheaper is to increase the levels of integration. Accordingly, engineers at AT&T in Reading, Pennsylvania have devised a new system that enables inductors to be placed onto one of their silicon processes. This enables many more functions required in radio frequency design to be put onto the integrated circuit.

The inductors are fabricated on a silicon process called CBIC-V2 introduced just over two years ago. This was introduced as a result of industry demand for a low cost radio frequency technology for cellular phones. With this process it is possible to integrate a wide variety of radio frequency components and functions onto the silicon.

The basic CBIC-V2 process uses vertical *npn* and *pnp* transistors with cutoff frequencies of over 5GHz. As the process also generates low-noise circuits it forms the ideal basis for fabricating high performance radio frequency integrated circuits. Now with the possibility of including inductors onto the basic chip the flexibility of the process has been vastly increased.

The inductors have a quality factor or *Q* of up to twelve. This is not as high as most conventionally wound inductors. However, it is four times higher than anything which was previously possible and it is perfectly adequate for many applications. Indeed, the low *Q* is partly compensated by the fact that the inductor is on the chip itself and does not have long leads with high levels of spurious inductance and capacitance.

Gold Standard

The inductors are formed by laying a layer of metallisation down onto the substrate in the required pattern, as shown in Fig. 1. One of the problems with achieving a high level of *Q* with a normal process is that a very conductive substrate increases the transmission losses reducing the effectiveness of the coil.

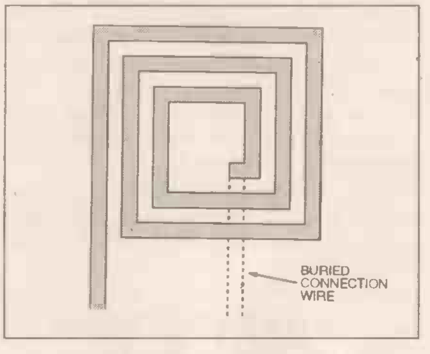


Fig. 1. An i.c. inductor.

Typical figures for the resistivity of normal substrates might be around 10 ohm/centimetres. The substrate for the CBIC-V2 process is much higher at around 200 ohm/centimetres.

To improve the performance of the inductor even further aluminium used for most i.c. metallisation processes is replaced by gold. This reduces the resistance of the coil, another feature which improves its *Q*.

Track widths can be anywhere between five and 24 microns, with the gap between them only four microns. With these dimensions and the square coil, inductors with values between two and 35 nanoHenries can be made.

From the diagram it can be seen that one of the problems to be overcome is that the centre connection needs to be brought out to connect with the other circuitry. This is done using a wire running under the coil. This is insulated from the remainder of the coil using a thin layer of silicon oxide nitride.

Using these coils it is possible to save having to include costly inductors outside the chip. Tuned circuits and various forms of filter can all be made, reducing the number of components which are required outside the chip and thereby enabling the performance of the whole circuit to be improved.

Bipolar revitalised

Nowadays everybody seems to be looking to f.e.t.s to replace bipolar transistors. However, the bipolar transistor is fighting back and proving that there is still plenty of life in this technology.

Field Effect Transistors (f.e.t.s) are fast, have a good high voltage performance and they are easy to drive. For similar die sizes, though, the f.e.t. will have a higher ON resistance. The way around the problem is to increase the size of the die, but this results in the device needing a larger package.

This means that the cost increases, reducing the advantages of the f.e.t. when compared to a similar bipolar transistor. Although the bipolar transistor may appear to have an advantage there are still some problems to be overcome.

Increasing the current capability of a f.e.t. is relatively simple. They consist of thousands of small f.e.t.s in parallel. Increasing their capacity simply requires more f.e.t.s to be placed in parallel in the die.

Matters are not nearly as simple for a bipolar device. It is not possible to place a number of transistors in parallel with one another in the same way. Instead the structure of the device has to be changed.

A bipolar transistor uses the substrate as the collector, as shown in Fig. 2. The base and the emitter are areas which are diffused into this. As a result the base of the transistor is buried in the structure.

In order to increase the current carrying capability of the device, the current flowing into the base must be increased, and distributed evenly over its area. Unfortunately

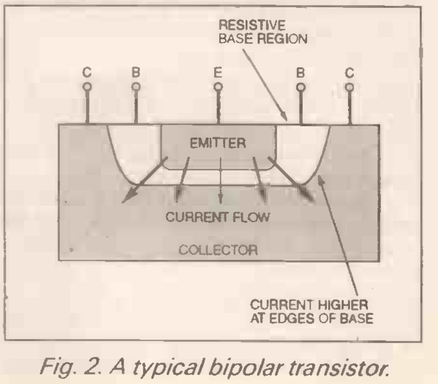


Fig. 2. A typical bipolar transistor.

the base area is resistive and this means that there will be less current flowing in the inner regions of the base than those closer to the edge. In turn this leads to an uneven flow of collector current and poor usage of the transistor's capability.

To overcome this problem a matrix structure has been developed by Zetex. This involves connections being made to the inner parts of the base through vertical wells cut through the emitter section of the transistor, as shown in Fig. 3. Aluminium metallisation is then used to ensure that all areas of the base are connected together, thereby allowing efficient use of all the area available.

The results of this process enable small transistors to be used for switching very high currents.

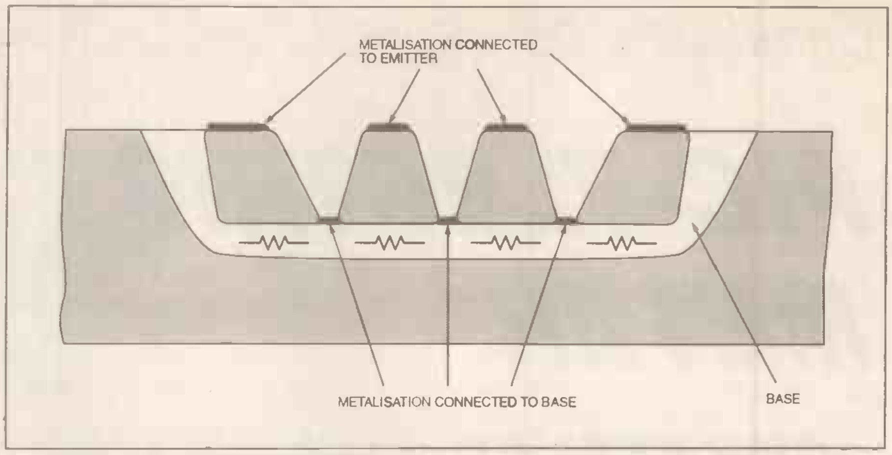


Fig. 3. The concept of a matrix transistor.

SHOP TALK
with David Barrington

PIC-Electric Meter

Some of the components needed to complete the requirements for the *PIC-Electric Meter* have been specially selected for their "performance" and consequently the printed circuit boards have been designed to accept these components. Also, being a bit "special" these are not readily available items.

The special "Hall-effect" current transducer is an RS device and is the multi-range version. This can be ordered through their mail order outlet, **Electromail** (☎ *01536 204555*) code 286-311.

The 3VA mains transformer, with twin 12V secondaries, was also purchased from the above source, code 210-780. Likewise, the four-digit 7-segment display was obtained at the same time, code 597-024 (common anode). Other common anode displays may possibly be available from different suppliers, but check the pinout alignment against the circuit and p.c.b. before purchase.

In case of any difficulty in finding the TLC549 8-bit serial ADC, this can be ordered (see above) as: code 650-093. Do NOT use the 4078 (from the 4000 series of i.c.s.), the near-equivalent, in place of the 74HC4078 OR/NOR gate, it does not have the extra OR gate.

A ready-programmed PIC16C84 EEPROM is obtainable, together with the two p.c.b.s, from **Magenta Electronics, Dept EPE, 135 Hunter Street, Burton-on-Trent, Staffs, DE14 2ST**, for the sum of £21. They are also happy to supply the p.c.b.s on receipt of £9.90 or the chip alone for £12. There is a post and packing charge of £3.

The two printed circuit boards for the *PIC-Electric* are available from the *EPE PCB Service*, codes 977 (Sens/PSU) and 978 (Cont/Disp) respectively. The source-code listing is obtainable on a 3·5in Disk (together with the Simple PIC Programmer software) from the Editorial Offices (see page 101 for address) for £2.50 (overseas – surface £3.10; airmail £4.10).

Analogue Frequency Meter

The LM2917N frequency-to-voltage converter i.c., which forms the heart of the *Analogue Frequency Meter* project, may prove a little elusive to find locally. Most of our component advertisers should stock this item, but you must request the ***14-pin*** version when ordering.

Similar problems may arise when trying to locate a local source for the voltage converter i.c. This device may be prefixed with the letters ICL or SI and either chip is suitable for this circuit. The ICL7660 is currently listed by **Electromail** (☎ *0153 204555*) and **Farnell Components** (☎ *0113 263 6311*) and the SI7660, as used in the model, by **Maplin** (☎ *01702 554161*), code YY75S.

Remember to quote the *L* suffix when ordering the BC184L and BC214L transistors, other types have differing pinout arrangements. The 22-turn cermet potentiometer should be the vertical mounting type with an in-line pin format and a top adjusting preset screw.

There are various options open regarding selection of the meter and this is left to individual choice. Suffice to say, **Bull Electrical, Greenweld** and **J&N Factors** often have "deals" on panel meters and it may pay to ring them first before making a final decision.

The single-sided printed circuit board is available from the *EPE PCB Service*, code 957.

Mains Signalling Unit

Particular care must be exercised when selecting the two resistors and capacitor C1 for the small *12V Capacitive PSU* section of the *Mains Signalling Unit*.

The resistors should be new and unused metal film types: Resistor R1 being rated at 2W; and R2 from a "high voltage" range, quoted as being up to 2500V a.c. and 3500V d.c. for the one megohm value. These should be available from most of our components advertisers, the ones used on the p.c.b. came from Maplin, codes D120R and V1M respectively.

As with last month's Transmitter and Receiver, capacitor C1 ***MUST*** be new and rated for ***continuous*** connection directly across the 230V a.c. mains supply. These capacitors are normally sold as suppression components and should be available from any good component supplier. The one on the PSU board is a "high voltage interference suppression (IS)" type purchased from **Maplin**, code JR36P. A normal high voltage capacitor is NOT suitable and MUST NOT BE USED.

The transient suppressor or voltage dependent resistor (VDR) also came from the above source, code HW13P. The PSU printed circuit board is available from the *EPE PCB Service*, code 975.

We do not expect any buying problems to be encountered when putting together the parts for the *Two-Tone Siren Alarm*.

Finally, constructors of the Mains Signalling Units must heed the warnings in the articles regarding the presence of mains voltages and take due care. It is important that all polarities are double-checked before making any final connections.

Simple PIC 16C84 Programmer

As far as the components for the *Simple PIC Programmer* go, they should all be readily available from your usual component supplier. Most of them should have supplies of unprogrammed PIC16C84 microcontrollers and certainly carry the 25-way D-connector.

Switching to the programming side, the TASM software and associated program files (but not including a text editor) are available on 3·5in. disk from the *EPE* Editorial offices for £2.50 (overseas – surface £3.10; airmail £4.10) to cover administration costs. This is not a payment for the software itself, for which we make no charge. The disk also contains the *PIC-Electric* software.

The current registration fee for the shareware TASM assembler software is about £25. This fee is only payable if you intend to *regularly* use the software beyond a *reasonable* evaluation period.

Readers are strongly recommended to honour the registration payment request. Payments for the use of the TASM software can be made to a USA address, details are given on the disk.

For further information about TASM and other shareware software contact: The **Public Domain Shareware Library, Dept EPE, Winscombe House, Beacon Road, Crowborough, Sussex, TN6 1UL.**

Vari-Speed Dice (Teach-In '96)

We do not anticipate any component buying problems to occur to when shopping for parts to build the *Vari-Speed Dice*, this month's *Teach-In '96* project.

The small p.c.b. for the Dice is available from the *EPE PCB Service*, code 974.

PLEASE TAKE NOTE

Sound Switch (Oct'95)

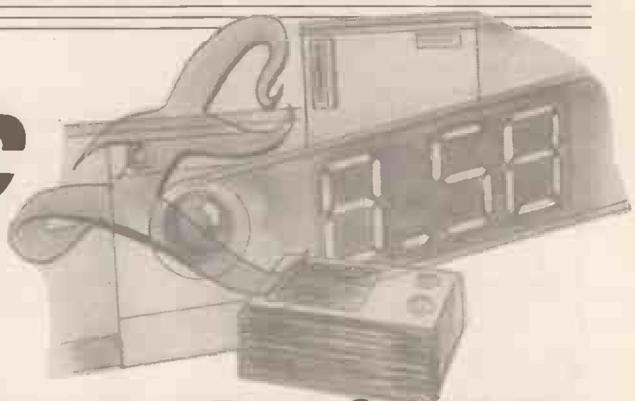
The remote location of the sensing loudspeaker extends the mains earth (via 0V rail of 12V supply) outside the building. Under exceptional mains fault conditions, it could be "live" up to 240V relative to any nearby surfaces at ground potential (e.g. metal railings, metal greenhouse frames) and may present a shock risk.

Readers should ensure that the cable to the speaker is doubly insulated and that the speaker itself is adequately enclosed in its plastic case without possibility of external contact to it being made. **If in any doubt, consult a qualified electrician.**

Similar action should be taken when any mains earth connection is extended outdoors.

Digital Delay Line (Nov '95)

Some readers have experienced excessive output level problems from the Digital Delay Line. The output level of the circuit can be reduced by increasing the value of R9. If the problem is related to input overloading, it might be better to increase the value of R1. The value of R6, which controls the gain of the 8955's internal preamp, could be reduced.



PIC-ELECTRIC METER

JOHN BECKER

Part One

Know just how much each electrical appliance in your home is adding to your electricity bill.

Learn more about the EEPROM version of the PIC family of microcontrollers.

THIS microcontrolled PIC-Electric Meter monitors domestic electricity consumption and gives a digital readout of cost. Any 230V to 240V a.c. mains powered electrical appliance, such as a Fridge; Washing Machine; Tumble Dryer; Room Heater; Kettle; Computer and so forth, can be plugged into the meter.

Loads from about 60W to 3500W can be monitored. Data acquired using the meter has obvious benefits in terms of evaluating the economical use of most household electrical equipment, so helping to keep electricity bills down.

Since PIC-Electric carries potentially lethal mains voltages at high currents, its construction should only be undertaken by an *experienced* constructor. It should NOT be attempted by the *beginner*, unless carefully supervised by a qualified person.

Be aware that while PIC-Electric is plugged into the mains supply, potentially lethal voltages will be present within its case. Always *unplug* the unit from the mains *before* making any assembly changes.

WHAT IT DOES

Current sampling takes place 100 times a second, detecting the amperage being drawn by the monitored appliance at the positive and negative peaks of each mains a.c. sinewave. The total number of electrical units (one unit = one kilowatt/hour) and the cumulative cost since monitoring commenced is updated at each sampling.

A four-digit l.e.d. module displays the results, automatically alternating between the two totals. Elapsed time since monitoring started can be displayed by pressing a pushbutton switch. Instantaneous load values can also be displayed.

The cost per unit of electricity, to two decimal places, is programmed into PIC-Electric by two pushbutton switches. The value is stored in the microcontroller's non-volatile memory which retains the data even when it is unpowered.

Stored information can be updated at any time. The cumulative totals of the units used and their cost are reset each time PIC-Electric is switched on, and can also be reset at any time during monitoring.

The advantage of taking samples synchronously with the mains cycles is that with appliances whose consumption varies irregularly, such as a washing machine working through its programmed cycle, for example, the operational costs over a given period can be calculated with an excellent degree of accuracy. Estimating the running costs of such equipment from its quoted maximum wattage specification is highly unreliable.

Cumulative units and cost are displayed in a repeating cycle of four display formats: pounds, pence to two decimal places, hundreds of units, tens of units to two decimal places, each being displayed for about five seconds.

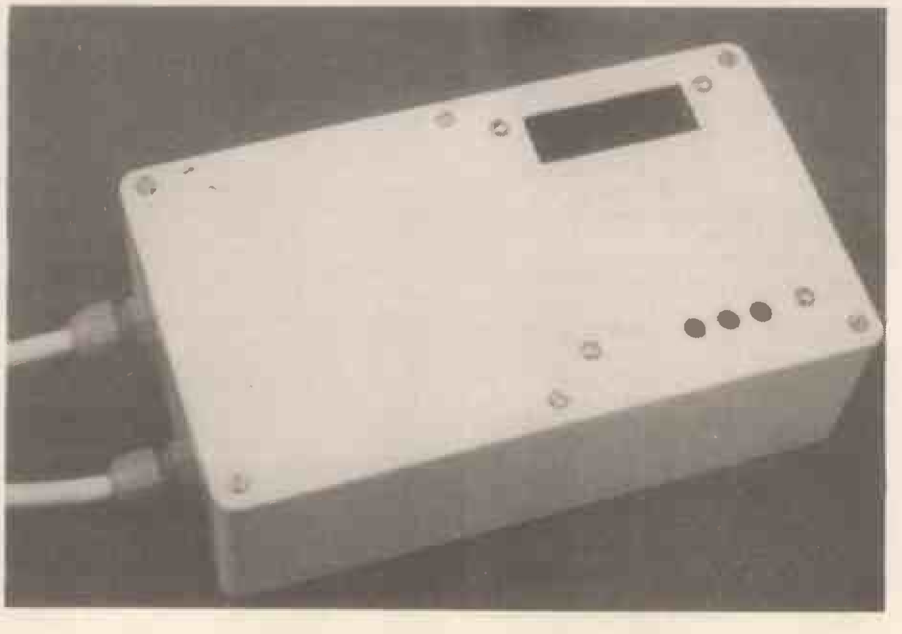
IN CONTROL

The microcontroller used in the PIC-Electric is the PIC16C84 device manufactured by Microchip Technology. This is a high performance, low cost, CMOS device having 1K × 14-bits of EEPROM (Electrically Erasable Programmable Read-Only Memory) program memory, 64 bytes of 8-bit EEPROM data memory and 36 × 8-bit general purpose SRAM (Static Random Access Memory) registers.

SPECIFICATION . . .

There are six basic display functions available:

- ★ **Cost per unit of electricity to 99·99 pence**
- ★ **Units of electricity used to 9999·99**
- ★ **Cumulative cost to £99 99·99 pence**
- ★ **Elapsed time to 159 hours 59 minutes and 59 seconds**
- ★ **Instantaneous current flow up to 15A**
- ★ **Initial setting-up (very simple)**



PIC-Electric has been designed so that the PIC16C84 can be programmed in situ on the assembled printed circuit board. Data is transferred to the microcontroller via the serial port of a PC-compatible computer.

Other than a connector and cable, no additional hardware is needed, although a suitable software program is required. This facility makes it possible to use the PIC-Electric assembly for other applications, using different analogue sensors and controlling software. Both software and pre-programmed PIC16C84s are available – see *Shoptalk* page.

HOW IT WORKS

A block diagram for the PIC-Electric Meter is shown in Fig. 1. The meter comprises a current sensor, analogue-to-digital converter (ADC), sync pulse generator, microcontroller, display module and a power supply (PSU).

The sensor is connected in series with the load (appliance) being monitored, producing an output voltage which increases linearly with the amount of current flowing. The resulting voltage is fed to a serial ADC which is sampled by the microcontroller each time a sync pulse derived from the mains power supply is received.

Software programmed, the microcontroller processes the sampled data, stores it and displays the appropriate results according to the stage of the processing cycle and in response to the "mode" pushbutton switch commands.

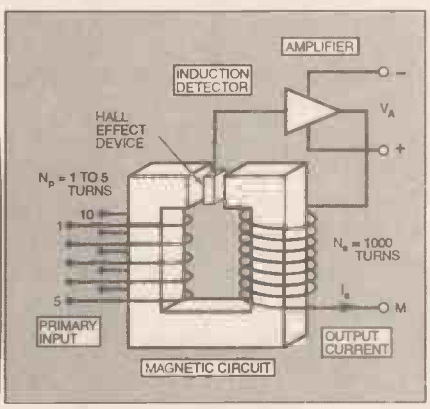


Fig. 2. Hall-effect current sensor and transducer functional diagram.

CURRENT SENSOR

The current sensor is a dedicated transducer which uses Hall-effect technology, whereby current measurement is carried out by measuring the magnetic field that is generated by a current carrying conductor. The schematic drawing of the Hall-effect Transducer is shown in Fig. 2.

Basically, the device consists of a ferromagnetic former around which are wound two coils. The primary coil is tapped and the number of turns through which the current flows can be selected according to the maximum current to be monitored. In the PIC-Electric, the primary winding is connected so that only one coil turn is used, allowing a theoretical maximum of 25A to be drawn through the sensor.

Within the gap between the legs of the magnetic former is a Hall-effect semiconductor device. This is placed at right angles to the magnetic field generated by current passing through the primary coil. The resulting voltage generated across the semiconductor is linearly proportional to the magnetic field, and hence to the current flowing in the circuit.

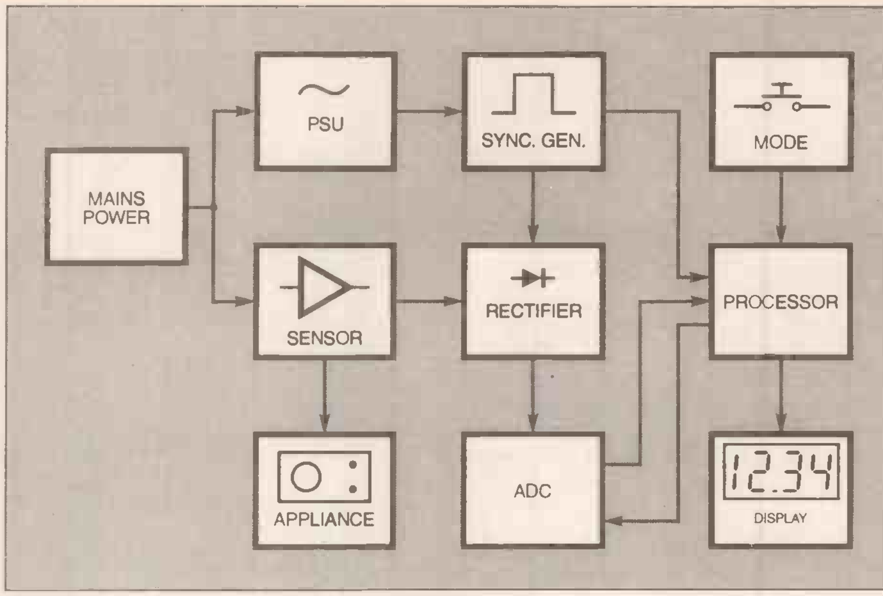


Fig. 1. Block diagram for the PIC-Electric Meter.

The device can be used to measure alternating or direct currents (a.c. or d.c.). Its output does not depend on a changing magnetic field, only on the instantaneous strength of the field. The bandwidth of the device is from d.c. to 150kHz.

The voltage generated across the semiconductor is processed by an internal amplifier and fed through the secondary winding of the transducer, generating an output current. An output current of 25mA is generated by a 25A primary current flowing through the sensor, to within ±0·6 per cent. By feeding the current through a known value resistor, typically 100Ω to 190Ω, the current can be converted to an equivalent output voltage.

When connected for 25A maximum current, the resistance of the primary coil is only 0·3 milliohms, and so imposes very little insertion loss between the mains power source and the appliance being monitored. The isolation between the primary coil and the sensor's output is 2·5kV r.m.s. at 50Hz for one minute.

The sensor also requires a dual d.c. supply voltage of ±15V, consuming about 10mA, plus the output current.

SENSOR CIRCUIT AND PSU

The circuit diagram for the Sensor connections and the Main Power Supply for the PIC-Electric is shown in Fig. 3. Mains power input to the circuit is via plug PL1.

The Hall-effect sensor, X1, has its primary winding inserted in series with the Live connection between PL1 and the output socket SK1. The mains Neutral and Earth lines are taken direct to SK1.

From PL1, mains power is also supplied to the primary winding of transformer T1. This has two 12V secondary windings connected in series, with the junction, or centre tap, of the two windings providing the 0V line. The output of the sensor is connected to the 0V line via resistor R1, into which the output current flows, creating an equivalent voltage which is destined for the ADC (IC7 in Fig. 6, later).

The secondary voltage from transformer T1 is bridge rectified by REC1, whose posi-

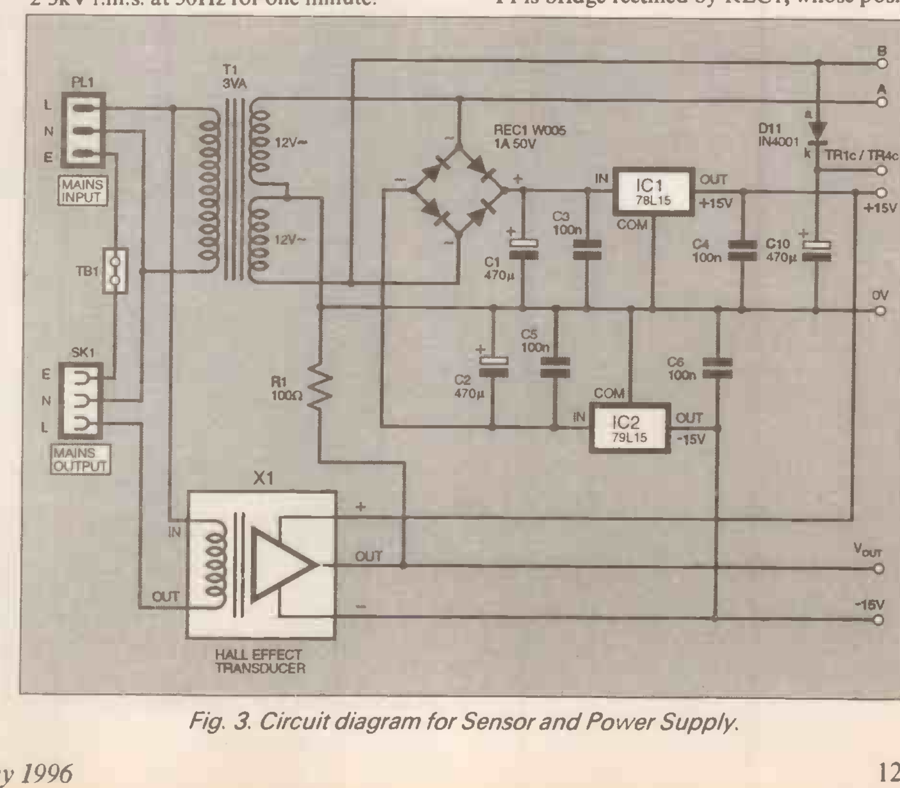


Fig. 3. Circuit diagram for Sensor and Power Supply.

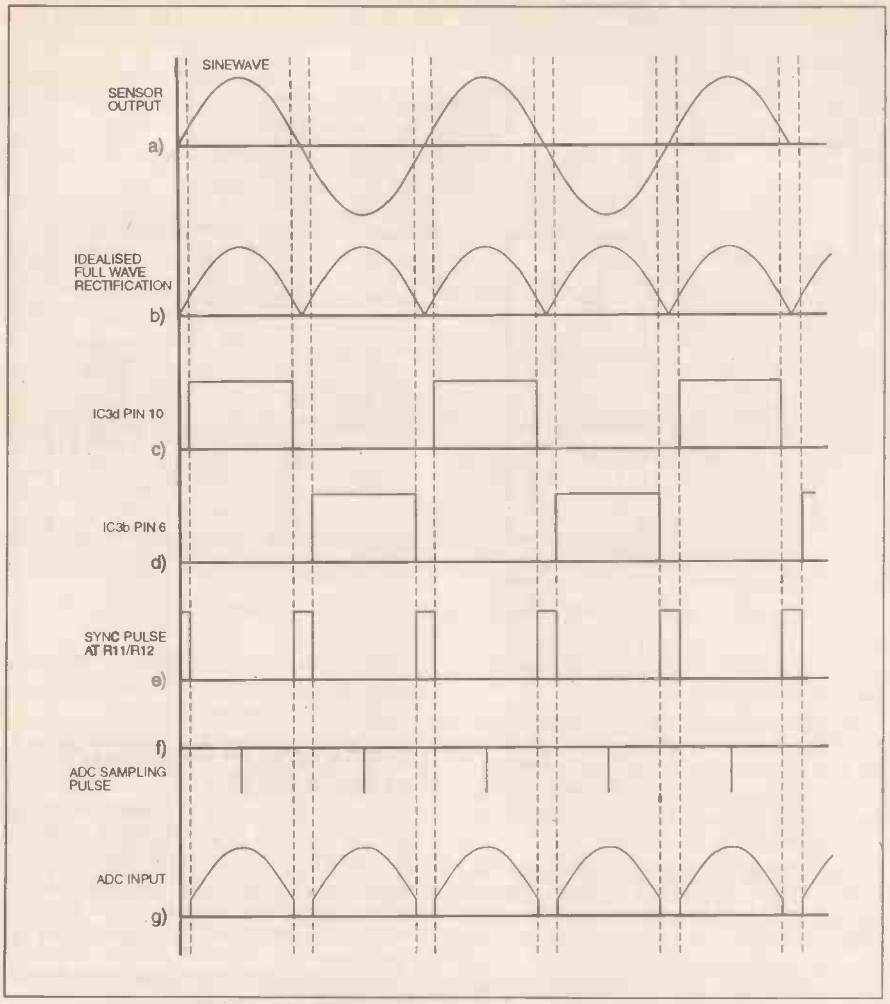


Fig. 4. Significant waveforms associated with the PIC-Electric.

tive output is smoothed by capacitors C1 and C3, and regulated down to +15V d.c. by IC1. The negative output from REC1 is smoothed by capacitors C2 and C5, and regulated down to −15V by IC2. This dual voltage (+/−) 15V supply powers the d.c. aspect of the sensor X1.

An additional unregulated ***positive*** d.c. voltage is required to power the 7-segment display (X3) l.e.d.s. This is generated from only one of the transformer's secondary windings. Diode D11 half-wave rectifies the voltage and capacitor C10 provides the necessary smoothing.

SIGNAL FORMAT

The output from the Hall-effect sensor X1 is a sinewave whose amplitude increases with the current sensed, peaking above and below the 0V power line, as shown in Fig. 4a. To suit the ADC, the signal needs to be rectified so that the negative portion of the waveform is inverted to make both its aspects positive, as shown idealised in Fig. 4b.

Normally, rectification requires the use of diodes in series with the voltage path. Silicon diodes, though, cause an insertion loss of about 0·7V, which is undesirable when dealing with low level signals.

There are several ways in which this problem can be overcome. The technique chosen here is shown in the Signal Formatting and Sync circuit diagram of Fig. 5. Also shown is the circuit which generates the 100Hz synchronisation signal.

The Hall-effect sensor output signal is first fed to the non-inverting buffer op.amp IC5a pin 3, whose output is fed to analogue gate "switch" IC4a pin 4, via resistor R7. The output from IC5a is also inverted by IC5b and fed through resistor R8 to a second analogue gate, IC4b pin 1. Diodes D3 and D4 prevent IC4a and IC4b from being adversely affected by the negative aspects of the signals.

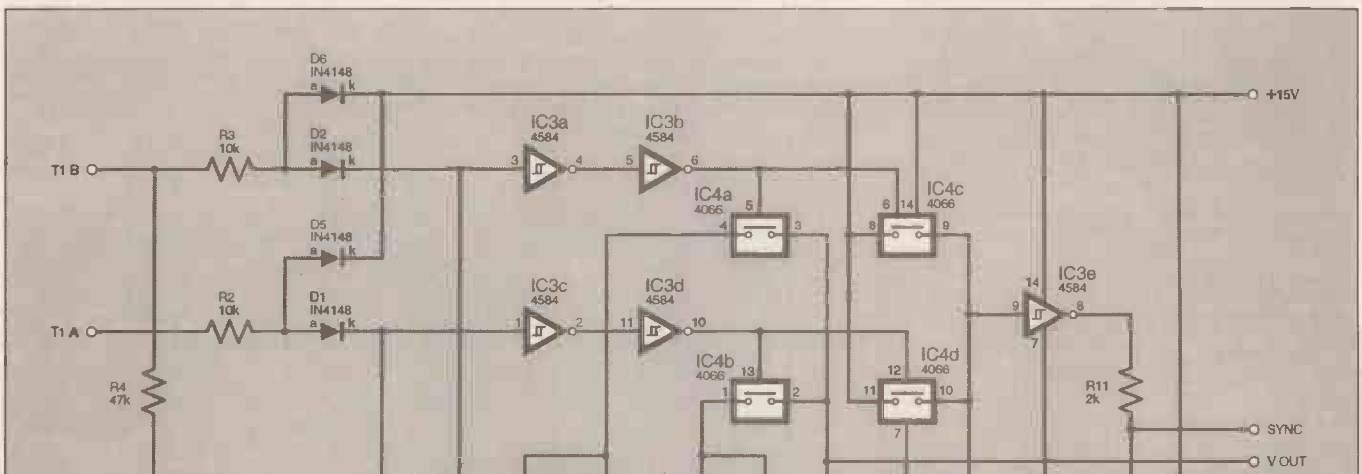


Fig. 5. Sync and Signal Formatting circuit diagram.

CONTROL SIGNALS

Controlling signals for IC4a and IC4b are derived from the secondary windings of transformer T1. Transformer line *B* in Fig. 3 is fed, via resistor R3 and diode D2, to Schmitt trigger inverters IC3a and IC3b.

This sequence of components rectifies the positive-going signals from the transformer, reshaping them to square wave pulses at positive supply line amplitude. Only voltages above the positive-going Schmitt trigger threshold of about 8V trigger IC3a (with +15V supply); the equivalent negative-going threshold is typically about 6·9V. Diode D6 limits the maximum voltage which can be presented to the input of IC3a.

The output from IC3b controls analogue gate IC4a via its pin 5 which, when high, allows signals from IC5a to pass through the gate from pin 4 to pin 3.

Signals from transformer line *A*, which are of opposite phase to those from line *B*, are similarly processed by inverters IC3c, IC3d and their associated components, controlling analogue gate IC4b and the signals fed to it from IC5b.

The outputs of IC4a and IC4b are connected together, feeding into resistor R9 from where they are routed to the ADC (IC7). Since the controlling signals are of opposite phase, the gates open or "switch" alternately, passing through only the positive aspects of the analogue voltages from the op.amps. Because the Schmitt threshold voltages for IC3a and IC3c are several volts above 0V, the analogue voltage presented to the ADC appears similar to the waveform in Fig. 4g.

Note that an oscilloscope may show slight differences in the relative amplitudes of alternate peaks of the actual waveform fed to the ADC. This is due to the inherent and uncorrected offset voltages of the op.amp circuits. The differences are balanced out in the software summing routines.

Synchronisation pulses at 100Hz are generated by gates IC4c and IC4d, which are controlled respectively by the outputs from IC3b and IC3d. Both inputs (pins 8, 11) to IC4c and IC4d are tied to the positive supply line.

COMPONENTS

Approx cost guidance only **£55**
excluding case, mains socket and cable

Resistors

R1, R24 to R32	100Ω (10 off)
R2, R3, R7, R8, R33	10k (5 off)
R4	47k
R5, R6, R10, R13 to R17	100k (8 off)
R9	1M
R11, R34	2k (2 off)
R12, R18 to R23, R35 to R37	1k (10 off)

All 0·25W 5% carbon film or better.

Potentiometers

VR1, VR2	10k enclosed carbon preset (2 off)

Capacitors

C1, C2, C10	470μ radial elect., 35V (3 off)
C3 to C7, C11, C12	100n polyester (7 off)
C8, C9	15p polystyrene (2 off)

Semiconductors

D1 to D8	1N4148 signal diode (8 off)
D9	red l.e.d., sub-min
D10	BZY88C12 12V 400mW Zener diode
D11	1N4001 1A 50V rect. diode
REC1	WOO5 50V 1A bridge rect.
TR1 to TR4	BC337 *npn* transistor
IC1	78L15 +15V 100mA regulator
IC2	79L15 −15V 100mA regulator
IC3	4584 Hex Schmitt inverter
IC4	4066 quad bilateral analogue switch
IC5	LM358 dual op.amp
IC6	78L05 +5V 100mA regulator
IC7	TLC549IP 8-bit serial ADC
IC8	74HC4078 8-input OR/NOR gate
IC9	PIC16C84 programmed EEPROM microcontroller (see text)

See SHOP TALK Page

Miscellaneous

X1	current transducer, Hall-effect
X2	4MHz crystal
X3	4 × 7-segment display module, common anode
S1	d.p.s.t. min. slide switch, p.c.b. mounting (see text)
S2 to S4	pushbutton p.c.b. mounting switch, push-to-make (see text) (3 off)
T1	3VA mains, p.c.b. mounting, transformer with twin 12V secondaries

Printed circuit boards for Sensor/PSU and Controller/Display, available from the *EPE PCB Service*, codes 977 (Sen/PSU) and 978 (Cont./Disp.) respectively; 8-pin d.i.l. socket (2 off); 14-pin d.i.l. socket (3 off); 18-pin d.i.l. socket; plastic case, 188mm × 108mm × 160mm; mains cable gland (2 off); 2-way 15A mains terminal block; mains plug and socket; p.c.b. mounting supports, screw base (4 off); nuts and bolts; connecting wire; mains cable; cable ties (3 off); terminal pins; solder, etc.

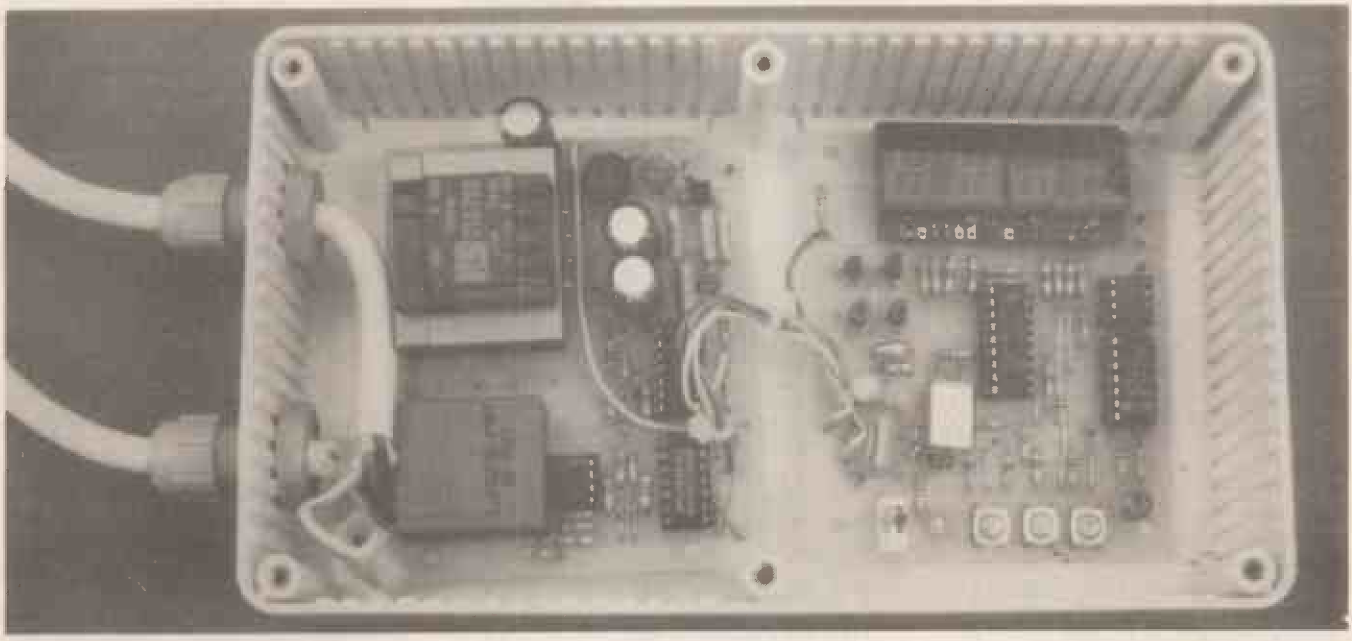
Their outputs (pins 9, 10) are connected together and fed into resistor R10 and Schmitt inverter IC3e. The potential divider formed by resistors R11 and R12 across the output of IC3e limits the resultant sync pulse amplitude to a maximum of +5V, to suit the PIC microcontroller IC9.

The waveforms of the sync pulse and the signals which control IC4 are shown in Fig. 4c to Fig. 4e. The point at which the ADC samples the analogue signal is shown in Fig. 4f.

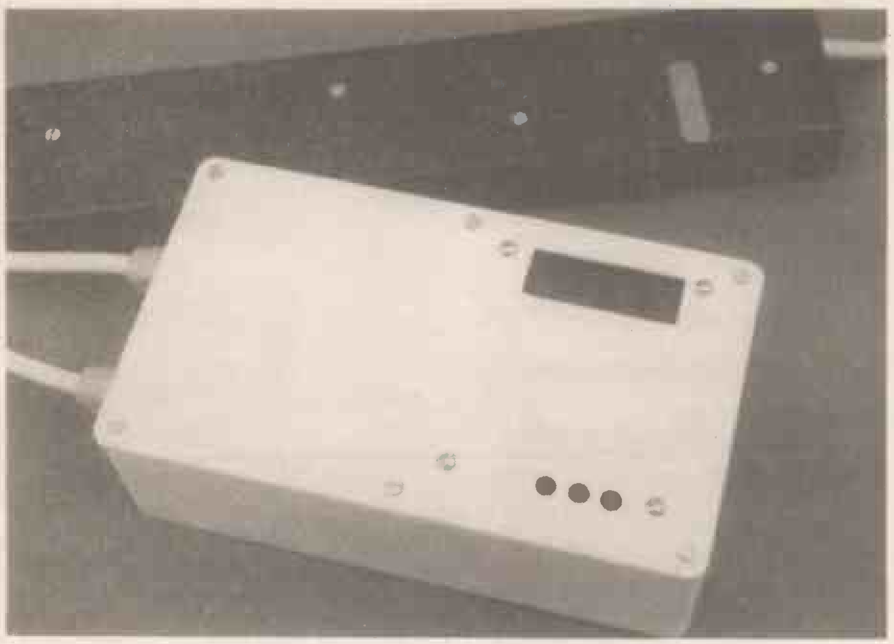
TEST CIRCUIT

Also shown in Fig. 5 are details of a simple test circuit formed by resistor R4 and preset VR1. R4 is connected to transformer line *B* which supplies a sinewave having the same phase as that from the sensor.

The wiper of VR1 can be linked to the analogue processing circuit at IC5a pin 3 to provide a test signal in place of that from the sensor. This allows tests to be made without plugging a mains appliance into PIC-Electric.



The completed PIC-Electric Meter with lid removed to show siting of circuit boards. Note that the Display p.c.b. is normally bolted to the rear of the case lid, behind the display window.



The completed PIC-Electric Meter showing the readout display window and three holes for access to the Reset and Function setting switches.

CONTROL AND DISPLAY

Details of the Control and Display circuit are shown in Fig. 6. Basically, the circuit comprises the PIC microcontroller IC9, the ADC IC7, and display module X3. The majority of the circuit is under control by the microcontroller and its software.

The power supply for most of this circuit has to be regulated at +5V, a function which is carried out by IC6.

ADC

Analogue-to-digital conversion of the processed signal is performed by IC7. This is an 8-bit serial ADC chip whose reference voltage is provided by the potential divider consisting of resistors R33, R34 and preset VR2.

Data conversion and output are controlled by the chip's internal clock system and external input/output (I/O) clock pulses. The maximum sampling rate the chip can handle is about 40kHz.

When IC7's $\overline{CS}$ pin 5 is high, the data output (D OUT) pin 6 is in a high impedance state and the I/O clock (CLK) pin 7 is disabled. Reading of the conversion result is initiated when $\overline{CS}$ is brought low.

On this action, the most significant bit (MSB) of the previous conversion appears on the data output. The falling edges of the next four I/O clock cycles shift out the next four MSB data bits.

The on-chip sample-and-hold begins sampling the analogue input after the fourth high-to-low transition of the I/O clock. The sampling operation basically involves the charging of internal capacitors to the level of the analogue input voltage.

Three more I/O clock cycles are then applied to the CLK pin and the final three conversion bits are shifted out. After the eighth I/O clock cycle, $\overline{CS}$ must go high or the I/O clock remain low for at least 36 internal system clock cycles to allow completion of the internal hold and conversion functions.

In Fig. 6, the $\overline{CS}$ pin is brought low only when microcontroller IC9 lines RA0 to RA3 are all low simultaneously, causing IC8's output pin 8 to also go low. Note that IC8 is a 74HC4078 8-input OR/NOR gate used in its OR mode and that the 4000 series near-equivalent *4078 cannot* be substituted since the latter is purely a NOR gate without the extra OR inversion at pin 1.

DISPLAY MODULE

Each of the multiplexed four digits of the l.e.d. display module has seven segments and a decimal point which are controlled by microcontroller's data lines RB1 to RB7, plus RA4. The segments and decimal point are turned on when their respective data lines are low. Resistors R24 to R31 limit the current flowing through the segments.

Technical literature shows that PIC16C84 microcontrollers can supply (source) 20mA or sink 25mA per data line, though each port (RA or RB) is limited to the total amount of current which can be sunk or sourced: 80mA sunk by Port RA, 150mA sunk by Port RB, 50mA sourced by Port RA and 100mA sourced by Port RB.

With resistors R24 to R31 at the values shown, when each digit has all seven segments and a decimal point turned on, the source current required is about 120mA. Although Port RB can sink this amount of current, Port RA cannot source it. Increasing the resistor values to suit Port RA would not allow the l.e.d.s to glow with adequate brightness, consequently current boosting is required and is supplied by transistors TR1 to TR4.

The transistors are connected in series with the common-anode digits of the display and are controlled by IC9's data lines RA0 to RA3. Each data line when taken high allows the transistor to conduct voltage to the selected digit. Although the transistors' collectors are fed from a voltage greater than the +5V available from IC7, the maximum voltage which is fed from their emitters to each digit is about 0·7V below the voltage of the controlling RA data line connected to their bases, i.e. about 4·3V.

FUNCTION SWITCHES

Function switches S3 and S4 select which data is displayed on the l.e.d. module. Their use and effect is determined by which routine the software is running at the time of their pressing, as discussed next month.

In all routines, the status of the switches S3 and S4 can only be read when software sets data lines RA0 to RA3 low, so setting low IC8 pin 1. If either of the switches is pressed at that time, a logic 0 will be read from the respective data line RB2 or RB3.

Resistors R16 and R17 tie the outputs of the switches to the positive rail, consequently if a switch is unpressed or IC8 pin 8 is high, a logic 1 will be read. R36 and R37 ensure that no connection is made between the two data lines if both switches are pressed simultaneously.

MICRO-CONTROLLER

The PIC16C84 microcontroller is shown as IC9 in Fig. 6. As a device which has an EEPROM program memory, it can be repeatedly reprogrammed without the need for ultra-violet (UV) erasure, unlike the rest of the current PIC range of microcontrollers. The reprogrammability, of at least 1000 times and probably more, makes it ideal for situations where controlling software is being developed step by step.

An additional advantage over other PIC devices is that this chip also has a EEPROM data memory which can be written to and read from by the controlling software, with a maximum of about one million write cycles. This facility makes the processor eminently suitable for systems which require some data factors to be changed according to varying situations, such as the need to periodically update the PIC-Electric Meter with revised electricity unit prices.

PIC-Electric has been designed so that the microcontroller can be serially programmed from a PC-compatible computer, running suitable software, whilst plugged into the printed circuit board. All that is required is that the PC should provide data via resistor R22 to IC9 pin 13, the DIO/RB7 data line, and a clock signal via R23 to IC9 pin 12, the CLK/RB6 data line, plus the 0V common connection.

The PIC16C84 cannot be programmed by the *PIC-DATS System* published in *EPE* May '95 issue, but it can be programmed by the Simple PIC16C84 Programmer published in this issue. Proprietary software is also available from a variety of commercial sources. The chip's programming instruction codes are common to all current PIC devices, except for four additional commands.

The microcontroller IC9 is powered at +5V and in normal running mode its $\overline{MCLR}$ (master clear, or reset) pin 4 is held at about the same voltage, as supplied via diode D7 and resistors R20, R32. In programming mode, though, the pin needs to be held at between +12V and +14V.

For programming, S1 switches the +15V supply line through diode D8, overriding the voltage from D7. Zener diode D10 reduces the programming voltage to +12V.

To reset IC9, $\overline{MCLR}$ has to be taken to 0V, an action performed by pushswitch S2. Resistor R20 prevents the voltage at the D7/D8 junction from being shorted to 0V when S2 is pressed. R32 is included at the manufacturer's recommendation.

The microcontroller contains its own clock generating circuit whose frequency and mode of operation is determined by a choice of external component types, as detailed in the chip's data sheet. For this application, a clock frequency of 4MHz is set by crystal X2 in conjunction with capacitors C8, C9 and resistor R21.

Since the microcontroller effectively acts upon software instruction codes at one quarter of the clock frequency, an operational speed of 1MHz is achieved here. This is more than fast enough to process data acquired from the ADC at a 100Hz sampling rate, even though the software contains around 700 commands.

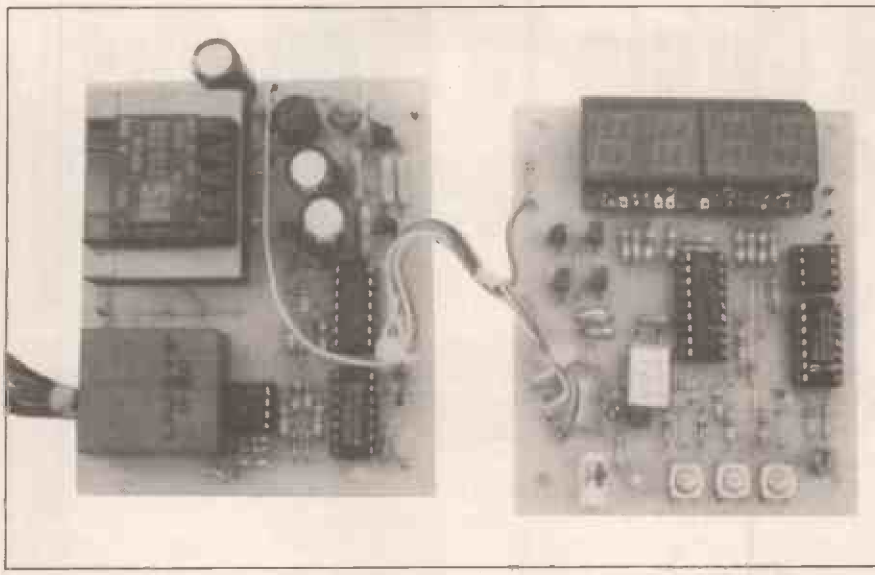
SOFTWARE

Software of the source-code listing for the PIC-Electric Meter (together with Simple PIC16C84 Programmer software) can be supplied from the Editorial Office as a 3.5in. disk (UK £2.50, overseas surface £3.10, airmail £4.10). A pre-programmed PIC16C84 chip (together with p.c.b.s) for PIC-Electric, ready to plug straight in, is obtainable from Magenta Electronics. See *Shoptalk* for details.

Detailed description of all the software for the PIC-Electric is beyond the scope of this article. A brief operational description follows the "First Tests" section (next month). The source code listing available has comments embodied into it which clarify further aspects of the program.

There are also four software routines in the listing which will be of general interest to PIC programming readers since they show practical examples of coding procedures which were found to be unclearly explained by the *Microchip Data Book*. The routines include EEPROM data storage and retrieval, multiplexed display look-up tabling, and indirect addressing.

Next Month: Constructional details, testing procedures and using the Meter.



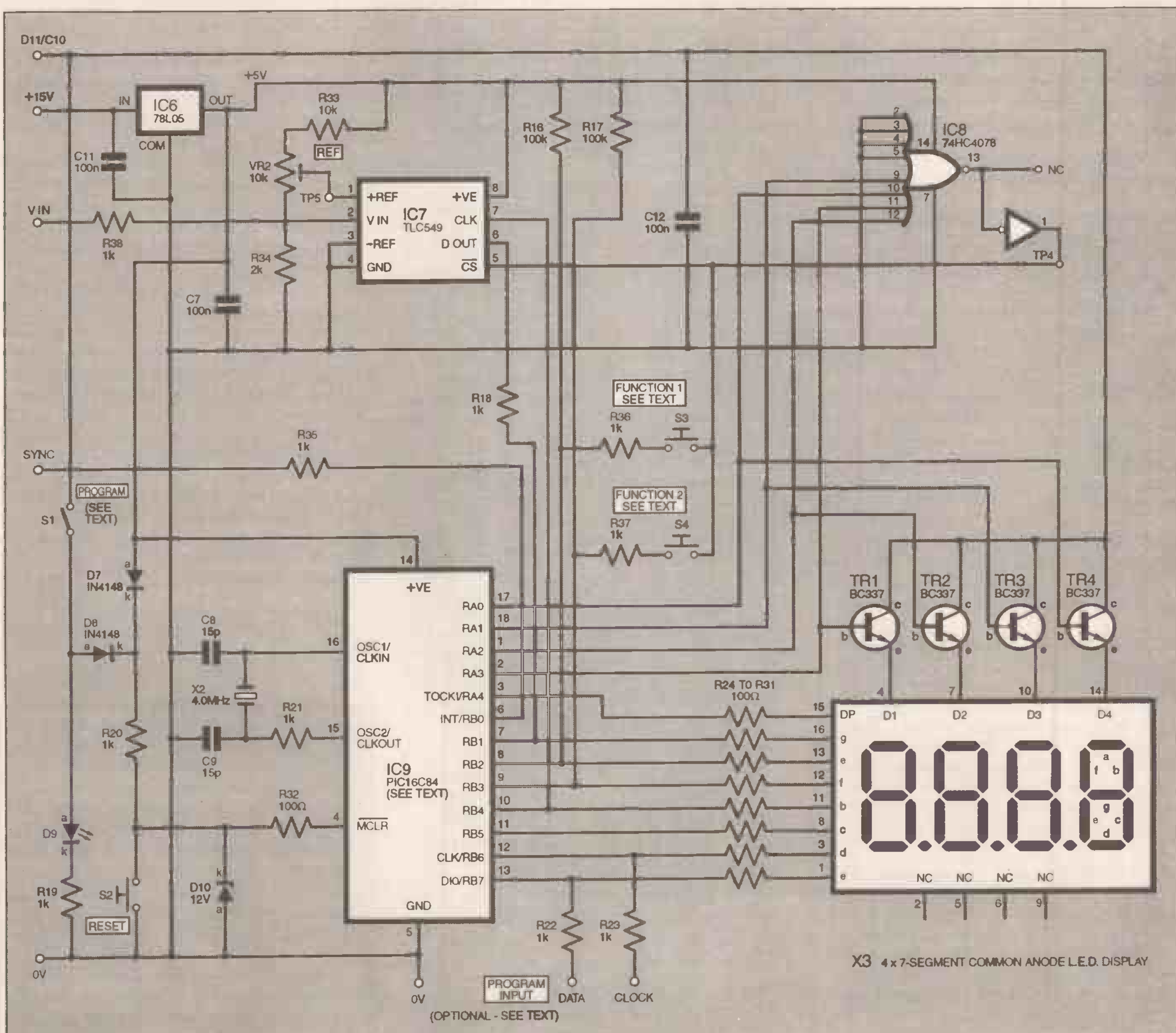
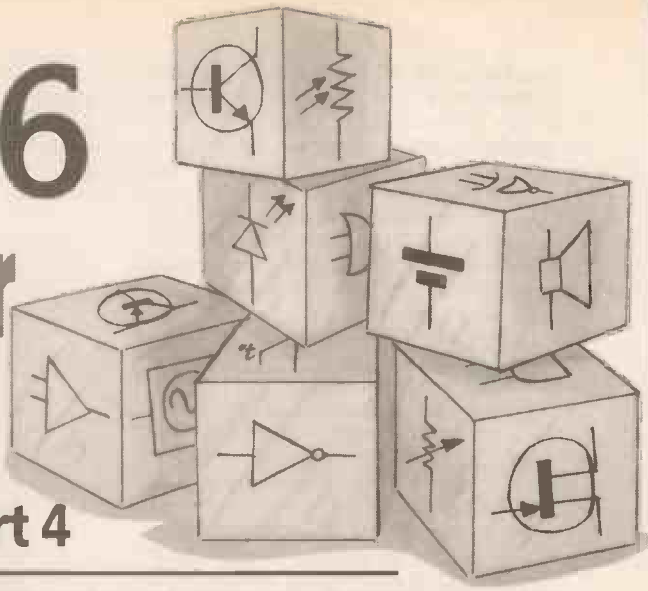


Fig. 6. PIC-Electric Controller and Display circuit.

TEACH-IN '96



A Guide to Modular Circuit Design

Max Horsey

Part 4

DURING this series of articles, a range of circuit modules is examined, divided into Input, Processor and Output sections. Where possible a choice of module is offered within each section.

Each of the ten Parts of the Series is accompanied by a constructional article explaining how a complete project may be devised by employing the modules described, together with a p.c.b. design. Each project will be one of many possible ideas that could be implemented and it is hoped that readers will design for themselves a variety of circuits by combining modules provided in the whole series.

The proposed range of modules covered by the Series is detailed in Part 1, Table 1.1. Each module is chosen to link easily with adjacent modules in the same Part, but modules may also be linked with modules in other Parts of the Series.

Max Horsey is Head of Electronics at Radley College.

HERE in this fourth Part of *Teach-In*, the following Input, Processor and Output modules are examined:

INPUT MODULES: Astables, based on:

- a. logic gates – simple arrangement
- b. voltage controlled variable frequency version
- c. logic gates – improved square wave oscillator
- d. 741 relaxation oscillator
- e. 555 timer

PROCESSOR MODULES: Decade chaser and counter

OUTPUT MODULE: L.E.D., discussing series resistance

The accompanying example project described separately is based around a selection of these modules and is a Vari-Speed Dice indicator. It contains two sets of six l.e.d.s which "chase" when a switch is pressed. When the switch is released the chase speed slows down and finally stops, resulting in a pair of random numbers being highlighted. The effect can be likened to the action of a roulette wheel.

ASTABLE MODULES

Astable circuits based around digital gates generate a continuous stream of "clock pulses", usually square waves. The term *clock pulse* implies a clean change between two voltage levels, often between 0V and close to the positive power rail voltage, generally referred to as *logic 0* and *logic 1*, respectively.

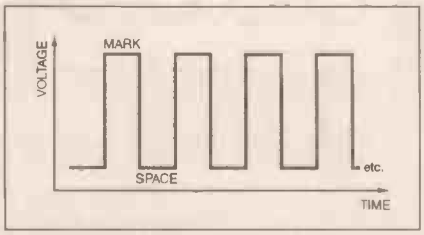


Fig. 4.1. Pulse train with even mark/space ratio.

Some oscilloscopes may have difficulty displaying the vertical aspects of *good quality* pulses (i.e. which rapidly change their logic states), such as those forming the pulse train illustrated in Fig. 4.1, and only the horizontal parts may be seen clearly.

If the time for which the pulse voltage is high equals the time for which it is low, it is said that the pulse *mark/space* ratio is equal, a condition which defines a square wave. If the *mark* (logic 1 level) time is added to the *space* (logic 0 level) time, the total is known as the *period* of the waveform. From this quantity, the frequency of the waveform (i.e. number of waves per second) can be calculated using the formula:

Frequency = 1 / Period

where the frequency is measured in Hertz (Hz), and the period is measured in seconds (s).

Counter circuits increment (add one to) their count value at the instant when the voltage on their clock input changes in a given direction, either positive-going (upwards) or negative-going (downwards). Although most counter circuits require a clock pulse having a clean transition between the two voltage levels, the pulse's mark/space ratio need not be equal.

SIMPLE ASTABLE

If the inputs of a NOR gate or a NAND gate are connected together, the NOR or NAND behaves like a NOT gate or inverter. Since all the following logic-based astable circuits require NOT gates, it follows that NOT gates, NOR gates or NAND gates may be used, and the choice may depend upon the requirements of other parts of the project.

The circuit diagram in Fig. 4.2 shows how a pair of NOR gates can be used to produce a simple astable which generates reasonably good square wave pulses. The frequency is variable by means of potentiometer VR1.

The output frequency signal is normally taken from point Y, as shown, but an inverted output is available from point X if required. Output X is positive when Output Y is at 0V, and vice-versa.

Frequency is determined by the values of capacitor C1, resistor R1 and the resistance set by potentiometer VR1. If the total resistance set by R1 plus VR1 is doubled, or if the value of C1 is doubled, the frequency will be halved.

Select a maximum value for VR1 which provides a frequency slightly lower than that likely to be needed. Resistor R1 should be about one kilohm (1k), and is used to prevent the total resistance approaching zero when VR1 is set for minimum resistance.

Example component values and output frequencies are as follows:

C1	R1 + VR1	Frequency
10nF	56kΩ	1kHz
10nF	560kΩ	100Hz
100nF	560kΩ	10Hz
100nF	56kΩ	100Hz
100nF	5k6Ω	1kHz

Note: 10nF (nanofarads) = 0·01μF (microfarads) and 100nF = 0·1μF.

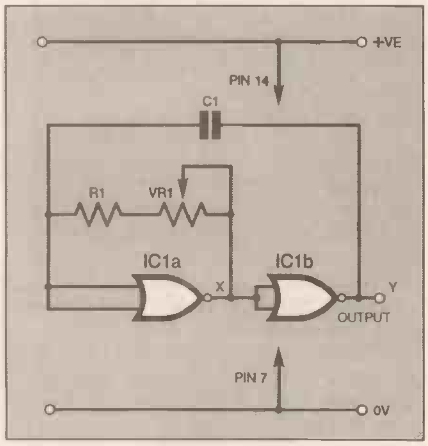


Fig. 4.2. Astable based on two NOR gates.

Be aware that the results shown are approximate and that this type of circuit should only be used if the exact frequency is unimportant.

In practice, select a total resistance (R1 + VR1) of between 4k7 and 1M ohms, and a capacitor in the range 56pF to 100µF. Electrolytic capacitors should have their positive ends connected to the output of IC1b. If capacitor values larger than 100µF (for lower frequencies) are required, use the "improved square wave oscillator" module described later.

If a fixed frequency is required, potentiometer VR1 may be omitted, connecting R1 between the input and output of IC1a.

STARTING AND STOPPING

It is often useful to be able to start and stop an astable circuit without switching off the power supply. The circuits in Fig. 4.3 show how the connections to one gate (IC1a) may be modified so that the gate is forced into one state ensuring that the circuit cannot oscillate.

The gate must be either a NOR or a NAND. Note that the logic levels at the control input and the output when "jammed" in Fig. 4.3a are opposite to those in Fig. 4.3b.

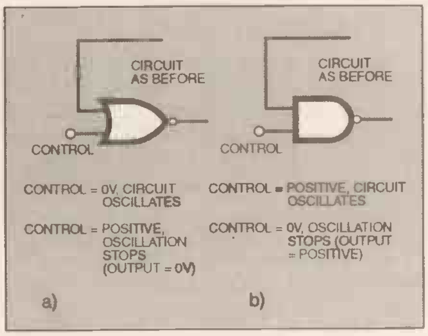


Fig. 4.3. Gated control for astable.

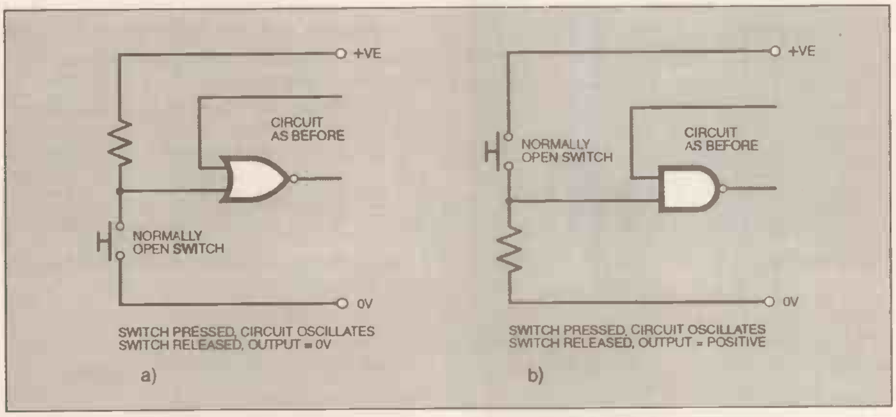


Fig. 4.4. Switched implemention for the circuit in Fig. 4.3.

As explained in Part 1, inputs to CMOS logic gates must *not* be left "open circuit". Consequently, the control input must be connected to a definite logic level, such as the output from another gate in the main circuit. Alternatively, switches may be used to control the logic level of the control input, as shown in Fig. 4.4.

The value of the biasing resistor is not critical and should be somewhere between 10k and 1M ohms.

Either of the two gates in the astable circuit of Fig. 4.2 may be controlled in this way. The choice of which is used will depend on the needs on the following circuit, and on the signal availability from the preceding circuit.

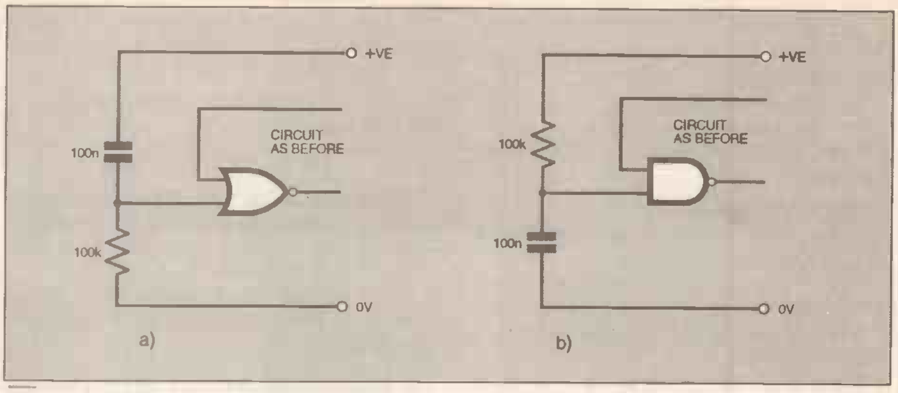


Fig. 4.5. Using a resistor and capacitor to "kick-start" an astable.

Note that the word *output* in Fig. 4.3 and Fig. 4.4 refers to the output of the gate under control, which may or may not be the final output of the astable. For example, if the gate under control is IC1a in Fig. 4.2, the output at IC1b will have the opposite logic level to that shown in Fig. 4.3 and Fig. 4.4.

KICK-STARTING

The circuit shown in Fig. 4.3 may not reliably start to oscillate when power is first switched on and may "jam" into one particular and unpredictable state. Adding one of the switched controls shown in Fig. 4.4 will solve the problem, although manual control is not always convenient.

A useful alternative is to add a resistor and capacitor to "kick-start" the circuit whenever power is applied, as shown in Fig. 4.5.

Referring to the NOR gate circuit in Fig. 4.5a, when power is first applied, the rising voltage at the top end of the capacitor (as seen in the diagram) causes a similar rise on the lower side, (see A.C. Coupling In Part 2). After a very short time, the voltage on the lower side will collapse as the charge leaks to 0V through the resistor. The action is similar to pressing the switch in Fig. 4.4, and the circuit jerks into action.

A similar, though opposite, effect applies to the NAND gate circuit. When first switched on, the voltage on the top side of the capacitor is zero. After a very short time enough current will have passed through the resistor to positively charge the capacitor to a logic 1 level. This is also like pressing the switch in Fig. 4.4.

A practical circuit, based on NOR gates and using the kick start method from Fig. 4.5, is shown In Fig. 4.6.

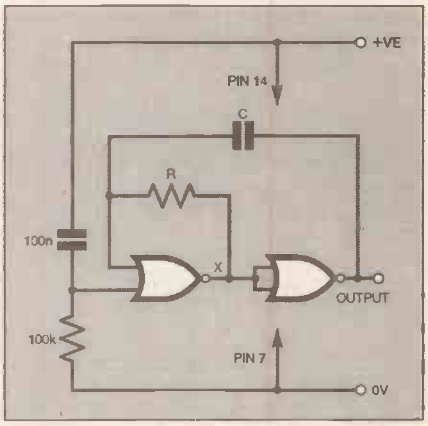


Fig. 4.6. A practical "kick-started" astable.

VOLTAGE CONTROL

It is sometimes useful to control frequency by a varying a voltage, rather than by mechanically setting a variable resistor. The circuit of Fig. 4.2 may be modified to allow simple voltage control as shown in Fig. 4.7.

If the voltage control input is connected to 0V, the circuit will oscillate at its maximum frequency – as determined by the values of the resistors and capacitors. If the voltage control input is raised above 0V the frequency will be reduced, reaching its minimum when the voltage control is at half the supply voltage. If the control voltage is raised further, the frequency will increase again.

This circuit may be also be started and stopped using the control shown in Fig. 4.4 and Fig. 4.5, or kick-started when first switched on by the arrangement shown in Fig. 4.6.

These simple astable circuits sometimes produce "glitches" (unclean switching pulses) which can cause problems in counting circuits.

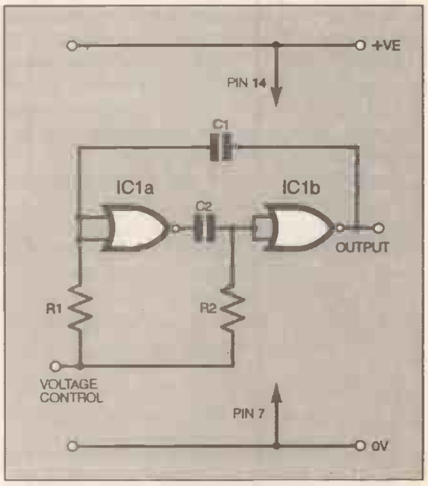


Fig. 4.7. Voltage controlled oscillator.

To sum up the astable circuits in Fig. 4.3 to Fig. 4.7:

ADVANTAGES:
Wide frequency range
Very low current consumption
Easy to interface (connect) to other modules

DISADVANTAGES:
Frequency is approximate, and tends to vary with the supply voltage
Output is quite a good square wave, but not perfect
Glitches may be produced, which could cause problems
Unreliable starting at power-up without additional controls

If a better square wave output without glitches is required, a third gate may be used as shown in Fig. 4.8.

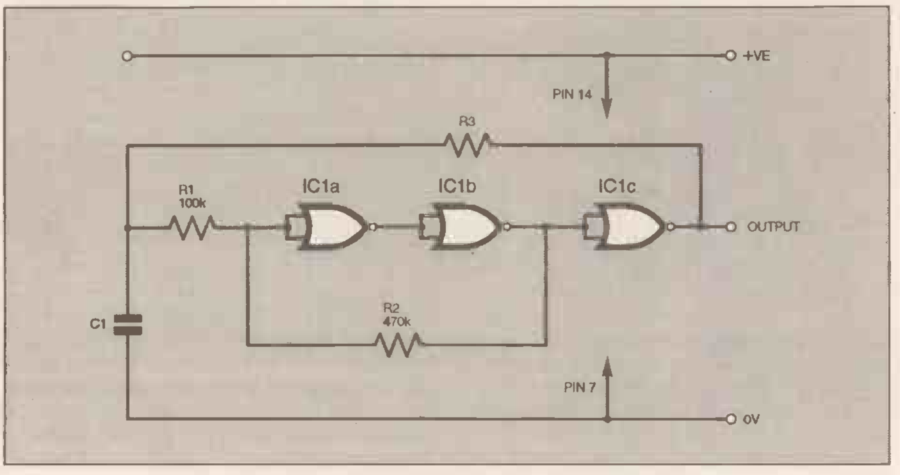


Fig. 4.8. A more reliable square wave oscillator.

IMPROVED SQUARE WAVE OSCILLATOR

An improved square wave oscillator circuit is shown in Fig. 4.8. As can be seen, a third NOR gate is required but the circuit always self-starts at power on, and produces a glitch-free output. Two considerable advantages!

The gates may be NORs as shown, or NANDs or NOTs. Any of the three gates (unless they are NOT gates) may be given the treatment shown in Fig. 4.3 and Fig. 4.4 to enable start/stop control.

The first two gates, IC1a and IC1b, together with resistors R1 and R2, make a non-inverting Schmitt trigger circuit (see Part 1). The third gate, IC1c, inverts the output voltage from IC1b feeding it back to capacitor C1 via R3.

Resistor R3 and capacitor C1 control the frequency of the module. For example, if R3 has a value of 10k and the capacitor a value of 10nF, then the frequency will be about 1.25kHz. If R3 and/or C1 are reduced in value, the frequency will increase proportionally.

Variable control of the frequency may be achieved by inserting a potentiometer, wired as a variable resistor, in series with R3. Note that the ratio of R1 to R2 will also have a small effect on the frequency.

In general terms, and assuming that the values of R1 and R2 are as shown in Fig. 4.8, the frequency will be given by:

$$f = 1 / (8 \times R \times C)$$

where, f = frequency, R = R3, C = C1

Remember that as in all such formulae, R should be measured in ohms, C in farads and f in hertz, although, as discussed in Part 3, it may be more convenient to measure R in megohms, and C in microfarads. For example:

if R = 330kΩ (= 0·33MΩ) and C = 0·1μF, then

$$f = 1 / (8 \times 0{\cdot}33 \times 0{\cdot}1) = 3{\cdot}8\text{Hz}$$

Note that in this, as in the previous modules, no resistor should have a value of less than 4·7kΩ or too much current will flow via a CMOS 4000 series output.

This type of circuit, with a Schmitt trigger at its heart, is known as a relaxation oscillator.

The circuit of Fig. 4.8 could be simplified by using a single 2-input Schmitt NAND gate, as shown in Fig. 4.9. The CMOS 4093 chip houses four 2-input Schmitt NAND gates, and the CMOS 40106 houses six Schmitt NOT gates (inverters).

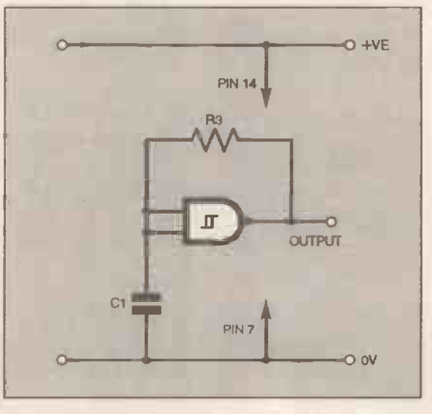


Fig. 4.9. Schmitt trigger oscillator.

To sum up the improved square wave oscillator circuits of Fig. 4.8 and Fig. 4.9:

ADVANTAGES:
All the advantages of the previous circuits (Fig. 4.2, Fig. 4.7)
Output is free of glitches
Single Schmitt gate can be used for Fig. 4.9

DISADVANTAGES:
An extra gate is required for Fig. 4.8
Frequency is slightly dependent on the supply voltage

OP.AMP OSCILLATOR

Like the last two modules, Fig. 4.8 and Fig. 4.9, the op.amp relaxation oscillator circuit shown in Fig. 4.10 is always self-starting at power on and provides an output free of glitches.

The frequency of the output depends upon the values of resistor R1 and

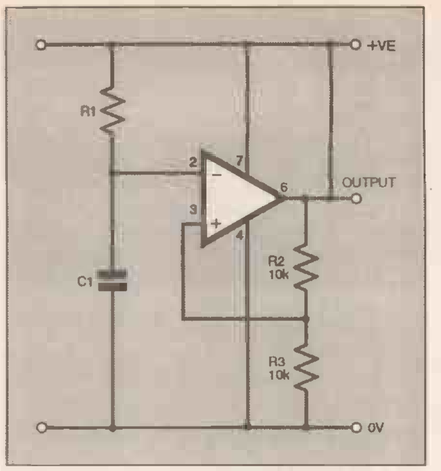


Fig. 4.10. Op.amp relaxation oscillator.

capacitor C1, and is given by the formula:

$$f = 1 / (2{\cdot}2 \times R1 \times C1)$$

where f is measured in hertz, R1 in ohms and C1 in farads.

As before, a more manageable combination of units is: R in MΩ, C in μF; f will still be in hertz. As an example:

if R1 = 470kΩ (= 0·47MΩ) and
C1 = 0·22μF, then

$$f = 1 / (2{\cdot}2 \times 0{\cdot}47 \times 0{\cdot}22) = 4{\cdot}4\text{Hz}$$

The formula may be changed round if a particular frequency is required. For example, suppose a frequency of 2kHz (i.e. 2000Hz) is needed. Since the range of values of capacitors is limited, choose a capacitor value and then calculate the required resistor.

Selecting a capacitor with a value of 100pF (= 0·0001μF) and changing the formula round:

$$R = 1 / (2{\cdot}2 \times f \times C)$$

therefore, $R = 1 / (2{\cdot}2 \times 2000 \times 0{\cdot}0001) = 2{\cdot}27\text{k}\Omega$

In practice, select a 2·2kΩ (2k2) resistor, or use a 4·7kΩ (4k7) preset and adjust it for the correct frequency.

For many simple applications below about 20kHz, a type 741 op.amp may be used in the above circuit. For higher frequencies, other op.amps, such as the 748 or TL071, will provide good results. Low current CMOS versions of op.amps may also be substituted.

To sum up the op.amp relaxation oscillator in Fig. 4.10:

ADVANTAGES:
Uses a simple op.amp
Produces a stable, glitch-free output

DISADVANTAGE:
Output may not swing fully between power line levels
Uses more current than a logic gate i.c.

555 ASTABLE

The timer i.c. type 555 is specifically designed for monostable and astable circuits. When used as an astable, as shown in Fig. 4.11, it is another example of a relaxation oscillator.

Referring to the graph in Fig. 4.11, where T1 is the "mark" time in seconds, T2 is the "space" time and "Total T" is the whole period, then:

$$T1 = 0{\cdot}7\,(R1 + R2) \times C$$
$$T2 = 0{\cdot}7 \times R2 \times C$$

and $\text{Total } T = 0{\cdot}7 \times (R1 + 2R2) \times C$

thus, $f = 1 / (0{\cdot}7 \times (R1 + 2R2) \times C)$

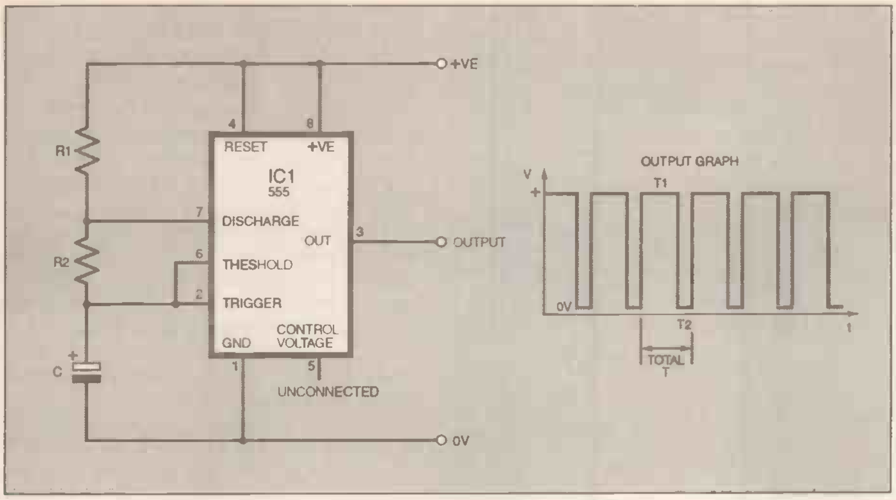


Fig. 4.11. A 555 astable and example output graph.

however, if R2 is much larger than R1 (e.g. R2 = 100kΩ, R1 = 4·7kΩ)

then, f = 1 / (1·4 × R2 × C)

For example, suppose a value of 680kΩ is selected for R2, but R1 remains at 4·7kΩ. This would be a sensible choice since it results in the output having a nearly equal mark/space ratio, and the simple formula which ignores R1 can be used.

Using a capacitor of, say, 10nF and changing the units: 680kΩ = 0·68M and 10nF = 0·01µF

then, f = 1 / (1·4 × 0·68 × 0·01) = 105Hz

Note that in Fig. 4.11 an electrolytic capacitor is shown, which is more suited to low frequencies. For higher frequencies, a non-polarised capacitor would normally be used.

The formulae above can be used to calculate:

Time period (T1) for which the output is positive
Time period (T2) for which the output is at 0V
Total time period (T1 + T2)
Frequency for all values of R1 and R2
Frequency formula simplified, if R2 is much larger than R1

Remember that if R2 is much larger than R1, the output wave has a nearly equal mark/space ratio (i.e. T1 = T2).

Some further example values and results are as follows (the answers are approximate):

R1	R2	C	f
4·7kΩ	100kΩ	0·001µF (1nF)	7kHz
4·7kΩ	100kΩ	0·01µF (10nF)	700Hz
4·7kΩ	1MΩ	0·01µF (10nF)	70Hz
4·7kΩ	1MΩ	0·1µF (100nF)	7Hz

If a variable frequency is required, replace R2 with a potentiometer wired as a variable resistor.

To sum up the 555 astable circuit of Fig. 4.11:

ADVANTAGES:

Easy to handle and use (standard version is not static sensitive)
Provides a stable frequency
Output can supply at least 100mA, and can drive small loudspeakers directly

DISADVANTAGES:

Standard version consumes more current than CMOS logic gates
Standard version can cause interference to other chips, e.g. counters
CMOS version is static sensitive

DECADE COUNTER AND CHASER

The Processor/Output module shown in Fig. 4.12 is based on the CMOS decade counter i.c. type 4017. Whenever its "clock Input" (pin 14) is switched from 0V to positive, the i.c. counts up by one.

When the counter is in its reset condition, output Q0 (pin 3) is positive (high) and all the other outputs (Q1 to Q9) are at 0V. At each count, the currently high output pin returns to 0V and the next output pin in sequence switches high, in numerical Q order. When Q9 is high, the next clock pulse sets it low, and Q0 again goes high.

Note that the clock input must not be left "floating". It must either be connected to the output of another circuit, or be connected to 0V via a resistor of, say, 100k. Output pin 12, the CO (carryout) pin, is not used in this circuit and must not be connected to either power line.

In Fig. 4.12, outputs Q0 to Q9 are connected to l.e.d.s. Since only one l.e.d. is ever on at any time, a single series resistor is used to control their current.

Using the standard 4017, the l.e.d.s will not be very bright (although low current, high brilliance types could be used), since the outputs are not really designed for driving them, being capable of delivering very little current (see Part 1).

Alternatively, the 74HC4017 version could perhaps be substituted, which can deliver about 25mA per output pin. The l.e.d.s will be brighter, but this version of the counter *must* be used on a lower supply voltage. A *maximum* of 6V is permitted, although in practice it is safer to use a 4·5V battery, or a 5V regulated supply.

In reality, more current can probably be drawn from the pins of the standard 4017 than nominally allowed, although the output voltage level will fall accordingly. The subject of l.e.d. series resistors is discussed later, but assume now that a value of 220Ω for the resistor in Fig. 4.12 will probably be satisfactory when the circuit is powered at 12V.

Although the counter outputs are shown driving l.e.d.s, they may be used to drive other devices, such as transistors, if a larger output current is required. (See the section on *npn* drivers and Darlington drivers in Part 1.)

COUNTER RESETTING

Although the counter automatically resets back to zero on the tenth pulse, it is often desirable for it to be reset at an earlier point in the cycle. This may be achieved by using the counter's reset (RST) input pin 15. When pin 15 is connected to 0V the i.c. does not reset until each tenth pulse is received, but if pin 15 is made positive at any time, the counter will reset immediately (i.e. output Q0, pin 3, will switch high again).

There are several ways in which the counter can be reset. A manual reset control can be provided by a pushswitch, as shown in Fig. 4.13a. Normally, pin 15 is held at 0V via the resistor but when the pushswitch is pressed, pin 15 goes high, so resetting the counter.

In another situation, it may be required that the counter should be reset on a count

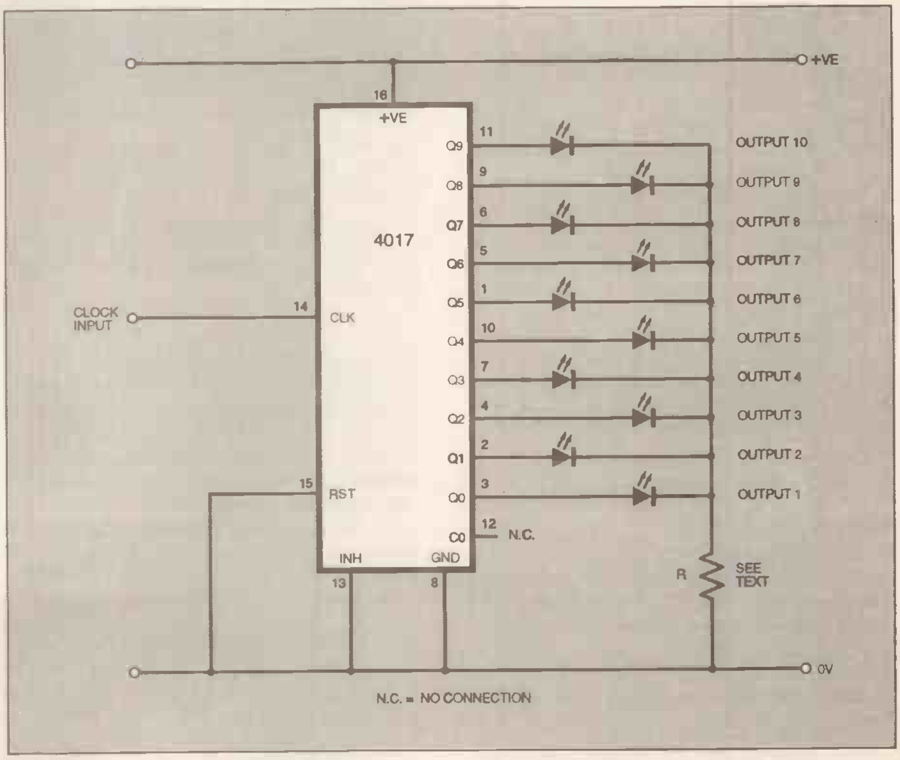


Fig. 4.12. Decade counter and chaser circuit.

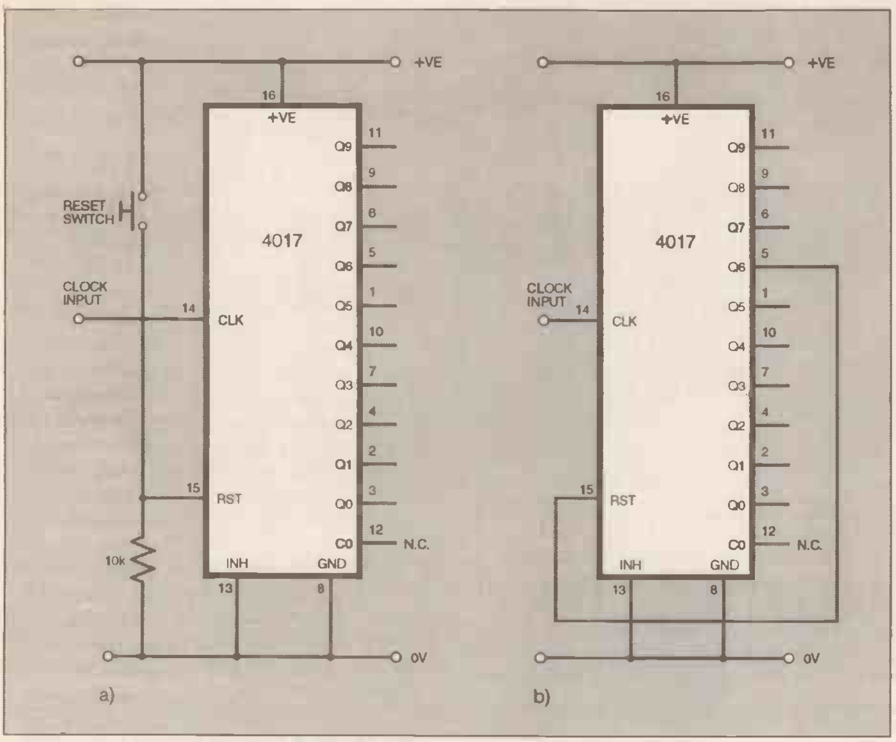


Fig. 4.13. Two methods by which the 4017 can be reset.

of six (for use as a dice indicator, for example). How this is done is shown in Fig. 13b.

The reset pin 15 is connected to the seventh output (Q6), which is normally at 0V. Starting from output Q0, the count proceeds upwards to output Q5, each output remaining high until the next clock pulse is received.

On the sixth clock pulse, though, output Q6 goes high, automatically resetting the counter back to zero via pin 15, and setting output Q0 high again. Consequently, output Q6 is only momentarily held high, a pulse period which is so short that it would be difficult to see it even on an oscilloscope.

CASCADING AND INHIBIT

A "carryout" function is provided via pin 12 (CO). It may be used to drive the clock input of a second counter if it is necessary to count up beyond nine. The use of this principle is illustrated in the *Vari-Speed Dice* project (see other pages).

An "inhibit" function is also provided on this type of counter, via pin 13 (INH). If this pin is taken high, the counter will cease to respond to clock pulses on its input pin 14, with the last-triggered output remaining high.

As soon as pin 13 is returned to 0V, the counter again responds to clock pulses as normal, continuing from the last output triggered. The inhibit function can be controlled by a switch in same way as shown in Fig. 4.13a.

L.E.D. SERIES RESISTORS

So far in this series, values for various l.e.d. series resistors have been suggested. These values were first calculated, and then the result was sometimes modified according to experience with a particular circuit.

For example, the 220Ω value for the resistor in Fig. 4.12 is actually much lower than calculation would suggest, due to the output resistance within the i.c. Even so, the method by which values are calculated is fairly straightforward and provides a good starting point in selecting a resistor value. First, though, consider why a series resistor is actually needed.

When a *bulb* is connected to a power supply, as in Fig. 4.14a (in this case a 12V bulb and a 12V battery), the circuit will function satisfactorily. However, if an *l.e.d.* is substituted for the lamp, as in Fig. 4.14b, the l.e.d. will glow briefly and then die. Before it dies, though, it passes so much current that a small battery could quickly run down.

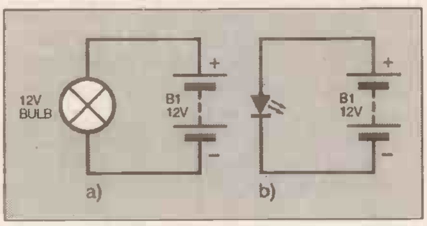


Fig. 4.14. The bulb circuit (a) will work happily but the l.e.d. in the other circuit (b) will die rapidly.

The reason is that a bulb has resistance and will pass an amount of current according to Ohm's Law:

$$I = V / R$$

The formula shows that the amount of current (I) depends up on the resistance (R) of the bulb and the voltage (V) across it. Once the bulb filament has reached its working temperature, its resistance is fairly constant and the current flowing depends only upon the voltage.

An l.e.d. is quite different. It is a diode which, in the direction that current can flow through it, has little appreciable resistance.

As stated in Ohm's Law, when resistance (R) is very small, the current (I) flow through it is very large. Consequently, the 12V battery in Fig. 4.14b causes a great deal of current to flow through the l.e.d., although the current will also be slightly limited by the additional resistance of the wires linking the l.e.d. to the battery, plus the internal resistance of the battery itself.

FORWARD VOLTAGE

There is a complication which arises regarding the calculation of current flow through an l.e.d. Although l.e.d.s can be said to have no appreciable resistance to current flow, a voltage difference, known as the *forward voltage drop*, exists across the l.e.d. when current flows through it.

The forward voltage drop varies slightly with different types of l.e.d., but is typically about 2V. In one sense, then, an l.e.d. *does have* significant resistance, but only to the first 2V or so of its supply voltage. It is therefore difficult to make a simple statement about its resistance and to apply this conventionally to Ohm's Law.

However, if an l.e.d. has a forward voltage drop of 2V, then the 12V battery in Fig. 4.14b can be likened to a 10V battery connected to a short-circuit. Both components will be very unhappy!

A good catalogue will state the forward voltage drop (V_f) of the l.e.d. being selected. Typically, the V_f for standard red l.e.d.s ranges from about 1·8V to 2V; other colours may range from 2V to 2·2V. However, if a forward voltage of 2V is assumed, calculation results will be accurate enough.

RESISTOR CALCULATION

Since an l.e.d. does not have resistance in the normal sense, a resistor has to be connected in series between it and the power supply to limit the current flow to a safe level, as shown in Fig. 4.15.

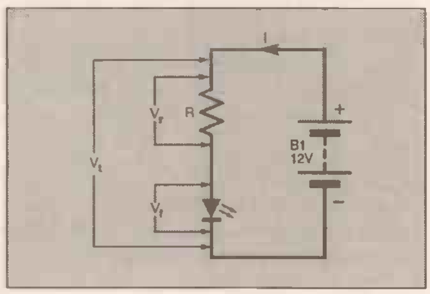


Fig. 4.15. Using a current-limiting resistor in series with an l.e.d.

To calculate the value of the resistor (R) the following information is required:

Total voltage applied (V_t)
Forward voltage drop (V_f) across the l.e.d.
Current required through the l.e.d. (I)

In the example shown in Fig. 4.15, V_t is 12V and V_f is 2V. A catalogue will state the maximum current which can be permitted to flow through an l.e.d. Standard types require around 10mA to 20mA, although low current types are available which typically require 2mA, but these are more expensive. Currents less than the maximum can be used, although the brilliance of the l.e.d. will diminish accordingly. For this example, a current of about 15mA is desired.

Because the resistor in Fig. 4.15 is in series with the l.e.d., the current flow through the l.e.d. will be equal to the current flow through the resistor, in this case, about 15mA.

The forward voltage drop across the l.e.d. (V_f) is taken as 2V, and the voltage across the resistor (V_r) is the total voltage (V_t) less V_f.

thus, $V_r = V_t - V_f$

therefore, $V_r = 12 - 2 = 10V$

So, in the example, the voltage across the resistor is 10V. If the voltage across a resistor and the current flowing through it are known, the required resistance value can be calculated using Ohm's Law:

$R = V / I$

Note that V must be in volts, I in amps, and R in ohms. The current of 15mA should be re-written as 0·015A, therefore:

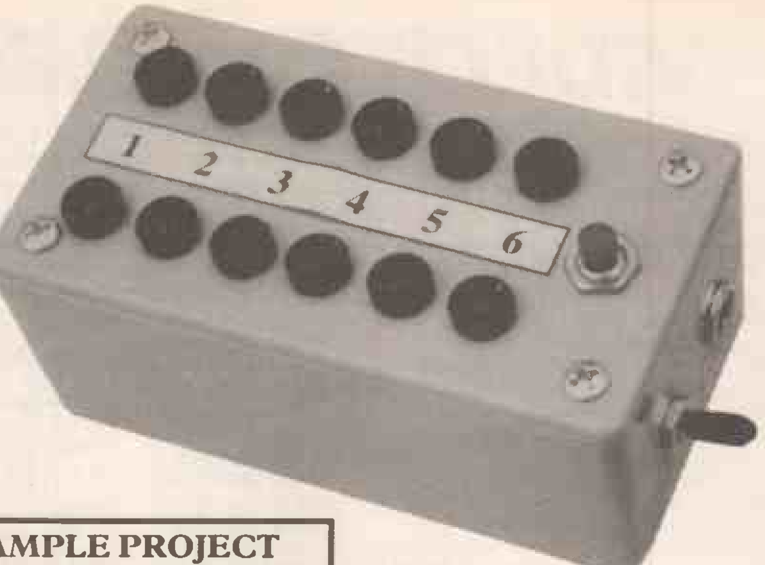
$R = 10 / 0{\cdot}015 = 667\Omega$

The standard resistor value nearest to 667Ω is 680Ω. This represents a good choice since the l.e.d. will be quite bright on a total voltage of 12V. Remember, though, that increased brilliance requires more current and results in a shorter battery life.

NON-STANDARD L.E.D.S

The calculations above apply to ordinary cheap l.e.d.s. It is possible to buy l.e.d.s which have a built-in resistor (although they cost more), in which case either a 5V type or 12V type must be selected, as appropriate.

Flashing l.e.d.s have an integral i.c. and are designed for a particular voltage range. Providing the voltage is within that range, the i.c. regulates the current supplied to the l.e.d. without the need for a series resistor.



EXAMPLE PROJECT

The Vari-speed Dice is the example project (elsewhere in these pages) which shows how the modules in *Teach-In* Part 4 can be combined in a practical application.

PART FIVE

The modules to be examined in *Teach-In* Part 5 are an I.R. receiver, encoder/decoder, bistables and a pulsed Darlington output. The example project is an Infra-Zapper.

Ohm Sweet Ohm

Max Fidling

Snowbound

I'm often amazed how the United Kingdom grinds to a complete halt when the first seasonal snowflakes land on our island. An inch is enough to close motorways and cause all sorts of national catastrophes and disasters – all of which, though, pale into insignificance compared with the time the Fidling household experienced a sudden shortage of tinned cat food for you-know-who!

Having received my marching orders from the Boss, I'd ventured out on a treacherous snowy pavement to the nearby corner shop, to purchase some tinned grub for my mange-tout moggie. What I would do for one of those snow scooters I'd seen on the telly! (A funny place to keep a snow scooter, I know.)

The biting wind did nothing to cheer my soul on this wintry day, as I shuffled home carrying a plastic bag of clattering tins of cat food, plus a packet of chocolate biscuits with which I'd decided to treat myself.

Hence, today saw me stuck in the workshop, which had donned a wig of freshly fallen snow. Inside the 'shop, though, the electric fan heater was blasting out three kilowatts of glorious heat, with myself and Piddles (my pesky puss) toasting nicely.

I was slowly thawing out after my expedition while Piddles was scoffing merrily away, clattering his plastic bowl on the floor of the shack oblivious to the fact that I'd nearly succumbed to terminal frostbite purely for his benefit (or so it felt like).

Thermal Contact

Upon my return I had been duly honoured with a mug of tea which I slurped appreciatively, whilst pondering whether there was any similarity between the name of my companion and the flavour of the tea . . . Dunking a biscuit in my cuppa, (one of my uncouth habits, I'm afraid), half of the soggy bikky suddenly fell into the tea with a "ploop". I polished off the cheering brew with a gulp.

As you'd expect, the electric fan heater had not escaped the attention of my electronic meanderings. I'd recently completed an electronic thermostat project which I'd seen published in the magazine; my new temperature-sensitive gizmo sat there on the bench, with a thermistor probe stuck unceremoniously to the wall with Blu-Tak and the fan heater plugged into a mains socket mounted on top of the housing.

The heater whirred away, providing a handsome level of heat, and an l.e.d. on the panel glowed benignly as a confirmation that all was well with this negative tempco contraption . . . Or so I hoped!

The trouble with dinner time is that I have to make it back to the house, leaving the cushy comfort of the snug 'shop, rather an inconvenience but you can't have everything these days, I sighed. At least we had an intercom between the workshop and the kitchen, another project I'd made recently and installed using a part drum of surplus 15A three-core cable. You could probably route a city's entire telephone exchange down the cable but never mind!

The intercom performed magnificently as the Boss summoned me to chow time. I reckoned Piddles would be safe enough in the shack, and I left the heater blazing merrily away so that all would be cosy upon my return.

Taking the Biscuit

About an hour later, and feeling suitably full of scrummy Yorkshire Pudding with gravy, I sneeked out and slithered back to my bolt-hole in the back garden. The menacing moggie had sprung onto the bench and was peering out at me through the window, tail swishing, having spotted some birds pecking away at the bird nut feeder I'd nailed up outside.

Not wanting to see my feathered friends dashed to ribbons at the paws of my marauding moggie, I quickly nipped through the door which I bolted firmly shut behind me! A certain fragrance greeted my nostrils . . . a sort of biscuity, chocolatey kind of odour (I always thought I'd make a good wine buff) which I wanted to eat, it smelled so good!

Looking down at the floor, I could see the remains of several of my favourite chocolate biscuits which that dang-nabbing cat had snaffled! Piddles looked at me innocently, with his "Who, Me?" kind of expression: I glared back with my "Yes! You!" evil stare.

Worse still, the cocoa-flavour pong was traced to the pack of biscuits which he'd knocked over in front of the fan heater, where the blow-torch breath of the heater had melted the biscuits together into a chocolate digestive brick!

Undeterred, and not wanting to waste good food, I grabbed the freezer aerosol from the shelf above and I sprayed the outermost packet liberally. Whether it was entirely foodsafe I wasn't sure, but a deft application of a one-inch woodworking chisel separated the amalgamated sweetmeats inside into pieces which Piddles and I started to scoff between us, whilst peering out of the window wondering what we'll do next for entertainment.

VIDEOS ON ELECTRONICS

A range of videos designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. They have proved particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc.

VT201 to VT206 is a basic electronics course and is designed to be used as a complete series, if required.

VT201 54 minutes. Part One; **D.C. Circuits**. This video is an absolute must for the beginner. Series circuits, parallel circuits, Ohms law, how to use the digital multimeter and much more. **Order Code VT201**

VT202 62 minutes. Part Two; **A.C. Circuits**. This is your next step in understanding the basics of electronics. You will learn about how coils, transformers, capacitors, etc are used in common circuits. **Order Code VT202**

VT203 57 minutes. Part Three; **Semiconductors**. Gives you an exciting look into the world of semiconductors. With basic semiconductor theory. Plus 15 different semiconductor devices explained. **Order Code VT203**

VT204 56 minutes. Part Four; **Power Supplies**. Guides you step-by-step through different sections of a power supply. **Order Code VT204**

VT205 57 minutes. Part Five; **Amplifiers**. Shows you how amplifiers work as you have never seen them before. Class A, class B, class C, op.amps. etc. **Order Code VT205**

VT206 54 minutes. Part Six; **Oscillators**. Oscillators are found in both linear and digital circuits. Gives a good basic background in oscillator circuits. **Order Code VT206**

By the time you have completed VT206 you have completed the basic electronics course and should have a good understanding of the operation of basic circuit elements.

VCR MAINTENANCE

VT102 84 minutes: Introduction to VCR Repair. Warning, not for the beginner. Through the use of block diagrams this video will take you through the various circuits found in the NTSC VHS system. You will follow the signal from the input to the audio/video heads then from the heads back to the output. **Order Code VT102**

VT103 35 minutes: A step-by-step easy to follow procedure for professionally cleaning the tape path and replacing many of the belts in most VHS VCR's. The viewer will also become familiar with the various parts found in the tape path. **Order Code VT103**

Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier.

(All videos are to the UK PAL standard on VHS tapes)

Now for the digital series of six videos. This series is designed to provide a good grounding in digital and computer technology.

VT301 54 minutes. Digital One; **Gates** begins with the basics as you learn about seven of the most common gates which are used in almost every digital circuit, plus Binary notation. **Order Code VT301**

VT302 55 minutes. Digital Two; **Flip Flops** will further enhance your knowledge of digital basics. You will learn about Octal and Hexadecimal notation groups, flip-flops, counters, etc. **Order Code VT302**

VT303 54 minutes. Digital Three; **Registers and Displays** is your next step in obtaining a solid understanding of the basic circuits found in todays digital designs. Gets into multiplexers, registers, display devices, etc. **Order Code VT303**

VT304 59 minutes. Digital Four; **DAC and ADC** shows you how the computer is able to communicate with the real world. You will learn about digital-to-analogue and analogue-to-digital converter circuits. **Order Code VT304**

VT305 56 minutes. Digital Five; **Memory Devices** introduces you to the technology used in many of todays memory devices. You will learn all about ROM devices and then proceed into PROM, EPROM, EEPROM, SRAM, DRAM, and MBM devices. **Order Code VT305**

VT306 56 minutes. Digital Six; **The CPU** gives you a thorough understanding in the basics of the central processing unit and the input/output circuits used to make the system work. **Order Code VT306**

By now you should have a good understanding of computer technology and what makes computers work. This series is also invaluable to the computer technician to understand the basics and thus aid troubleshooting.

VT401 61 minutes. **A.M. Radio Theory**. The most complete video ever produced on a.m. radio. Begins with the basics of a.m. transmission and proceeds to the five major stages of a.m. reception. Learn how the signal is detected, converted and reproduced. Also covers the Motorola C-QUAM a.m. stereo system. **Order Code VT401**

VT402 58 minutes. **F.M. Radio Part 1**. F.M. basics including the functional blocks of a receiver. Plus r.f. amplifier, mixer oscillator, i.f. amplifier, limiter and f.m. decoder stages of a typical f.m. receiver. **Order Code VT402**

VT403 58 minutes. **F.M. Radio Part 2**. A continuation of f.m. technology from Part 1. Begins with the detector stage output, proceeds to the 19kHz amplifier, frequency doubler, stereo demultiplexer and audio amplifier stages. Also covers RDS digital data encoding and decoding. **Order Code VT403**

VT501 58 minutes. **Fibre Optics**. From the fundamentals of fibre optic technology through cable manufacture to connectors, transmitters and receivers. **Order Code VT501**

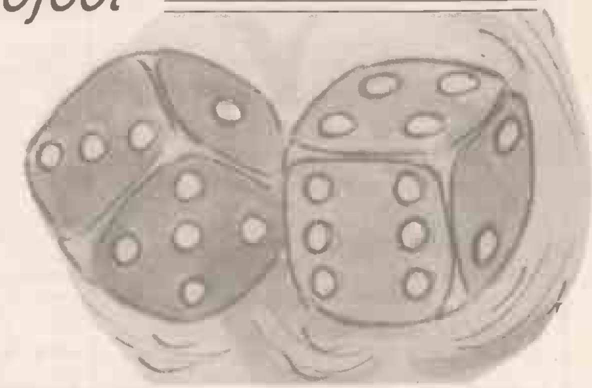
ORDERING: Add £1.50 p&p *per order* for UK orders. **OVERSEAS ORDERS:** Add £3 postage for countries in the EEC. Overseas orders outside the EEC countries add £3 *per tape* airmail postage (or £6 *per order* surface mail postage). All payments in £ sterling only (send cheque or money order drawn on a UK bank).

Visa and Mastercard orders accepted – please give card number, card expiry date and cardholder's address if different from the delivery address.

Orders are normally sent within seven days but please allow a maximum of 28 days – longer for overseas orders.

Send your order to: Direct Book Service, 33 Gravel Hill, Merley, Wimborne, Dorset BH21 1RW (Mail Order Only)

Direct Book Service is a division of
Wimborne Publishing Ltd.,
Tel: 01202 881749. Fax: 01202 841692



VARI-SPEED DICE

MAX HORSEY   PCB DESIGN BY ALEX SIMM

When the chips are down, let them shake, rattle and roll out your fate. Illustrates how Teach-In Part Four might be applied.

THIS project is based on the information provided in *Teach-In* Part 4 and shows how modules may be selected and combined to produce a working project.

The Vari-Speed Dice includes a simple l.e.d. display, formed around two rows of six l.e.d.s which "chase" before stopping at "random". A novel feature of the circuit is that instead of the display stopping abruptly it gently slows to a halt, rather like a roulette wheel, thereby adding to the excitement if a particular number is required.

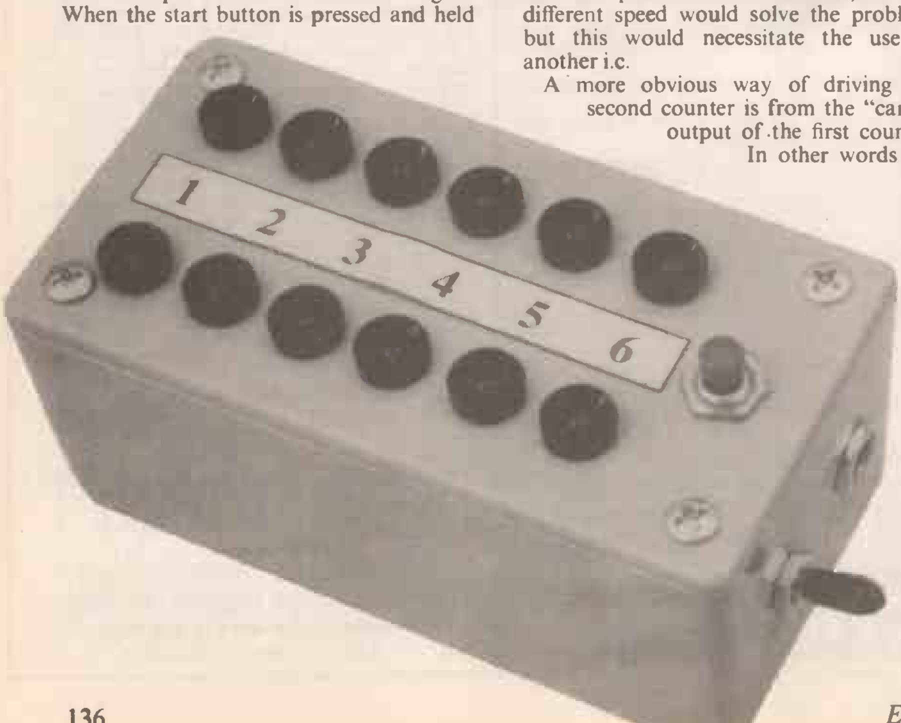
Making electronic circuits "random" is very difficult since any monostable or timer module will use a fixed time sequence. The project therefore relies upon a simple timer, plus the time for which the Start button is held down. The human factor adds the required degree of randomness!

BLOCK DIAGRAM

A block diagram of the modules required to make up the circuit is shown in Fig. 1. When the start button is pressed and held down, the timer causes the astable to start at full speed. The square wave from the astable drives the first counter/l.e.d. driver module, which causes six l.e.d.s to flash in sequence.

The same output from the astable could be used to drive the second counter, but this would make the l.e.d.s always stop at the same pairs. A second astable, set at a different speed would solve the problem, but this would necessitate the use of another i.c.

A more obvious way of driving the second counter is from the "carry" output of the first counter. In other words the second counter moves one step for every six steps of the first. The result is just as random as using two astable modules.



CHOOSING THE MODULES

The complete circuit diagram for the Vari-Speed Dice is shown in Fig. 2.

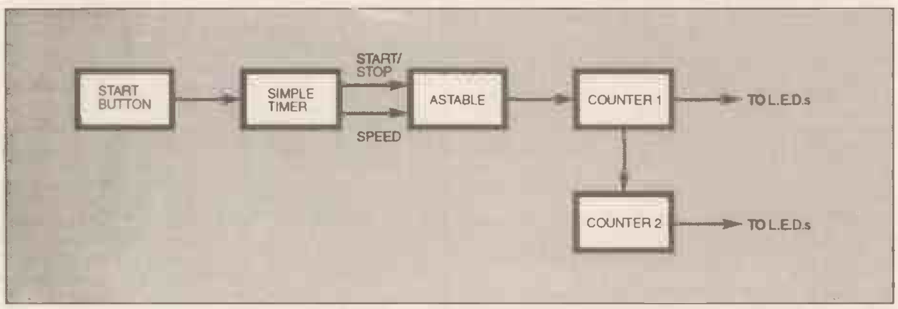


Fig. 1. Block diagram for the Vari-Speed Dice.

The Timer is based on the Simple Capacitive Delay module described in *Teach-In* Part 2 (Fig. 2.3). When the Start switch S1 is pressed, capacitor C1 is discharged. When S1 is released, C1 charges up slowly via resistor R1. The values of R1 and C1 determine the speed with which the voltage across C1 rises – higher values equals longer time.

A slowly changing voltage is often a nuisance in logic circuits, many of which require a sudden change from logic 0 to logic 1. However, in this design the slowly rising voltage is put to good use in controlling the speed of the astable.

VOLTAGE CONTROLLED ASTABLE

A number of astable modules are outlined in *Teach-In* Part 4. The one chosen for use here is the Voltage Controlled Frequency module of Fig. 4.7, which has its frequency (speed) varied by changing the voltage on the two input resistors, R2 and R3 in Fig. 2. This circuit does not provided a "glitch- free" output, but this is of no consequence since any glitches which cause the counter to move one step more than expected will add to the randomness.

In Fig. 2, the astable is formed around two NOR gates, IC1c and IC1d. Its basic frequency is determined by the values of resistors R2 and R3, and capacitors C2 and C3 (larger values = lower frequency). Their values have been chosen to set the oscillator speed to make it impossible to predict the outcome of the count. (If the value of C2 were to be increased to 100nF the speed would be just slow enough to allow a sharp contestant to fix the result by releasing the button at a particular moment.)

A method of switching an astable on and off by controlling the voltage at one of the pins was also discussed in Part 4 (Fig. 4.3). The technique is used here in the circuit of Fig. 2, IC1c pin 9 being the on/off input, which is controlled by the output from IC1b pin 4. When IC1c pin 9 is held high (made positive) the astable stops oscillating.

Referring to IC1a and IC1b, when the voltage at the junction of R1 and C1 is low, pins 1 and 2 will be low, consequently pins 3, 5 and 6 will be high and pin 4 low. In other words, output pin 4 merely copies the logic on input pins 1 and 2. Using a pair of gates in this way provides a cleaner voltage change at IC1c pin 9 than would be the case if the pin was connected directly to C1.

When switch S1 is pressed, the voltage at the positive side of capacitor C1 falls to zero and, as a result, IC1c pin 9 also goes low. Since the lower ends of resistors R2 and R3 are also connected to C1, and thus also at 0V, the astable oscillates at its maximum speed (as discussed in Part 4).

As C1 charges, the voltage at its junction with R2 and R3 rises, causing the astable to slow down. When the voltage across C1 reaches half the supply voltage, the astable is at its minimum speed. Then, as this voltage crosses the half way level, the logic at IC1b pin 4 changes from low to high, causing the astable to stop oscillating.

COUNTER/ CHASER

The l.e.d. counter/chaser circuits are based on those discussed in Part 4, Fig. 4.12 and Fig. 4.13, using a CMOS 4017B decade counter. Essentially, both counters are identical and are formed around IC2 and IC3. Each is connected so that it counts from one to six, then resets to one again at the next clock pulse.

Counter IC2 is "Clocked" on its input pin 14 by the output pulses from IC1d pin 11 of the astable. Pulses from the "Carry Out" pin 12 of IC2 provide the clock pulses for counter IC3.

On both IC2 and IC3, Reset pin 15 is connected to output pin 5, which is the seventh output (Q6). Consequently, each i.c. counts from the first output (Q0), through outputs Q1 to Q5, then resetting back to Q0 immediately the count reaches output Q6.

Each output is connected to an l.e.d. Since only one l.e.d. can be on at any one time, a single series resistor, R4 for IC2 and R5 for IC3, is used to control the current. The current available from each output

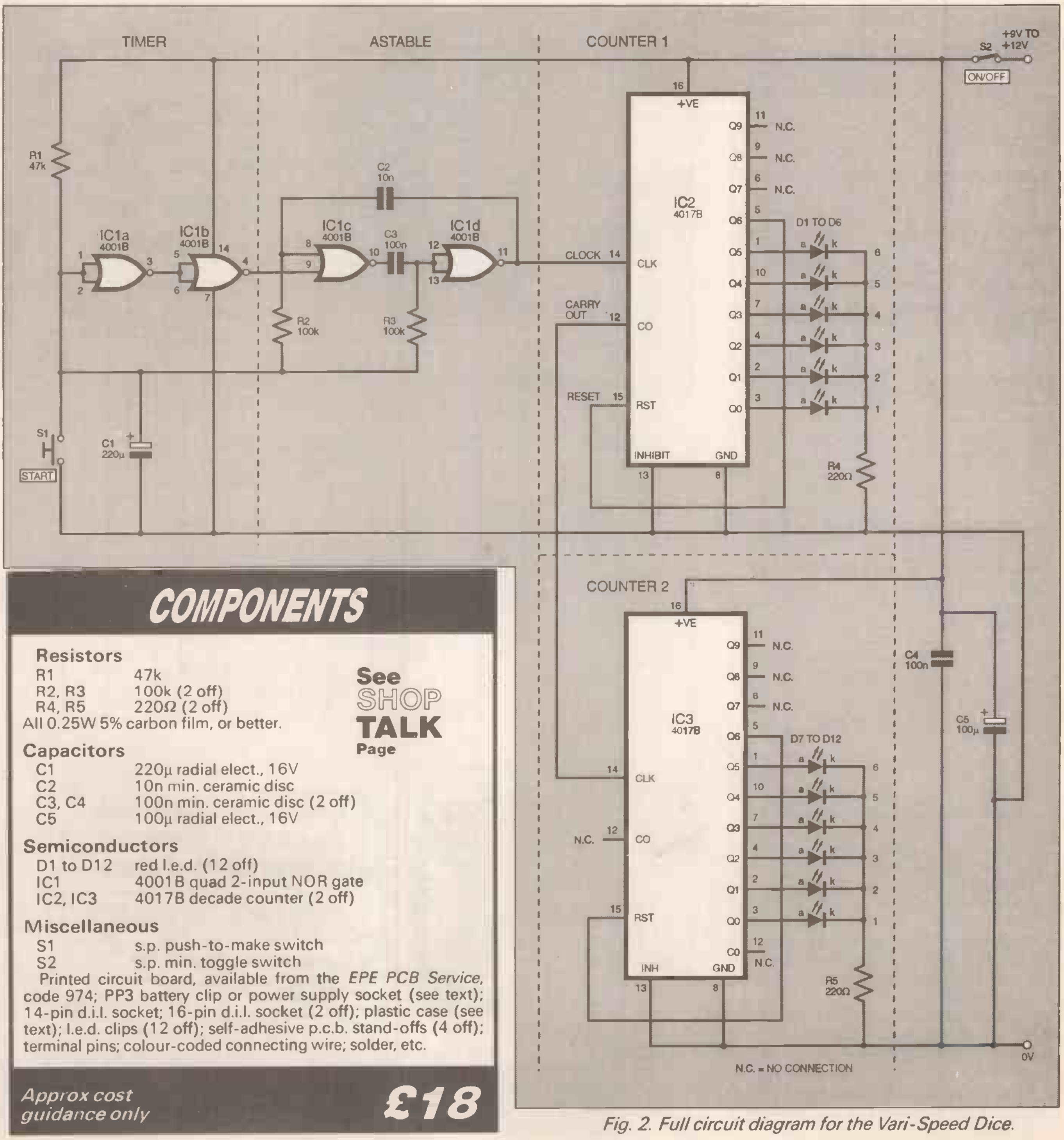


Fig. 2. Full circuit diagram for the Vari-Speed Dice.

COMPONENTS

Resistors
R1 47k
R2, R3 100k (2 off)
R4, R5 220Ω (2 off)
All 0.25W 5% carbon film, or better.

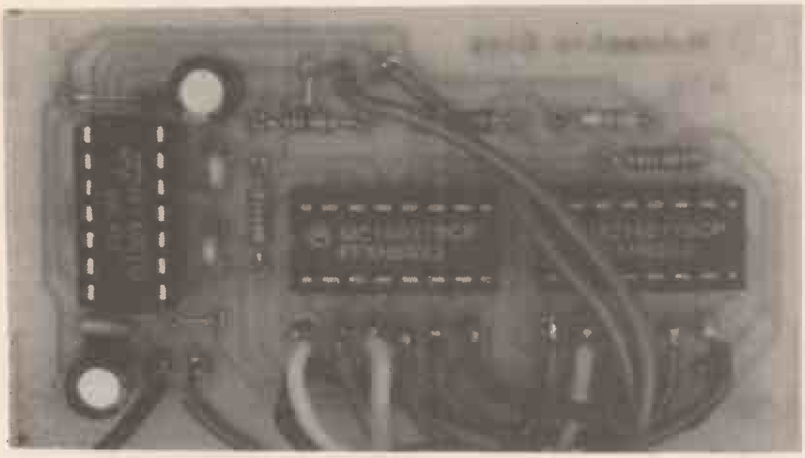
See SHOP TALK Page

Capacitors
C1 220µ radial elect., 16V
C2 10n min. ceramic disc
C3, C4 100n min. ceramic disc (2 off)
C5 100µ radial elect., 16V

Semiconductors
D1 to D12 red l.e.d. (12 off)
IC1 4001B quad 2-input NOR gate
IC2, IC3 4017B decade counter (2 off)

Miscellaneous
S1 s.p. push-to-make switch
S2 s.p. min. toggle switch
Printed circuit board, available from the *EPE PCB Service*, code 974; PP3 battery clip or power supply socket (see text); 14-pin d.i.l. socket; 16-pin d.i.l. socket (2 off); plastic case (see text); l.e.d. clips (12 off); self-adhesive p.c.b. stand-offs (4 off); terminal pins; colour-coded connecting wire; solder, etc.

Approx cost guidance only **£18**



Completed printed circuit board.

is rather small, and the i.c. is not really designed for driving l.e.d.s directly. However, with a supply of 9V or 12V (from, say, a mains adaptor) the l.e.d.s are more than adequately lit.

If extra brightness is required, special low-current l.e.d.s are available. Alternatively the CMOS 4017B could be replaced by the 74HC4017 which has a much higher output current, but *MUST NOT* be used on a supply of *MORE* than 6V. The subject of CMOS output currents and l.e.d. series resistors is referred to in Part 4.

Capacitors C4 and C5 provide the required power line decoupling, as discussed in Part 1. Switch S2 is a power supply On/Off switch, particularly important if a battery is used to power the circuit.

CONSTRUCTION

Details of the printed circuit board (p.c.b.) and its connections for the Vari-Speed Dice are shown in Fig. 3. This board is available from the *EPE PCB Service*, code 974.

Fit the two short wire links (not the connecting wires), followed by the i.c. sockets and resistors. Now fit the small ceramic disc capacitors. The labelling of these can sometimes be confusing. Note that if the legend "103" is printed on the capacitor body it means the capacitance value is 10nF (0·01μF) and that "104" means 100nF (0·1μF).

To some readers, this may seem quite illogical. However, "103" actually translates like a resistor colour code, namely, "one", "zero" plus "three" more zeros, i.e. 10,000, measured in picofarads (pF). Clarifying further:

$$1F = 10^6\mu F = 10^9 nF = 10^{12} pF$$

Capacitors C1 and C5 are electrolytic and must be fitted the correct way round. The negative end is normally printed on the body; the positive end is indicated by a longer lead.

Solder terminal pins into the p.c.b. for all the external connections.

The p.c.b. allows the l.e.d.s to be mounted directly to it, if preferred. However, in the prototype, the l.e.d.s were mounted on the case lid and linked to the p.c.b. with wires. It is *much* easier to mount the l.e.d.s in the case *before* connecting them to the circuit.

If this is the chosen method, note from Fig. 3 that the l.e.d. anodes (a) have separate wires connecting back to the board. The l.e.d. cathodes (k), however, are soldered to each other in two groups, each group is then connected to the board via a single wire.

HOUSING THE DICE

The prototype was used with a 12V battery eliminator (mains adaptor) and was housed in a plastic case measuring 104mm × 53mm × 44mm. Although the circuit can be powered by a 9V battery, note that a PP3 battery will not easily fit into this size of box.

As seen in the photographs, l.e.d.s were mounted in two straight lines. Alternatively, two circular arrangements could be used. When marking out the positions of the l.e.d.s, allow room for their mounting clips. Although the l.e.d.s could be inserted directly into the case, the use of clips makes the mounting task easier and provides a much neater finish.

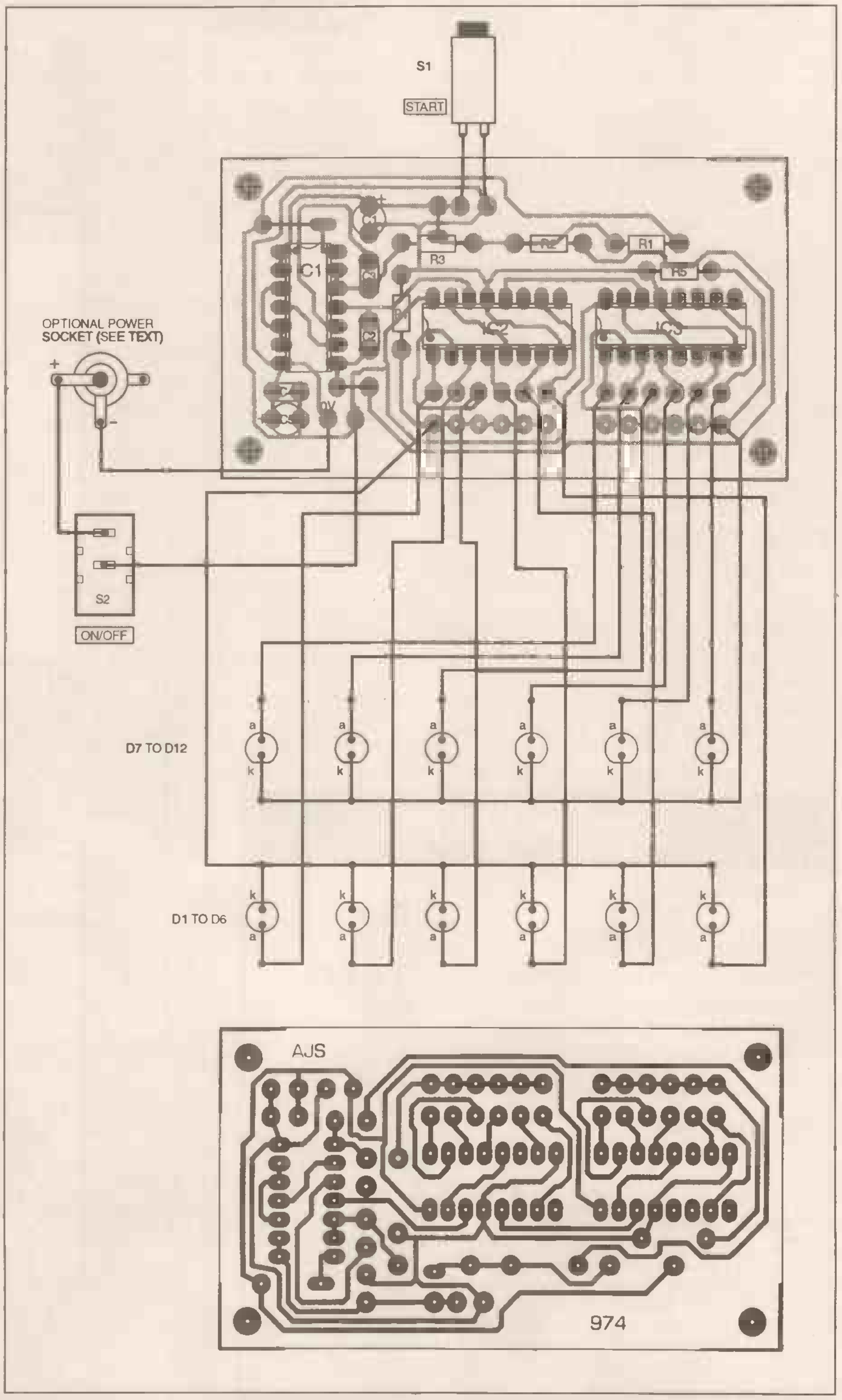
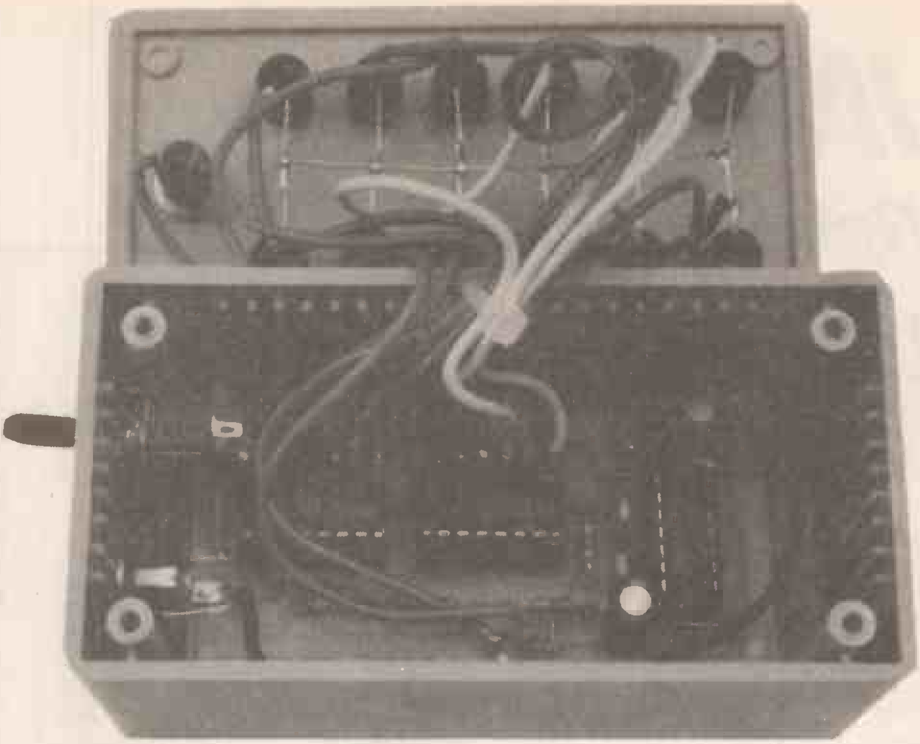


Fig. 3. Printed circuit board component layout, interwiring and full size underside copper foil master pattern. The spare copper pads, below IC2/IC3, can be used for direct board mounting of the l.e.d.s.



The p.c.b. is positioned on the base of the box with self-adhesive stand-offs. Take care that the lid mounted components do not short on the p.c.b.

Mark the positions of the Start pushbutton switch, On/Off switch and Power Input socket, if required. Drill the holes, taking particular care to get the l.e.d. holes in line – even if just one l.e.d. is not exactly in line the appearance is spoilt. It helps if a very small drill is used first.

Position the l.e.d.s into their clips ensuring that the cathode (k) leads are all facing the same way as shown in Fig. 3. This makes the common cathode (k) connections much simpler to arrange. The cathode side of an l.e.d. is usually the shorter lead. If the leads have been cut, note that the cathode of a round l.e.d. is likely to be denoted by a tiny flat mark at the base of the body.

Now connect and solder the l.e.d. cathodes using a length of *bare* wire. This common junction is connected to the p.c.b. using a length of *insulated* wire.

Use colour coded insulated wire to link the l.e.d.s to the terminal pins. In other words, use a black lead for the common cathode connection, a brown lead for l.e.d. D1, red for D2, orange for D3, etc. Using coloured leads in resistor colour code order greatly eases assembly, particularly if fault finding is necessary.

The l.e.d. leads should be shortened before soldering and bent neatly against the plastic body of the case after soldering.

Complete the external wiring. Discharge static electricity from your body before handling the i.c.s, by touching a grounded item first. Then insert the i.c.s into their sockets ensuring that their orientation notches line up as shown.

Now thoroughly check the board with a magnifying glass, ensuring that components are correctly positioned and that all solder joints are correctly made.

TESTING

A regulated 9V or 12V supply which can be limited to a maximum output current of 100mA is ideal for testing, and will be unlikely to harm the circuit even if major mistakes have been made.

Connect the supply, switch on S2, and check that one l.e.d. of each set lights up. If this does not happen, switch off and recheck for mistakes.

If all is well, press switch S1. The l.e.d.s should chase, with one set chasing six times faster than the other. Release S1. After a brief pause, the chase should slow down and finally stop. The pause length may be shortened by reducing the value of either resistor R1 or capacitor C1.

FAULT FINDING

If the circuit does not behave as expected, decide first if the fault affects the whole circuit, or just one module and if so, which one. For example, measure the voltage across pins 7 and 14 of IC1, and across pins 8 and 16 of IC2 and IC3. If a voltage reading equal to that of the power supply is present, and with the correct polarity, check each module as described below. If not, check that the power socket has been connected correctly and that there is a voltage across it.

Read the fault finding guide in Part 1 of the series for general help, and using a voltmeter with its negative side connected to 0V in the circuit try the following tests:

When S1 is pressed, the voltage at IC1 pins 1 and 2 should be 0V. When S1 is released this voltage should rise to the maximum power supply level. The voltage at IC1 pins 3, 5 and 6 should be equal to the positive supply when S1 is pressed, switching to about 0V a few seconds after S1 is released. IC1 pin 4 should do the opposite of pin 3. Check that the voltage on IC1 pin 9 copies that on IC1 pin 4.

Correct operation of the astable can only be checked with the aid of an oscilloscope: a square wave should be seen at IC1 pin 11 and IC2 pin 14.

Failure of all the l.e.d.s is likely to imply that they are connected the wrong way round or the common connection between their cathodes and the p.c.b. has been forgotten.

INSTALLATION

The p.c.b. may be fastened to the base of the case using self-adhesive p.c.b. supports. Check that when the lid is positioned, a short circuit cannot occur between exposed parts on the p.c.b. and the bare l.e.d. wires. Screw the lid into position, and give the project a final test. □

PART FIVE

Next month an Infra-Red Zapper construction project will be the subject of *Teach-In* Part Five.

Collection of "demonstration" modules used to back up the Teach-In Series.

INTERFACE

Robert Penfold

THIS month we continue with the theme of computers and model railways. This is a popular subject which has been covered spasmodically in *Interface* articles over the years.

In this article we will look at a simple method of providing keyboard control of a signal and the train using hardware that has been covered in previous articles. The circuits and software are designed for use with a PC, and they operate via one of the printer ports.

Provided you have the requisite technical know-how it should be possible to adapt this system to suit other computers. It should also be possible to use them with PCs via some form of parallel input/output card.

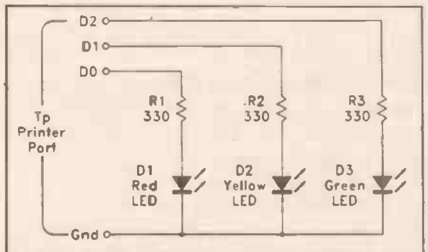


Fig. 1. The signal l.e.d.s are driven from three of the printer port's data outputs.

Key To Success

The function of the system is quite simple, and it is centred on a three aspect (Red – Amber – Green) signal which is controlled from the computer's keyboard. The red, amber, and green signal lights are selected by pressing the "R", "A", and "G" keys respectively.

The train automatically responds to the signal, and stops just in front of the signal if it is set to "red". If the signal is set to "green" or "amber", the train will, where necessary, alter its speed as it passes the signal.

This is essentially the opposite of the system described in the previous *Interface* article. This had manual control of the train, with the signal automatically operated by the train as it passed sensors under the track. In this case the *signal* is controlled manually, and the train automatically responds to the signal. You take the role of the signalman and the computer drives the train!

On the face of it, the speed of the train simply has to be set at something appropriate when the signal is given a new setting. In practice matters are not quite as simple as this, because the train must only respond to a change in the setting of a signal as it actually approaches the signal. It must not simply change speed as soon as the signal is altered, regardless of the train's position on the track.

The necessary hold-off is achieved using a track sensor positioned just in front of the signal. Any change in speed dictated by the setting of the signal is not actually implemented until the train activates this sensor.

Light Work

The signal l.e.d.s are driven from data lines D0 to D2, as shown in Fig. 1. This is the same method that was utilized in the signalling system featured last month. If preferred, small filament bulbs can be driven via common emitter switching stages, also described last month.

The same method can be used to drive l.e.d.s at higher currents than the printer port can provide. The red, amber (yellow), and green l.e.d.s are selected by respectively writing values of one, two, and four to input/output address &H378 (port 1) or &H278 (port 2).

Under Control

A circuit diagram for the Train Controller Interface, which is essentially the same circuit that was featured in *EPE* June '95 issue, is shown in Fig. 2. Consult the *Interface* article in that issue for a detailed description of the circuit and the way in which the controller functions.

Note that this version of the controller is driven from bit 2 at input/output address &H37A (port 1) or &H27A (port 2). In the original design it was driven from bit 0 of the main 8-bit output port, but in this system bit 0 of this port is "previously engaged" driving one of the signal l.e.d.s.

This controller functions by having the computer generate a suitable pulse signal, with the interface converting the signal to suitable drive levels for the electric motor in the train. In this case the computer only has to generate three types of pulse signal.

A signal having a high mark-space ratio provides full speed when the signal is at "green", a one-to-one mark-space ratio provides about half maximum speed when the signal is at "amber", and a low mark-space ratio brings the train to a halt when the signal is at "red."

Forward/Reverse

The forward/reverse switch S1, can be two sets of changeover relay contacts under control of the computer if desired. But the software provided here is not designed to handle this feature though, and having a bidirectional train complicates matters somewhat.

It would be necessary to have a sensor each side of the signal so that the train could be brought to a halt at the correct side of the signal, regardless of which way the train was moving. The signal itself would also need to be bidirectional. This is all quite feasible, but initially it is probably best to settle for a simple one-way system.

Although the controller is a pulsed type, transistor TR1 still has to dissipate a certain amount of power, particularly when the train is set at full speed. TR1 should therefore be fitted with a small bolt-on heatsink. The circuit works well using either a TIP121 or a TIP122 power Darlington transistor for TR1.

The controller circuit requires a reasonably stable 15V supply which must include overload protection, since the controller circuit itself has no form of short-circuit protection. A suitable mains power supply circuit is provided in Fig.3, and this is a conventional design using bridge rectification and a monolithic voltage regulator.

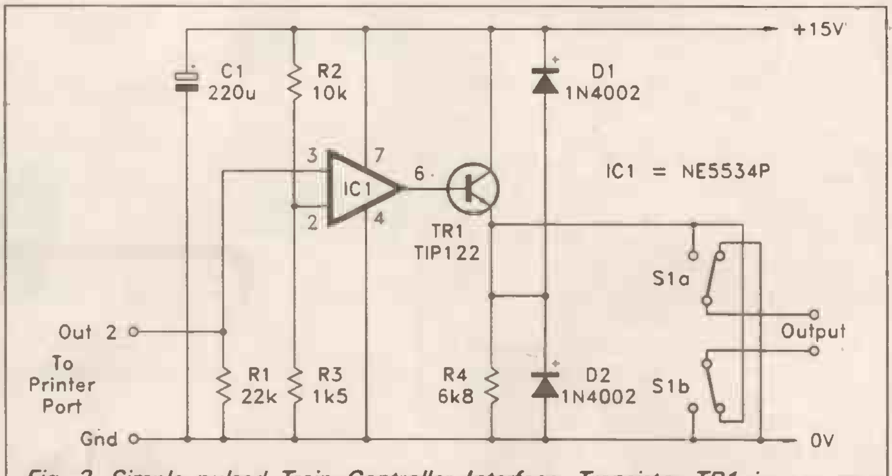


Fig. 2. Simple pulsed Train Controller Interface. Transistor TR1 is a power Darlington device.

This circuit is only included for the benefit of experienced readers, and beginners should not undertake projects which connect to the ***dangerous mains supply***. If you lack the necessary experience, power the circuit from a ready-made supply that can provide 15V at 1A or more.

On The Track

The circuit diagram for the Track Sensor Interface is shown in Fig. 4. This is basically the same as the interface used in the automatic signal described last month, but in this case only one sensor switch and pulse stretcher are needed.

The use of reed and microswitches for position sensing in model railways has been covered in previous articles, and is well known to many model railway enthusiasts. Consequently, it is not something we will consider in detail here.

The interface drives bit four of input/output address &H379 (port 1) or &H279 (port 2).

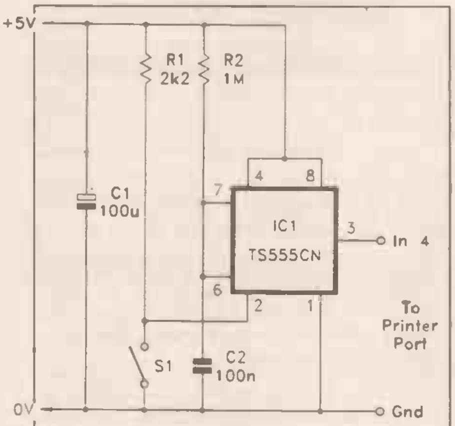


Fig. 4. Circuit diagram for the position Track Sensor Interface. S1 is a reed or microswitch.

Software

The software listing provided here is very simple, but it provides the required combination of manual and automatic control. Note that a reasonably fast PC is needed in order to obtain satisfactory results with this program.

Good results were obtained using a 33MHz 80386DX PC, but anything much slower than this would probably not give good results, with rather jerky movement of the train. The program is for use with printer port 1, but with the appropriate address changes it will obviously work properly with port 2.

Lines 20 to 50 clear the screen and print some on-screen instructions. Line 60 sets the signal initially at "amber", and the next two lines set variables "MARK" and "SPACE" at values of 50.

These two variables set the mark and space periods of the pulsed output signal, and the suggested values give about half speed. Other speeds can be obtained using different values, but they should total about 100. Lines 90 and 130 respectively set the output line high and low, and the two FOR....NEXT loops provide delays that control the mark-space ratio of the output signal.

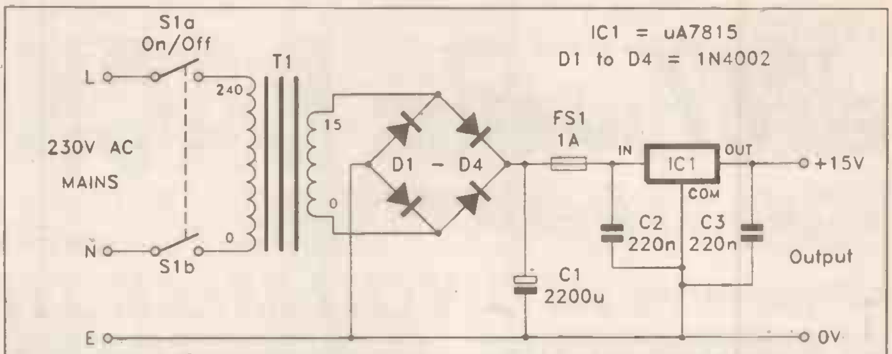


Fig. 3. Circuit diagram for a suitable 12V 1A mains power supply.

Subroutine

The program is taken into the subroutine beginning at line 170 if a key press is detected at lines 110 and 120. The main purpose of this subroutine is to set the state of the signal to match the key that has been pressed.

This is achieved using a series of IF....THEN statements. This subroutine also sets the variable called "SIGNAL" to a value of one, two, or three, depending on whether the signal has been set to "red", "amber", or "green."

Line 150 detects pulses from the track sensor, and each time a pulse is detected it branches the program to the subroutine starting at line 250. A series of IF....THEN statements are used to set variables "MARK" and "SPACE" at appropriate values for the current setting of the signal.

The setting of the signal cannot be determined by reading the 8-bit output port, since this is strictly an output address. The value of the variable "SIGNAL" is therefore used to determine the setting of the signal.

Listing 1: Automatic Model Train Control

```
10 REM AUTOMATIC TRAIN CONTROLLER PROG
20 CLS
30 PRINT "Press 'R' key for RED signal"
40 PRINT "Press 'A' key for AMBER signal"
50 PRINT "Press 'G' key for GREEN signal"
60 OUT &H378,2
70 MARK = 50
80 SPACE = 50
90 OUT &H37A,4
100 FOR DELAY = 1 TO MARK: NEXT DELAY
110 A$ = INKEY$
120 IF LEN(A$) = 1 THEN GOSUB 170
130 OUT &H37A,0
140 FOR DELAY = 1 TO SPACE: NEXT DELAY
150 IF (INP(&H379) AND 16) = 16 THEN GOSUB 250
160 GOTO 90
170 IF A$ = "s" THEN END
180 IF A$ = "r" THEN OUT &H378,1
190 IF A$ = "r" THEN SIGNAL = 1
200 IF A$ = "a" THEN OUT &H378,2
210 IF A$ = "a" THEN SIGNAL = 2
220 IF A$ = "g" THEN OUT &H378,4
230 IF A$ = "g" THEN SIGNAL = 3
240 RETURN
250 IF SIGNAL = 1 THEN MARK = 1
260 IF SIGNAL = 1 THEN SPACE = 100
270 IF SIGNAL = 2 THEN MARK = 50
280 IF SIGNAL = 2 THEN SPACE = 50
290 IF SIGNAL = 3 THEN MARK = 100
300 IF SIGNAL = 3 THEN SPACE = 1
310 RETURN
```

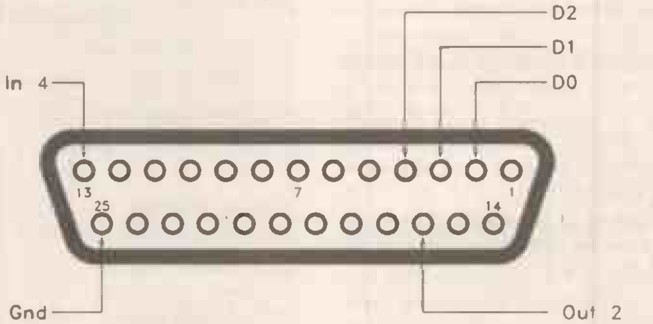


Fig. 5. Details of the connections to the printer port.

EVERYDAY PRACTICAL ELECTRONICS

BACK ISSUES

We can supply back issues of *EPE* by post, many issues from the past five years are available. An index for each year is also available – see order form. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photostat of any *one article* (or *one part* of a series) can be purchased for the same price.

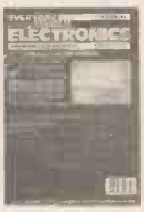
DID YOU MISS THESE?

AUG. '94

PROJECTS ● Experimental Noise Cancelling Unit ● Dancing Fountains, Part 1 ● Charged-Up (PC battery tip) ● 6802 Development Board ● TV Camera Update ● Stereo HiFi Controller, Part 2.
FEATURES ● Calculation Corner, Part 8 ● Best of British, Part 5 ● I'll Be Seeing You (multimedia communications)

SEPT. '94

PROJECTS ● Protector Plus Car Alarm ● Greenhouse Watering System ● Experimental Seismograph, Part 1 ● Three-Channel Lamp Controller ● Dancing Fountains, Part 2.
FEATURES ● Calculation Corner, Part 9 ● The Invisible Force (magnetic force).

OCT. '94

PROJECTS ● Digilogue Clock ● Visual/Audio Guitar Tuner ● Hobby Power Supply ● Audio Auxiplexer ● Experimental Seismograph, Part 2.
FEATURES ● Electronics from the Ground Up, Part 1 with **FREE** PC Software ● Calculation Corner, Part 10.

NOV. '94 Photostats Only (see below)

PROJECTS ● 1000V/500V Insulation Tester ● Video Modules, Part 1 (Simple Fader, Improved Fader, Video Enhancer) ● Active Guitar Tone Control ● Power Controller ● TV Off-er.
FEATURES ● Electronics from the Ground Up, Part 2 ● Consumer Electronics Show.

DEC. '94

PROJECTS ● Spacewriter Wand ● *EPE* Fruit Machine ● Universal Digital Code Lock ● Video Modules, Part 2 (Horizontal Wiper, Vertical Wiper, Audio Mixer) ● Rodent Repeller.
FEATURES ● Electronics from the Ground Up, Part 3 ● Embedded Controllers ● Index for Volume 23.

JAN. '95 Photostats Only (see below)

PROJECTS ● Magnetic Field Detector ● Moving Display Metronome ● Model Railway Track Cleaner ● Beating the Christmas Lights ● EPE Fruit Machine, Part 2 ● Video Modules, Part 3 (Dynamic Noise Limiter, System Mains Power Supply).
FEATURES ● Electronics from the Ground Up, Part 4 ● Electromagnetic Compatibility ● Checking Transistors.

FEB. '95

PROJECTS ● 12V 35W PA Amplifier ● Foot-Operated Drill Controller ● The Ultimate Screen Saver ● MIDI Pedal Board ● Model Railway Signals.
FEATURES ● Electronics from the Ground Up, Part 5 ● Transformerless Power Supplies ● Quickroute 3.0 Review.

MARCH '95

PROJECTS ● Multi-Purpose Thermostat ● Name of the Game-1 Counterspell ● Sound Activated Switch ● Audio Amplifier ● Light Beam Communicator.
FEATURES ● Electronics from the Ground Up, Part 6 ● Understanding PIC Microcontrollers ● Visio Graphics Software Review.
FREE Multi-Project PCB with this issue.

APRIL '95

PROJECTS ● National Lottery Predictor ● Auto-Battery Charger ● Light-Activated Switch ● Switch On/Off Timer ● Continuity Tester ● Name of the Game-2 Counterspin.
FEATURES ● Electronics from the Ground Up, Part 7 ● Circuit Surgery ● The Hard Cell (Mobile Telephones).

MAY '95

PROJECTS ● PIC-DATS-1 (PIC Development and Training System) ● R.F. Signal Generator – 1 ● MIDI Pedal ● Club Vote Totaliser ● Name of the Game-3, On Your Marks and Games Timer.
FEATURES ● Electronics from the Ground Up, Part 8 ● Las Vegas Show Report.

JUNE '95 Photostats Only (see below)

PROJECTS ● PIC-DATS-2 (PIC controlled 4-Channel Light Chaser) ● EPE HiFi Valve Amplifier – 1 ● R.F. Signal Generator – 2 ● AA to PP3 Converter ● Name of the Game – 4, Star-Struck!, Six-Shot Light Zapper, Wander Wands.
FEATURES ● Electronics from the Ground Up, Part 9 ● Smart Cards.

JULY '95

PROJECTS ● Windicator ● Curtain Winder ● Ramp Generator – 1 ● High Voltage Capacitor Reformer ● EPE HiFi Valve Amplifier – 2
FEATURES ● Bridge Rectification Enhanced ● Ingenuity Unlimited.

AUG '95

PROJECTS ● Solar Seeker ● Personal Practice Amplifier ● Infra-Red Remote Control Unit ● Versatile Microcontrolled 3-Digit Timer ● Ramp Generator – 2.
FEATURES ● Static ● Circuit Surgery.


SEPT '95

PROJECTS ● Simple Theremin ● Low Range Ohmmeter Adaptor ● Comprehensive Security System ● Vandata ● Hum-Free Battery Eliminator.
FEATURES ● Cave Radio ● Ingenuity Unlimited.


OCT '95

PROJECTS ● Ginormous VU Meter ● Sound Switch ● Audio Sinewave Generator ● Treble Booster ● Infra-Red Controller/Alarm ● Capacitor Check ● Experimenter's Bargraph Test Board.
FEATURES ● Circuit Surgery ● Security Tagging ● Using Bargraph Displays.
FREE ● Multi-Project PCB with this issue.

NOV '95

PROJECTS ● Digital Delay Line ● Video Enhancer ● 50Hz Field Meter ● Temperature Warning Alarm ● Current Tracer ● Distortion Effects Unit.
FEATURES ● Teach-In '96 Part 1 ● Developments in Radio Broadcasting Technology ● Turnpike for Windows Review ● Ingenuity Unlimited.

DEC '95

PROJECTS ● Light Operated Switch ● Stereo "Cordless" Headphones ● EPE Met Office – 1 ● Modular Alarm System ● Audio Meter and Amplifier.
FEATURES ● Teach-In '96 Part 2 ● Circuit Surgery ● Index for Volume 24.

JAN '96

PROJECTS ● Printer Sharer ● Mains Signalling Unit ● Automatic Camera Panning System ● Audio Signal Generator ● EPE Met Office – 2.
FEATURES ● Teach-In '96 Part 3 ● Ingenuity Unlimited ● European Consumer Electronics Show ● Techniques – Actually Doing It ● Maths Plus Review ● Decibels and dBm Scale.

BACK ISSUES ONLY £2.50 each inc. UK p&p.
Overseas prices £3.10 each surface mail, £4.10 each airmail.

We can also supply issues from earlier years: 1989 (**except** March, June and Nov), 1990 (**except** March), 1991 (**except** May, June, Aug., Sept. and Nov.), 1992 (**except** April and Dec.), 1993 (**except** Jan., Feb. and March), 1994 (**except** April, June and Nov.), 1995 (**except** Jan. and June). Please note we are not able to supply copies (or 'stats of articles) of *Practical Electronics* prior to the merger of the two magazines in November 1992.
Where we do not have an issue a photostat of any *one article* or *one part* of a series can be provided at the same price.

ORDER FORM – BACK ISSUES – PHOTOSTATS – INDEXES

☐ Send back issues dated ....
☐ Send photostats of (article title and issue date) ....
☐ Send copies of last five years indexes (£2.50 for five inc. p&p – Overseas £3.10 surface, £4.10 airmail)

Name ....
Address ....
....

☐ I enclose cheque/P.O./bank draft to the value of £..........
☐ Please charge my Visa/Mastercard £..........

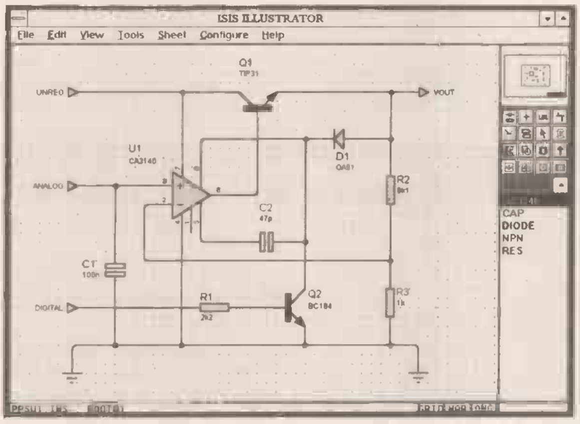
Card No. .... Card Expiry Date ....

Note: Minimum order for credit cards £5. Please supply name and address of cardholder if different from that shown above.
SEND TO: **Everyday Practical Electronics, Allen House, East Borough, Wimborne, Dorset BH21 1PF.**
Tel: 01202 881749. Fax: 01202 841692. (Due to the high cost we cannot reply to queries or orders by Fax.)
Payments must be in £ sterling – cheque or bank draft drawn on a UK bank.
Normally supplied within seven days of receipt of order.
Send a copy of this form, or order by letter if you do not wish to cut your issue.
M2/96

PROFESSIONAL CIRCUIT AND PCB DESIGN AIDS FOR WINDOWS

CADPAK for Windows

CADPAK is especially suited to educational, hobby and small scale schematic and PCB design. CADPAK includes both schematic drawing and 32-bit PCB drafting tools but as an entry level product, there is no netlist link between them.



The schematic drawing module of CADPAK, ISIS Illustrator, enables you to create circuit diagrams like the ones in the magazines.

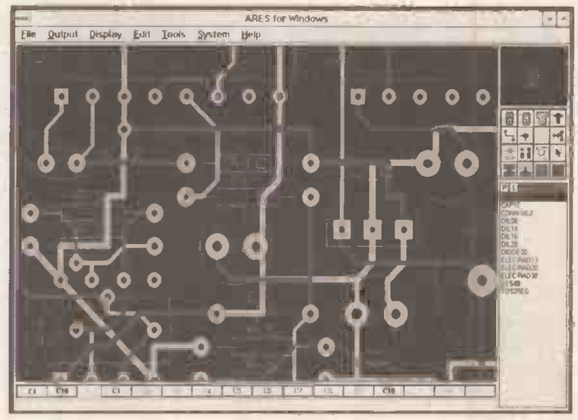
- *Runs under Windows 3.1 making full use of Windows features such as on-line help.*
- *Full control of appearance including line widths, fill styles, fonts, colours.*
- *Automatic wire routing & dot placement.*
- *Fully automatic annotator.*
- *Complete with device and comprehensive package libraries for both through hole and SMT parts.*
- *Advanced route editing allows deletion or modification of any section of track.*
- *Gerber, Excellon and DXF outputs as well as output via Windows drivers. Also includes Gerber viewer.*
- *Exports diagrams to other applications via the clipboard.*
- *CADPAK is also available for DOS.*

CADPAK FOR WINDOWS .... £ 149

CADPAK FOR DOS .... £ 79

PROPAK for Windows

PROPAK has all of the features in CADPAK plus netlist based integration, automatic power plane generation and a powerful auto-router. PROPAK includes enough schematic capture and PCB design functionality for all but the most demanding applications.



PROPAK's schematic drawing editor ISIS ILLUSTRATOR+ includes even more features than ISIS ILLUSTRATOR. PROPAK's 32-bit PCB design tool, ARES for Windows, is our most powerful and easy to use yet.

- *Multi-sheet and hierarchical designs.*
- *Netlist link between modules guarentees consistency between schematic and PCB.*
- *Netlists are also compatible with SPICE-AGE and most other electronics CAD packages.*
- *Generates a full bill of materials.*
- *ASCII data import facility.*
- *Electrical rules and connectivity checkers.*
- *Ratsnest display with automatic update during placement and routing.*
- *Multi-strategy autorouter gives high completion rates.*
- *Power plane generator creates ground planes with ease.*
- *PROPAK is also available for DOS.*

PROPAK FOR WINDOWS .... £ 495

PROPAK FOR DOS .... £ 395

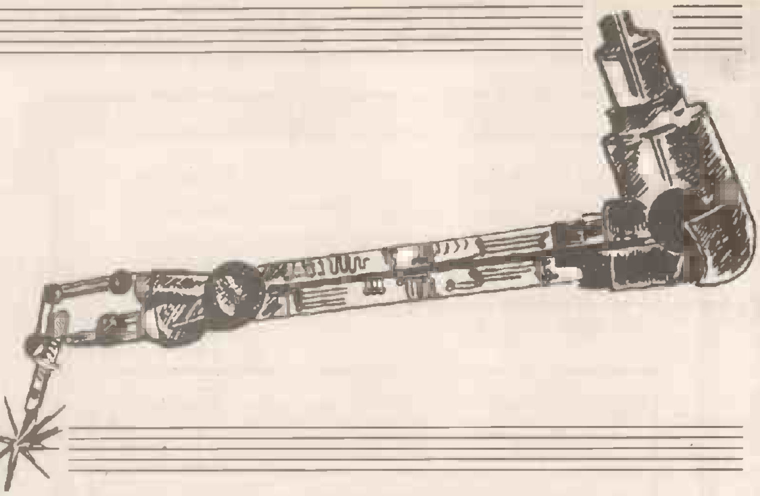
Call or fax us today for a demo pack. Please state whether you would like a DOS or Windows pack.

Prices exclude postage (£5 for UK) and VAT. ISIS ILLUSTRATOR and ARES for Windows are also available separately. All manufacturers trademarks acknowledged.

labcenter
Electronics
53-55 Main St. Grassington, N. Yorks. BD23 5AA
Tel: 01756 753440 Fax: 01756 752857

Regular Clinic

CIRCUIT SURGERY



ALAN WINSTANLEY

This month's 'clinic' looks at interesting pseudo-random digital signals, plus more on Ni-Cads, a follow-up on cycle l.e.d. flashers and more pointers for Internet users.

WELCOME aboard to *Circuit Surgery* – our two-way column discussing readers' queries and questions on hobby and educational electronics! If you have any topical comments or queries which you think would be of interest to others – or you have anything you'd like to say about any of our constructional projects – then *Circuit Surgery* will strive to help, so please write to us at the address given later.

Random Digital Pulses

A question cropped up in my post bag recently concerning a randomly-activated sequencer. A reader enquired about a method of operating randomly one of a number of loads, after a time period has elapsed.

It brought back memories of one of my own *Everyday Electronics* constructional projects – the *Security Vari-Light* dating back to December 1982, no less. This device operated a table lamp at random-looking intervals, to give the impression that the house was occupied at night, hopefully acting as a deterrent to burglars. (We were never burgled, so I guess it worked!)

The technique of ***pseudo-random pulse generation*** is an interesting topic to study. Note the phrases "pseudo-random" and "random-looking" – since these methods are never truly random, but they generate a sequence of bits which can be engineered to be "virtually random", as we'll see.

A circuit diagram for a simple 4-bit Shift Register, something like a CD4015 or the 74164 being fine for this application, is shown in Fig. 1. (Both types actually contains two individual registers.) The register has four outputs Q1 to Q4, a D (Data) pin and is edge-triggered by a clock.

A clock pulse enters at pin 9 and could be derived from a standard 555 astable (not shown). Connected to the output is an Ex-OR gate which feeds back to the Data pin.

The register's method of operation is straightforward enough: whenever a suitable clock edge pulse is received then the logic state at the Data pin is toggled over to the Q1 output. That bit is then carried to the next output Q2 on the next clock edge. Thus a simple bit sequence will be seen rippling along the Q1 to Q4 outputs.

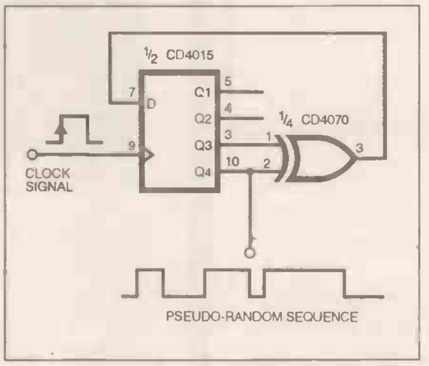


Fig. 1. Simple 4-bit register.

Adding the Ex-OR gate as shown has an extremely interesting effect: it produces a pseudo-random sequence where we can actually "predict" the randomness!

The truth table for a two-input Ex-OR gate (e.g. CD4070) is shown below:

A	B	Q=A+B
0	0	0
1	0	1
0	1	1
1	1	0

The Ex-OR output is Logic 1 when the inputs are dissimilar.

Imagine that all four shift register outputs are logic 0 initially, also a Logic 1 is present at the Data pin initially. Table 1 shows the sequence of events unfolding.

The Data 1 is clocked over to Q1, then on the third step the Ex-OR gate feeds back a logic 1 to the Data pin. Follow through the stages using the Ex-OR truth table to determine what the Data pin will do next.

Reading down the columns in Table 1, you'll see a sequence of bits which looks a little unpredictable: 000100110101111 With a four bit register clearly the pseudo-random sequence will repeat again after fifteen clock cycles.

Inherent in this arrangement is a "forbidden state" of 0000 – because this will cause the system simply to re-circulate logic zeros all the time and no sequence can appear! So although a 4-bit register could generate 16 sequences, you'll see that the maximum length available is actually 15 clock cycles (i.e. $2^4 - 1$).

To overcome any starting or jamming problems, in my original *Security Vari-Light*, a power-on reset circuit was used so that Q1 to Q4 are always initiated at logic 0, then I used Ex-NOR feedback instead, which guaranteed that the first clock cycle would cause a Logic 1 to be fed back to the Data pin. Thus a pseudo-random sequence would commence.

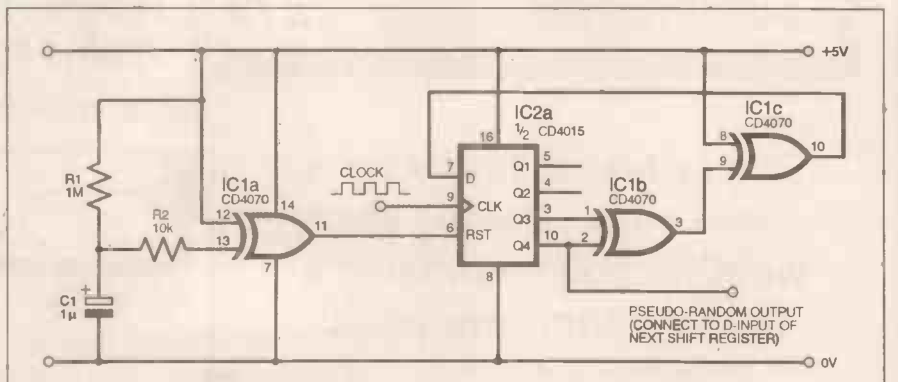


Fig. 2. A simple Pseudo-Random Sequencer.

However Ex-NOR feedback has the effect of making 1111 the forbidden state instead, so this state will never appear in the sequence. An Ex-NOR gate can be formed from an Ex-OR gate followed by an Ex-OR wired as an inverter.

A power-on reset can also be obtained, rather crudely, from a further Ex-OR gate with an *RC* pair on one input and the other input at Logic 1.

Right Feedback

A simple Pseudo-Random Sequencer, based on a single 4-bit shift register is shown in Fig. 2. It has both a power-on reset (IC1a) to write 0000 to the four outputs, and Ex-NOR feedback (IC1b and IC1c) to start up the sequence with a logic 1.

With only 15 steps available before repeating itself, the circuit isn't terribly useful. By extending the shift register length it's possible to increase the length of the pseudo-random sequence, e.g. by carrying the Q4 output to the D-input of another 4-bit shift register to form an 8-bit type.

An 8-bit register would generate a pseudo-random sequence of 255 steps ($2^8 - 1$) whilst a 16-bit type, say, would generate $2^{16} - 1 = 65,535$ steps. If we are to obtain a "maximal length" sequence, though, everything hinges around hooking up the Ex-OR feedback to the appropriate register outputs, otherwise the entire sequence may not be realised fully.

With some combinations of shift register length, more than one feedback tap is needed: for example an 8-bit register needs to be tapped at Q4, Q5, Q6 and Q8 to get maximal length, whilst a 16-bit register is tapped at Q4, Q13, Q15 and Q16. It isn't compulsory to use the "right" outputs, though – if you don't, you'll simply not obtain the most random-looking sequence.

A high frequency digital sequence can be exploited with further circuitry to provide a source of *analogue* noise. An excellent in-depth discussion on this topic is found in *The Art of Electronics* by Paul Horowitz and Winfield Hill (2nd Edition, Cambridge University Press, 1,125 pages, ISBN 0-521-37095-7) which is probably one of the world's best books on electronics. Rooting through my library, I also found that the technique is touched on in the *CMOS Cookbook* by Don Lancaster (2nd Edition, Publisher Sams, 512 pages, ISBN 0-672-22459-3) if you want to research it further.

Table 1: 4-bit pseudo-random sequence

Clock Cycle	Q1	Q2	Q3	Q4	D = Q3+Q4 (Transfer to Q1)
–	(Start Up) Data = Logic 1				1
1	1	0	0	0	0
2	0	1	0	0	0
3	0	0	1	0	1
4	1	0	0	1	1
5	1	1	0	0	0
6	0	1	1	0	1
7	1	0	1	1	0
8	0	1	0	1	1
9	1	0	1	0	1
10	1	1	0	1	1
11	1	1	1	0	1
12	1	1	1	1	0
13	0	1	1	1	0
14	0	0	1	1	0
15	0	0	0	1	1
1	1	0	0	0	0 . . . etc

Cycle L.E.D. Flasher

A follow-up concerning my suggested "Cycle L.E.D. Flasher" (October 1995's issue). ***Mr. J.C. Corfield of Bishop's Castle, Shropshire,*** who comments:
ments:

You proposed at some length how to provide a Cycle L.E.D. Flasher using a battery, switch, p.c.b., i.c. type LM3909 and at least one capacitor. Why didn't you suggest using a battery (3× AA), switch and a flashing l.e.d. at half the cost?

Is there a reason why flashing l.e.d.s are not suitable? If so, please let us know what it is.

Er, quite. Obviously a *single* flashing light-emitting diode can be formed simply with a ready-made device. However you cannot control the flash rate, and a voltage of about 4V (3·5V absolute minimum) is necessary or they won't operate – so one would make short shrift of three AA cells.

Using a ready-made device isn't necessarily the most "fuel-efficient" way of producing a flashing l.e.d. The LM3909 chip was shown as a way of driving a single l.e.d. from a 1·5V to 3V source. Its party trick is that it has a built-in voltage booster circuit to drive an l.e.d. (forward voltage 2V say), from a single 1·5V supply or even less, although a more useful pulse is obtained by using a couple of pencells instead.

By designing the circuit to give just a short "blink" (mark), using two alkaline AA pencells and one l.e.d. gives approximately nine months of *continuous* service, from experience. I often use the circuit as a battery-friendly imitation alarm (burglar deterrent).

In the case of a cycle l.e.d. flasher, these use multiple l.e.d.s (three or five, generally) and if the circuit is to be effective they should all flash *simultaneously*. This isn't possible if separate flashing l.e.d.s. are utilised since they don't flash at an identical rate and they eventually go out of "sync" – the impression from a distance is that of a steady or irregular lamp.

Furthermore, it is perfectly possible to adjust the flash rate using the "fast" or "slow" pins of the LM3909 and also by adjusting the values of the two or three external components. Overall, I thought the simple circuit was a good compromise.

Incidentally, an old National Semiconductor Data Book from 1977 shows a humungous variety of applications for the LM3909 – everything from an a.m. radio to an electronic trombone, 'scope calibrator and triac trigger! It can be used as an audio tone generator as well. (NS Application Note AN154, *"1·3 Volt i.c. Flasher, Oscillator, Trigger or Alarm."*)

Ni-Cads – yet more!

Regular readers may recall my item in the August 1995 issue when I offered a reprint of a "discussion" which took place earlier in the year on the Internet, concerning the performance of Nickel-Cadmium rechargeable cells. Many scores of readers asked for this reprint and we gladly obliged. I have often found that there have been conflicting views as to what constitutes kindness or cruelty to NiCads, but opinions gradually seem to be gelling along the following lines:

The main point is, there's a difference between the *capacity* of a NiCad and its *voltage*. People often confuse the two. The discharge characteristic of a NiCad approximates a flat curve (see Fig. 3) – unlike a zinc carbon cell, for example, its voltage does not gradually tail off but suddenly plummets! A NiCad should be considered as ready for recharging when its (on-load) voltage has fallen to about 1V per cell, though some folks use a potential of 1·1V as the crucial point.

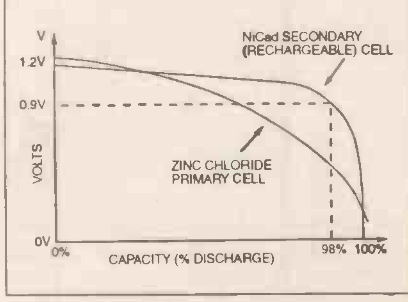


Fig. 3. Discharge characteristics.

Typically, NiCads will have discharged well over 95 per cent of their *capacity* when their voltage has dropped to about 1V on-load. It's bad news to "flatten" a NiCad until its potential is nearly zero volts!

The NiCad is to all intents fully discharged (~ 98%) when its voltage has dropped below, say, 0·9V and it's pointless draining it any further! Internal damage may be caused which may not be entirely reversible!

Be kind to NiCads by discharging no lower than 1V, then recharge in accordance with the manufacturers' recommended charging times. This means that if they recommend 14 hours, don't leave it to trickle charge afterwards unless they clearly state you can!

The so-called "memory effect" relates to ***voltage depression*** caused by a poor charging/discharging regime. Voltage depression (increased internal resistance leading to reduced capacity) can quite often be reversed by deliberately discharging the cells, never letting them fall under 1V each on-load, and then recharging them for a full cycle. Do this several times in succession and the NiCad's capacity may be restored.

Bear in mind we're talking about 1V per *cell*, not per complete *battery*. A 6V battery will have five cells (1·2V each) – so overall it should not be allowed to drop below 5V. Some say that a slight overcharge (say 30 minutes' worth) is also beneficial during rejuvenation and helps reverse the "memory effect". I showed a simple constant current load for this type of application in the February 1995 issue.

Just a reminder to those who have access to an Internet connection: an interesting document is available by file transfer protocol (ftp) which covers this topic in some depth. The address is ftp.armory.com/pub/user/rstevew and you should download the dozen page document nicad.faq.zip for more information about how to treat NiCads, plus a detailed look at their chemistry.

We can still reprint it for readers at a cost of 60 pence to cover the copying (cheques, P.O.s payable to *Wimborne Publishing Ltd.*, together with an A4 self-addressed envelope stamped 38 pence). My thanks to all those who have requested the reprint so far – I hope you found it worthwhile.

Auto Battery Back Up

The Auto Battery Charger *constructional project (April 1995 issue) is indeed very useful. Can you please say if the same design could cater for batteries with higher capacities, e.g. 30Ah to 50Ah perhaps for caravan use. We appreciate your feedback over here! Thanks and regards from* ***Gary M. Leyte****, Nizwa, Sultanate of Oman.*

The EPE *Auto Battery Back Up* project was designed to trickle charge a small lead acid battery by monitoring its voltage and switch itself on and off at hysteresis levels which the users sets with two trimmer resistors. It could be used with virtually any 12V (nominal) lead acid accumulator: the designer has used it with batteries up to 8Ah (Ampere-hour) capacity.

The charge current is typically 1A or less: the question is, is this adequate for bigger batteries? Larger and more deeply discharged batteries demand a higher charge current – say 2A or 3A or more. (For example, a deeply discharged car battery may draw some 5A or 6A or more, as I have found on many a winter morning, armed with a battery charger!)

The design at it stands would probably perform adequately with larger batteries *only if they are not used too heavily*, otherwise the 1A nominal maximum charge current could become insufferably (s)low. The only modification you can perform is to increase the transformer rating to, say, 50VA (12V a.c. 4 Amps) and uprate the bridge rectifier to say 3A or more.

Also, omit resistor R6 which limits the current to 1A. The unit will then be able to provide a greater charge current at a level determined by the state of the battery. Extra care is needed to ensure that the power supply current rating is not exceeded, but the rest of the electronics can remain unchanged.

Internet Round-up

Finally this month, for Internet enthusiasts, a few interesting developments in the Newsgroups. A couple of days before you read this, on 2 January 1996 the *sci.electronics* Newsgroup will officially cease to exist – though doubtless it will continue to appear on servers for some time to come.

The group has now been divided into new sub-groups which are already up and running, the charters for which are summarised as follows:

sci.electronics.basic "A forum for discussion of electronics where there is no such thing as a stupid question. Beginners questions. Discussion of electronics education. Requests for other sources of information."

sci.electronics.components "Discussions of electronics at the component level. The use, limitations, and identification of resistors, capacitors, integrated circuits, connectors, enclosures, and so on. Locations and contact information for Manufacturers, Distributors, and other sources for supply and technical information."

sci.electronics.design "Discussions relevant to the design of electronics circuits." The design group is for persons combining components into circuits. Discussion on design solutions and techniques.

sci.electronics.equipment "Discussion of the application and internal operation and relative merits of test equipment, laboratory equipment, and industrial equipment." Not intended as a FS (For Sale) or WTB (Want To Buy) group!

sci.electronics.misc "General discussions on the topic of electronics." Includes gossip, history, trivia, manufacturing, systems, standards, announcements, etc.

sci.electronics.repair continues as a place to ask about (or help with) repairs to electronic equipment – everything from my electric breadmaker to our PC monitor (temporarily deceased) has been in there! Computer equipment, audio, video, TV also.

By posting to the right *UseNet* group, there's more chance of targeting your question at the right kind of people who can answer correctly. Even if they answer wrongly, there's also a good chance that others will jump in with a correction!

Careful posting is always appreciated by regulars subscribers, many of whom, like myself, don't have time to sort through hundreds of irrelevant postings.

UK Sources FAQ

My own humble effort to redress our country's balance of payments deficit is my ***UK Sources FAQ (Frequently Asked Questions)***. This is a listing of over 150 names and addresses of UK-based mail order electronics specialists, industrial franchised distributors, manufacturer's UK addresses, and more.

This has been combined into a 15-page document available to everyone subscribing to ***sci.electronics.components*** and which will be regularly updated by your scribe. By the time you read this, it will also hopefully be available by Email from myself upon request. I welcome contributions to this, all of which will be acknowledged in the FAQ!

Circuit Surgery appears bi-monthly. If you have any suggestions for inclusion in a future *Circuit Surgery*, please write to: Alan Winstanley, *Circuit Surgery*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom, or Email to **alan@epemag.demon.co.uk.**

Please note we cannot deal with queries concerning the repair or modification of commercial equipment. A personal reply cannot always be guaranteed but we will attempt to offer help wherever possible.

WINTER 1995/6 CATALOGUE

The new winter '95/96 edition has 280 pages packed with over 4000 products.

- New editions to our computer section further extending our range of PC components and accessories at unbeatable prices
- Free competition with a chance of winning a Hameg 30MHz oscilloscope
- 100's of new products including; Books, Component Packs, Connectors, Switches, Test Equipment and Tools.
- New range of oscilloscopes from Hameg and extended range of mobile phone batteries and accessories
- Latest PIC Microcontroller IC's and programmer
- New 70cms mobile transceiver for the novice radio amateur enthusiast
- 280 pages, 26 sections and over 4000 products from some of the worlds finest suppliers
- Available at most newsagents or direct from Cirkit
- **Send for your copy today!**

£1.95 + 30p p&p

Cirkit — Access — VISA

Cirkit Distribution Ltd

Park Lane · Broxbourne · Hertfordshire · EN10 7NQ

Telephone: 01992 448899 · Fax: 01992 471314

QUASAR Electronics

Unit 14 Sunnningdale BISHOP'S STORTFORD Herts CM23 2PA
E-mail: 101364.3510 @compuserve.com

SECURITY

ULTRASONIC MOVEMENT DETECTOR

Xtal controlled oscillator, detector circuits & edge mounted transducers on one PCB just 75x40mm. Detection range 4-7m. Adjustable sensitivity. LED indicator. Outputs to drive external relay/circuits. 9V DC operation. *3049-KT. £14.95*

CCD CAMERA Latest high quality low-light, IR-sensitive camera from KOCOM # CA-H34C for Video Intercom CCTV, Surveillance etc. Six IR LED's on board allow camera to 'see' in the dark. Less than half the size of a cigarette packet! *ASSEMBLED UNIT: 30A7-AS £89.95*

FEATURES
- Compact & light camera PCB module 54x38mm
- Low power consumption
- Low illumination requirements (0.1Lux)
- High quality, high resolution image
- Maintenance free
- Built-in electronically controlled auto-iris
- Internal synchronisation

COMBINATION LOCK Versatile electronic lock comprising main circuit & separate 9 key touch-pad for remote opening of lock. 120VAC/10A relay supplied. 9-12V. *3029-KT. £9.95*

LIGHT ALARM Protect your valuables with this practical, clever little circuit. Alarm sounds if even the smallest amount of light falls on the circuit. Place in cash box etc. *3008-KT. £4.95*

THE SCREAMER! Frighten the life out of any unsuspecting/unwanted guests! Painful alarm siren gives out a massive 110db of ear piercing noise. Box supplied has two 35mm piezo elements already built into their own resonant cavity. PCB also fits inside box to give a neat, compact unit. Can be used as part of an alarm circuit or just for the fun of it!! 6-9V operation. *3015-KT £9.95*

REPORTS & PLANS

N.B. MINIMUM ORDER CHARGE FOR PLANS AND REPORTS IS £5.00 PLUS NORMAL P.&P.

TELEPHONE BUG DETECTION Why spend a fortune on expensive bug detection equipment when you can Do-it-Yourself for next to nothing. All you need to know is in this easy to understand report. *R001 £2.00*

SUPER-EAR LISTENING DEVICE Complete plans to build your own parabolic dish microphone. Listen to distant voices and sounds through open windows and even walls! Made from readily available parts. *R002 £3.50*

TELEPHONE BUG PLANS Build you own micro-beetle telephone bug. Suitable for any phone. Transmits over 250 metres – more with good receiver. Made from easy to obtain, cheap components. *R006 £3.00*

RADIO & TV JOKER PLANS We show you how to build three different circuits for disrupting TV picture and sound plus FM radio! May upset your neighbours & the authorities!! DISCRETION REQUIRED. *R017 £3.50*

INFINITY TRANSMITTER PLANS Complete plans for building the famous Infinity Transmitter. Once installed on the target phone, device acts like a room bug. Just call the target phone & activate the unit to hear all room sounds. Great for home/office security! *R019 £3.00*

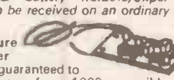
THE ETHER BOX CALL INTERCEPTOR PLANS Grabs telephone calls out of thin air! No need to wire-in a phone bug. Simply place this device near the phone lines to hear the conversations taking place! *R025 £3.00*

Full details of our complete range of Reports & Plans can be found in our Main catalogue.

SURVEILLANCE

High performance surveillance kits. Room transmitters supplied with sensitive electret microphones & battery holders/clips. All transmitters can be received on an ordinary VHF FM radio.

MTX - Miniature 3V Transmitter



Easy to build & guaranteed to transmit 500 metres (over 1000m possible with higher voltage & better aerial). 3-9V operation. Only 45x18mm. *3007-KT. £5.50*

MRTX - Miniature 9V Room Transmitter Our best selling 'bug'. Super sensitive, high power 1000m range (Up to 2 miles with 18V supply & better aerial!). 9V operation. 45x19mm. *3018-KT. £6.50*

HPTX - High Power Room Transmitter

High performance, 2 stage transmitter gives greater stability & high quality reception 1000m range with 9V battery, 6-12V operation. On/off switch. Size 70x15mm. *3032-KT. £7.50*

VTX - Voice Activated Transmitter Activates only when sounds are detected. Low standby current conserves battery power. Adjustable sensitivity & turn-off delay. 6V operation. Size 63x38mm. Powerful 2 stage transmitter. 1000m range. *3028-KT. £9.50*

TRI - Telephone Recording Interface Connect between phone line & cassette recorder. Automatic-ally switches on tape when phone is used. Records all conversations. Powered from line. 48x32mm. *3033-KT. £6.50*

TRVS - Tape Recorder Vox Switch Very sensitive, voice activated switch - automatically turns on cassette recorder when sounds are detected. Adjustable sensitivity & turn-off delay. 115x19mm inc. mic. *3013-KT. £7.50*

MTTX - Miniature Telephone Transmitter

Attaches anywhere to phone line. Transmits only when phone is used! Uses phone line as aerial & power source. 500m range. 45x15mm. *3016-KT £5.50*

Two Station Intercom/Hard Wired Bug Simple two wire intercom/hard wired bug. Each unit has its own speaker, microphone & amplifier (LM386). Can be modified to a hard wired 'bug' by using 4 strand ribbon cable to send power from the receiving unit to the remote 'bug' unit. 9V operation. *3021-KT. £12.95*

Telephone Amplifier Kit Pick-up coil & sensitive amplifier let you hear conversations without even holding the phone! Can be used for surveillance purposes. *3055-KT. £9.95*

GENERAL KITS

3 DIGIT LED COUNTER 2 board basic event counter. Main board has 3 digit counter circuit. 2nd board has Count & Reset switches & debounce circuit. Cascaded with other boards to provide more digits. Box & battery holder provided. 9V battery. 78x50x25mm. *3001-KT. £14.95*

LED SEQUENCE FLASHER 5 red LED's flash in sequence. Ideal for model railways On/off switch. COB PCB 15x8mm (spare provided). 3V powered. *3052-KT. £3.95*

OP-AMP FUNCTION GENERATOR Quad Op-Amp connected as oscillator & wave shapers to generate audio range wave-forms. Oscillator generates Square Wave from 6Hz to 6KHz. Other amps produce Triangle & pseudo Sine outputs. Solder pad outputs. 9V powered. 47x40x22mm. *3023-KT. £4.95*

LOGIC PROBE Original, modern design tests both CMOS & TTL circuits as well as detecting fast pulses. Gives visual & audio indication of logic states found. Powered from circuit under test. It's operation is fully explained. *3024-KT. £7.95*

ROULETTE LED A great introduction to gambling..... err electronics! Watch the 'ball' spin round the roulette wheel, slow down & drop into slot. Uses 10 LED's, CMOS decade counter & Op-Amp to teach Voltage Controlled Oscillator (VCO) principles 9V powered. Educational & fun!! *3006-KT. £10.95*

PELTIER JUNCTION HEAT PUMP Boil or freeze water instantly! Use for regulated cooling of temperature sensitive components and much more. *3066-KT. £21.95*

9V XENON TUBE FLASHER This powerful high voltage xenon flasher runs off a simple 9V battery. A transformer is used to step up the 9V supply voltage to the high voltage required to flash the 25mm long tube. Flash rate adjustable between 0.25 to 2 second intervals. *3022-KT. £11.95*

LM383 AMPLIFIER MODULE Proven, popular building block for use in any audio project where general amplification required. Power output dependent on supply voltage & load resistance. Typical ratings: Over 10W for 16V supply & 2W speaker, 1W for 9V supply & 8W speaker. *3047-KT. £9.95*

LED DICE The classic electronic project that never loses it's popularity. Combines a great game with an easy introduction to electronics & simple circuit analysis. 7 LED's simulate a real dice face. The dice rolls, slows down, stops on a number at random. Uses a 555 timer & counter IC. Box included 9V operation. *3003-KT. £8.95*

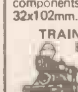
STAIRWAY TO HEAVEN GAME This game of skill tests your hand-eye co-ordination. If you press the switch each time the green part of the bi-polar LED lights you climb higher up the stairway - but miss & you start again! Introduces you to several basic electronic circuits. Box provided 9V operation. 78x50x19mm. Rolfe Harris NOT included! *3005-KT £8.95*

DC MOTOR SPEED CONTROLLER Control the speed of any common DC motor rated up to 100V (5A). Operates on 5-15V. Uses NE556 IC to pulse-width modulate a TIP122 high current, switching power transistor. In this way torque of the motor is not lowered. Box mounted. *3067-KT. £19.95*

SWITCHING POWER SUPPLY Replace expensive 9V batteries with cost-efficient 1.5V cells. IC based circuit acts as a step-up switching power supply. Selectable 1.5 or 3V DC inputs. Gives a fixed output of 9V @ 18mA from a 1.5V "AA" cell. Solder pads for input/output. 1 cell & 2 cell "AA" holders & jumper switches supplied. 40x15x12mm. *3035-KT. £4.95*

SINGLE CHIP AM RADIO Complete mini sized AM radio on a PCB. Tuned Radio Frequency front-end, AM Radio IC & 2 stages of audio amplification. All components supplied inc. prewound coil & speaker. 32x102mm. *3063-KT £9.95*

TRAIN SOUNDS

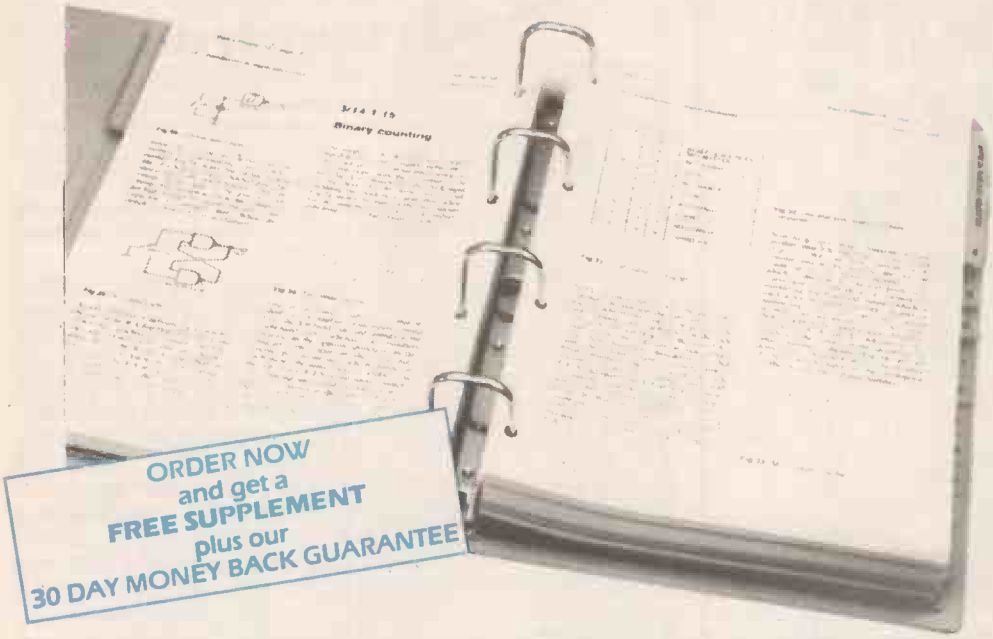


4 selectable sounds - Whistle Blowing, Level Crossing Bell, Chugging & "Clickety-Clack". 2.5-6V. Supplied with all components inc. speaker, 16 x 29mm COB PCB, switches & 2 x "AA" battery holders. *SG1. £4.95*

plus AUDIO • EDUCATIONAL • LASER • SECURITY • TEST GEAR • BOOKS & more

All kits are high quality projects supplied with all components, fibre glass PCB's & comprehensive Instructions. FREE CATALOGUE with order or send 2 x 1st Class stamps (refundable) for details of over 100 kits & publications. Mail order only. Please ADD £1.50 P. & P. per order & make cheques/PO's payable to Quasar Electronics. Goods normally despatch within 5 working days but please allow 28 days for delivery.

LEARN ALL ABOUT ELECTRONICS



The essential reference work

- Easy-to-use format
- Clear and simple layout
- Comprehensive subject range
- Regular Supplements
- Sturdy ring-binder
- Projects to build
- Components checklists
- Extensive data tables
- Detailed supply information
- Ready-to-transfer PCBs
- Detailed assembly instructions
- Professionally written

The revised edition of The Modern Electronics Base Manual contains practical, easy-to-follow information on the following subjects:

BASIC PRINCIPLES: Symbols, components and their characteristics, active and passive component circuits, power supplies, acoustics and electroacoustics, the workshop, principles of metrology, measuring instruments, digital electronics, analogue electronics, physics for electronics.

CIRCUITS TO BUILD: From basic principles to circuit-building, The Modern Electronics Manual and its Supplements describe how to assemble radios, loudspeakers, amplifiers, car projects, computer interfaces, measuring instruments, workshop equipment, security systems, etc.

GUARANTEE

Our 30 day money back guarantee gives you **complete peace of mind.** If you are not entirely happy with the Manual, for whatever reason, simply return it to us in good condition within 30 days and we will make a **full refund of your payment** – no small print and no questions asked.

(Overseas buyers do have to pay the postage charge)

ESSENTIAL DATA: Extensive tables on diodes, transistors, thyristors and triacs, digital and linear i.c.s, microprocessors.

The Manual also has an extensive **Glossary,** and covers **Safety, Specialist Vocabulary with Abbreviations** and **Suppliers.** The most comprehensive reference work ever produced at a price you can afford, the revised edition of **THE MODERN ELECTRONICS MANUAL** provides you with all the essential information you need.

OVER 1,000 A4 loose leaf pages in a sturdy ring binder all for just **£39.95** plus **£6.00** post and packing. Regular Supplements continuously extend the Manual with new material, each Supplement contains approximately 160 pages of information. These and sent about five times a year and cost **£23.50** plus **£2.50** p&p. You can of course return any Supplement (within 10 days) or cancel the Supplements at any time.

Wimborne Publishing Ltd., Dept. Y2
Allen House, East Borough,
Wimborne,
Dorset BH21 1PF
Tel: 01202 881749 Fax: 01202 841692

PLEASE

send me **THE MODERN ELECTRONICS MANUAL** plus a **FREE SUPPLEMENT.**

I enclose payment of **£45.95.** I shall also receive the appropriate supplements several times a year. These are billed separately and can be discontinued at any time. Should I decide not to keep the Manual I will return it to you within 30 days for a full refund.

FULL NAME ....
(PLEASE PRINT)

ADDRESS...

....

.... POSTCODE ....

SIGNATURE...

☐ I enclose cheque/PO payable to Wimborne Publishing Ltd.

☐ Please charge my Visa/Mastercard/Access

Card No. .... Card Ex. Date ....

ORDER FORM

Simply complete and return the order form with your payment to the following address:

Wimborne Publishing Ltd, Dept. Y2
Allen House, East Borough, Wimborne,
Dorset BH21 1PF

OVERSEAS ORDERS: All overseas orders **must** be prepaid and are supplied under a money-back guarantee of satisfaction. If you are not entirely happy with the Manual return it within a month for a refund of the purchase price (you do have to pay the overseas postage). **SEND £39.95 PLUS THE POSTAGE SHOWN BELOW:**

EIRE		AIR MAIL ONLY £11
EUROPE (E.E.C. Countries)		AIR MAIL ONLY £20
EUROPE (non E.E.C.)	SURFACE MAIL £20,	AIR MAIL £26
U.S.A. & CANADA	SURFACE MAIL £25,	AIR MAIL £32
FAR EAST & AUSTRALIA	SURFACE MAIL £31,	AIR MAIL £33
REST OF WORLD	SURFACE MAIL £25,	AIR MAIL £44

Note surface mail can take over 10 weeks to some parts of the world. Each manual weighs about 4kg including the free supplement when packed.

All payments must be made in £'s Sterling payable to Wimborne Publishing Ltd. We accept Mastercard (Access) and Visa credit cards.

Techniques

ACTUALLY DOING IT!

by Robert Penfold

AS pointed out at least once previously, letters from readers who are having problems with projects that refuse to work are relatively rare these days. Although the general level of sophistication of published projects has steadily risen over the years, much of this sophistication is handled by complex integrated circuits.

The number of components in the average project has probably changed little over the years. This factor, coupled with increased use of custom printed circuit boards, means that modern projects are generally easier to construct than those of twenty or so years ago.

Beginners Luck

This is good news for beginners at electronic project construction, as they have a relatively good chance of constructing a project that will work first time. Feedback from readers would tend to suggest that the main problem these days is in locating and identifying the right components, and that assembling the components into a finished project is the easy part! In truth there should be no major problems in obtaining and identifying components provided you go about things the right way.

I make no excuse for repeating the much given advice that a couple of the larger component catalogues should be regarded as an essential part of the hobby. They may cost a few pounds to buy, but this is money well spent.

The larger catalogues contain a wealth of useful data and illustrations, and beginners can learn a great deal from them. Obtaining the components you need is always going to be an uphill struggle without the aid of one or two decent component catalogues.

It may be stating the obvious when I suggest reading the articles describing the projects you intend to build, but a certain percentage of queries from readers requests information that is provided in the articles concerned. In the case of projects in *EPE* you should also consult the *ShopTalk* feature, which gives buying advice for any out of the ordinary components used in that month's projects.

With any project it is worthwhile ensuring that you can obtain any unusual components before buying the rest of the parts. With older designs it is essential to do so, as it is quite likely that any components that were out of the ordinary several years ago will be totally unobtainable now.

It may be possible to track down obsolete semiconductors for an old design, and there are one or two companies amongst the advertising pages that specialise in this type of thing. The problem with many of these components is that their current prices are often quite high, and they can be as much as ten times their original price. They are mainly sold as spares for existing equipment, and are not necessarily a realistic prospect for new projects.

Numbers Game

Semiconductor type numbers seem to cause a certain amount of confusion, and not just to beginners! In fact they are probably the main cause of difficulties when trying to identify and buy the correct components.

The problem stems from the fact that many semiconductors are produced by more than one manufacturer. In an ideal world the type number would be exactly the same regardless of the manufacturer, and with most semiconductors this is indeed the case. A BC549 transistor is always a BC549 transistor, no matter which company manufactured it.

Most of the confusion with transistors and diodes occurs because the actual devices are often marked with a few numbers and letters in addition to the type number. These extra characters are usually of no practical importance, and simply indicate the name of the manufacturer, the date of manufacture in some highly cryptic form, a batch number, or something of this nature. Extraneous numbers and letters are to be found on capacitors and many other components, but you soon get used to sorting out the "wheat from the chaff."

Some transistor type numbers carry a suffix letter, and this can sometimes be of importance. This suffix letter is "A", "B", or "C", and indicates the gain group of the device ("A" is the lowest and "C" is the highest). A BC549C for example, is a BC549 transistor in the highest gain group.

If a particular gain group is specified in a components list, then it is important that a device having the appropriate suffix letter is used. In all other cases it is acceptable to use a device having any suffix letter, or no suffix at all.

It used to be quite common for transistors to have a suffix letter which indicated that a different leadout configuration was used for that particular version of the device. This type of thing is less common these days, and it is now the norm for each version of a device to have its own type number. However, some of the older devices having a suffix letter are still available and in use today.

The only common examples are the BC182/3/4, and BC212/3/4 series, which are available with and without an *"L"* suffix. Fig.1 shows the leadout configurations for the "L" suffix and non-suffix versions of these transistors.

As is the convention for transistors, thyristors, etc., Fig.1 shows base views (i.e. the device viewed with the leads pointing towards you). The only difference between the two types is the leadout configuration, so they are interchangeable, provided you are careful to get them connected correctly.

On the other hand, mistakes are less likely to be made if you obtain the right type. There should be no difficulty here, as the "L" suffix and plain versions are both readily available.

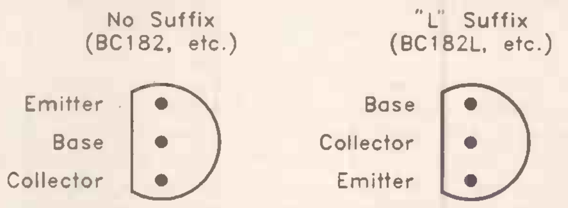


Fig. 1. Pinout details for the BC182 series of transistors, and the "L" suffix versions (underside, pin view).

Some Confusion

From time-to-time, letters are received from readers who are having difficulty in getting J-f.e.t. transistors connected correctly. The main offenders seem to be the 2N3819, and the BF244. The latter is also available with "A" and "B" suffix letters, but these are equivalent to the gain grouping of some bipolar transistors, and do not indicate a different leadout configuration.

The initial cause of confusion over J-f.e.t. leadouts was caused by the drain (d) and source (s) terminals being transposed on the leadout diagrams in the initial 2N3819 data sheets. Apparently some circuits functioned quite well despite the fact that the 2N3819 was connected around the wrong way!

More recently, confusion has arisen due to the introduction of a different case style having a totally different leadout configuration. Leadout diagrams for both types are shown in Fig. 2.

As the encapsulations are different for the two types, it should be obvious which particular version you have, even though the type numbers would seem to be exactly the same for both versions.

Integrated Numbers

Probably most of the confusion over type numbers occurs with integrated circuits (i.c.s). Many integrated circuit type numbers are devised by individual manufacturers, and are not standardised in the same way as most transistor and diode type numbers.

This is fine for integrated circuits that are only produced by a single manufacturer, but most devices are produced by two or more manufacturers. This often leads to an i.c. being produced under several similar type numbers.

Many integrated circuit type numbers break down into *three* sections. First there are one, two, or three letters which identify the manufacturer.

For example, devices produced by RCA usually have the letters "CA" at the start of the type number. Table 1 gives details of some of the prefixes used by some of the larger semiconductor manufacturers.

Next there is a three or four digit number, and this is the actual type number.

Finally, there is usually a one or two letter suffix which indicates the type of encapsulation. Devices used by the home constructor are generally in a d.i.l. (dual-in-line) plastic encapsulation, and have either a "C", "N", "E", or "P" suffix.

A "Components List" might just give the basic type number, or it could give a full type number. For example, the popular 741 operational amplifier (op.amp) might be specified as a "741", or as something like a µA741C.

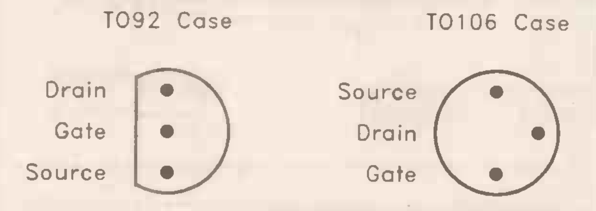


Fig. 2. Alternative encapsulations/pinouts for the 2N3819 and some other J-f.e.t.s. (underside, pin view).

Table 1:

PREFIX	*MANUFACTURER*
AD, OP	Analogue Devices
CA, CD	RCA
HA	Harris Semiconductors
ICL, ICM	Intersil
LM, LF, LH	National Semiconductors
LT	Linear Technology
MAX	Maxim
MC	Motorola
NE, SE	Signetics
SN,TL	Texas
SP,SL	Plessey
TS	Teledyne Components
µA	Fairchild
Z	Ferranti

Similarly, in component catalogues a 741 might be listed as such, or under a specific type number, or both. This could obviously lead to confusion, with the same basic type number being used for totally different devices.

In practice this is rarely a problem, but it is a potential pitfall. The components lists in *Everyday Practical Electronics* specify the basic function of each semiconductor (Bifet op.amp, quad 2-input NAND gate, etc.).

This should avoid any problems with the wrong device being ordered. If a component in a catalogue has the right basic type number and function, then you can be fairly certain that it is the device you require.

Logical Numbers

TTL logic devices differ slightly from the standard scheme of things. The original series of TTL chips conform to the standard setup, and have the 74** number sandwiched between the manufacturer's prefix and what is usually an "N" suffix to denote a plastic d.i.l. encapsulation.

As various series of improved TTL chips were introduced, they had two or three letters added into the middle of the type numbers. These extra letters indicate the logic family of each chip.

For example, the 7408 is the original TTL quad 2-input AND gate, the 74LS08 is the low power Schottky version, and the 74HC08 is the high speed CMOS version.

The compatibility (or lack of it) between TTL logic families is a complex matter, and is something that beginners should not become embroiled with. Only use the exact type specified in a components list, and do not be tempted to a type from the wrong logic family.

Genuine "Duds"

Some readers worry about the type numbers on i.c.s differing slightly from what they ordered. I suppose that strictly speaking if you order (say) an LF351N op.amp, then you should be supplied with a genuine LF351N, and not an exact equivalent such as a KF351N.

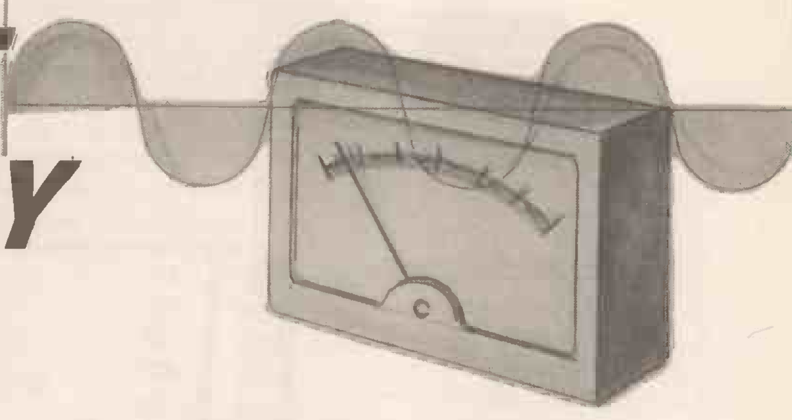
Not unreasonably, retailers tend to buy semiconductors from the firm offering the best price, and this can lead to alternatives being supplied. This is of no practical consequence to the consumer. You are getting exactly the same device, but from a different manufacturer and under a slightly different type number.

Where an alternative device is supplied, the retailer should make this clear on the invoice, or in a simple explanatory note supplied with the order. If in doubt, an enquiry to the retailer should soon ascertain whether the devices supplied are proper alternatives to the devices you ordered, or the wrong goods have been supplied in error.

About 25 to 30 years ago there were problems with sub-standard or even totally non-functioning devices being relabelled to look like the "real thing", and sold as such. At one time there was quite a major problem with these so-called "genuine duds."

It would seem that this practice has returned recently, but it only seems to be the more expensive chips, particularly some microprocessors and memory chips, that are the subject of this scam. Most of the semiconductors used in electronic projects cost a few pence when bought in bulk, and there is presumably no point in counterfeiting such low cost items. Any semiconductors you buy will be of good quality and the "genuine article."

ANALOGUE FREQUENCY METER



ANDY FLIND

Switch on to the right frequency with this easy to use and construct, piece of test equipment.

AMONGST numerous items of test equipment built over the years, one of the most consistently useful has been an Analogue Frequency Meter. Despite the acquisition of a digital instrument the home-built analogue unit is still preferred in many cases because it is so quick and simple to use.

The six-place accuracy of a digital meter is often unnecessary, whilst the procedure of setting the count period, decoding the decimal position and adjusting input and filtering levels are a hassle one could do without. By contrast the analogue meter is simply connected to the circuit and a suitable range selected to obtain a reading.

Much of the time it is only necessary to know, perhaps, if the circuit is oscillating at two or ten kilohertz, or if its adjustment range is around ten to one, so reduced accuracy is perfectly acceptable whilst speed and ease of taking the reading is a distinct advantage. However, since the original analogue meter was designed over ten years ago, it seemed worthwhile to re-examine its design with a view to improvement. This article describes the construction of the new meter.

HEART OF THE MATTER

The heart of the instrument is a 0 to 100Hz frequency-to-voltage circuit. This is very simple to calibrate because all the constructor has to do is apply a 50Hz mains-derived signal and complete a single adjustment for a half-scale indication. The remaining ranges, extending to a 1MHz full scale, are simply obtained by preceding the basic movement with decade divider stages.

A suitable input circuit for converting various input waveforms to pulses with rapid and jitter-free edges completes the circuit. A block diagram of the complete system is shown in Fig. 1.

One area where worthwhile improvement has been achieved is in the frequency-to-voltage conversion. The original design simply integrated pulses from a timer. A custom i.c., the LM2917N, is now available to perform this task in a much more sophisticated manner, resulting in a simpler circuit with greater accuracy.

An internal block schematic diagram of the frequency-to-voltage converter i.c. is shown in Fig. 2. From this it can be seen that the chip contains an input amplifier which has some built-in hysteresis although this function is not important in this circuit. The input stage is followed by the heart of the chip, a "charge pump", which transfers a fixed charge to pin 3 for each input pulse. The magnitude of this charge is set by the value of the capacitor connected to pin 2.

Finally, an op.amp and transistor are provided for buffering the output. These can be used in various ways, including the linear driving of meters. As can be seen the chip requires a minimum of external components and a single adjustment is all that is necessary to calibrate its output.

SUPPLY LINES

The power supply arrangement of the LM2917N suggests that it is really intended for use in automotive rev counters. Positive supply is applied to pin 9 and negative "ground" to pin 12. Between these two pins there is an internal 7·6V Zener diode which regulates the voltage for the rest of the internal circuitry.

The manufacturer's information suggests that pin 9 should be supplied from 12V via a current-limiting resistor. Using this feature with a 9V battery supply requires ingenuity, but the feature can be put to good use.

CIRCUIT DESCRIPTION

Moving to the full circuit for the Analogue Frequency Meter, shown in Fig. 3, the power supply will be described first. To ensure an adequate voltage for the internal 7·6V Zener of IC5, bearing in mind that a 9V battery should be able to fall to at least seven volts and preferably six before it has to be discarded, the primary supply is first doubled by the 7660 converter IC4.

This is arranged as a "charge-pump" delivering current to capacitor C10. With a fresh battery, about 17·5V appears across this capacitor, falling to less than 10V as the battery ages.

To avoid current variations that would occur if the Zener in the LM2917N was supplied by a resistor, the constant current source consisting of transistors TR3 and TR4 is used instead. This supplies about 8mA to pin 9 of IC5.

The constant voltage appearing at pin 9 is then buffered by transistor TR5 and used to supply the rest of the circuit, thus avoiding

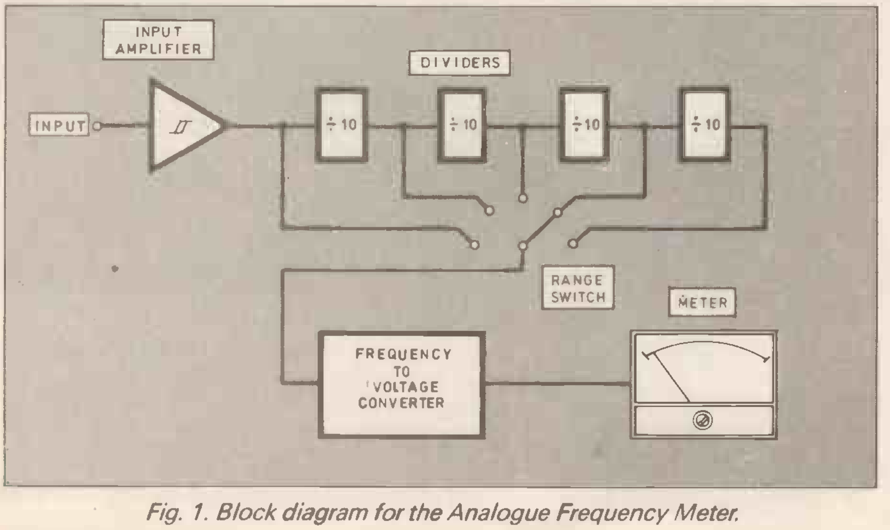


Fig. 1. Block diagram for the Analogue Frequency Meter.

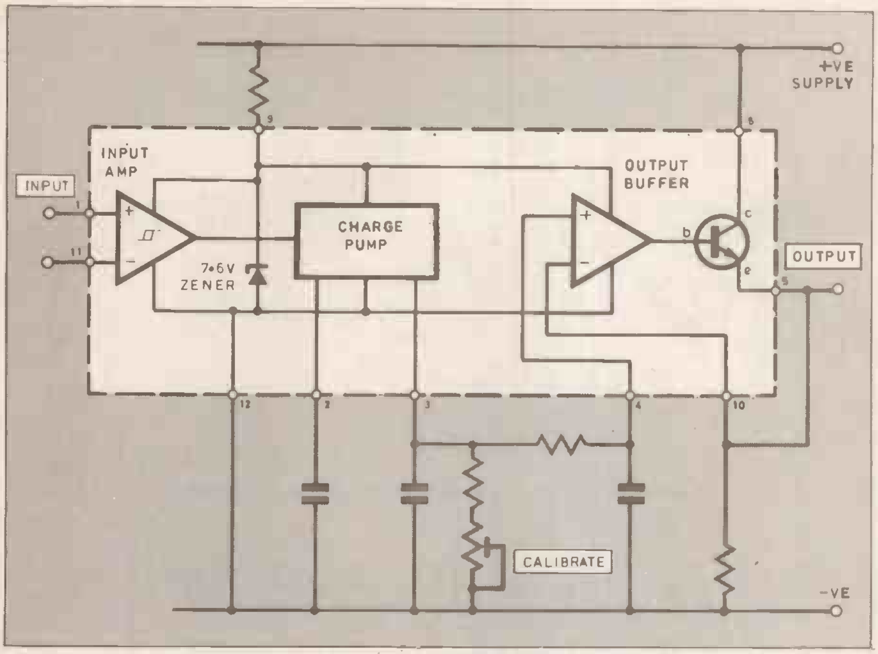


Fig. 2. Internal structure of the LM2917N frequency-to-voltage converter i.c.

the need for a separate regulator. Because of the 0·6V drop across the base-emitter junction of TR5, this supply is about 7V.

INPUT SIGNAL

Moving to the other end of the circuit, the input signal is a.c.-coupled through capacitor C1 to the gate (g) of the f.e.t. buffer TR1. The diode (D1, D2) and resistor (R1 to R3) network clamps the gate voltage of TR1 to a maximum of about 1·2V peak-to-peak, whilst capacitor C3 compensates for the capacitance of the two diodes at high frequencies.

Transistor TR2 provides a voltage gain of about ten. A *pnp* transistor is used here to maintain correct voltage polarity across the coupling capacitor C4. The output of TR2 is taken to a Schmitt trigger and buffer stage built with IC1.

The design aim was for a circuit that would operate reliably with an input of about 100mV r.m.s., and in fact this begins to respond at about 80mV, well within the objective. The upper voltage limit of the input is dependant mainly upon the voltage ratings of resistor R2 and capacitor C3, so signals up to and possibly beyond 50V r.m.s. should be acceptable without damage. This input circuit operates reliably with no loss of sensitivity to beyond 1·2MHz.

DIVIDERS

Following the input stage, the signal is taken to a group of four CMOS decade dividers contained in the two CMOS 4518B chips, IC2 and IC3. The appropriate output is selected by Range switch S1b and taken to the frequency-to-voltage converter IC5. Switch S1 is a 2-pole 6-way rotary type, with the second half (S1a) serving as the power On/Off switch. It has been arranged so that the highest range is selected first to reduce the chance of over-driving the meter when it is switched on with a high frequency present at the input.

The output from IC5's charge pump is dumped into capacitor C14 with calibration and discharge resistor R18 and preset VR1 across it. The voltage on this capacitor, nominally one volt at full scale, is taken through the low-pass filter, made up of R19 and C15, to pin 4 which is the input of the output buffering op.amp. The other input to this op.amp appears at pin 10 and is connected to ground with the one kilohm (1k) resistor R20.

Two possible options are available for

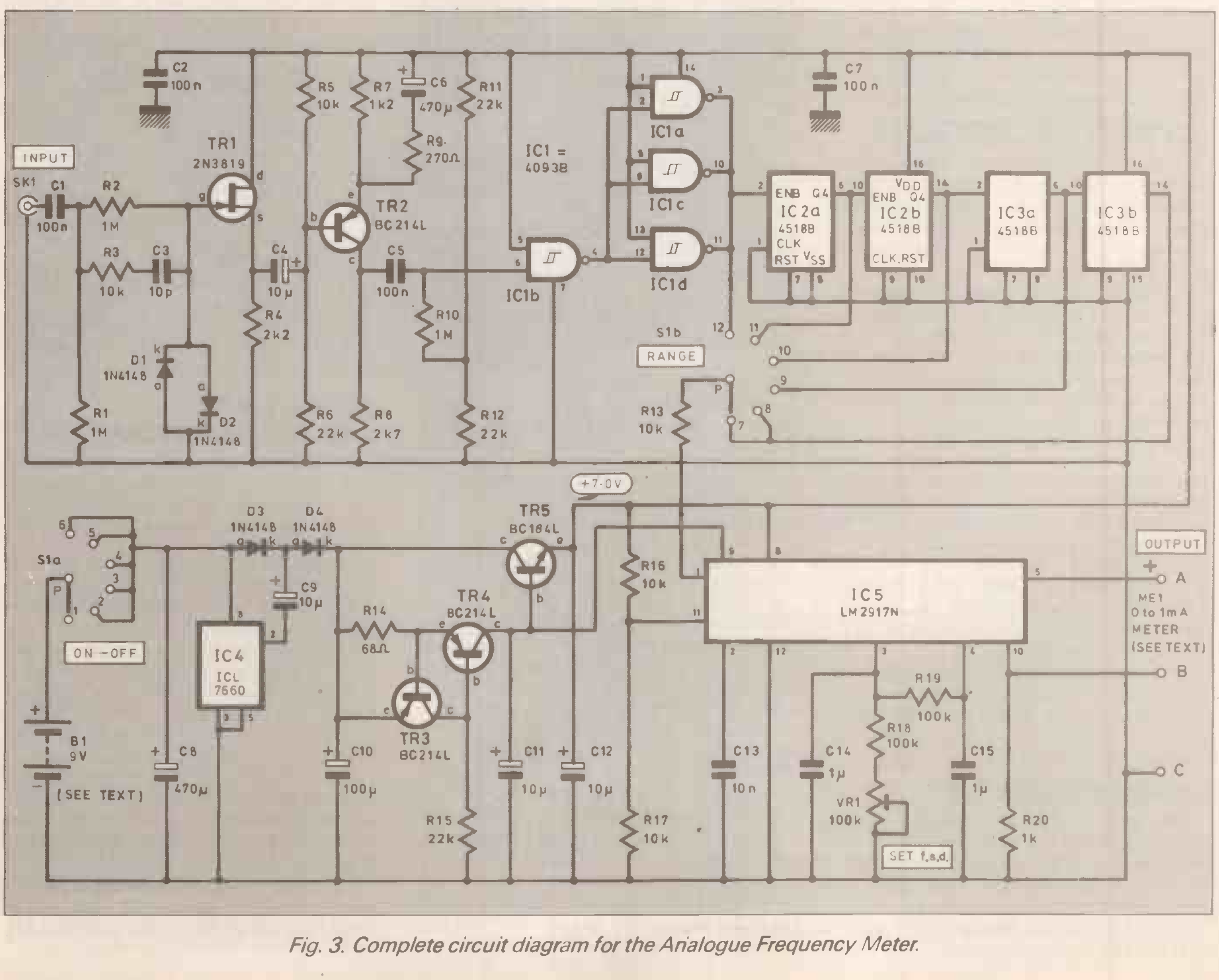
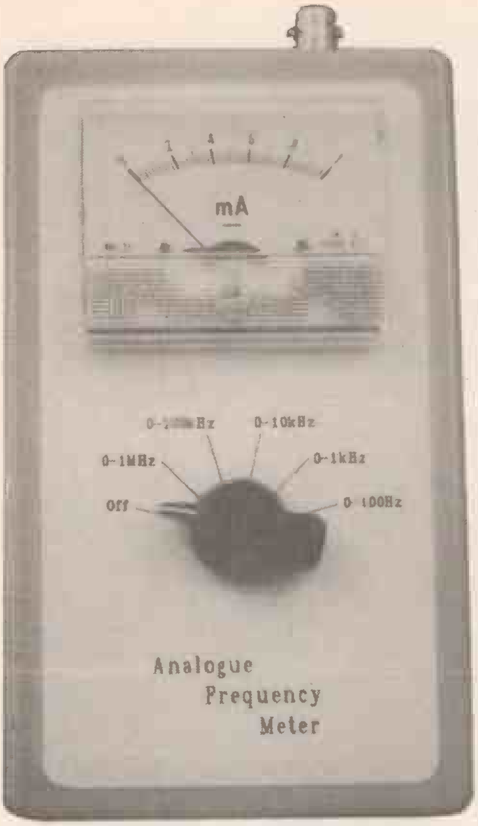


Fig. 3. Complete circuit diagram for the Analogue Frequency Meter.



connecting the meter. The internal output transistor emitter (e), from pin 5, can be shorted to pin 10 and the output will then consist of 0V to 1V at low impedance, which can be used with a one volt meter. Alternatively, where a 1mA movement is to be used as in the prototype, this can be connected between pins 5 and 10, in which case resistor R20 becomes part of a feedback network and the circuit delivers a 0 to 1mA output. This will be described in greater detail later.

CONSTRUCTION

Most of the components for this project are assembled onto a compact printed circuit board, the topside component layout and full size copper foil master is shown in Fig. 4. This board is available from the *EPE PCB Service*, code 957.

To ensure the best chance of successful construction, it is recommended that the following sequence is followed. Firstly, all the passive components should be fitted. This is everything except the transistors and i.c.s, and for ease they should be fitted in order of height.

The twenty resistors can be fitted first, followed by the four diodes, then the small ceramic capacitors, the 10n polyester capacitor C13, and the larger 1µ polyesters C14 and C15. These should be followed by the electrolytics, starting with the four 10µ components, then the 100µ C10 and finally the two 470µ capacitors C6 and C8. Note that all the electrolytics have their positive connections towards the top of the board.

The calibration cermet preset VR1, can now be fitted, noting that the adjustment screw is at the top. It will still work if it is placed the other way up, but the effect of rotation will be reversed.

FIRST TESTS

The first test can now be carried out. Power leads and the socket for IC4 should be fitted, and IC4 inserted. This, like IC1, IC2 and IC3, is a CMOS component, so precautions against static should be observed whilst handling these.

If the circuit is now powered, there will be a brief surge as the capacitors charge, following which the current drawn from the supply should settle to less than 100µA. The exact value will depend on the leakage of the electrolytics, which may take a few minutes to "form". The presence of around 17V across capacitor C10 should be checked, confirming that IC4 is operating.

Following this the socket for IC5 can be fitted along with transistors TR3, TR4, and TR5, taking care with their type and orientation. The p.c.b. should be powered up again and, using a 10mA meter with a one kilohm (1k) resistor in series to protect it, the current between pin 9 of IC5's *socket* and negative should be measured.

This should read about 8mA to 9mA. If this checks out, IC5 can be fitted and the circuit powered up again. Tests should be made for the presence of 7·6V at pin 9 of IC5 and 7V at pin 8. The overall current drain, if measured, should now be about 21mA.

Transistors TR1 and TR2 can be fitted next. Static precautions may be advisable whilst fitting the f.e.t. TR1 as a couple of these mysteriously expired during development of this project, suggesting they may be electrically fragile.

If the circuit board is now powered up, the collector (c) voltage of TR2 should be around 3·5V, an easy point to check this being the top of resistor R8. The source(s) voltage of TR1 can be checked at the top of R4. This will vary with the particular f.e.t. in use, but should be somewhere between 0·5V and 2·5V. If a fault occurs in this stage it will usually be zero or nearly full supply, 7V.

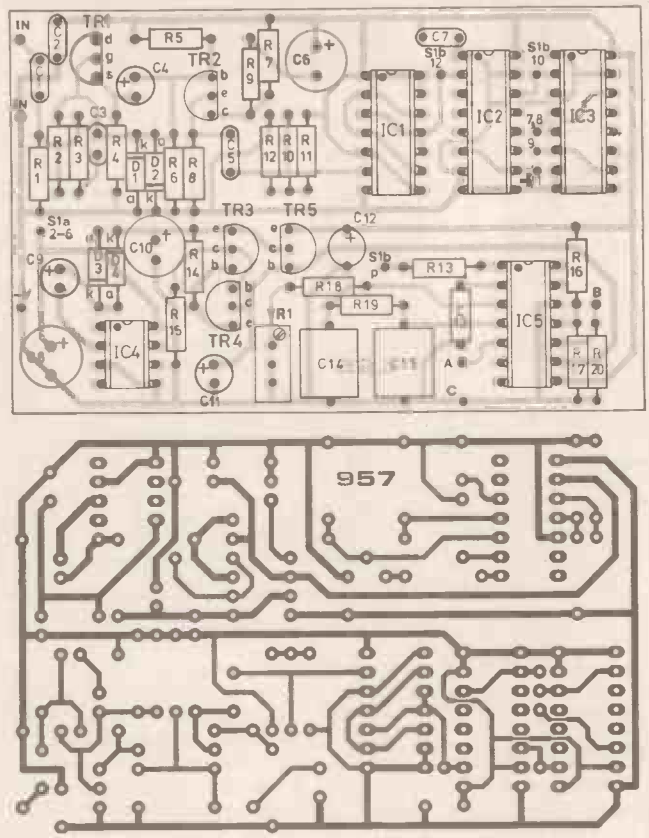
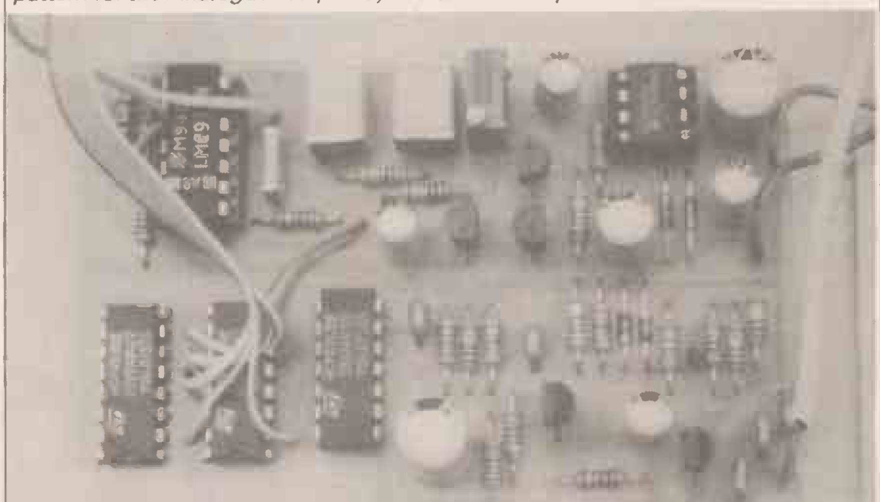


Fig. 4. Printed circuit board component layout and full size copper foil master pattern for the Analogue Frequency Meter. The completed board is shown below.



COMPONENTS

Approx cost guidance only excluding Batt. **£32**

Resistors

R1, R2, R10	1M (3 off)
R3, R5, R13, R16, R17	10k (5 off)
R4	2k2
R6, R11, R12, R15	22k (4 off)
R7	1k2
R8	2k7
R9	270Ω
R14	68Ω
R18, R19	100k (2 off)
R20	1k

All 0·6W 1% carbon film

See SHOP TALK Page

Potentiometer

VR1	100k 22-turn cermet preset, vertical

Capacitors

C1, C2, C5, C7	100n resin-dipped ceramic (4 off)
C3	10p resin-dipped ceramic
C4, C9, C11, C12	10µ radial elect. 50V (4 off)
C6, C8	470µ radial elect. 16V (2 off)
C10	100µ radial elect. 25V
C13	10n polyester layer
C14, C15	1µ polyester layer (2 off)

Semiconductors

D1, D2, D3, D4	1N4148 silicon diode (4 off)
TR1	2N3819 *n*-channel f.e.t.
TR2, TR3, TR4	BC214L *pnp* silicon transistor (3 off)
TR5	BC184L *npn* silicon transistor
IC1	4093B CMOS quad NAND gate
IC2, IC3	4518B CMOS dual decade divider (2 off)
IC4	ICL7660 voltage converter
IC5	LM2917N frequency-to-voltage converter

Miscellaneous

ME1	0-1mA f.s.d. moving coil meter (see text)
S1	2-pole 6-way rotary switch
SK1	50 ohm BNC socket
B1	9V PP3 battery (or six AA cells in holder – see text)

Printed circuit board available from *EPE PCB Service*, code 957; ABS plastic case, size 90mm × 149·5mm × 52·5mm external; 8-pin d.i.l. socket; 14-pin d.i.l. socket; pointer knob; PP3 type battery clip; multi-strand connecting wire; short piece of *screened* lead; solder pins; solder etc.

The quad NAND Schmitt trigger IC1 can be fitted next. Sockets were not used for this or the two divider i.c.s (IC2, IC3) in the prototype in order to avoid any extra capacitance they might introduce into the circuit. Where CMOS i.c.s are soldered directly into circuit, it is sometimes recommended that the *supply pins* should be soldered first, as this enables the internal static protection of these chips to operate correctly.

INPUT/OUTPUT TESTING

A lead for the input signal should be fitted, *screened* lead being preferable. The next test involves applying an input. In many cases touching the input with a finger will be sufficient as the level of "hum" voltage induced in the body is often sufficient to operate the input circuit. In the event that it isn't, a small mains transformer with a few volts output can be used, or a signal generator if one is available.

With an input applied, the output from pins 10 or 11 of IC1 should be checked either with an oscilloscope, where the "squared" waveform should be seen, or with a meter to inspect the average level. The exact voltage will depend on the waveform of the input signal, but it should not be far away from half supply, 3·5V. With the input removed, this point should stop at zero or full supply voltage.

Finally, the dividers IC2 and IC3 can be fitted. If the 50Hz input is re-applied, it will be possible to inspect the output of the first three dividers. The first, at IC2 pin 6, will show an average d.c. level of about 1·4V, and where an analogue meter is used there may be a distinct visible flicker as it is pulsing at 5Hz. The next output, from IC2 pin 14, will be a pulse every two seconds. The third output, from IC3 pin 6, pulses every 20 seconds.

Only very patient constructors will wish to test the last output with a 50Hz input as it pulses only once every 200 seconds! If a signal generator is available a higher input frequency can be used, the last output being from IC3 pin 14.

CASE DETAILS

The prototype instrument was fitted into an ABS plastic case having external dimensions of 90mm × 149·5 × 52·5mm. The layout is not critical in any way, and the general arrangement can be seen from the photographs.

A frequency meter is normally used only for relatively short periods so the prototype is fitted with a PP3 battery. However, the circuit has an overall drain of 25mA, so if extended use is envisaged it might be preferable to use a pack of six AA cells instead. There is ample room for one of these, so long as the Range/On-Off switch is not placed too close to the end of the case.

The connections between the board and other parts are shown in Fig. 5. Although not essential, ribbon cable produces a much neater assembly, particularly for the range switch S1. A BNC socket is recommended for the input, as these are far more reliable than cheaper types such as u.h.f. or phono sockets. They look more professional too.

METER OPTION

Various meter options are available. The unit could be fitted in a case without a meter, and terminals provided for connection to the workshop multimeter. It could even be used with a DVM for a digital readout.

If the points "A" and "B" are shorted together, a 0 to 1V output can be taken from between them and "C" for connection to a meter having a 1V range. If a 1mA meter is used as in the prototype, it is suggested that this is placed between points "A" (positive) and "B", leaving "C" *unused*.

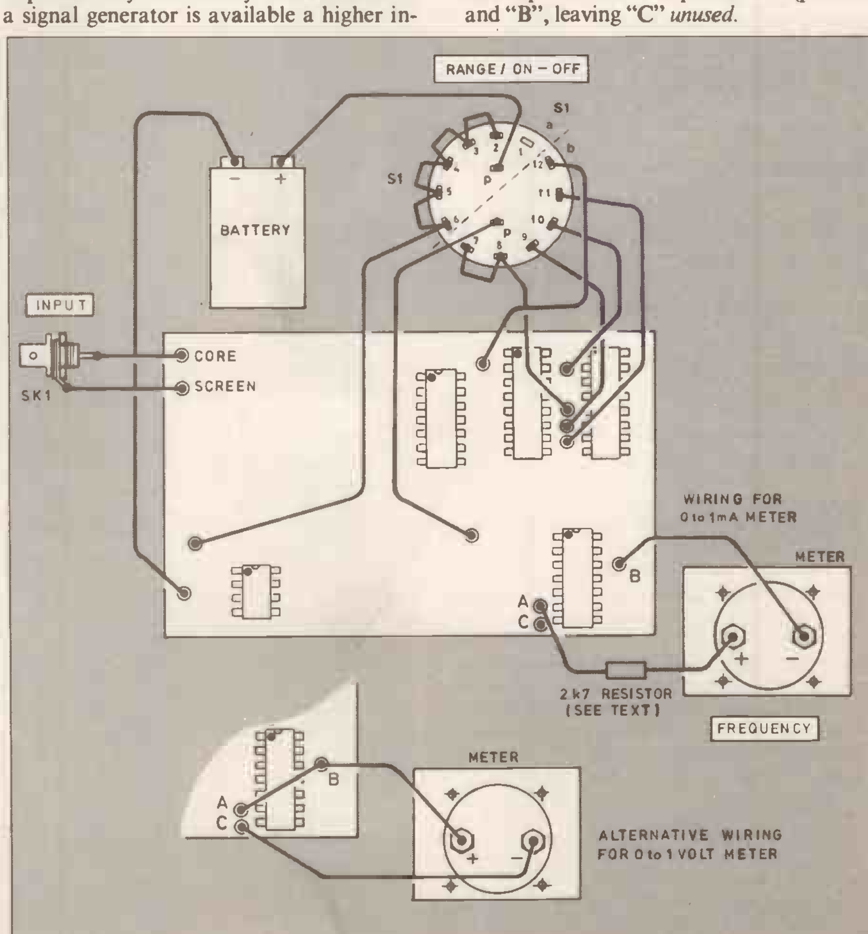
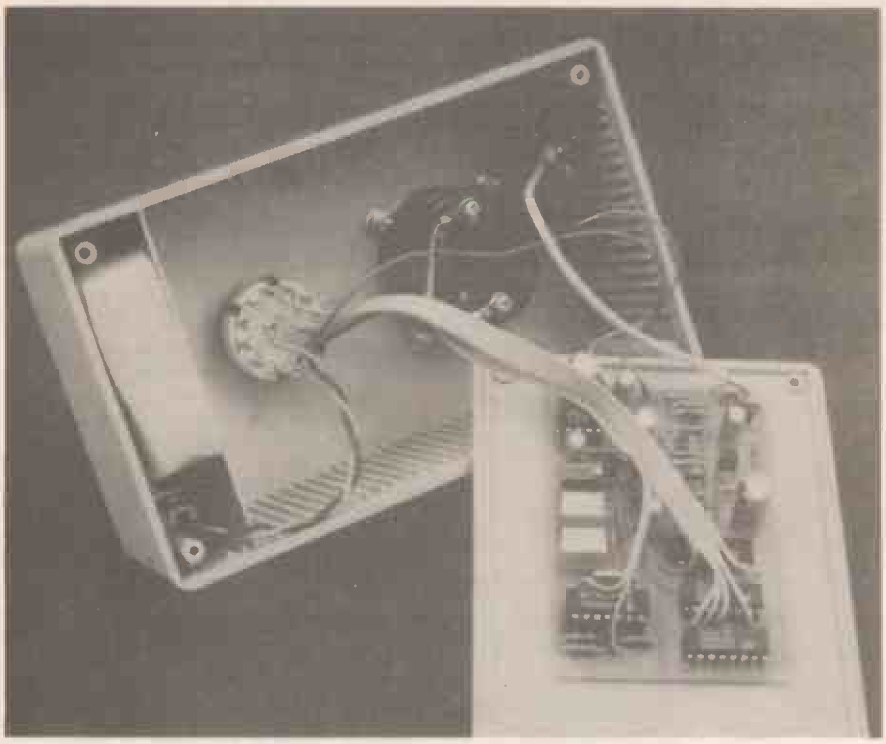


Fig. 5. Interwiring between the p.c.b. and off-board components. Also included are details for wiring to the alternative meter.



Bottom "lid" of the plastic case removed and flipped-over to reveal positioning of the p.c.b. and the layout of components in the "base" of the meter. Note the battery "compartment".

If this is done, some extra resistance can be placed in series with the meter to reduce overloading it when the circuit tries to drive it beyond full scale. This will not affect the reading because the meter is now in a feedback loop and the output op.amp will automatically compensate for the voltage appearing across this resistor. The value will depend on the meter being used, but 2·7k proved about right in the prototype.

CALIBRATION

To calibrate the instrument, it should first be switched on and, with no input, any necessary adjustment to the meter's zero should be made. A 50Hz signal should then be applied, using the basic 0Hz to 100Hz range. A wet finger may suffice, or the output from a small low-voltage transformer may be used. Preset VR1 is then adjusted as accurately as possible to a *half-scale* reading, following which the instrument is ready for use.

With its custom frequency-to-voltage output i.c. this meter is considerably more accurate and linear than its predecessor. It's less than half the size and displays less flicker at low frequencies, in fact it is perfectly readable down to about 5Hz, a twofold improvement.

Last but not least, it uses only one battery in place of two. With the present high cost of batteries, this improvement alone perhaps justifies the effort. □

RING BINDERS FOR EPE

This ring binder uses a special system to allow the issues to be easily removed and reinserted without any damage. A nylon strip slips over each issue and this passes over the four rings in the binder, thus holding the magazine in place (see photo).

The binders are finished in hard wearing royal blue p.v.c. with the magazine logo in gold on the spine. They will keep your issues neat and tidy but allow you to remove them for use easily.

The price is £5.95 plus £3.50 post and packing. If you order more than one binder add £1 postage for each binder after the initial £3.50 postage charge, (for overseas readers the postage is £6.00 each to everywhere except Australia and Papua New Guinea which costs £10.50 each).

Send your payment in £'s sterling cheque or PO (Overseas readers send £ sterling bank draft, or cheque drawn on a UK bank or pay by credit card), to Everyday Practical Electronics, Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749. Fax: 01202 841692 (We cannot reply to queries or confirm orders by fax due to the high costs).

We also accept credit card payments. Mastercard (Access) or Visa (minimum credit card order £5). Send your card number and card expiry date plus cardholders address (if different to the delivery address).

Direct Book Service

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page. For another selection of books see next month's issue.

Everyday Practical Electronics Books

ELECTRONIC PROJECTS – BOOK 1
Published by *Everyday Practical Electronics* in association with Magenta Electronics.
Contains twenty of the best projects from previous issues of EE each backed with a kit of components. The projects are: Seashell Sea Synthesiser, EE Treasure Hunter, Mini Strobe, Digital Capacitance Meter, Three Channel Sound to Light, BBC 16K Sideways Ram, Simple Short Wave Radio, Insulation Tester, Stepper Motor Interface, Eprom Eraser, 200MHz Digital Frequency Meter, Infra Red Alarm, EE Equaliser Ioniser, Bat Detector, Acoustic Probe, Mains Tester and Fuse Finder, Light Rider – (Lapel Badge, Disco Lights, Chaser Light), Musical Doorbell, Function Generator, Tilt Alarm, 10W Audio Amplifier, EE Buccaneer Induction Balance Metal Detector, BBC Midi Interface, Variable Bench Power Supply, Pet Scarer, Audio Signal Generator.
128 pages (A4 size) Order code EP1 £2.45

ELECTRONICS TEACH-IN 88/89 – INTRODUCING MICROPROCESSORS
Mike Tooley BA (published by *Everyday Practical Electronics*)
A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc. Starting with basic terminology, integrated circuits, logic families and numbering systems the text builds in stages, with revision and assessments built in, up to programming, languages, flow charts, etc. The course is ideal for the newcomer to the subject.
80 pages (A4 size) Order code TI-88/89 £2.45

ELECTRONICS TEACH-IN No. 6
DESIGN YOUR OWN CIRCUITS
(Published by *Everyday Practical Electronics*)
Mike Tooley BA
This book is designed for the beginner and experienced reader alike, and aims to dispel some of the mystique associated with the design of electronic circuits. It shows how even the relative newcomer to electronics can, with the right approach, design and realise quite complex circuits.
Fourteen individual p.c.b. modules are described which, with various detailed modifications, should allow anyone to design and construct a very wide range of different projects. Nine "hands-on" complete DIY projects have also been included so readers can follow the thinking behind design, assembly, construction, testing and evaluation, together with suggested "mods" to meet individual needs. The practical projects have each been designed to stand on their own as complete items of equipment. P.C.B.s for all the modules and projects are available by mail order.
The subjects covered in each chapter of the book are: Introduction and Power Supplies: Small Signal Amplifiers: Power Amplifiers: Oscillators: Logic Circuits; Timers; Radio; Power Control; Optoelectronics.
The nine complete constructional projects are: Versatile Bench Power Supply; Simple Intercom; Bench Amplifier/Signal Tracer; Waveform Generator; Electronic Die; Pulse Generator; Radio Receiver; Disco Lights Controller; Optical Communications Link.
136 pages (A4 size) Order code T16 £3.45

TEACH-IN No. 7 plus FREE Software
ANALOGUE AND DIGITAL ELECTRONIC COURSE
(Published by *Everyday Practical Electronics*)
Alan Winstanley and Keith Dye B.Eng(Tech)AMIEE
The highly acclaimed *Teach-In* series, which included the construction and use of the *Mini Lab* and *Micro Lab* test and development units, has been put together in book form. Additionally EPT Educational Software have developed a GCSE Electronics software program to compliment the course and a FREE DISC covering the first two parts of the course is included with the book.
An interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels, and starts with fundamental principles.
If you are taking electronics or technology at school or college, this book is for you. If you just want to learn the basics of electronics then this is for you. If you are teaching electronics or technology you must make sure you see it. *Teach-In No. 7* will be invaluable if you are considering a career in electronics or even if you are already training in one. The Mini Lab and software enable the construction and testing of both demonstration and development circuits. These learning aids bring electronics to life in an enjoyable and interesting way: you will both see and hear the electron in action! The Micro Lab microprocessor add-on system will appeal to higher level students and those developing microprocessor projects.
152 pages (A4 size) Order code T17 £3.95

Computers and Computing

HOW TO CHOOSE A SMALL BUSINESS COMPUTER SYSTEM
D. Weale
This book is for anyone intending to buy an IBM compatible computer system, whether it is their first system or a replacement. There are sections on hardware, application and systems programs and how to actually make your choice as well as sections on the law, ergonomics and a glossary of common terms.
The text contains many useful tips and some warnings (which could save much effort and expense).
114 pages Order code BP323 £4.95

MAKING MS-DOS WORK FOR YOU (covers version 6.2)
N. Kantaris & P. R. M. Oliver
This book was written with the busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the book has also been designed to be circular, which means that you don't have to start at the beginning and go to the end.
The book explains: How to write customised batch files which allow you to display what you want on your screen, and in the form and order you want it, instead of being forced to use the DOS prompt on a blank screen. How to design and set up a fast interactive and professional looking menu system, so that you or anyone else can run utility applications or commercial software packages easily. How the ANSI.SYS display and keyboard commands can be used to position the cursor on any part of the screen, change the intensity of the displayed characters or change their colour. How the Edit screen editor or the Edlin line editor can be used to enter ESCape (ANSI.SYS) commands into simple ASCII files to allow control of both your screen display and your printer. How to control the operation of the two main types of printers in use today, Epson compatible dot matrix and HP compatible laser printers. How to use several routines, such as moving and finding files, protecting files from accidental erasure, a simplified backup process, a screen saver, and a disc cataloguing system.
The Debug program and how it can be used to create, see and change the contents of any file, including those of programs written in assembler code. This includes how to find your way around the names and tasks of the CPU registers and the meeting of some simple assembler mnemonics.
182 pages Order code BP319 £4.95

MULTIMEDIA ON THE PC
Ian R. Sinclair
In this book, you'll find out what a CD ROM is, how it works, and why it is such a perfect add-on for a PC, allowing you to buy programmes, text, graphics and sound on a CD. It also describes the installation of a CD ROM drive and a sound card, pointing out the common problems that arise, and then shows how to use them to create a complete multimedia presentation that contains text, photos, a soundtrack with your own voice recorded as a commentary, even animation and edited video footage.
184 pages Order code PC112 £11.95

A CONCISE INTRODUCTION TO MS-DOS
N. Kantaris
(Revised Edition Covers Version 6.2)
This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nevertheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.
176 pages Order code BP232 £3.95

UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold (Revised Edition)
If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.
This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!
128 pages Order code BP282 £4.95

AN INTRODUCTION TO 6800 ASSEMBLY LANGUAGE
R. A. & J. W. Penfold
Obtain a vast increase in running speed by writing programs for 6800 based micros such as the Commodore, Amiga, Atari ST range or Apple Macintosh range etc., in assembly language. It is not as difficult as one might think and this book covers the fundamentals.
112 pages Order code BP184 £2.95

Testing and Test Gear

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold
This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators.
104 pages Order code BP267 **£3.50**

Audio and Music

PRACTICAL MIDI HANDBOOK
R. A. Penfold
The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.
The Practical MIDI Handbook is aimed primarily at musicians, enthusiasts and technicians who want to exploit the vast capabilities of MIDI, but who have no previous knowledge of electronics or computing. The majority of the book is devoted to an explanation of what MIDI can do and how to exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those manuals.
128 pages Order code PC101 **£6.95**

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN
V. Capel
This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.
148 pages Order code [illegible] **£2.95**

ACOUSTIC FEEDBACK – HOW TO AVOID IT
V. Capel
Feedback is the bane of all public address systems. While feedback cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem.
Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce or reduce feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.
The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.
Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.
92 pages Order code BP310 **£3.95**

PREAMPLIFIER AND FILTER CIRCUITS
R. A. Penfold
This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases).
The preamplifier circuits featured include: Microphone preamplifiers (low impendance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A. equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).
Other circuits include: Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls.
92 pages Order code BP309 **£3.95**

COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold
Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.
If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.
This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.
174 pages Order code PC107 **£8.95**

ELECTRONIC PROJECTS FOR GUITAR
R. A. Penfold
This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.
Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.
110 pages **Temporarily out of print**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold
Practical constructional details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. Includes MOSFET and bipolar transistor designs.
96 pages Order code [illegible] **£3.95**

Theory and Reference

UNDERSTANDING DIGITAL TECHNOLOGY
F. A. Wilson C.G.I.A., C.Eng., F.I.E.E., F.I. Mgt.
This book examines what digital technology has to offer and then considers its arithmetic and how it can be arranged for making decisions in so many processes. It then looks at the part digital has to play in the ever expanding Information Technology, especially in modern transmission systems and television. It avoids getting deeply involved in mathematics.
Various chapters cover: Digital Arithmetic, Electronic Logic, Conversions between Analogue and Digital Structures, Transmission Systems. Several Appendices explain some of the concepts more fully and a glossary of terms is included. Altogether a useful foray into the digital world both for newcomers and also for those who need some revision or updating.
183 pages Order code BP376 **£4.95**

A REFERENCE GUIDE TO PRACTICAL ELECTRONICS TERMS
F. A. Wilson C.G.I.A., C.Eng., F.I.E.E., F.I. Mgt.
Electronic devices surround us on all sides and their numbers are increasing without mercy. Ours is the problem therefore in keeping up with this relentless expansion. Unfortunately we cannot know it all and most of us do not wish to afford the cost of large reference books which explain many concepts in fair detail. Here is an answer, an inexpensive reference guide which explains briefly (but we hope, well) many of the underlying electronics features of practical devices, most of which, to a certain extent, control our lives.
This book is in effect more than just a dictionary of practical electronics terms, it goes a stage further in also getting down to fundamentals. Accordingly the number of terms may be limited but the explanations of the many which are included are designed to leave the reader more competent and satisfied – and this is without the use of complicated mathematics which often on first reading can be confusing.
For those who also wish to get right down to the root of the matter, there is a second volume entitled *A Reference Guide to Basic Electronics Terms* (BP286), each of the books referring to its companion as necessary.
A reference guide for practically everybody concerned with electronics.
432 pages Order code BP287 **£5.95**

ELECTRONIC MODULES AND SYSTEMS FOR BEGINNERS
Owen Bishop
This book describes over 60 modular electronic circuits, how they work, how to build them, and how to use them. The modules may be wired together to make hundreds of different electronic systems, both analogue and digital. To show the reader how to begin building systems from modules, a selection of over 25 electronic systems are described in detail, covering such widely differing applications as timing, home security, measurement, audio (including a simple radio receiver), games and remote control.
200 pages Order code BP266 **£3.95**

Project Building

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold
Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.
The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.
138 pages Order code [illegible] **£4.95**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.
The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.
All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.
132 pages Order code BP374 **£4.95**

45 SIMPLE ELECTRONIC TERMINAL BLOCK PROJECTS
R. Bebbington
Contains 45 easy-to-build electronic projects that can be constructed, by an absolute beginner, on terminal blocks using only a screwdriver and other simple hand tools. No soldering is needed.
Most of the projects can be simply screwed together, by following the layout diagrams, in a matter of minutes and readily unscrewed if desired to make new circuits. A theoretical circuit diagram is also included with each project to help broaden the constructor's experience and knowledge.
The projects included in this book cover a wide range of interests under the chapter headings: Connections and Components, Sound and Music, Entertainment, Security Devices, Communication, Test and Measuring.
163 pages Order code [illegible]78 **£4.95**

HOW TO DESIGN AND MAKE YOUR OWN P.C.B.S
R. A. Penfold
Deals with the simple methods of copying printed circuit board designs from magazines and books and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.
80 pages Order code [illegible] **£2.50**

A BEGINNER'S GUIDE TO MODERN ELECTRONIC COMPONENTS
R. A. Penfold
The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.
166 pages Order code [illegible] **£3.95**

ELECTRONICS SIMPLIFIED – CRYSTAL SET CONSTRUCTION
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.
Especially written for those who wish to participate in the intricacies of electronics more through practical construction than by theoretical study. It is designed for all ages upwards from the day one can read intelligently and handle simple tools.
80 pages Order code BP92 **£1.75**

Circuits and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.
88 pages Order code BP299 **£4.95**

ELECTRONIC ALARM CIRCUITS MANUAL
R. M. Marston
One hundred and forty useful alarm circuits, of a variety of types, are shown in this volume. The operating principle of each one is explained in concise but comprehensive terms, and brief construction notes are given where necessary.

Aimed at the practical design engineer, technician and experimenter, as well as the electronics student and amateur.
124 pages Order code N 11 **£13.95**

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair
This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.
200 pages Order code PC106 **£8.95**

ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS
Robert Penfold
Robots and robotics offer one of the most interesting areas for the electronics hobbyist to experiment in. Today the mechanical side of robots is not too difficult, as there are robotics kit and a wide range of mechanical components available. The microcontroller is not too much of a problem either, since the software need not be terribly complex and many inexpensive home computers are well suited to the task.

The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge this gap.
92 pages Order code BP179 **£2.95**

ELECTRONIC POWER SUPPLY HANDBOOK
Ian R. Sinclair
This book covers the often neglected topic of electronic power supplies. All types of supplies that are used for electronics purposes are covered in detail, starting with cells and batteries and extending by way of rectified supplies and linear stabilisers to modern switch-mode systems, i.c. switch-mode regulators, DC-DC converters and inverters.

The devices, their operating principles and typical circuits are all dealt with in detail. The action of rectifiers and the reservoir capacitor is emphasised, and the subject of stabilisation is covered. The book includes some useful formulae for assessing the likely hum level of a conventional rectifier reservoir supply.
136 pages Order code PC108 **£7.95**

50 SIMPLE LED CIRCUITS
R. N. Soar
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components – the light-emitting diode (LED). Also includes circuits for the 707 common anode display.
64 pages Order code BP42 **£1.95**

BOOK 2 50 more l.e.d. circuits.
50 pages Order code BP87 **£1.95**

CIRCUIT SOURCE BOOK 1
A. Penfold
Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.

The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.

Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
182 pages Order code BP321 **£4.95**

CIRCUIT SOURCE BOOK 2
R. A. Penfold
This book will help you to create and experiment with your own electronic designs by combining and using the various standard "building blocks" circuits provided. Where applicable, advice on how to alter the circuit parameters is provided.

The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.

The topics covered in this book include: 555 oscillators; sinewave oscillators; function generators; CMOS oscillators; voltage controlled oscillators; radio frequency oscillators; 555 monostables; CMOS monostables; TTL monostables; precision long timers; power supply and regulator circuits; negative supply generators and voltage boosters; digital dividers; decoders, etc; counters and display drivers; D/A and A/D converters; opto-isolators, flip/flops, noise generators, tone decoders, etc.

Over 170 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
192 pages Order code BP322 **£4.95**

HOW TO USE OP.AMPS
E. A. Parr
This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.
160 pages Order code BP88 **£2.95**

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold
This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world"
142 pages Order code BP332 **£4.95**

Radio, TV, Satellite

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold
This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include:– An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.
92 pages Order code BP304 **£3.95**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole
Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.

This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.
150 pages Order code BP257 **£3.50**

AERIAL PROJECTS
R. A. Penfold
The subject of aerials is vast but in this book the author has considered practical aerial designs, including active, loop and ferrite aerials which give good performances and are relatively simple and inexpensive to build. The complex theory and mathematics of aerial design have been avoided.

Also included are constructional details of a number of aerial accessories including a pre-selector, attenuator, filters and a tuning unit.
96 pages **Temporarily out of print**

SIMPLE SHORT WAVE RECEIVER CONSTRUCTION
R. A. Penfold
Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to construct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.

The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.

Contains everything you need to know in order to get started in this absorbing hobby.
88 pages Order code BP275 **£3.95**

AN INTRODUCTION TO AMATEUR COMMUNICATIONS SATELLITES
A. Pickford
Communications and broadcast satellites are normally inaccessible to individuals unless they are actively involved in their technicalities by working for organisations such as British Telecom, the various space agencies or military bodies. Even those who possess a satellite television receiver system do not participate in the technical aspects of these highly technological systems.

There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively inexpensive equipment. This equipment can be connected to a home computer such as the BBC Micro or IBM compatible PCs, for the decoding of received signals.

This book describes several currently available systems, their connection to an appropriate computer and how they can be operated with suitable software.
102 pages Order code BP290 **£3.95**

A GUIDE TO THE WORLD'S RADIO STATIONS (1995/96)
P. Shore
Provides the casual listener, amateur radio DXer and the professional radio monitor with an essential reference work designed to guide him or her around the ever more complex radio bands. This new edition has been completely revised and rewritten and incorporates much more information which is divided into the following sections:

Listening to Short Wave Radio; Choosing a Short Wave Radio Receiver; How to Use the IRSG; Abbreviations; County Codes; Worldwide Short Wave Radio Stations; European, Middle Eastern and African Long Wave Radio Stations; European, Near and Middle Eastern and African Medium Wave Radio Stations; Canadian Medium Wave Radio Stations; USA Medium Wave Radio Stations; Broadcasts in English; Programmes for DXers and Short Wave Listeners; UK FM Radio Stations; Time Differences From GMT; Wavelength/Frequency Conversion.
256 pages Order code BP355 **£5.95**

DIRECT BOOK SERVICE
ORDERING DETAILS

Please state the title and order code clearly, print your name and address and add the required postage to the total order.

Add £1.50 to your total order for postage and packing (overseas readers add £3 for countries in the EEC, or add £6 for all countries outside the EEC, surface mail postage) and send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or credit card details (including card expiry date), Visa or Mastercard (Access) – minimum credit card order is £5 – quoting your name and address, the order code and quantities required to **DIRECT BOOK SERVICE, 33 GRAVEL HILL, MERLEY, WIMBORNE, DORSET BH21 1RW** *(mail order only).*

Although books are normally sent within seven days of receipt of your order, please allow a maximum of 28 days for delivery. Overseas readers allow extra time for surface mail post.

Please check price and availability (see latest issue of Everyday Practical Electronics*) before ordering from old lists.*

For a further selection of books see next month's issue.

DIRECT BOOK SERVICE IS A DIVISION OF WIMBORNE PUBLISHING LTD.

BABANI BOOKS

We now supply *all* the books published by Bernard Babani (Publishing) Ltd. We have always supplied a selected list of Babani books and you will find many of them described on the previous pages or in next month's issue of *Everyday Practical Electronics* (all books with a BP prefix to the order code are Babani books). Many readers have asked us to also supply various other Babani books, which have a reputation for value for money.

Our customers tell us they appreciate our speedy service and low postage charge and they would like to be able to purchase all the books from us and thus keep the postage charge to an absolute minimum **(£1.50 for UK p&p no matter how many books you buy)**. We are pleased to be able to respond; we are now able to meet all your requirements for Babani books.

Code	Title	Price
BP37	50 Projects using Relays, SCRs and TRIACs	£2.95
BP39	50 (FET) Field Effect Transistor Projects	£2.95
BP44	IC 555 Projects	£2.95
BP48	Electronic Projects for Beginners	£1.95
BP56	Electronic Security Devices	£2.95
BP76	Power Supply Projects	£2.50
BP78	Practical Computer Experiments	£1.75
BP84	Digital IC Projects	£1.95
BP90	Audio Projects	£2.50
BP95	Model Railway Projects	£2.95
BP115	The Pre-computer Book	£1.95
BP125	25 Simple Amateur Band Aerials	£1.95
BP126	BASIC & PASCAL in Parallel	£1.50
BP132	25 Simple SW Broadcast Band Aerials	£1.95
BP136	25 Simple Indoor and Window Aerials	O.O.P.
BP144	Further Practical Electronics Calculations & Formulae	£4.95
BP145	25 Simple Tropical and MW Band Aerials	£1.75
BP147	An Introduction to 6502 Machine Code	£2.95
BP148	Computer Terminology Explained	£1.95
BP171	Easy Add-on Projects for Amstrad CPC 464, 664, 6128 and MSX Computers	£2.95
BP182	MIDI Projects	£2.95
BP190	More Advanced Electronic Security Projects	£2.95
BP192	More Advanced Power Supply Projects	£2.95
BP193	LOGO for Beginners	£2.95
BP198	An Introduction to Antenna Theory	O.O.P.
BP245	Digital Audio Projects	£2.95
BP246	Musical Applications of the Atari ST's	£5.95
BP249	More Advanced Test Equipment Construction	£3.50
BP250	Programming in FORTRAN 77	£4.95
BP251	Computer Hobbyists Handbook	£5.95
BP258	Learning to Program in C (revised edition)	£4.95
BP259	A Concise Introduction to UNIX – Revised Edition	£4.95
BP261	A Concise Introduction to Lotus 1-2-3 (revised edition)	£3.95

Code	Title	Price
BP262	A Concise Introduction to WordPerfect (revised edition)	£3.95
BP264	A Concise Advanced User's Guide to MS-DOS (revised edition – covers version 6.2)	£4.95
BP273	Practical Electronic Sensors	£4.95
BP274	A Concise Introduction to SuperCalc5	£4.95
BP276	Short Wave Superhet Receiver Construction	£2.95
BP280	Getting the Most From Your PC's Hard Disk	£3.95
BP281	An Induction to UHF/VHF for Radio Amateurs	£3.50
BP284	Programming in QuickBASIC	£4.95
BP292	Public Address Loudspeaker Systems	£3.95
BP293	An Introduction to Radio Wave Propagation	£3.95
BP294	A Concise Introduction to Microsoft Works (revised edition)	£4.95
BP298	A Concise Introduction to the Mac System & Finder	£3.95
BP301	Antennas for VHF and UHF	£4.95
BP305	Learning CAD with AutoSketch for Windows	£5.95
BP306	A Concise Intoduction to AmiPro 3	£4.95
BP311	An Introduction to Scanners and Scanning	£4.95
BP312	An Introduction to Microwaves	£3.95
BP313	A Concise Introduction to Sage	£3.95
BP315	An Introduction to the Electromagnetic Wave	£4.95
BP317	Practical Electronic Timing	£4.95
BP320	Electronic Projects for Your PC	£3.95
BP324	The Art of Soldering	£3.95
BP325	A Concise Users Guide to Windows 3.1	£4.95
BP326	An Introduction to Satellite Communications	£5.95
BP327	DOS One Step at a Time (covers Version 6.2)	£3.95
BP328	Sage Explained	£5.95
BP329	Electronic Music Learning Projects	£4.95
BP330	A Concise User's Guide to Lotus 1-2-3 Release 2.4	£4.95
BP331	A Beginners Guide to MIDI	£4.95

Code	Title	Price
BP334	Magic Electronics Projects	£4.95
BP336	A Concise Users Guide to Lotus1-2-3 Release 3.4	£5.95
BP337	A Concise Users Guide to Lotus1-2-3 for Windows	£5.95
BP341	MS-DOS 6 Explained (covers V6.2)	£5.95
BP343	A Concise Introduction to Microsoft Works for Windows	£5.95
BP345	Getting Started in Practical Electronics	£4.95
BP346	Programming in Visual BASIC for Windows	£5.95
BP349	Practical Opto-Electronic Projects	£4.95
BP350	Electronic Board Games	£4.95
BP351	WordPerfect 6 Explained	£5.95
BP352	Excel 5 Explained	£5.95
BP353	WordPerfect 6.0 for Windows Explained	£5.95
BP354	Word 6 for Windows Explained	£5.95
BP357	A Concise Introduction to Pressworks	£5.95
BP367	Electronic Projects for the Garden	£4.95
BP370	The Superhet Radio Handbook	£4.95
BP372	CA-SuperCalc for Windows Explained	£5.95
BP373	An Introduction to Networks for PC and Mac Users	£5.95
BP362	Access One Step at a Time	£4.95
BP360	A Practical Introduction to Sage Sterling + 2 for Windows	£4.95
BP361	Sage Sterling + 2 for Windows Explained	£5.95
BP363	Practical Electronic Music Projects	£4.95
BP364	A Concise Introduction to Designworks 2	£5.95
BP385	Easy PC Interfacing	£4.95
BP387	Windows One Step at a Time	£4.95
BP388	Why Not Personalise Your PC	£4.95
BP389	Power Point for Windows Explained	£5.95
BP400	Windows 95 Explained	£5.95
BP401	Transistor Data Tables	£5.95
BP402	MS Office – One Step at a Time	£5.95

IF NO PRICE IS SHOWN THE BOOK IS OUT OF PRINT (O.O.P.)

SEE PREVIOUS PAGE FOR FULL ORDERING DETAILS

PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remitances should be sent to **The PCB Service, *Everyday Practical Electronics*, Allen House, East Borough, Wimborne, Dorset BH21 1PF.** Cheques should be crossed and made payable to *Everyday Practical Electronics* (Payment in £ sterling only).

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photostats of articles are available if required – see the *Back Issues* page for details.

Please check price and availability in the latest issue.

Boards can only be supplied on a payment with order basis.

Special KNOCK DOWN SALE of PCBs.

£1.00 EACH inc. VAT and p&p

We have a few p.c.b.s left from past projects these are being offered at the knock down price of £1.00 each – *no matter what size they are* **(some of these boards are worth over £8.00 each)** while stocks last. This price includes VAT and UK post – overseas orders please add 50p postage (or £1 per board for airmail postage).

Doorbell Delay 616; Midi Pedal 639, Midi Merge 640; Audio Lead Tester 641; Power Supply 25V 700mA 656; Hand Tally, main board 699 and display board 700; Amstrad PCW Sound Generator 715; Automatic Light Control – PSU board 747 and logic board 748; Modular Disco Lights – Masterlink 752 – Dimmer Interface 765 – VU Sound Module 767 – Supersweep 772; Knockerbox 775; Auto Nightlight 779; Micro-Sense Alarm 783; Telesound 784; Programmable Timer, 785; Economy Seven Timer, 788; Sonic Continuity Tester, 789; Telephone Ringer, 790; 12V Drill Charger/PSU (both boards), 793; Tie Pulser, 794; CCD Reverb Unit, 795; Switch-Mode Power Supply, 796; UV Exposure Timer, 797; Cricket Game, 798; Quick Prom, 799; Dual Metronome, 801; Quicktest, 803; Personal Stereo Amplifier, 808; Combination Switch, 812; TV/UHF Aerial Amp (double-sided), 814; Emergency Lighting Unit, 816; Car Electric Window Enhancer, 821; Simplifly Atari STFM Interface, 822; Personal Stereo Amp. Add-On, 823; Electronic Fire, 820; Mind Machine MkII – Magic Lights, 827; Superhet Radio Control Receiver, 828.

Any of the above for just £1 each inc. VAT and p&p.

Back numbers or photostats of articles are available see the *Back Issues* page for details.

PROJECT TITLE		Order Code	Cost
Linear Clock – Timing Board	MAY'93	830	£8.00
Display Board		831	£7.00
Universal Alarm Module		9070	£3.00
Electronic Snooker Scoreboard	JUNE'93	832	£9.17
Mind Machine MkII	JULY'93		
– Computer Interface		833	£6.39
Electronic Gong		835	£7.50
Micro Lab – p.c.b., EPROM, PAL and booklet		MICRO	£35.00
Bike Odometer (pair of boards)	AUG'93	836/7	£7.00
Amstrad PCW A to D Converter (double-sided)		838	£9.85
Experimental Electronic Pipe Descaler		839	£5.50
Sound Activated Camera Trigger	SEP'93	840	£5.34
L.E.D. Sandglass	OCT'93		
Main and Display boards		841/2	£7.30
Kettle Alert		843	£5.19
Linear Power Supply (double-sided)		844	£9.77
Multi-Purpose Audio System			
Six Channel Stereo Mixer		845	£11.98
Multi-Purpose Audio System	NOV'93		
Microphone Pre-Amp module		846	£4.88
RIAA Pre-Amp module		847	£5.11
20 Metre Receiver		848	£6.63
Multi-Purpose Audio System	DEC'93		
Tone Control and 1W Stereo Amplifier		849	£6.09
Tone Control		850	£5.12
1W Stereo Amplifier		851	£4.88
Three-Way Christmas Tree Lights Flasher		853	£5.65
Auto Alarm		854	£5.49
250W/600W Battery to Mains Inverter		855	£13.92
Multi-Purpose Audio System	JAN'94		
10W + 10W Stereo Power Amplifier			
Amplifier		852a	£5.65
Power Supply		852b	£5.49
Pond Heater Thermostat		856	£5.77
Timer/NiCad Capacity Checker		857	£6.30
Multi-Purpose Audio System	FEB'94		
Balanced Microphone Preamplifier		858	£5.30
Balanced Microphone Power Supply		859	£5.14
Whistle Controlled Light Switch		860	£5.19
Battery to Mains Inverter – U.P.S. charger board		862	£7.38

PROJECT TITLE	Order Code	Cost
Three Phase Generator **MAR'94**	861	£5.95
Visual Doorbell	863	£5.80
CCD TV Camera – Control Board		
(double-sided, plated-through-hole)	865	£15.00
Telephone RIng Detector **APR'94**	864	£4.72
CCD TV Camera		
Combined Video, Test & Ext Plug Boards	866a/e	£11.00
Frame Grab Control (double-sided p.t.h.)	867	£15.00
EPE SounDAC PC Sound Board	868	£4.77
MOSFET Variable Bench Power Supply	869	£5.80
L.E.D. Matrix Message Display Unit **MAY'94**		
Display Board	870	£18.00
CPU Board	871	£7.20
Stereo Noise Gate	873	£6.14
Simple TENS Unit	875	£5.84
Capacitance/Inductance Meter	876	£6.44
Advanced TENS Unit **JUN'94**	877	£6.56
Digital Water Meter – Scaler	878	£11.19
Counter/Display	879	pair
L.E.D. Matrix Message Display Unit		
Keypad	872	£5.19
PC Interface	880	£5.82
Microprocessor Smartswitch	881	£5.61
Microcontroller P.I. Treasure Hunter	882	£6.60
Print Timer **JULY'94**	874	£5.82
Watering Wizard	883	£6.60
Simple NiCad Charger	884	£4.98
Voxbox	885	£6.90
Stereo HiFi Controller – 1 Power Supply	886	£5.66
Stereo HiFi Controller – 2 **AUG'94**		
Main Board	887	£7.39
Expansion/Display Boards (pair)	888	£9.80
Dancing Fountains – 1 Pre.amp	889	£5.28
Pump Controller	890	£5.41
Filter	891	£5.23
6802 Microprocessor Development Board	894	£9.15
Dancing Fountains – 2 **SEPT'94**		
PC-Compatible Interface (double-sided)	892	£10.90
Automatic Greenhouse Watering System	895	£5.33
Seismograph – 1 Sensor/Filter	896	£6.23
Clock/Mixer	897	£5.87
3-Channel Lamp Controller	899	£8.17
Seismograph – 2 **OCT'94**		
PC-Compatible Interface (double-sided)	898	£10.72
Visual/Audio Guitar Tuner	900	£7.55
Digilogue Clock	901	£12.50
Hobby Power Supply	902	£5.00
Audio Auxiplexer – Control Board	903	£7.72
Receiver	904	£6.24
Power Controller **NOV'94**	905	£4.99
1000V/500V Insulation Tester	906	£5.78
Active Guitar Tone Control	907	£4.50
TV Off-er (pair)	908/909	£7.25
Video Modules – 1 Simple Fader	910	£5.12
Improved Fader	911	£6.37
Video Enhancer	912	£5.15
Rodent Repeller **DEC'94**	913	£6.26
EPE Fruit Machine	914	£8.14
Video Modules – 2 Horizontal Wiper	916	£6.23
Vertical Wiper	917	£6.35
4-Channel Audio Mixer	918	£6.20
Spacewriter Wand	921	£4.00
Universal Digital Code Lock	922	£6.25
Video Modules – 3 **JAN'95**		
Dynamic Noise Limiter	919	£5.92
System Mains Power Supply	920	£4.98
Magnetic Field Detector	923	£5.77
Model Railway Track Cleaner	924	£5.11
Moving Display Metronome	925	£6.24
The Ultimate Screen Saver **FEB'95**	927	£5.66
Foot-Operated Drill Controller	928	£5.73
Model Railway Signals	929	£5.96
12V 35W PA Amplifier	930	£12.25
Multi-Purpose Thermostat **MAR'95**	931	£6.30
Multi-Project PCB	932	£3.00
Sound-Activated Switch		
Audio Amplifier		
Light Beam Communicator (2 boards required)		
Multi-Project PCB **APR'95**	932	£3.00
Light-Activated Switch		
Switch On/Off Timer		
Continuity Tester		
Auto Battery Charger	934	£5.36
National Lottery Predictor	935	£5.34
R.F. Signal Generator - R.F./Mod. **MAY'95**	936	£6.48
Coil & Power Supply (pair)	937a/b	£6.10
MIDI Pedal	938	£7.78
Club Vote Totaliser	939	£6.05
PIC-DATS Development System		
(double-sided p.t.h.)	940	£9.90

PROJECT TITLE	Order Code	Cost
EPE HiFi Valve Amplifier – **JUNE'95**		
Phase splitter	941	£6.71
PIC-DATS 4 -channel Light Chaser	942	£7.90
HV Capacitor Reformer **JULY'95**	943	£5.60
Ramp Generator		
Logic Board (double-sided p.t.h.) & Analogue		
board (pair)	944/5	£32.00
Automatic Curtain Winder	946	£6.75
Windicator	947	£4.10
Microcontrolled 3-Digit Timer **AUG'95**	933	£6.61
IR Remote Control – Transmitter	948	£5.76
– Receiver	949	£6.14
Personal Practice Amplifier	950	£6.09
Low-Range Ohmmeter Adaptor **SEPT'95**	926	£5.55
Simple Theremin	952	£6.68
Vandata		
Boot Control Unit	953	£10.52
Display Unit	954	£6.61
Sound Switch **OCT'95**	915	£6.55
Multiple Project PCB	932	£3.00
Audio Sinewave Generator		
Treble Booster		
Infra-Red Controller/Alarm (2 boards required)		
Capacitor Check	955	£5.76
Ginormous VU Meter	956	£9.31
Multiple Project PCB **NOV'95**	932	£3.00
Video Enhancer		
Current Tracer		
Distortion Effects Unit		
Digital Delay Line	958	£8.04
50Hz Field Meter	959	£8.32
Temperature Warning Alarm (Teach-In '96)	960	£6.15
Stereo "Cordless" Headphones **DEC'95**		
Transmitter	961	£8.04
Receiver	962	£7.66
EPE Met Office – Sensor/Rainfall/Vane	963/965	£11.33
Spiral transparency free with above p.c.b.		
Light-Operated Switch	966	£6.37
Modular Alarm System (Teach-In '96)	967a/b	£7.12
Audio Meter and Amplifier	968	£5.99
EPE Met Office – **JAN'96**		
Computer Interface (double-sided)	964	£7.69
Audio Signal Generator	969	£6.58
Mains Signalling Unit, Transmitter and Receiver	970/971 (pr)	£9.09
Automatic Camera Panning (Teach-In '96)	972	£6.63
Printer Sharer	973	£9.93
Analogue Frequency Meter **Feb'96**	957	£6.70
Vari-Speed Dice (Teach-In '96)	974	£5.69
Mains Signalling Unit – 2		
12V Capacitive PSU	975	£6.07
PIC-Electric Meter – Sensor/PSU– Control/Display	977/978 (pr)	£9.90

EPE PRINTED CIRCUIT BOARD SERVICE

Order Code **Project** **Quantity** **Price**

....

Name...

Address..

....

....

I enclose payment of £..............................(cheque/PO in £ sterling only) to:

Everyday Practical Electronics

Access (MasterCard) or Visa No.
Minimum order for credit cards £5

Signature...Card Exp. Date............................

Please supply name and address of cardholder if different from the address shown

REPORTING AMATEUR RADIO

Tony Smith G4FAI

MORSE – NO CHANGE!

The ITU World Radio Conference (*WRC-95*) which ended in Geneva on November 17, decided not to accept New Zealand's proposal for the abolition of the amateur Morse test. During discussion of the proposal most delegates thought the issue needed further study within the amateur community. To give time for such consideration, it was decided the matter should be included on the agenda of a future conference, possibly *WRC-99*.

As a result, the International Amateur Radio Union, recognised by the ITU as the organisation representing national radio societies around the world, has disbanded its "Ad Hoc Committee on Roaming License Qualifications", mentioned last month, and has set up an alternative committee to consider the future of the amateur service.

This committee will prepare proposals for discussion by all member societies, including the need or otherwise for a compulsory Morse test. Once agreed internationally, recommendations on the future of the amateur radio service will be presented for consideration by the appropriate *WRC*.

As a result of the decision of *WRC-95*, the Morse test will continue, until 1999 at least, as a necessary qualification for amateurs wishing to operate on the HF bands below 30 MHz.

RSGB OPEN LETTER

The President of the Radio Society of Great Britain, Clive Trotman GW4YKL, has published an "Open Letter" addressed to the 1300 members and non-members of the Society who wrote to him following the recent exchange of letters between the RSGB and the Radiocommunications Agency. This related to the RA's decision to support the abolition of the Morse test without discussing the matter with the RSGB.

Mr Trotman stresses how important it is that there be no major change in direction without consultation between the administration and the amateur radio fraternity. He reports that the exchange of correspondence has had the desired effect and there now has been consultation.

Questions that immediately spring to mind, he says, include "what are we going to replace the test with?" and "Are we going to replace it?, both of which give rise to a whole new set of questions."

He concludes, "The decision has been postponed to 1999, now we must work in collaboration with other societies and administrations to achieve a feasible and workable system that will be acceptable across the whole amateur radio fraternity ... we must start to make moves to find a solution immediately, four years is but a short time."

RSGB ANNUAL REPORT

The Annual Report of the RSGB for 1994/95 records a successful year. It has achieved a modest increase in membership, and has maintained a good relationship with the Radiocommunications Agency (apart from the furore over the Morse test).

It has been represented at many international meetings and conferences; and its "Intruder Watch" now has a full complement of monitors dedicated to protecting exclusive amateur frequency allocations from illegal transmissions.

The Data Communications Committee has been concerned with the day to day management and development of the UK datacomms network; the Repeater Management Group performed much the same function for the repeater network; while an Emergency Communications Officer co-ordinated the work of various emergency networks nationwide.

During the year, the competitive side of the hobby was well catered for with a comprehensive program of operating contests and awards. The QSL bureau sorted and distributed over two million cards for UK amateurs and shortwave listeners; the audio visual library hired out 168 videos to 101 clubs; and the society organised, or was represented at, various rallies, conventions and other events throughout the year.

The HQ library houses the largest collection of English language amateur radio books in Europe, and is available to members and *bona fide* researchers on request. Several new titles were added to the list of books published by the society, and the major success of the year was the long-awaited 6th edition of the *Radio Communication Handbook*. This was published in October, sold out in May, and subsequently reprinted.

SCHOOLS LINKS STRENGTHENED

The society's Training and Education Committee has been restructured to take account of the growing need to involve schools in amateur radio. This need has been highlighted by the activities of the STELAR Group (Science and Technology through Educational Links with Amateur Radio), with which liaison has been strengthened.

It is reported that since the Novice Licence training scheme began in 1991 almost 4,500 students have satisfactorily completed the course. In a large number of cases they have upgraded to the full licence immediately, or after a very short spell as Novice licensees.

Despite all these activities, and many more not mentioned, only about 50 percent of UK amateurs are members of the RSGB. If there were more the society would be that much stronger, more influential, and could provide even better services.

Membership is open to anyone interested in amateur radio, whether licensed or SWL, and full details can be obtained from: *RSGB, Dept EPE, Lambda House, Cranborne Road, Potters Bar, Herts EN6 3JE.*

CRASH COURSE FOR TEACHERS

The next STELAR crash course for teachers who wish to take the radio amateur's examination will be held on April 8 to 13 at Rickmansworth, Herts. The course, sponsored by Trio-Kenwood UK Ltd, provides free hotel accommodation and meals, free course materials, free tuition, and one year's subscription to STELAR.

Places are allocated to teachers who work in schools where there is no amateur radio activity at present, or where the licensed member of staff is about to leave. Full information can be obtained from the *STELAR RAE Course Organizer, Dept EPE, 115 Marshalswick Lane, St Albans, Herts AL1 4UU.* Please mention that you read about the course in *EPE*.

For teachers new to the subject, AMRED (Amateur Radio in Education) the journal of STELAR, carries very informative introductory articles relating to all aspects of amateur radio.

The current issue covers slow scan television (and includes a free SSTV disk); a continuing history of amateur radio; "easy-match" wire antennas; and transmitters. Such good quality back-up and encouragement is essential if schools are to continue to take up, and benefit from amateur radio. STELAR are to be congratulated on their efforts.

SATELLITE LAUNCH ARRANGED

The launch of the eagerly awaited *Phase 3-D* international amateur radio satellite has been arranged to take place in September 1996. The launch by the European Space Agency will cost about $1 million US, and its primary launch opportunity will be via the second test flight of ESA's new *Ariane 5* booster (*Ariane 502*).

If, for some reason, ESA decides that a launch via *Ariane 502* is not possible, the contract calls on ESA to exercise their "best efforts" to orbit *Phase 3-D* on an *Ariane 4* booster no later than mid-1997. This possibility had been anticipated, and the satellite has been constructed to be easily compatible with either booster.

The final negotiated price is somewhat reduced from earlier estimates. Through the generous contributions of individuals and organisations around the world, $800,000 is already available to pay the first instalment of the launch bill. Another $200,000 is still needed to complete the satellite and prepare it for launch (*W5YI Report*).

PIC EEZE

LOW COST POWERFUL PIC DEVELOPMENT SYSTEM

This is the easiest way to start using PIC microcontrollers. The system allows a cheap entry into the world of PIC based applications and can be upgraded whenever you like.

PIC EEZE-1

Programs/reads and verifies PIC 16C61/64/71/74/84 (even while in circuit). Includes Z.I.F. socket for both 18 and 28-pin devices, lead to connect to standard PC parallel port for fast data exchange, Microchip's own assembler and simulator software and powerful programming/editing software. Upgradable to PIC EEZE-2/-3 by plug-in firmware. Built and tested £44.95 A suitable PSU is required.

PIC EEZE-2

Specification as PIC EEZE-1 but also supports PIC 16C54/55/56/57/58 and can read/write 93Cxx and 24Cxx Serial EEPROMs. Built and tested £52.95 or upgrade from PIC EEZE-1 £9.95.

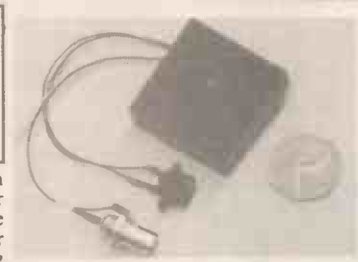
PIC EEZE-3

Specification as PIC EEZE-1 with PIC EEZE-2 with the added capability of In-Circuit Emulation of 18 and 28-pin devices (even A-to-D on 16C71). Built and tested £74.95 or upgrade from PIC EEZE-1 £29.95, upgrade from PIC EEZE-2 £24.95.

We have developed the firmware of the PIC EEZE system so that it can be software upgraded when Microchip bring out new versions in the PIC range. The programming software upgrades will be *FREE* to PIC EEZE users. Also, we supply PICs and Serial EEPROMs at affordable prices with discounts to users of our system. We intend to develop the system even further with expansions to give other features e.g. a Smart Card reader/programmer. We will also give continuing support.

Immediate next day response. Prices are exclusive of postage and package.
Please add £2.00 (UK) and make cheques payable to Lennard Research, and send to
29 Lavender Gardens, Jesmond, Newcastle upon Tyne NE2 3DD,
or Telephone 0191 281 8050 for further information.

HIGH QUALITY LOW COST
C.C.T.V. CAMERA
**VERY LOW LIGHT LEVEL.
AUTO ELECTRONIC SHUTTER.
COMPOSITE VIDEO OUT VIA BNC PLUG.
SMALL DISCRETE SIZE.
CAN BE USED WITH PC DIGITISER.**



This super quality CCD camera can be connected into your existing TV or video using the AV channel and can be used for discrete surveillance or observing your property externally using a suitable weatherproof housing. Can accommodate lighting levels ranging from daylight to street lighting using its built in electronic shutter. Excellent when using with an infra red source. Built in wide angle fixed focus lens the camera has a resolution of 380 TVL. Can be housed inside an empty floodlight case, (extra).

Special offer price of only: **£79.95 Plus VAT** (P&P £3.50)

**For full range of CCTV products send SAE to:
Direct CCTV Ltd., Dept. PE27., Unit 6, Carrick Court, Forrest Grove Business Park, Middlesbrough, TS2 1QE.**

MICRO TRANSMITTERS GUIDE

★ **Only £3.95**

★ Easy to follow guide to building short range F.M. transmitters and surveillance devices. Packed with useful information and circuits.
(Some of the circuits included cannot be used legally in the UK)

KITS

RADIO KITS/TRANSMITTERS/ REMOTE CONTROLS

MICRO FM (a). 1km range transmitter, 80-100MHz preset. Received on any FM Radio. 2 x 3cm. **£6.95**
MICRO FM (b). Variable mic. sensitivity. Tuneable 80-110MHz. 1km range, 2 x 3·5cm **£7.95**
ULTRA MINI FM. 200mtrs range. 80-100MHz, runs off watch battery (inc.), only 1 x 2cm **£8.95**
FM TRACKER. Transmits a constant tone for direction finding, tracking etc. 80-110MHz **£8.50**
FM RECEIVER (a). Small high quality FM receiver. Covers standard FM broadcast bands. Will drive headphones (not inc.) **£10.90**
FM RECEIVER (b). As (a) but with 3 watt audio power amplifier and tuning LED **£13.50**
CRYSTAL RADIO. Great introduction to radio electronics. Includes tuner, ferrite aerial and earphone **£8.50**
AM RADIO. Single chip radio for use with headphones, (not inc.) or an external amplifier **£9.90**
I.R. REMOTE CONTROL. Single channel for lights, garage doors etc. Transmitter – **£6.95**
Receiver (with mains relay) – **£11.60**
27MHz RADIO CONTROL.
Single channel, XTAL controlled Transmitter – **£9.50**
Receiver (with mains relay) – **£15.45**

PREAMPS/AUDIO

AU10 GENERAL PURPOSE PREAMP for audio applications where low noise isn't a priority – guitar amps etc. 9V-15V, variable gain and high output **£4.20**
AU11 LOW NOISE PREAMP for more critical Input stages. Ideal for mixers etc. 9V-15V, variable gain **£4.50**
AU12 ULTRA LOW NOISE PREAMP. Professional standard. Uses an NE5534 i.c. 9V-15V, variable gain **£5.99**
AU13 SMALL SIGNAL. Single FET preamp for boosting low output piezo pickups or acoustic transducers **£3.90**
AU14 SMALL SIG + EQ. An AU13 with a simple three-band passive EQ circuit. Designed for piezo pu's **£6.90**
AU15 SINGLE TRANSISTOR. Low noise preamp for electric guitars etc. Preset gain. BC184L **£3.90**
AU16 ACTIVE TONE CONTROL. 12dB cut and boost bass and treble with preamp. Includes pots. **£9.95**
AU17 7-BAND EQ board for graphic/tone control applications. Pots included **£14.95**
AU18 NOISE REDUCTION SYSTEM. High quality dynamic noise gate with variable effect and level **£15.95**
AU19 ANALOGUE DELAY. "Bucket brigade" delay line. Variable clock frequency for producing double track and echo effects etc. Delay times from 2·5 to 51ms. **£18.50**
AU20 CONTROL OSC. Low frequency oscillator to modulate the analogue delay line for Flanging, Chorus and other effects **£8.50**
AU21/21 DIGITAL DELAYS. 200ms and 800ms digital delay lines with 10-bit A/D D/A conversion. Variable sample rate from 25kHz-50kHz variable delay time, 200ms – **£20.40**, 800ms – **£24.95**

POWER AMPS

P2 15 WATT. General purpose upgrade. Uses TDA2030. 24V single rail with heatsink **£9.95**
P3 40 WATT. High quality power amp for compact disc and other demanding applications. Switch on mute, thermal/short protecction. Distortion less than 0·003% 27V± with heatsink. **£16.50**
P4 150 WATT. Rugged and powerful MOSFET design, excellent responses and reliability. 50V± with heatsink. Ideal for guitar amps. PA or sound system. **£24.95**

JCG Electronic projects

PO BOX HP79 WOODHOUSE STREET HEADINGLEY LEEDS LS6 3XN

SEND S.A.E. FOR A LIST OF OUR FULL RANGE OF RADIO AND AUDIO KITS. ALL KITS COME COMPLETE WITH PRE-DRILLED P.C.B.'s, HIGH SPEC COMPONENTS AND FULL INSTRUCTIONS – MAIL ORDER ONLY – MAKE CHEQUES PO'S PAYABLE TO J.C.G. PLEASE ADD 50p POSTAGE AND PACKING.

VARIABLE VOLTAGE TRANSFORMERS

**INPUT 220V/240V AC 50/60
OUTPUT 0V-260V**

	Price	P&P
0·5KVA 2·5 amp max	£31.90	£6.00
	(£44.53 inc VAT)	
1KVA 5 amp max	£41.15	£7.00
	(£56.58 inc VAT)	
2KVA 10 amp max	£59.40	£8.50
	(£79.78 inc VAT)	
3KVA 15 amp max	£78.65	£8.50
	(£102.40 inc VAT)	
5KVA 25 amp max	£139.15	(Plus Carriage)

Buy direct from the Importers. Keenest prices in the country

COMPREHENSIVE RANGE OF TRANSFORMERS–LT–ISOLATION & AUTO

110V-240V Auto transfer either cased with American socket and mains lead or open frame type. Available for immediate delivery.

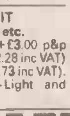
WIDE RANGE OF XENON FLASHTUBES
Write/Phone your enquiries

ULTRA VIOLET BLACK LIGHT FLUORESCENT TUBES

4ft 40 watt £14.00 (callers only) (£16.45 inc VAT)
2ft 20 watt £9.00 (callers only) (£10.58 inc VAT)
12in 8 watt £4.80 + 75p p&p (£6.52 inc VAT)
9in 6 watt £3.96 + 50p p&p (£5.24 inc VAT)
6in 4 watt £3.96 + 50p p&p (£5.24 inc VAT)

230V AC BALLAST KIT
For either 6in, 9in or 12in tubes £6.05 + £1.40 p&p (£8.75 inc VAT)

The above Tubes are suitable for Forged Bank Note detection, security marking etc.
Other Wavelengths of U.V. TUBE available please telephone your enquiries.



400 WATT UV LAMP
Only £38.00 + £4.00 p&p (£49.35 inc VAT)

160 WATT SELF-BALLASTED BLACK LIGHT MERCURY BULB
Available with E.S. fitting.
Price inc VAT & p&p £25.55

12V D.C. BILGE PUMPS
500 GPH 15ft head 3 amp £19.98
1750 GPH 15ft head 9 amp £34.55
Also now available:
24V D.C. 1750 GPH 15ft head 5 amp £35.55
All designed to be used submerged.
PRICES INCLUDE P&P & VAT

SUPER HY-LIGHT STROBE KIT
Designed for Disco, Theatrical use etc.
Approx 16 joules. Adjustable speed £50.00 + £3.00 p&p (£62.28 inc VAT)
Case and reflector £24.00 + £3.00 p&p (£31.73 inc VAT).
SAE for further details including Hy-Light and Industrial Strobe Kits.

5 KVA ISOLATION TRANSFORMER
As New Ex-Equipment, fully shrouded, Line Noise Suppression, Ultra Isolation Transformer with terminal covers and knock-out cable entries. Primary 120V/240V. Secondary 120V/240V. 50/60Hz, 0·005pF Capacitance. Size, L 37cm x W 19cm x H 16cm, Weight 42 kilos. Price £120 + VAT. Ex-warehouse. Carriage on request.

24V DC SIEMENS CONTACTOR
Type 3TH8022-0B 2 x NO and 2 x NC 230V AC 10A. Contacts. Screw or Din Rail fixing. Size H 120 x W 45 x D 75mm. Brand New Price £7.63 incl. P&P and VAT.

240V AC WESTOOL SOLENIODS
TT2 Mod. 1 Rat. 1 Max. stroke 5/8 in. Base mounting 1/2in. stroke 5lbs pull approx. **TT6** Mod. 1 Rat. 1 Max. stroke 1 in. Base mounting 1/2in. stroke 15lbs pull approx. **SERIES 400** Mod. 1 Rat. 2 Max. stroke 11/8in. Front mounting 1/2in. stroke 15lbs pull approx. Price incl p&p & VAT. **TTS £5.88, TT6 £8.81, SERIES 400 £7.64.**

AXIAL COOLING FAN
230V AC 120mm square x 38mm 3 blade 10 watt Low Noise fan. Price £7.29 incl. P&P and VAT.
Other voltages and sizes available from stock. Please telephone your enquires.

240V AC CENTRIFUGAL BLOWER
New Manuf. Surplus Skeleton Blower suitable for mounting inside an enclosure to cool equipment. Overall size 130 x 110 x 85mm. Outlet 80 x 35mm. Impellor 60mm dia. x 60mm long. Price £14.10 inc p&p & VAT.

SEWING MACHINE MOTOR
Brand new 220V/240V AC/DC SEW-TRIC 2 lead Brush Motor. Size L 100mm x H. 70mm x W. 55mm. Spindle ¼ in. dia. x 1 in. long. Price £14.10 Inc p&p & VAT.

GEARED MOTORS
71 RPM 20lb/inch torque reversable 115V AC input including capacitor and transformer for 240V AC operation. Price inc VAT and p&p £27.73.

SOLID STATE EHT UNIT
Input 230V/240V AC. Output approx 15KV. Producing 10mm spark. Built-in 10 sec timer. Easily modified for 20 sec, 30 sec to continuous. Designed for boiler ignition. Dozens of uses in the field of physics and electronics, e.g. supplying neon or argon tubes etc. Price less case £8.50 + £2.40 p&p (£12.81 inc VAT) NMS.

EPROM ERASURE KIT
Build your own **EPROM ERASURE** for a fraction of the price of a made-up unit. Kit of parts less case includes 12in 8 watt 2537 Angst Tube Ballast unit, pair of bi-pin leads, neon indicator, on/off switch, safety microswitch and circuit £15.00 + £2.00 p&p (£19.98 inc VAT)

WASHING MACHINE WATER PUMP
Brand new 240V AC fan cooled. Can be used for a variety of purposes. Inlet 1½in., outlet 1in. dia. Price includes p&p. & VAT. £11.20 each or 2 for £20.50 inclusive.

SERVICE TRADING CO

57 BRIDGMAN ROAD, CHISWICK, LONDON W4 5BB
TEL: 0181-995 1560 FAX: 0181-995 0549
ACCOUNT CUSTOMERS MIN. ORDER £10
Showroom open Monday/Friday — VISA — *Ample Parking Space*

WE HAVE THE WIDEST CHOICE OF USED OSCILLOSCOPES IN THE COUNTRY

TEKTRONIX TAS475 4 Channel 100MHz Delay/Cursors	£1300
TEKTRONIX TAS455 Dual Trace 60MHz Delay/Cursors	£900
TEKTRONIX 2335 Dual Trace 100MHz Delay	£750
TEKTRONIX 485 Dual Trace 350MHz Delay Sweep	[illegible]
TEKTRONIX 475 Dual Trace 200MHz Delay Sweep	£500
TEKTRONIX 465 Dual Trace 100MHz Delay Sweep	[illegible]
TEKTRONIX SC5044 Dual Trace 80MHz in TM503	£400
H.P. 1740A Dual Trace 100MHz Delay Sweep	£350
TEKTRONIX 2225 Dual Trace 50MHz Alt TB Magnification	£450
TEKTRONIX 2215 Dual Trace 60MHz Delay Sweep	£400
TEKTRONIX 2213 Dual Trace 60MHz	£350
PHILIPS PM3217 Dual Trace 50MHz Delay Sweep	£400
HITACHI V423 Dual Trace 40MHz Delay Sweep	£350
GOULD OS1100 Dual Trace 30MHz Delay Sweep	£240
GOULD OS1100S1 Dual Trace 30MHz	£200
BECKMAN 9020 Dual Trace 20MHz Delay Sweep	£240
KIKUSUI 5530A Dual Trace 35MHz	£220
IWATSU SS5702 Dual Trace 20MHz	£200
GOULD OS300 Dual Trace 20MHz (No handle)	£180
TEKTRONIX 2230 Dual Trace 100MHz Digital Storage Cursors etc	POA
GOULD OS4040 Dual Trace 10MHz Digital Storage	£300
GOULD OS4020 Dual Trace 10MHz Digital Storage	£250
H.P. 1741A Dual Trace 100MHz Analogue Storage	[illegible]

THIS IS JUST A SAMPLE – MANY OTHERS AVAILABLE

EATON/AILTECH 380K11 Synthesized Sig. Gen 1MHz-2000MHz with PM3602 AM/FM Phase Mod	POA
MARCONI 2019 Synthesized AM/FM Sig. Gen 80kHz-1040MHz	£1900
MARCONI 2018 Synthesized AM/FM Sig. Gen 80kHz-520MHz	£800
ADRET 7100D AM/FM Sig Gen 300kHz-1.3GHz	£1000
ADRET 7100A AM/FM Sig Gen 300kHz-650MHz	£650
H.P. 8620C Sweep Oscillator Main Frame only	£200
RACAL 9081 Syn. AM/FM Sig. Gen 5MHz-520MHz	£450
MARCONI TF2337 Automatic Distortion Meter	£200
MARCONI TF2331A Dist. Fct. Meter 20Hz-20kHz 0·05% un-used	£225
MARCONI TF893B Audio Power Meter Sinad	£250
MARCONI TF2163 Attenuator DC-1GHz	£100
H.P. 8495B Attenuator DC-18GHz 0-70dB in 10dB Steps	£350
HATFIELD 2105 Attenuator 50 Ohm	£75
R & S Video Noise Meter UPSF2 with UPSF2E2 40Hz-10MHz	£1500
WILTRON 6409 RF Analyser 10MHz-2000MHz	POA
WILTRON 6610A Programmable Sweep Gen 1GHz-2GHz	POA
W&G Selective Level Meter SPM11 with Harmonic Distortion Analyser PSE11	POA
H.P. 4277A LCZ Meter with Test Fixture	POA
R&S VHF Field Strength Meter type HFV 25MHz-300MHz	£250

BRUEL & KJOER EQUIPMENT AVAILABLE – PLEASE ENQUIRE

SPECTRUM ANALYSERS

H.P. 8565A 0.01SGHz-22GHz	£4000
H.P. 182 with 8558B 100kHz-1500MHz	from £1500
H.P. 141T with 8555A & 8552B 10MHz-18GHz	£1700
H.P. 141T with 8554B & 8552B 500kHz-1250MHz	£1200
H.P. 141T with 8553B & 8552A 1kHz-110MHz	£800
H.P. 3580A 5Hz-50kHz	£800
MARCONI TF2370 30Hz-110MHz	£1000

STABILOCK 4021 RADIO TEST SET ONLY £800

RACAL 1998 Freq. Counter 1·3GHz (options GPIB & High Stab)	£900
RACAL/DANA 1991 Universal Counter/Timer 160MHz 9 digit	£300
MARCONI 2437 Universal Counter/Timer DC-100MHz 8 digit	£175
RACAL 9916 Frequency Counter 10Hz-520MHz	£175
RACAL 9906A Universal Counter Timer 10Hz-200MHz	£250
SOLARTRON 7065 6½ digit Microprocessor Voltmeter AC/DC/Ohms/Auto	£400
SOLARTRON 7150 6½-3½ digit DMM with IEEE	£400
SOLARTRON 7045 4½ digit Multimeter Volts/Amps/Ohms	[illegible]
FLUKE 77 Handheld DMM 3½ digit with case	£100
FLUKE 8050A Bench/Portable DMM 4½ digit True RMS	£225
FLUKE 8010A Bench/Portable DMM 3½ digit True RMS	£150
GOULD J3B Sine/Square Oscillator 10Hz-100kHz	£150
FEEDBACK FG600 Sine/Sq/Tri 001Hz-100kHz	£60
THANDER TG501 Func. Gen. 0·0005Hz-5MHz Sine/Sq/Tri/Ramp/Pulse/etc	£175
THANDER TG502 as TG501 with Sweep Facilities	£275
UNAOHM EP501 Audio Analyser	£350
PHILIPS PM5565 Waveform Monitor	£300
PHILIPS PM8917 Video Line Selector	£200
FERROGRAPH RTS2 Recorder Test Set	£250
AWA F242A Distortion Noise Meter	[illegible]
LEADER LSG216 Standard Signal Generator	£450
KEMO Dual Variable Filter VBF/3 0·1Hz-10kHz	£200
RACAL Instrumentation Recorder type Store 4DN	£350
RACAL Instrumentation Recorder type Store 7DS	£500
MARCONI TF2700 Universal Bridge, Battery Operated	from £150
WAYNE KERR B424 Digital Component Meter LCR	£200
H.P. 16300 43 Channels	£750
SORENSEN DCR600-4.5B 0-600V; 0-4.5A	£700
H.P. 6268 0-40V; 0-30A	£500
FARNELL H30/100 0-30V; 0-100A Metered	£800
THURLBY PL320QMD 0-30V; 0-2A Twice Digital	£225
THURLBY PL320 0-30V; 0-2A Digital	£100
FARNELL L30-5 0-30V; 0-5A Two Meters	£150
FARNELL LT30-2 0-30V; 0-2A Twice	£160
FARNELL L30-2 0-30V; 0-2A Metered	£80
FARNELL LT30-1 0-30V; 0-1A Twice	£130
FARNELL L30-1 0-30V; 0-1A Metered	£65
BRANDENBURG Model 472R +/- 2kV Metered	£200

MANY OTHER POWER SUPPLIES AVAILABLE

NEW EQUIPMENT

HAMEG OSCILLOSCOPE HM1005 Triple Trace 100MHz Delay Timebase	£847
HAMEG OSCILLOSCOPE HM604 Dual Trace 60MHz Delay Sweep	£653
HAMEG OSCILLOSCOPE HM303 Dual Trace 30MHz Comp. Tester	£422
HAMEG OSCILLOSCOPE HM205-3 Dual Trace 20MHz Digital Storage	£653

All other models available – all oscilloscopes supplied with 2 probes

BLACK STAR EQUIPMENT (P&P all units £5)

APOLLO 10 100MHz Counter Timer Ratio/Period/Time int. etc	£234
APOLLO 100 100MHz (as above with more functions)	£332
METEOR 100 FREQUENCY COUNTER 100MHz	£119
METEOR 600 FREQUENCY COUNTER 600MHz	£145
METEOR 1000 FREQUENCY COUNTER 1GHz	£189
JUPITOR 500 FUNCTION GEN. 0·1Hz-500kHz Sine/Sq/Tri	£125
ORION COLOUR BAR GENERATOR Pal/TV/Video	£243

All other Black Star equipment available

OSCILLOSCOPE PROBES Switched X1 X10 (P&P £3)	£13

Used Equipment – Guaranteed. Manuals supplied if possible.
This is a VERY SMALL SAMPLE OF STOCK. SAE or telephone for lists. Please check availability before ordering. CARRIAGE all units £16. VAT to be added to Total of Goods and Carriage.

STEWART OF READING

110 WYKEHAM ROAD, READING, BERKS RG6 1PL
Tel: 01734 268041 Fax: 01734 351696 Callers welcome 9am to 5.30pm MON-FRI (UNTIL 8pm THURS) — VISA

EVERYDAY PRACTICAL ELECTRONICS CLASSIFIED

Everyday Practical Electronics reaches nearly twice as many UK readers as any other independent monthly hobby electronics magazine, our audited sales figures prove it. We have been the leading independent monthly magazine in this market for the last eleven years

If you want your advertisements to be seen by the largest readership at the most economical price our classified and semi-display pages offer the best value. The prepaid rate for semi-display space is £8 (+VAT) per single column centimetre (minimum 2.5cm). The prepaid rate for classified adverts is 30p (+VAT) per word (minimum 12 words).

All cheques, postal orders, etc., to be made payable to Everyday Practical Electronics. **VAT must be added.** Advertisements, together with remittance, should be sent to Everyday Practical Electronics Advertisements, Holland Wood House, Church Lane, Great Holland, Essex CO13 0JS. Phone/Fax (01255) 850596.

For rates and information on display and classified advertising please contact our Advertisement Manager, Peter Mew as above.

RCS VARIABLE VOLTAGE D.C. BENCH POWER SUPPLY

Up to 38 volts d.c. at 6 amps continous, 10 amps peak, fully variable from 1 to 38 volts. Twin Voltage and Current meters for easy read-out. 240 volt a.c. input. Fully smoothed, size 14½ x 11 x 4½ inches.

£96 inc. VAT carriage £6

RADIO COMPONENT SPECIALISTS

337 WHITEHORSE ROAD, CROYDON SURREY, CR0 2HS. Tel: 0181-684 1665

Lots of transformers, high volt caps, valves, speakers, in stock. • Phone or send your wants list for quote.

IRISH READERS

Phone/Fax now for our list of quality used test equipment. Scopes, Storage Scopes, Counters, PSUs, Sig. Gens, Manuals.

Brian Connolly Electrical Engineering

Bagenalstown, Co. Carlow.

Tel: 0503 21612

Z88

CAMBRIDGE Z88 A4 NOTEBOOK COMPUTER AVAILABLE AGAIN £99.

ONLY 1" THICK, 4xAA BATTS, 20 HOURS WORK. LCD SCREEN, 72 Crs, 6 LINES, 82K RAM, EXTRA RAMS & EPROMS, 9 pin D SERIAL PORT, ROM HAS BBC BASIC, W/PROCESSOR, SPREADSHEET, DATA BASE, IMP/EXPORT TO PC etc, V52 TERMINAL.

W.N. RICHARDSON & CO.

PHONE/FAX 01494 871319

6 RAVENSMEAD, CHALFONT ST PETER, BUCKS, SL9 0NB.

POST £5. ACCESS, VISA, ETC.

MINI CCD CAMERA

Latest low-light (0·1lux), IR-sensitive mini camera from KOCOM #CA-H34C. 6 IR LEDs on board. 54mm x 38mm. 12V. Uncased. 33gm. Plugs direct into VCR or video monitor. £59 reg. airmail. Bank draft on any HK or UK bank.

See our web page at:

http://www.hk.super.net/~diykit

DIY ELECTRONICS

PO Box 88458, Sham Shui Po, Hong Kong.

BTEC ELECTRONICS TECHNICIAN FULL-TIME TRAINING

THOSE ELIGIBLE CAN APPLY FOR E.T. GRANT SUPPORT AN EQUAL OPPORTUNITIES PROGRAMME

O.N.C., O.N.D. and H.N.C.

Next course commences

Monday 22nd April 1996

FULL PROSPECTUS FROM

LONDON ELECTRONICS COLLEGE (Dept EPE) 20 PENYWERN ROAD EARLS COURT, LONDON SW5 9SU TEL: 0171-373 8721

THE BRITISH AMATEUR ELECTRONICS CLUB

exists to help electronics enthusiasts by personal contact and through a quarterly Newsletter.

For membership details, write to the Secretary:

Mr. J. F. Davies,
70 Ash Road, Cuddington,
Northwich, Cheshire CW8 2PB.

Space donated by Everyday Practical Electronics

YOUR COMPANY's AGENT IN BRAZIL?

please contact for first information:
Ulrich Kull, El.Engineer, Switzerland
Tel. +Fax +41 61 261 72 66
or Mr. Liscio, Licht Eletro-Eletrônica
Tel. +5511 869 0188 Brazil
Fax: +5511 819 0444 Brazil

Miscellaneous

PROTOTYPE PRINTED CIRCUIT BOARDS one offs and quantities, for details send s.a.e. to B. M. Ansbro, 38 Poynings Drive, Hove, Sussex BN3 8GR, or phone Brighton 883871.

G.C.S.E. ELECTRONICS KITS, at pocket money prices. S.A.E. for FREE catalogue. SIR-KIT Electronics, 70 Oxford Road, Clacton, CO15 3TE.

PLDs AND EPROMS copied or programmed. We supply logic devices/convert discrete logic to PLDs. Also PCBs designed. Send for details to PO Box 1561 Bath (01225 444467).

VALVE ENTHUSIASTS: Capacitors and other parts in stock. For free advice/lists please ring, Geoff Davies (Radio), Tel: 01788 574774.

PRINTED CIRCUIT BOARDS – QUICK SERVICE. Prototype and Production. Artwork raised from magazines or draft designs at low cost. PCB's also designed from schematics. Production assembly also undertaken. For details send to P. Agar, 36 Woodcot Avenue, Belfast, BT5 5JA or phone 01232 473533 (7 days).

HUNDREDS OF UNUSUAL ITEMS CHEAP! Send £1 coin for interesting samples and list. Grimsby Electronics, Lambert Road, Grimsby.

PRINTED CIRCUIT BOARD ARTWORK LAYOUT, product design, schematic, surface-mount component design and supply and much more ... Details: Tel. 01708 379054 Fax: 01708 379404 Mobile: 0850 973555.

OSCILLOSCOPES. Telequipment D52/D43, £35 each. Tektronix S65/RMS02, £40 each. 01453 546971.

AMAZE YOUR FRIENDS with your own "PLASMA DISPLAY LAMP". Fascinating science project! Complete kit only £24.95 (+£1.50 p&p) or plans only £5.95 (+50p p&p). Cheques or postal orders to: P.P.S., 33B Rowlands Road, Worthing, W. Sussex, BN11 3JJ.

60 WATT AMPLIFIERS, £6.00 ex-equipment. Variable power supplies 12V-25V + slider, £3.99 ... catalogue +30 component samples ... £1.00 ... K.I.A. 1 Regent Road, Ilkley LS29 9EA.

RETIRED ELECTRONICS/AUDIO ENGINER offers for sale: two Oscilloscopes, R.F. and Audio Signal Generators, Ferrograph RTS2 Test Set, Function Generator, Frequency Counter, Digital VOM, Bench Power Supplies, Tools, Hardware, Components' Spares, complete package for quick sale £300. Phone 01942 883908.

EVERYDAY PRACTICAL ELECTRONICS

SUBSCRIPTION ORDER FORM

Annual subscription rates (1996):
UK £24.00.

Overseas £30.00 surface mail, £47.50 airmail.

To:
Everyday Practical Electronics, Allen House, East Borough, Wimborne, Dorset BH21 1PF
Tel: 01202 881749
Fax: 01202 841692

Name ....

Address ....

....

....

....

I enclose payment of £..............................

(cheque/PO in £ sterling only, payable to Everyday Practical Electronics). Alternatively send Access or Visa number and card expiry date.

Signature ....

Please supply name and address of cardholder if different from the subscription address shown above. Subscriptions can only start with the next available issue. For back numbers see the Back Issues page.

M2/96

NEW MINI CAMERA and SPECIAL OFFERS

NEW – Mini Waterproof TV Camera, 40 x 40 x 15mm, requires 10V to 16V at 120mA with composite video output (to feed into a Video or a TV with a SCART plug) it has a high resolution of 450 TV lines vertical and 380 TV lines horizontal, electronic auto Iris for nearly dark (1 LUX) to bright sunlight operation and a pinhole lens with a 92 degree field of view, it focuses down to a few CM. It is fitted with a 3-wire lead (12V in gnd and video out). £93.57 + VAT = £109.95 or 10+ £89.32 + VAT = £104.95.

High quality Stepping Motor Kits (all including stepping motors) 'Comstep' independent control of two stepping motors by PC (via the Parallel Port) with two motors and software.......Kit £67.00; Built £99.00

Software support and 4-digital inputs kit.......£27.00

Power Interface: 4A kit £36.00, 8A kit, £46.00.

Stepper kit 4 (manual control) includes 200 step stepping motor and control circuit.......£23.00

Hand Held Transistor Analyser. It tells you which lead is the base, the collector and emitter and if it is *NPN* or *PNP* or faulty, £33.45. Spare 6V battery £1.20.

LEDs 3mm or 5mm Red or Green 7p each. Yellow 11p each

Cable Ties 1p each, £5.95 per 1000, £49.50 per 10,000.

RECHARGEABLE BATTERIES

AA (HP7) 500mAH.......£0.99
AA 700mAH.......£1.75
C 2AH with solder tags.......£3.60
D 4AH with solder tags.......£4.95
1/2AA with solder tags.......£1.55
AAA (HP16) 180mAH.......£1.75
AA 500mAH with solder tags.......£1.55
C (HP11) 1·2AH.......£2.20
D (HP2) 1·2AH.......£2.60
PP3 8·4V 110mAH.......£4.95
Sub C with solder tags.......£2.50
1/3 AA with tags (Philips CTV).......£1.95

Standard Charger, charges 4 AA cells in 5 hours or 4 Cs or Ds in 12 to 14 hours, plus 1xPP3 (1, 2, 3 or 4 cells may be charged at a time).......£5.95

High Power Charger, as above but charges the Cs and Ds in 5 hours; AAs, Cs and Ds *must* be charged in twos or fours.......£10.95

Nickel Metal Hydryde AA cells, high capacity with no memory If charged at 100mA and discharged at 250mA or less 1100mAH capacity (lower capacity for high discharge rates).......£3.75

SPECIAL OFFERS – PLEASE CHECK FOR AVAILABILITY

Stick of 4, 42mm x 16mm NiCad batteries, 171mm x 16mm dia., with red and black leads, 4·8V.......£5.95

Five button cell, 6V 280mAH battery with wires (Varta 5 x 250DK).......£2.45

Shaded-pole motor, 240V a.c. 5mm x 20mm shaft, 80mm x 60mm x 55mm, excluding the shaft.......£4.95

115V a.c. 80V d.c. motor, 4mm x 22mm shaft. 50mm dia. x 60mm long body (excluding the shaft) it has a replaceable thermal fuse and brushes.......£4.94each, £3.95 100+

7-Segment, common anode l.e.d. display, 12mm.......45p

LM337K, TO3 case, Variable regulator £1.95, 100+ £1.44

GaAs **F.E.T.** low leakage current S8873.......£12.95 each, £9.95 10+, £7.95 100+

BS250 *p*-channel MOSFET.......45p
BC559 transistor.......£3.95 per 100
BC547A transistor.......20 for £1.00
74LS05 Hex inverter.......£10.00 per 100
Used 8748 Microcontroller.......£3.50
SL952 UHF Limiting amplifier, LC 16 surface mounting package with data sheet.......£1.95
AM27S02.......£1.25 each; 90p 100+
CD4007UB.......10p 100+, 6p 1000+

Sinclair Light Gun, terminated with a jack plug and PP3 clip, gives a signal when pointed at 50Hz flickering light, with output waveform chart.......£3.95

DC-DC Converter, Reliability model V12P5, 12V in, 5V 200mA out, 300V input-to-output isolation, with data.......£4.95 each or pack of 10 £39.50

Hour Counter used 7 digit 240V a.c. 50Hz.......£1.45

QWERTY keyboard, 58-key, good quality switches, new.......£6.00

Airpax A82903-C large stepping motor 14V 7·5° step, 27 ohm, 68mm dia body, 6 3mm shaft.......£8.95 or £200 for a box of 30

Polyester capacitors, box type, 22.5mm lead pitch 0·9µF 250V d.c. 18p each, 14p 100+, 9p 1000+ 1µF 250V d.c. 20p each, 15p 100+, 10p 1000+

1µF 50V bipolar electrolytic axial leads, 15p each, 7·5p 1000+

0·22µF 250V polyester axial leads, 15p each, 100+ 7·5p each

Polypropylene 1µF 400V d.c. (Wima MKP10) 27.5mm pitch, 32mm x 29mm x 17mm case, 75p each, 60p 100+

Philips 123 series solid aluminium axial leads, 33µF 10V and 2·2µF 40V 40p each, 25p 100+

Philips 108 series, long life. 22µF 63V axial.......30p each, 15p 1000+

Multilayer AVX ceramic capacitors, all 5mm pitch, 100V 100pF, 150pF, 220pF, 10,000pF (10n) 10p each, 5p 100+, 3.5p 1000+

500pF compression trimmer capacitor.......60p

40µF 370V a.c. motor start capacitor (dialectrol type containing no p.c.b.s).......£5.95 or £49.50 for 10

Solid carbon resistors, very low inductance, ideal for r.f. circuits, 27 ohm 2W, 68 ohm 2W 25p each, 15p each 100+

We have a range of 0·25W, 0·5W, 1W and 2W solid carbon resistors – please send SAE for list

P.C. 400W PSU (Intel part 201035-001) with standard motherboard and five disk drive connectors, fan and mains input/output connectors on back and switch on the side (top for tower case) dims 212mm x 149mm x 149mm excluding switch, £26.00 each, £138.00 for 6

MX180 Digital Multimeter 17 ranges, 1000V d.c. 750V a.c. 2Megohm 200mA transistor Hfe 9V and 1.5V battery test.......£9.95

AMD 27256-3 EPROMs £2.00 each, £1.25 100+

Inmac deluxe anti-glare static control panel, window size 228mm x 161mm, overall size 264mm x 200mm, held to the monitor with hook and loop tape pads.......£7.95 each

DIP switch 3PCO 12-pin (ERG SDC-3-023) 60p each, 40p 100+

Disk Drive Boxes for a 5·25 disk drive, with room for a power supply, light-grey plastic 67mm x 268mm x 247mm.......£7.95 or £49.50 for 10

Handheld Ultrasonic Remote Control.......£3.95

CV2486 Gas Relay 30mm x 10mm dia. with 3-wire terminals, will also work as a neon light.......20p each, or £7.50 per 100

All products advertised are new and unused unless otherwise stated.

Wide range of CMOS TTL 74HC74F Linear, Transistors kits, rechargeable batteries, capacitors, tools etc. always in stock.

Please add £1.95 towards P&P. VAT included in all prices

JPG ELECTRONICS
276-278 Chatsworth Road
Chesterfield S40 2BH
Access/Visa Orders:
Tel: (01246) 211202 Fax: (01246)550959
Callers welcome 9.30am to 5 30pm
Monday to Saturday

Millions of quality components at lowest ever prices!

Plus Tools, Watches, Fancy Goods, Toys.
Mail order UK only.

All inclusive prices –
NO VAT to add on.
Send 43p stamped self addressed label or envelope for catalogue/clearance list.

At least 2,100 offers to amaze you.

Brian J Reed
6 Queensmead Avenue, East Ewell
Epsom, Surrey KT17 3EQ
Tel: 0181-393 9055

***The Security Centre** (EST. 1980)*

275 Linthorpe Road, Middlesbrough, Cleveland TS1 4AS
Telephone (01642) 241151
OPEN MONDAY-FRIDAY 9A.M. UNTIL 5P.M. SATURDAY 9A.M.-1P.M.

D.I.Y ALARM KITS AT GREATLY REDUCED PRICES!

SALE NOW ON OF A FULL D.I.Y. KIT.
BUY THE FULL KIT AND SAVE OVER £17!

KIT COMPRISES OF:
ONE ZX6 6 ZONE PUSH BUTTON PANEL.
ONE STANBY RECHARGING BATTERY.
ONE P.I.R. MOVEMENT DETECTOR.
ONE FRONT DOOR SWITCH.
ONE POLYCARBONATE BELL BOX.
(NOT to be confused with the cheaper POLPROPYLENE box)
ONE LOUD EXTERNAL SIREN.
50 METRES FOUR CORE CABLE.
100 CABLE CLIPS.

IF PURCHASED SEPARATELY THIS KIT WOULD COST OVER £86!!

SALE PRICE FOR THE FULL KIT:

£69.00!

OVERNIGHT CARRIAGE £8.00 (VAT INCLUDED)

(SAVING OVER £17!)

Offer on while stocks last. Discount vouchers excluded.

Mixed metal/carbon film resistors ⅛W E12 series 10 ohms to 1 Megohm.......2p
Carbon Film resistors ¼W 5% E24 series 0.51 R to 10MO.......1p
100 off per value – 75p. even hundreds per value totalling 1000.......£6.00p
Metal Film resistors ¼W 10R to 1 MO 5% E12 series – 1½p. 1% E24 series.......2p
Mixed metal/carbon film resistors ½W E24 series 1RO to 10MO.......1½p
1 watt mixed metal/Carbon Film 5% E12 series 4R7 to 10 Megohms.......5p
Linear Carbon pre-sets 100mW and ¼W 100R to 2M2 E6 series.......7p

Miniature polyster capacitors 250V working for vertical mounting
.015, .022, .033, .047, .068-4p. 0.1 - 5p. 0.12, 0.15, 0.22 - 6p. 0.47 - 8p. 0.68 - 8p. 1.0 - 12p

Mylar (polyester) capacitors 100V working E12 series vertical mounting
1000p to 8200p - 3p. .01 to .068 - 4p. 0.1 - 5p. 0.12, 0.15, 0.22 - 6p. 0.47/50V - 8p

Submin ceramic plate capacitors 100V wkg vertical mountings. E12 series
2% 1.8pf to 47pf - 3p. 2% 56pf to 330pf - 4p. 10% 390p-4700p.......4p
Disc/plate ceramics 50V E12 series 1PO to 1000P, E6 Series 1500P to 47000P.......2p

Polystyrene capacitors 63V working E12 series long axial wires
10pf to 820pf - 5p. 1000pf to 10,000pf - 6p. 12,000pf.......7p
741 Op Amp - 20p. 555 Timer – 20p. LM3900.......80p
CMOS 4001 - 20p. 4011 - 22p. 4017 – 40p. 4069UB unbuffered.......20p
DIL holders, 8-pin 9p; 14-, 16-, 18-pin 12p; 24-pin 18p; 28-pin 20p; 40-pin 25p.

ALUMINIUM ELECTROLYTICS (Mfds/Volts)
1/50, 2.2/50, 4.7/50, 10/25, 10/50.......5p
22/16, 22/25, 22/50, 33/16, 47/16, 47/25, 47/50.......6p
100/16, 100/25 7p; 100/50.......12p
220/16 8p; 220/25, 220/50 10p; 470/16, 470/25.......11p
1000/25 25p; 1000/35, 2200/25 35p; 4700/25.......70p

Subminiature, tantalum bead electrolytics (Mfds/Volts)
0.1, 0.22, 0.47, 1.0, 2.2, 3.3 @ 35V – 4.7/16, 6.8/10, 10/6, 10p; 6.8/35, 12p.
4.7/25, 6.8/16, 10/6, 11p; 15/16, 22/6, 33/10, 15p; 10/25, 16p; 10/35, 22/16, 20p.
47/10, 20p; 47/16, 25p; 47/20, 30p; 47/35, 32p; 100/3, 18p; 100/6, 220/6, 20p.

VOLTAGE REGULATORS
1A + or – 5V, 8V, 12V, 15V, 18V & 24V - 55p. 100mA. 5.8, 12, 15, V +.......30p

DIODES (piv/amps)
75/25mA 1N4148 2p. 800/1A 1N4006 4½p. 400/3A 1N5404 14p. 115/15mA OA91.......8p
100/1A 1N4002 3½p. 1000/1A 1N4007 5p. 60/1.5A S1M1 5p. 100/1A bridge.......25p
400/1A 1N4004 4p. 1250/1A BY 127 10p. 30/150mA OA47 gold bonded.......18p
Zener diodes E24 series 3V3 to 33V 400mW - 6p. 1 watt.......10p
Battery snaps for PP3 - 7p for PP9.......12p
L.E.D.'s 3mm. & 5mm. Red, Green, Yellow - 10p. Grommets 3mm - 2p. 5mm.......2p
Red flashing L.E.D.'s require 9-12V supply only, 5mm.......50p
Mains indicator neons with 220k resistor.......10p
20mm fuses 100mA to 5A. O. blow 6p. A/surge 10p. Holders, chassis, mounting.......6p
High speed pc drill 0.8, 1.0, 1.3, 1.5, 2.0mm - 40p. Machines 12V dc.......£15.00
HELPING HANDS 6 ball joints and 2 croc clips to hold awkward jobs.......£4.50
AA/HP7 Nicad rechargeable cells 90p each. Universal charger unit.......£6.50
AA/HP7 zinc/carbon batteries in packs of 4.......£1.10 per pack
Glass reed switches with single pole make contacts - 8p. Magnets.......20p
0.1" Stripboard 2½" x 1" 9 rows 25 holes - 25p. 3¾ x 2½" 24 rows 37 holes.......70p
Jack plugs 2.5 & 3.5m – 14p; Sockets Panel Mtg. 2.5 & 3.5m.......10p
Ear pieces 2.5 & 3.5mm, dynamic – 20p; 3.5mm crystal.......£1.50
Multi cored solder, 22G – 8p yard, 18G – 14p yard.

TRANSISTORS
BC107/8/9 - 12p. BC547/8/9 - 8p. BC557/8/9 - 8p. BC182, 182L, BC183, 183L, BC184, 184L, BC212, 212L - 10p.
BC327, 337, 337L - 12p. BC727, 737 - 12p. BD135/6/7/8/9 - 25p. BCY70 - 18p. BFY50/51/52 - 20p.
BFX88 - 15p, 2N3055 - 55p, TIP31, 32 - 30p, TIP41, 42 - 40p. BU208A - £1.50, BF195, 197 - 12p
Ionisers with seven year guarantee, 240V AC, list price £16.95 or more.......£12.50

Do not add VAT. Postage 30p (free over £5). Stamp for list.

THE CR SUPPLY CO
127 Chesterfield Rd., Sheffield S8 0RN Tel: 0114 2557771 *Return posting*

ADVERTISERS INDEX

ADVERTISEMENT MANAGER: PETER J. MEW
ADVERTISEMENT OFFICES:
EVERYDAY PRACTICAL ELECTRONICS, ADVERTISEMENTS, HOLLAND WOOD HOUSE, CHURCH LANE, GREAT HOLLAND, ESSEX CO13 0JS. Phone/Fax: (01255) 850596

For Editorial address and phone numbers see page 101.

Published on approximately the first Friday of each month by Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Printed in England by Benham & Co. Ltd. Colchester, Essex. Distributed by Seymour, Windsor House, 1270 London Road, Norbury, London SW16 4DH. Subscriptions INLAND £24 and OVERSEAS £30 (£47.50 airmail) payable to "Everyday Practical Electronics", Subs Dept, Allen House, East Borough, Wimborne, Dorset BH21 1PF. EVERYDAY PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

POWER AMPLIFIER MODULES-TURNTABLES-DIMMERS-LOUDSPEAKERS-19 INCH STEREO RACK AMPLIFIERS

★ PRICES INCLUDE V.A.T. ★ PROMPT DELIVERIES ★ FRIENDLY SERVICE ★ LARGE (A4) S.A.E. 60p STAMPED FOR CATALOGUE ★

OMP MOS-FET POWER AMPLIFIERS HIGH POWER, TWO CHANNEL 19 INCH RACK

THOUSANDS PURCHASED BY PROFESSIONAL USERS

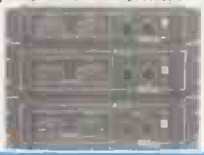
THE RENOWNED MXF SERIES OF POWER AMPLIFIERS

FOUR MODELS:- MXF200 (100W + 100W) MXF400 (200W + 200W) MXF600 (300W + 300W) MXF900 (450W + 450W)

ALL POWER RATINGS R.M.S. INTO 4 OHMS, BOTH CHANNELS DRIVEN

FEATURES: ★Independent power supplies with two toroidal transformers ★ Twin L.E.D. Vu meters ★ Level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low distortion ★ Aluminium cases ★ MXF600 & MXF900 fan cooled with D.C. loudspeaker and thermal protection.

USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.



SIZES:- MXF200 W19"xH3½" (2U)xD11"
MXF400 W19"xH5¼" (3U)xD12"
MXF600 W19"xH5¼" (3U)xD13"
MXF900 W19"xH5¼" (3U)xD14¾"

PRICES:- MXF200 £175.00 MXF400 £233.85 MXF600 £329.00 MXF900 £449.15

SPECIALIST CARRIER DEL. £12.50 EACH

OMP XO3 STEREO 3-WAY ACTIVE CROSS-OVER

Advanced 3-Way Stereo Active Cross-Over, housed in a 19" x 1U case. Each channel has three level controls: bass, mid & top. The removable front fascia allows access to the programmable DIL switches to adjust the cross-over frequency: Bass-Mid 250/500/800Hz, Mid-Top 1.8/3/5KHz, all at 24dB per octave. Bass invert switches on each bass channel. Nominal 775mV input/output. Fully compatible with OMP rack amplifier and modules.

Price £117.44 + £5.00 P&P

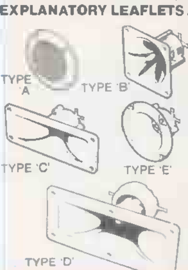
STEREO DISCO MIXER SDJ3400SE ★ ECHO & SOUND EFFECTS★

STEREO DISCO MIXER with 2 x 7 band L & R graphic equalisers with bar graph LED Vu meters. MANY OUTSTANDING FEATURES:- including Echo with repeat & speed control, DJ Mic with talk-over switch, 6 Channels with individual faders plus cross fade, Cue Headphone Monitor. 8 Sound Effects. Useful combination of the following inputs:- 3 turntables (mag), 3 mics, 5 Line for CD, Tape, Video etc.

Price £144.99 + £5.00 P&P SIZE: 482 x 240 x 120mm

PIEZO ELECTRIC TWEETERS - MOTOROLA

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



TYPE 'A' (KSN1036A) 3" round with protective wire mesh. Ideal for bookshelf and medium sized Hi-Fi speakers. Price £4.90 + 50p P&P.

TYPE 'B' (KSN1005A) 3½" super horn for general purpose speakers, disco and P.A. systems etc. Price £5.99 + 50p P&P.

TYPE 'C' (KSN1016A) 2"x5" wide dispersion horn for quality Hi-Fi systems and quality discos etc. Price £6.99 + 50p P&P.

TYPE 'D' (KSN1025A) 2"x6" wide dispersion horn. Upper frequency response retained extending down to mid-range (2KHz). Suitable for high quality Hi-Fi systems and quality discos. Price £9.99 + 50p P&P.

TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-Fi monitor systems etc. Price £5.99 + 50p P&P.

LEVEL CONTROL Combines, on a recessed mounting plate, level control and cabinet input jack socket. 85x85mm. Price £4.10 + 50p P&P.

ibl FLIGHT CASED LOUDSPEAKERS

A new range of quality loudspeakers, designed to take advantage of the latest speaker technology and enclosure designs. Both models utilize studio quality 12" cast aluminium loudspeakers with factory fitted grilles, wide dispersion constant directivity horns, extruded aluminium corner protection and steel ball corners, complimented with heavy duty black covering. The enclosures are fitted as standard with top hats for optional loudspeaker stands.

POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET FREQUENCY RESPONSE FULL RANGE 45Hz - 20KHz

ibl FC 12-100WATTS (100dB) PRICE £159.00 PER PAIR
ibl FC 12-200WATTS (100dB) PRICE £175.00 PER PAIR

SPECIALIST CARRIER DEL. £12.50 PER PAIR

OPTIONAL STANDS PRICE PER PAIR £49.00
Delivery £6.00 per pair

IN-CAR STEREO BOOSTER AMPS

THREE SUPERB HIGH POWER CAR STEREO BOOSTER AMPLIFIERS

150 WATTS (75 + 75) Stereo, 150W Bridged Mono
250 WATTS (125 + 125) Stereo, 250W Bridged Mono
400 WATTS (200 + 200) Stereo, 400W Bridged Mono

ALL POWERS INTO 4 OHMS

Features:
★ Stereo, bridgable mono ★ Choice of high & low level inputs ★ L & R level controls ★ Remote on-off ★ Speaker & thermal protection.

PRICES: 150W £49.99 250W £99.99 400W £109.95 P&P £2.00 EACH

POSTAL CHARGES PER ORDER £1.00 MINIMUM. OFFICIAL ORDERS FROM SCHOOLS, COLLEGES, GOVT. BODIES, PLCs ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER. VISA AND ACCESS ACCEPTED BY POST, PHONE OR FAX.

OMP MOS-FET POWER AMPLIFIER MODULES

SUPPLIED READY BUILT AND TESTED.

These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal power supply, integral heat sink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof.

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 123 x 60mm.
PRICE £40.85 + £3.50 P&P

OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 300 x 155 x 100mm.
PRICE £64.35 + £4.00 P&P

OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
PRICE £81.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE £132.85 + £5.00 P&P

OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110 dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE £259.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.

LOUDSPEAKERS

LARGE SELECTION OF SPECIALIST LOUDSPEAKERS AVAILABLE, INCLUDING CABINET FITTINGS, SPEAKER GRILLES, CROSS-OVERS AND HIGH POWER, HIGH FREQUENCY BULLETS AND HORNS, LARGE (A4) S.A.E. (60p STAMPED) FOR COMPLETE LIST.

McKenzie and Fane Loudspeakers are also available.

EMINENCE:- INSTRUMENTS, P.A., DISCO, ETC

ALL EMINENCE UNITS 8 OHMS IMPEDANCE

8" 100 WATT R.M.S. ME8-100 GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID, DISCO.
RES. FREQ. 72Hz, FREQ. RESP. TO 4KHz, SENS 97dB. PRICE £32.71 + £2.00 P&P

10" 100 WATT R.M.S. ME10-100 GUITAR, VOCAL, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 71Hz, FREQ. RESP. TO 7KHz, SENS97dB. PRICE £33.74 + £2.50 P&P

10" 200 WATT R.M.S. ME10-200 GUITAR, KEYB'D, DISCO, VOCAL, EXCELLENT HIGH POWER MID.
RES. FREQ. 65Hz, FREQ. RESP. TO 3.5KHz, SENS 99dB. PRICE £43.47 + £2.50 P&P

12" 100 WATT R.M.S. ME12-100LE GEN. PURPOSE, LEAD GUITAR, DISCO, STAGE MONITOR.
RES.FREQ. 49Hz, FREQ. RESP. TO 6KHz, SENS 100dB. PRICE £35.64 + £3.50 P&P

12" 100 WATT R.M.S. ME12-100LT (TWIN CONE) WIDE RESPONSE, P.A., VOCAL, STAGE MONITOR. RES. FREQ 42Hz, FREQ. RESP. TO 10KHz, SENS 98dB. PRICE £36.67 + £3.50 P&P

12" 200 WATT R.M.S. ME12-200 GEN. PURPOSE, GUITAR, DISCO, VOCAL, EXCELLENT MID.
RES. FREQ. 58Hz, FREQ. RESP. TO 6KHz, SENS 98dB. PRICE £46.71 + £3.50 P&P

12" 300 WATT R.M.S ME12-300GP HIGH POWER BASS, LEAD GUITAR, KEYBOARD, DISCO ETC.
RES. FREQ. 47Hz, FREQ. RESP. TO 5KHz, SENS 103dB. PRICE £70.19 + £3.50 P&P

15" 200 WATT R.M.S. ME15-200 GEN. PURPOSE BASS, INCLUDING BASS GUITAR.
RES. FREQ. 46Hz, FREQ. RESP. TO 5KHz, SENS 99dB. PRICE £50.72 + £4.00 P&P

15" 300 WATT R.M.S. ME15-300 HIGH POWER BASS, INCLUDING BASS GUITAR.
RES. FREQ. 39Hz, FREQ. RESP. TO 4KHz, SENS 103dB. PRICE £73.34 + £4.00 P&P

EARBENDERS:- HI-FI, STUDIO, IN-CAR, ETC

ALL EARBENDER UNITS 8 OHMS (Except EB8-50 & EB10-50 which are dual impedance tapped @ 4 & 8 ohm)

BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND

8" 50watt EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 7KHz SENS 97dB. PRICE £8.90 + £2.00 P&P

10" 50WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS. 99dB. PRICE £13.65 + £2.50 P&P

10" 100WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz, FREQ. RESP. TO 3KHz, SENS 96dB. PRICE £30.39 + £3.50 P&P

12" 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz, SENS 93dB. PRICE £42.12 + £3.50 P&P

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

5¼" 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB. PRICE £9.99 + £1.50 P&P

6½" 60WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB. PRICE £10.99 + 1.50 P&P

8" 60WATT EB8-60TC (TWIN CONE) HI-FI, MILTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB. PRICE £12.99 + £1.50 P&P

10" 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC.
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB. PRICE £16.49 + £2.00 P&P

TRANSMITTER HOBBY KITS

PROVEN TRANSMITTER DESIGNS INCLUDING GLASS FIBRE PRINTED CIRCUIT BOARD AND HIGH QUALITY COMPONENTS COMPLETE WITH CIRCUIT AND INSTRUCTIONS

3W TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 38 x 123mm, SUPPLY 12V @ 0.5AMP.
PRICE £14.85 + £1.00 P&P

FM MICRO TRANSMITTER 100-108MHz, VARICAP TUNED, COMPLETE WITH VERY SENS FET MIC, RANGE 100-300m, SIZE 56 x 46mm, SUPPLY 9V BATTERY.
PRICE £8.80 + £1.00 P&P

PHOTO: 3W FM TRANSMITTER

B.K. ELECTRONIC

UNITS 1 & 5 COMET WAY, SOUTHEND-ON-SEA ESSEX. SS2 6TR.
Tel.: 01702-527572 Fax.: 01702-420243