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AUGUST 1997

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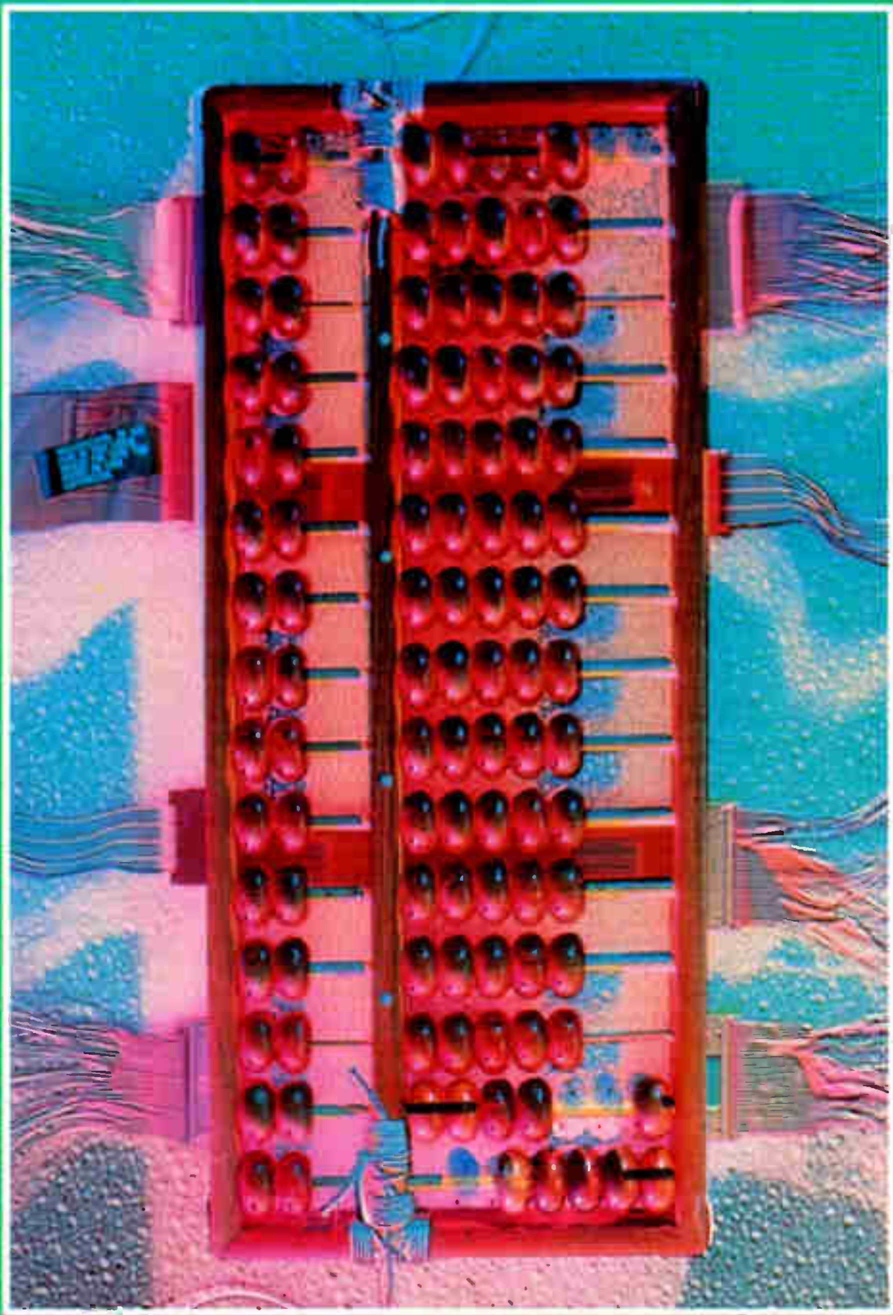

PIC-OLO

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THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

THERE IS ONE DANGER YOU CAN'T SEE, HEAR, SMELL OR FEEL- ITS RADIATION. THERE ARE OVER 10,000 SHIPMENTS OF RADIOACTIVE MATERIAL IN THE UK EVERY YEAR BY ROAD AND RAIL! WOULD ANYBODY TELL YOU OF A RADIATION LEAK?

NEW GEIGER COUNTER IN STOCK Hand held unit with LCD screen, auto ranging, low battery alarm, audible 'click' output. New and guaranteed. £129 ref GE1

RUSSIAN BORDER GUARD BINOCULARS £1799 Probably the best binoculars in the world! ring for colour brochure.

RUSSIAN MULTIBAND WORLD COMMUNICATIONS RECEIVER Exceptional coverage of 9 wave bands, (5 short, 1 LW, 1FM, 1MW) internal ferrite and external telescopic aerials, mains/ battery. £45 ref VEGA

NEW LASER POINTERS 4.5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm. £29 ref DEC49

HOW TO PRODUCE 35 BOTTLES OF WHISKY FROM A SACK OF POTATOES Comprehensive 270 page book covers all aspects of spirit production from everyday materials. Includes construction details of simple stills etc. £12 ref MS3

NEW HIGH POWER MINI BUG With a range of up to 800 metres and a 3 days use from a PP3 this is our top selling bug! less than 1" square and a 10m voice pickup range. £28 Ref LOT102.

BUILD YOU OWN WINDFARM FROM SCRAP New publication gives step by step guide to building wind generators and propellors. Armed with this publication and a good local scrap yard could make you self sufficient in electricity! £12 ref LOT81

PC KEYBOARDS PS2 connector, top quality suitable for all 286/ 386/486 etc £10 ref PCKB. 10 for £65.

NEW LOW COST VEHICLE TRACKING TRANSMITTER KIT £29 range 1.5-5 miles, 5,000 hours on AA batteries, transmits info on car direction, left and right turns, start and stop information. Works with any good FM radio. £29 ref LOT101a

HIGH SECURITY ELECTRIC DOOR LOCKS Complete brand new Italian lock and latch assembly with both Yale type lock (keys inc) and 12v operated deadlock. £10 ref LOT99

***NEW HIGH POWER WIRELESS VIDEO AND AUDIO BUG KIT 1/2 MILE RANGE** Transmits video and audio signals from a minature CCTV camera (included) to any standard television! Supplied with telescopic aerial. £169

CCTV PAN AND TILT KIT Motorize your CCTV camera with this simple 12vdc kit. 2 hermentically sealed DC linear servo motors 5mm threaded output 5 secs stop to stop, can be stopped any where, 10mm travel, powerful. £12 ref LOT125

GPS SATELLITE NAVIGATION SYSTEM Made by Garmin, the GPS38 is hand held, pocket sized, 255g, position, altitude, graphic compass, map builder, nitro filled. Bargain price just £179 ref GPS1.

CCTV CAMERA MODULES 46X70X29mm, 30 grams, 12v 100mA, auto electronic shutter, 3.6mm F2 lens, CCIR, 512x492 pixels, video output is 1v p-p (75 ohm). Works directly into a scart or video input on a tv or video. IR sensitive. £79.95 ref EF137.

IR LAMP KIT Suitable for the above camera, enables the camera to be used in total darkness! £6 ref EF138

INFRA RED POWERBEAM Handheld battery powered lamp, 4 inch reflector, gives out powerful pure infrared light! perfect for CCTV use, nightsights etc. £29 ref PB1.

SUPER WIDEBAND RADAR DETECTOR Detects both radar and laser, X K and KA bands, speed cameras, and all known speed detection systems. 360 degree coverage, front &rearwaveguides, 1.1"x2.7"x4.6" fits on sun visor or dash £149 ref

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS

Could be adapted for laser listener, long range communications etc Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignement. 7 mile range, no circuit diagrams due to MOD, new price £50,000? us? £199. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt. 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. £199 for one. Ref LOT4.

EASY DIY/PROFESSIONAL TWO WAY MIRROR KIT Includes special adhesive film to make two way mirror(s) up to 60"x20", (glass not included) includes full instructions. £12 ref TW1.

NEW LOW PRICED COMPUTER/WORKSHOP/HI-FI RCB UNITS Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends it by 750mm), fitted in less than 10 seconds, reset/test button, 10A rating £6.99 each ref LOT5. Or a pack of 10 at £49.90 ref LOT6. If you want a box of 100 you can have one for £250!

TWO CHANNEL FULL FUNCTION B GRADE RADIO CONTROLLED CARS From World famous manufacturer these are returns so they will need attention (usually physical damage) cheap way of buying TX and RX plus servos etc for new projects etc. £12 each sold as seen ref LOT2.

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleads, designed to read standard credit cards! complete with control electronics PCB and manual covering everything you could want to know about whats hidden in that magnetic strip on your card! just £9.95 ref BAR31

HIGH POWER DC MOTORS, PERMANENT MAGNET 12 - 24v operation, probably about 1/4 horse power, body measures 100mm x 75mm with a 60mm x 5mm output shaft with a machined flat on it. Fixing is simple using the two threaded bolts protruding from the front of the motor 4mm x 12mm). These motors are perfect for model engineering etc they may even be suitable as a cycle motor? We expect high demand so if you would like one or think you may require one in the future place your order today! £22 ref MOT4 10 pack £185

WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC. Also included is the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74

RUSSIAN 900X MAGNIFICATION ZOOM MICROSCOPE metal construction, built in light, mirror etc. Russian shrimp farm!, group viewing screen, lots of accessories. £29 ref ANAYLT

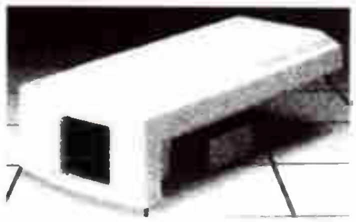
AA NICAD PACK Pack of 4 tagged AA nicads £2.99 ref BAR34

RUSSIAN NIGHTSIGHTS Model TZS4 with infra red illuminator, views up to 75 metres in full darkness in infrared mode, 150m range 45mm lens. 13 deg angle of view, focussing range 1.5m to infinity. 2 AA batteries required. 950g weight. £199 ref BAR61. 1 years warranty

LIQUID CRYSTAL DISPLAYS Bargain prices,
16 character 2 line, 99x24mm £2.99 ref SM1623A
20 character 2 line, 83x19mm £3.99 ref SM2024A
16 character 4 line, 62x25mm £5.99 ref SMC1640A

TAL-1, 110MM NEWTONIAN REFLECTOR TELESCOPE Russian. Superb astronomical 'scope, everything you need for some serious star gazing! up to 189x magnification. Send or fax for further information 20kg, 885x800x1650mm ref TAL-1, £249

YOUR HOME COULD BE SELF SUFFICENT IN ELECTRICITY Comprehensive plans with loads of info on designing systems, panels, control electronics etc £7 ref PV1



COLOUR CCTV VIDEO CAMERAS
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Works with most modern video's, TV's, Composite monitors, video grabber cards etc Pal, 1v P-P, composite, 75ohm, 1/3" CCD, 4mm F2.8, 500x582, 12vdc, mounting bracket, auto shutter, 100x50x180mm, 3 months warranty,1 off price £119 ref XEF150, 10 or more £99 ea 100+ £89

MICRO RADIO It's tiny, just 3/8" thick, auto tunning, complete with headphones. FM £9.99 ref EP35

25 SQUARE FOOT SOLAR ENERGY BANK KIT 100 6"x6" 6v Amorphous 100mA panels, 100 diodes, connection details etc to build a 25 square foot solar cell for just £99 ref EF112.

CONVERT YOUR TV INTO A VGA MONITOR FOR £25! Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware.. Ideal for laptops or a cheap upgrade.Supplied in kit form for home assembly. SALE PRICE £25 REF SA34

***15 WATT FM TRANSMITTER** Already assembled but some RF knowledge will be useful for setting up. Preamp req'd, 4 stage 80-108mhz, 12-18vdc, can use ground plane, yagi or dipole £69 ref 1021

***4 WATT FM TRANSMITTER KIT** Small but powerful FM transmitter kit. 3 RF stages, mic & audio preamp included £24 ref 1028

YUASHA SEALED LEAD ACID BATTERIES 12v 15AH at £18 ref LOT8 and below spec 6v 10AH at £5 a pair

ELECTRIC CAR WINDOW DE-ICERS Complete with cable, plug etc SALE PRICE JUST £4.99 REF SA28

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt £12.99 REF AUG10P3.

SOLAR POWER LAB SPECIAL You get 2 6"x6" 6v 130mA cells, 4 LED's, wire, buzzer, switch + 1 relay or motor. £7.99 REF SA27

12V DC MOTOR SPEED CONTROL KIT Complete with PCB etc. Up to 30A. A heat sink may be required. £19.00 REF: MAG17

SOLAR NICAD CHARGERS 4 x AA size £9.99 ref 6P476, 2 x C size £9.99 ref 6P477

MEGA POWER BINOCULARS Made by Helios, 20 x magnification, precision ground fully coated optics, 60mm objectives, shock resistant caged prisms, case and neck strap. £89 ref HPH1

GIANT HOT AIR BALLOON KIT Build a 4.5m circumfrence, fully functioning balloon, can be launched with home made burner etc. Reusable (until you loose it!) £12.50 ref HA1

AIR RIFLES .22 As used by the Chinese army for training puposes, so there is a lot about! £39.95 Ref EF78. 500 pellets £4.50 ref EF80

***NEW MEGA POWER VIDEO AND AUDIO SENDER UNIT.** Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 500m range! (tune TV to channel 31) 12v DC op. Price is £65 REF: MAG15 12v psu is £5 extra REF: MAG5P2

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range up to 2 km in open country. Units measure 22x52x155mm. Including cases and earp'ces. 2xPP3 req'd. £37.00 pr.REF: MAG30

***FM TRANSMITTER KIT** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £18 REF: EF62 (kit) Transmits to any FM radio. Built and tested version now available of the above unit at £45 ref EXM34

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £14.95 Ref EF82B extra pellets (500) £4.50 ref EF80.

HEAT PUMPS These are mains operated air to air units that consist of a aluminium plate (cooling side) and a radiator (warming side) connected together with a compressor. The plate if inserted into water will freeze it. Probably about 3-400 watts so could produce 1kw in ideal conditions. £30 ref HP1

3 FOOT SOLAR PANEL Amorphous silicon, 3' x 1' housed in an aluminium frame, 13v 700mA ouput. £55 ref MAG45

SOLAR/WIND REGULATOR Prevents batteries from over charging. On reaching capacity the regulator diverts excess power into heat avoiding damage. Max power is 60 watts. £27.99 ref S/CA11-/05

FANCY A FLUTTER? SEEN OUR NEW PUBLICATION? Covers all aspects of horse and dog betting, systems etc and gives you a betting system that should make your betting far more profitable! £6 a copy ref BET1

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

4X28 TELESCOPIC SIGHTS Suitable for all air rifles, ground lenses, good light gathering properties. £24.95 ref R/7.

GYROSCOPES Remember these? well we have found a company that still manufactures these popular scientific toys, perfect gift or for educational use etc. £6 ref EP70

NICAD CHARGERS AND BATTERIES Standard universal mains operated charger, takes 4 batts + 1 PP3, £10 ref PO11D. Nicads- AA size (4 pack) £4 ref 4P44, C size (2 pack) £4 ref 4P73, D size (4 pack) £9 ref 9P12.

RECHARGE ORDINARY BATTERIES UP TO 10 TIMES! With the Battery Wizard! Uses the latest pulse wave charge system to charge all popular brands of ordinary batteries AAA, AA, C, D, four at a time! Led system shows when batteries are charged, automatically rejects unsuitable cells, complete with mains adaptor. BS approved. Price is £21.95 ref EP31.

PHOTOGRAPHIC RADAR TRAPS CAN COST YOU YOUR LICENCE! The new multiband 2000 radar detector can prevent even the most responsible of drivers from losing their licence! Adjustable audible alarm with 8 flashing leds gives instant warning of radar zones. Detects X, K, and Ka bands, 3 mile range, 'over the hill' 'around bends' and 'rear trap facilities. micro size just 4.25"x2.5"x.75", Can pay for itself in just one day! £89 ref EP3.

3" DISCS As used on older Amstrad machines, Spectrum plus3's etc £3 each ref BAR400.

STEREO MICROSOPES BACK IN STOCK Russian, 200x complete with lenses, lights, filters etc etc very comprehensive microscope that would normally be around the £700 mark, our price is just £299 (full money back guarantee) full details in catalogue.

SECOND GENERATION NIGHT SIGHTS FROM £748

RETRON Russian night sight, 1 8x, infra red lamp, 10m-inf, standard M42 lens, 1.1kg. £349 ref RET1

LOW COST CORDLESS MIC 500' range, 90 - 105mhz, 115g, 193 x 26 x 39mm, 9v PP3 battery required. £17 ref MAG15P1

HI POWER SURVEILLANCE TELESCOPE Continuous zoom control from 20 times to an amazing 60 times magnification. 60mm fully coated objective lens for maximum light transmission, complete with tripod featuring micro elevation control. £75 ref ZT1

JUMBO LED PACK 15 10mm bicolour leds, plus 5 giant (55mm) seven segment displays all on a pcb £8 ref JUM1. Pack of 30 55mm seven seg displays on pcbs is £19 ref LED4, pack of 50 £31 ref LED50

12VDC 40MM FANS MADE BY PANAFLO, NEW £4. REF FAN12

WIND GENERATORS 380 WATT

1.14 dia blades, carbon matrix blades, 3 year warranty, 12vdc output, control electronics, brushless neodymium cubic curve alternator, only two moving parts, maintenance free, simple roof top installation, start up speed 7mph, max output (30mph) 380w, £499 ref AIR1

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EVERYDAY PRACTICAL ELECTRONICS

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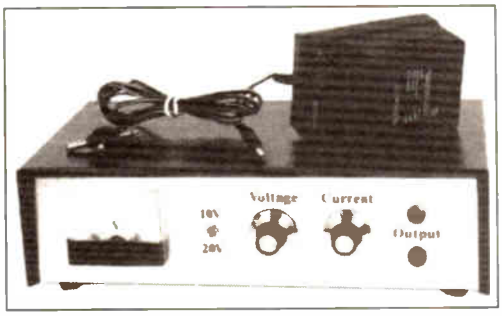
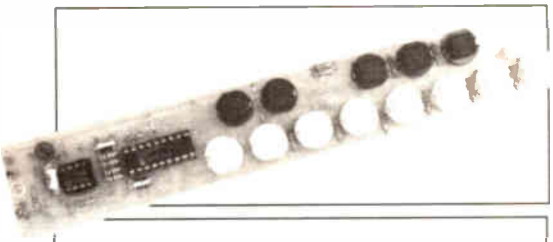
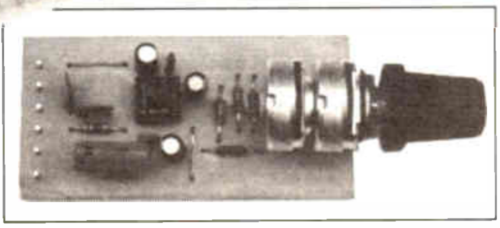
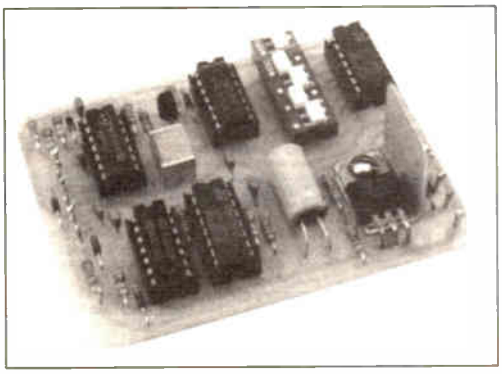
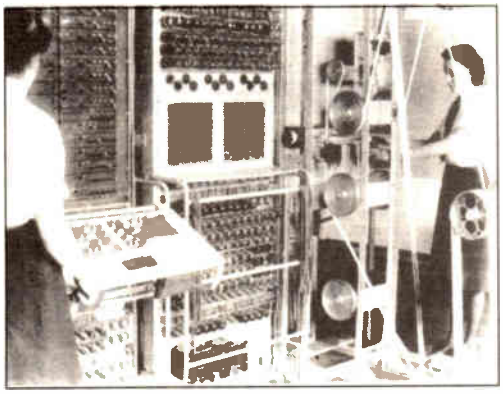
The No. 1 Magazine for Electronics Technology and Computer Projects











Projects and Circuits

Series and Features

Regulars and Services

Our September '97 issue will be published on Friday, 1 August 1997. See page 559 for details.

Electronics Principles 4.0

For Windows 3.1, '95 & NT.

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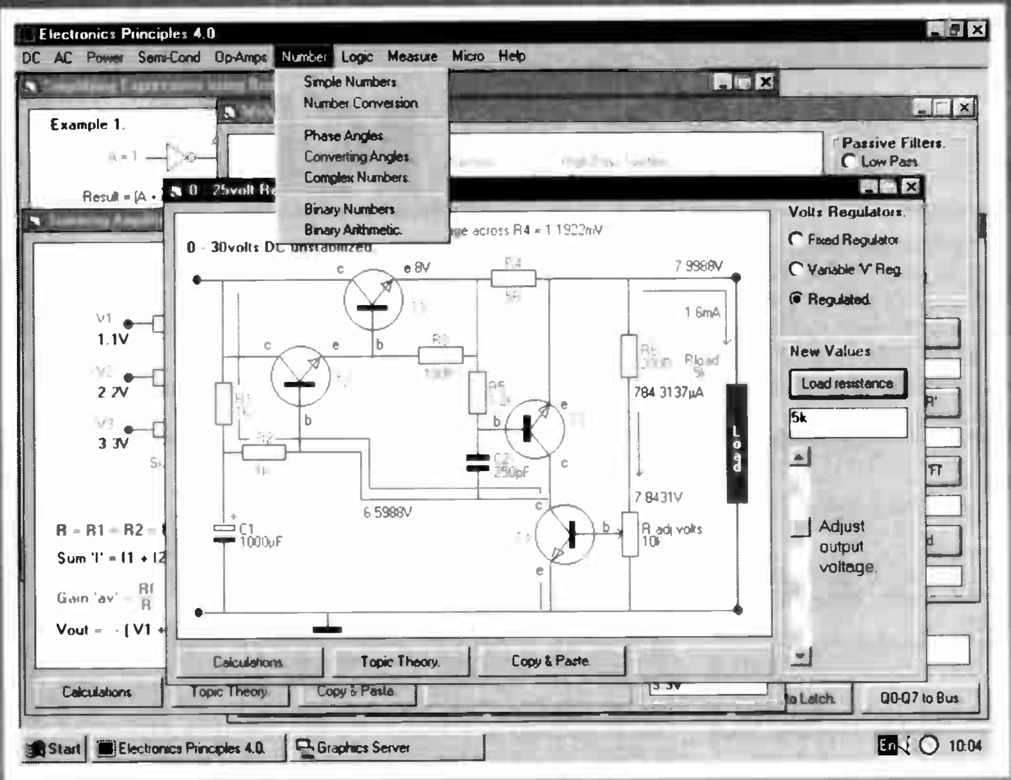
If you are looking for an easy and enjoyable way of studying or improving your knowledge of electronics then this is the software for you.



Electronics Principles 4.0 now has an even more comprehensive range of fully interactive analogue and digital topics. From current flow and dc circuits through switching and transistor operation to passive and active filters. Logic begins with simple gates through binary, hex and octal number conversion, addition and subtraction to Boolean algebra. Plus, microprocessor and microcomputer operation, registers, arithmetic and logic unit, ROM, RAM. Addressing modes and full instruction set which can be simulated on the screen. All version 3.0 topics are covered within this program.

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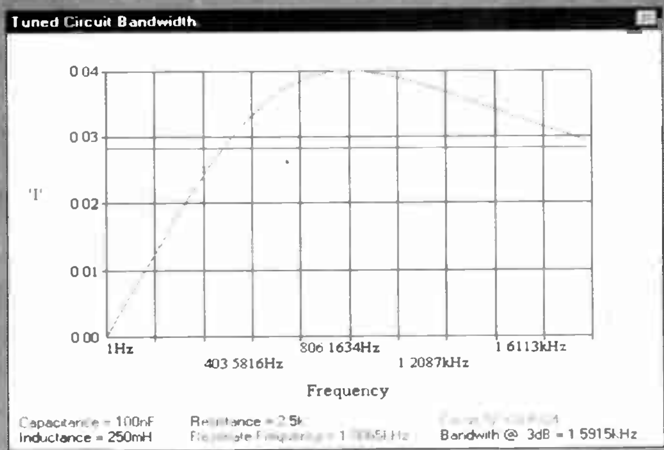
Mathematics Principles 3.0 — £49.95*

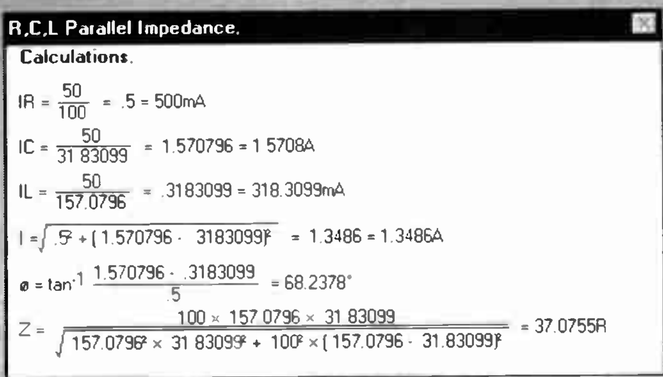
Study or revise mathematics in what we believe is an interesting and enjoyable way. Nearly two hundred graphics presentations, to enable learning by exploration. including the GCSE syllabus.

The popular Electronics Principles 3.0 — £49.95*

Contains nearly 300 fully interactive analogue and digital topics. Electron current flow, transistor operation and biasing, MOSFET enhancement and depletion modes. Frequency and tuned circuits. Logic gates, counters and shift registers to binary arithmetic. To list just a few of those available

- All inputs & outputs use electronics symbols.
- Hundreds of electronics formulae available for circuit investigation.
- Ideal for students and hobbyists who require a quick and easy way to get to grips with a particular point.
- Explore the subject as the interactive graphics are redrawn showing phase angles, voltage and current levels or logic states for your chosen component values.
- Generate hard copies of graphics, text and calculations.





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PROFESSIONAL QUALITY KITS

No. 1 for Kits

Whether your requirement for surveillance equipment is amateur, professional or you are just fascinated by this unique area of electronics SUMA DESIGNS has a kit to fit the bill. We have been designing electronic surveillance equipment for over 12 years and you can be sure that all our kits are very well tried, tested and proven and come complete with full instructions, circuit diagrams, assembly details and all high quality components including fibreglass PCB. Unless otherwise stated all transmitters are tuneable and can be received on an ordinary VHF FM radio.

Genuine SUMA kits available only direct from Suma Designs. Beware inferior imitations!

UTX Ultra-miniature Room Transmitter
Smallest room transmitter kit in the world! Incredible 10mm x 20mm including mic. 3V-12V operation. 500m range.......... £16.45

MTX Micro-miniature Room Transmitter
Best-selling micro-miniature Room Transmitter. Just 17mm x 17mm including mic. 3V-12V operation. 1000m range.......... £13.45

STX High-performance Room Transmitter
High performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22m, including mic. 6V-12V operation, 1500m range £15.45

VT500 High-power Room Transmitter
Powerful 250mW output providing excellent range and performance.
Size 20mm x 40mm. 9V-12V operation. 3000m range.......... £16.45

VXT Voice-Activated Transmitter
Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range. £19.45

HVX400 Mains Powered Room Transmitter
Connects directly to 240V A.C. supply for long-term monitoring.
Size 30mm x 35mm. 500m range.......... £19.45

SCRX Subcarrier Scrambled Room Transmitter
Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm. 9V operation. 1000m range...... £22.95

SCLX Subcarrier Telephone Transmitter
Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range.......... £23.95

SCDM Subcarrier Decoder Unit for SCRX
Connects to receiver earphone socket and provides decoded audio output to headphones. Size 32mm x 70mm. 9V-12V operation.......... £22.95

ATR2 Micro-Size Telephone Recording Interface
Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm. Powered from line.......... £13.45

★★★ Specials ★★★

DLTX/DLRX Radio Control Switch
Remote control anything around your home or garden, outside lights, alarms, paging system etc. System consists of a small VHF transmitter with digital encoder and receiver unit with decoder and relay output, momentary or alternate, 8-way d.i.l. switches on both boards set your own unique security code. TX size 45mm x 45mm. RX size 35mmx 90mm. Both 9V operation. Range up to 200m.
Complete System (2 kits).......... £50.95
Individual Transmitter DLTX.......... £19.95
Individual Receiver DLRX.......... £37.95

MBX-1 Hi-Fi Micro Broadcaster
Not technically a surveillance device but a great idea! Connects to the headphone output of your Hi-Fi, tape or CD and transmits Hi-Fi quality to a nearby radio. Listen to your farvourite music anywhere around the house, garden, in the bath or in the garage and you don't have to put up with the DJ's choice and boring waffle.
Size 27mm x 60mm. 9V operation. 250m range.......... £20.95

UTLX Ultra-miniature Telephone Transmitter
Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm! Connects to line (anywhere) and switches on and off with phone use.
All conversation transmitted. Powered from line. 500m range.......... £15.95

TLX 700 Micro-miniature Telephone Transmitter
Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range.......... £13.45

STLX High-performance Telephone Transmitter
High performance transmitter with buffered output stage providing excellent stability and performance. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line.
Size 22mm x 22mm. 1500m range.......... £16.45

TKX900 Signalling/Tracking Transmitter
Transmits a continuous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m.
Size 25mm x 63mm. 9V operation.......... £22.95

CD400 Pocket Bug Detector/Locator
LED and piezo bleeper pulse slowly, rate of pulse and pitch of tone increase as you approach signal. Gain control allows pinpointing of source.
Size 45mm x 54mm. 9V operation.......... £30.95

CD600 Professional Bug Detector/Locator
Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFORM mode to distinguish between localised bug transmission and normal legitimate signals such as pagers, cellular, taxis etc. Size 70mm x 100mm. 9V operation.......... £50.95

QTX180 Crystal Controlled Room Transmitter
Narrow band FM transmitter for the ultimate in privacy. Operates on 180MHz and requires the use of a scanner receiver or our QRX180 kit (see catalogue).
Size 20mm x 67mm. 9V operation. 1000m range.......... £40.95

QLX180 Crystal Controlled Telephone Transmitter
As per QTX180 but connects to telephone line to monitor both sides of conversations.
20mm x 67mm. 9V operation. 1000m range.......... £40.95

QSX180 Line Powered Crystal Controlled Phone Transmitter
As per QLX180 but draws power requirements from line. No batteries required.
Size 32mm x 37mm. Range 500m.......... £35.95

QRX 180 Crystal Controlled FM Receiver
For monitoring any of the 'Q' range transmitters. High sensitivity unit. All RF section supplied as pre-built and aligned module ready to connect on board so no difficulty setting up. Output to headphones. 60mm x 75mm. 9V operation.......... £60.95

A build-up service is available on all our kits if required.

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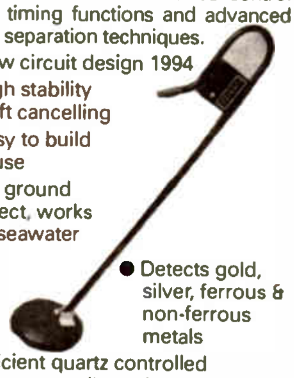
EPE MICROCONTROLLER P.I. TREASURE HUNTER

The latest MAGENTA DESIGN – highly stable & sensitive – with MC 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

MICRO PEsT SCARER

NEW *

Our latest design – The ultimate scarer for the garden. Uses special microchip to give random delay and pulse time. Easy to build reliable circuit. Keeps pets/pests away from newly sown areas, play areas, etc. Uses power source from 9 to 24 volts.

- RANDOM PULSES
- HIGH POWER
- DUAL OPTION

Plug-in power supply £4.99

KIT 867...............................£19.99
KIT + SLAVE UNIT...................£32.50

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 plus 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

WINDICATOR

A novel wind speed indicator with LED readout. Kit comes complete with sensor cups, and weatherproof sensing head. Mains power unit £5.99 extra.

KIT 856...£28.00

SUPER BAT DETECTOR

NEW!

1 WATT O/P, BUILT IN SPEAKER, COMPACT CASE
20kHz-140kHz
NEW DESIGN WITH 40kHz MIC.

A new circuit using a 'full bridge' audio amplifier i.c., internal speaker, *and* head-phone/tape socket. The latest sensitive transducer, and 'double balanced mixer' give a stable, high performance superheterodyne design.

KIT 861......................£24.99
ALSO AVAILABLE Built & Tested £39.99

★ TENS UNIT ★

DUAL OUTPUT TENS UNIT

NEW!

As featured in March '97 issue.

Magenta have prepared a FULL KIT for this excellent new project. All components, PCB, hardware and electrodes are included. Designed for simple assembly and testing and providing high level dual output drive.

KIT 866.... Full kit including four electrodes £32.90

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

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

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

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, nF 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

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

Based on our Mk1 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

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

SUPER ACOUSTIC PROBE

Our very popular project – now with ready built probe assembly and diecast box. Picks up vibrations amplifies, and drives headphones. Sounds from engines, watches, and speech through walls can be heard clearly. Useful for mechanics, instrument engineers and nosey parkers! A very useful piece of kit.

KIT 865........................£29.95

DOLBY PRO-LOGIC DECODER

DOLBY SURROUND PRO•LOGIC

Brings full Genuine PRO-LOGIC Surround Sound to you at a fantastic price. The circuit meets all *DOLBY specifications, with "Stereo", "3-Stereo" and "Surround" selections. Featured in *EPE* APRIL '96

Full kit with case and transformer, Kit Ref: 869 £124.99

Short Form KIT, Kit Ref: 858 £99.00

*DOLBY and the double-D symbol are trademarks.

ULTRASONIC PEsT SCARER

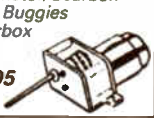
Keep pets/pests away from newly sown areas, fruit, vegetable and flower beds, children's play areas, patios etc. This project produces intense pulses of ultrasound which deter visiting animals.

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

KIT 812...£14.81

DC Motor/Gearboxes

Our Popular and Versatile DC motor/Gearbox sets. Ideal for Models, Robots, Buggies etc. 1·5 to 4·5V Multi ratio gearbox gives wide range of speeds.



LARGE TYPE – MGL £6.95
SMALL – MGS – £4.77

Stepping Motors

MD38...Mini 48 step...£8.65
MD35...Std 48 step...£12.98
MD200...200 step...£16.80
MD24...Large 200 step...£22.95

ESR ELECTRONIC COMPONENTS

Station Road, Cullercoats,
Tyne & Wear, NE30 4PQ
Tel: (0191) 251 4363
Fax: (0191) 252 2296
Email: sales@esr.co.uk
http: //www.esr.co.uk

See Next / Last Months Ad. for COMPONENT ACCESSORIES

4000 Series		74HC Series		74LS	
4000	£0.17	74HC00	£0.20	74LS47	£0.58
4001	£0.18	74HC02	£0.21	74LS51	£0.24
4002	£0.17	74HC03	£0.21	74LS73	£0.40
4006	£0.40	74HC04	£0.17	74LS74	£0.32
4007	£0.18	74HC08	£0.21	74LS75	£0.30
4008	£0.23	74HC10	£0.16	74LS76	£0.25
4009	£0.19	74HC11	£0.20	74LS83	£0.31
4010	£0.23	74HC14	£0.22	74LS85	£0.35
4011	£0.20	74HC20	£0.28	74LS86	£0.20
4012	£0.16	74HC27	£0.16	74LS90	£0.48
4013	£0.19	74HC30	£0.22	74LS92	£0.35
4014	£0.30	74HC32	£0.20	74LS93	£0.42
4015	£0.24	74HC42	£0.25	74LS107	£0.30
4016	£0.30	74HC73	£0.40	74LS109	£0.21
4017	£0.29	74HC74	£0.23	74LS112	£0.24
4018	£0.27	74HC75	£0.40	74LS113	£0.21
4019	£0.48	74HC76	£0.20	74LS114	£0.21
4020	£0.36	74HC85	£0.24	74LS122	£0.31
4021	£0.31	74HC86	£0.22	74LS123	£0.31
4022	£0.32	74HC107	£0.40	74LS125	£0.27
4023	£0.16	74HC123	£0.33	74LS126	£0.25
4024	£0.32	74HC125	£0.24	74LS132	£0.21
4025	£0.15	74HC126	£0.46	74LS133	£0.36
4026	£0.78	74HC132	£0.37	74LS136	£0.23
4027	£0.25	74HC133	£0.29	74LS138	£0.40
4028	£0.34	74HC138	£0.25	74LS139	£0.24
4029	£0.40	74HC139	£0.31	74LS145	£0.56
4030	£0.17	74HC151	£0.33	74LS147	£1.26
4031	£0.70	74HC153	£0.27	74LS148	£0.64
4033	£0.56	74HC154	£0.85	74LS151	£0.25
4034	£1.24	74HC157	£0.40	74LS153	£0.25
4035	£0.31	74HC158	£0.23	74LS154	£0.70
4040	£0.38	74HC160	£0.64	74LS155	£0.25
4041	£0.31	74HC161	£0.28	74LS156	£0.36
4042	£0.22	74HC162	£0.45	74LS157	£0.22
4043	£0.28	74HC163	£0.27	74LS158	£0.21
4044	£0.35	74HC164	£0.35	74LS160	£0.48
4046	£0.52	74HC165	£0.35	74LS161	£0.32
4047	£0.47	74HC173	£0.38	74LS162	£0.44
4048	£0.28	74HC174	£0.27	74LS163	£0.32
4049	£0.22	74HC175	£0.35	74LS164	£0.24
4050	£0.26	74HC192	£0.72	74LS165	£0.48
4051	£0.38	74HC195	£0.32	74LS170	£0.30
4052	£0.32	74HC240	£0.37	74LS173	£0.24
4053	£0.40	74HC241	£0.37	74LS174	£0.24
4054	£0.56	74HC243	£0.48	74LS175	£0.24
4055	£0.34	74HC244	£0.42	74LS190	£0.60
4060	£0.44	74HC245	£0.46	74LS191	£0.24
4063	£0.29	74HC251	£0.25	74LS192	£0.60
4066	£0.22	74HC253	£0.25	74LS193	£0.24
4067	£2.20	74HC257	£0.25	74LS195	£0.24
4068	£0.16	74HC259	£0.57	74LS196	£0.24
4069	£0.20	74HC273	£0.35	74LS197	£0.24
4070	£0.26	74HC299	£0.64	74LS221	£0.40
4071	£0.23	74HC356	£0.45	74LS240	£0.32
4072	£0.17	74HC365	£0.34	74LS241	£0.32
4073	£0.17	74HC367	£0.25	74LS242	£0.32
4075	£0.17	74HC368	£0.25	74LS243	£0.30
4076	£0.30	74HC373	£0.35	74LS244	£0.32
4077	£0.28	74HC374	£0.40	74LS245	£0.60
4078	£0.20	74HC390	£0.52	74LS247	£0.32
4081	£0.22	74HC393	£0.38	74LS251	£0.24
4082	£0.21	74HC423	£0.37	74LS257	£0.24
4085	£0.28	74HC553	£0.42	74LS258	£0.24
4086	£0.26	74HC563	£0.48	74LS266	£0.14
4089	£0.55	74HC564	£0.48	74LS273	£0.32
4093	£0.22	74HC573	£0.38	74LS279	£0.25
4094	£0.31	74HC574	£0.45	74LS365	£0.21
4095	£0.56	74HC640	£0.73	74LS367	£0.21
4097	£1.20	74HC688	£0.64	74LS368	£0.21
4098	£0.48	74HC4002	£0.31	74LS373	£0.33
4099	£0.38	74HC4017	£0.64	74LS374	£0.34
4502	£0.38	74HC4020	£0.36	74LS375	£0.34
4503	£0.40	74HC4040	£0.45	74LS377	£0.32
4508	£1.40	74HC4049	£0.31	74LS378	£0.62
4510	£0.36	74HC4050	£0.25	74LS390	£0.25
4511	£0.38	74HC4060	£0.44	74LS393	£0.24
4512	£0.32	74HC4075	£0.27	74LS395	£0.26
4514	£0.77	74HC4078	£0.32	74LS399	£0.62
4515	£0.99	74HC4511	£0.64	74LS670	£0.69
4516	£0.44	74HC4514	£0.84	**Linear ICs**	
4518	£0.44	74HC4538	£0.41	AD524AD	£23.04
4520	£0.41	74HC4543	£0.90	AD548JN	£1.62
4521	£0.62	**74LS Series**		AD590JH	£5.40
4526	£0.40	74LS00	£0.26	AD592AN	£4.52
4527	£0.40	74LS01	£0.14	AD595AQ	£12.65
4528	£0.40	74LS02	£0.29	AD620AN	£9.88
4529	£0.44	74LS03	£0.29	AD625JN	£16.20
4532	£0.32	74LS04	£0.21	AD633JN	£8.25
4534	£2.48	74LS05	£0.14	AD648JN	£2.57
4536	£1.00	74LS08	£0.23	AD654JN	£7.25
4538	£0.37	74LS09	£0.14	AD698AP	£23.28
4541	£0.33	74LS10	£0.14	AD708JN	£5.69
4543	£0.49	74LS11	£0.17	AD711JN	£1.51
4555	£0.32	74LS12	£0.14	AD712JN	£2.38
4556	£0.40	74LS13	£0.29	AD736JN	£8.75
4560	£1.18	74LS14	£0.21	AD795JN	£5.94
4566	£1.96	74LS15	£0.14	AD797AN	£8.69
4572	£0.25	74LS20	£0.16	AD811N	£6.73
4584	£0.24	74LS21	£0.14	AD812AN	£6.32
4585	£0.47	74LS22	£0.14	AD813AN	£8.81
4724	£0.94	74LS26	£0.14	AD817AN	£3.85
40106	£0.37	74LS27	£0.14	AD820AN	£3.24
40109	£0.58	74LS30	£0.20	AD822AN	£5.20
40163	£0.46	74LS32	£0.21	AD826AN	£5.33
40174	£0.46	74LS37	£0.14	AD829JN	£6.41
40175	£0.36	74LS38	£0.19	AD830AN	£6.14
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CA3080E	£0.73	TL074CN	£0.50
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CA3140E	£0.49	TL082CP	£0.54
CA3189E	£1.22	TL084CN	£0.50
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ICL7621	£1.70	ULN2803	£0.90
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ICM7555	£0.32	ULN2806	£1.20
ICM7556	£0.98	XR2206	£5.37
L165V	£2.72	ZN414Z	£1.16
L272M	£1.86	ZN416E	£1.99
L293E	£4.35	**EPROM's**	
L297	£6.37	2716	£4.74
L298	£6.99	2732	£4.84
L6219	£4.48	2764-25	£4.20
LF347N	£0.46	27C64-25	£3.44
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LF353N	£0.40	27128-20	£4.08
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LM319N-14	£0.90	4164-15	£1.90
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LM733	£1.04	AD7528JN	£7.04
LM748CN-8	£0.37	AD7545AKN	£14.04
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LM1458	£0.37	ICL7109CPL	£7.75
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MAX485CP	£2.58	78L24	£0.39
MAX631ACP	£4.99	78S05	£0.70
MAX635ACP	£4.99	78S12	£0.70
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MC1488	£0.39	7905	£0.40
MC1489	£0.39	7912	£0.30
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MC3340P	£1.60	7924	£0.38
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NE556N	£0.36	L200CV	£1.30
NE565	£1.84	L296	£6.87
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NE567N	£0.39	LM2940CT	£2.30
NE571N	£2.47	LM317T	£0.50
NE592	£0.62	LM323K	£2.84
NE5532N	£0.60	LM334Z	£1.35
NE5534N	£0.64	LM337T	£0.68
NE5539N	£4.35	LM338K	£5.52
NE5560N	£2.31	LM723	£0.29
OP07CN	£1.42	LP2950CZ	£2.70
OP27CN	£2.90	REF01CP	£3.44
OP77GP	£2.36	REF02CP	£4.66
OP90GP	£3.11	REF12Z	£1.28
OP97FP	£2.43	REF195GP	£4.72
OP113GP	£3.44	REF25Z	£1.24
OP176GP	£2.09	REF50Z	£1.22
OP177GP	£1.89	TL431CP	£0.45
OP200GP	£5.60	ZN423	£1.55
OP213FP	£5.20	ZN458B	£1.89
OP275GP	£2.57	**Diodes**	
OP282GP	£2.27	1N914	£0.06
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OP290GP	£5.40	1N4001	£0.06
OP297GP	£5.74	1N4002	£0.07
OP400GP	£11.81	1N4003	£0.07
OP495GP	£8.69	1N4004	£0.07
RC4136	£1.00	1N4005	£0.07
SAA1027	£4.46	1N4006	£0.08
SG3524N	£0.96	1N4007	£0.08
SG3543	£6.88	1N4148	£0.05
SL486	£2.88	1N4149	£0.06
SSM2015P	£12.32	1N5400	£0.09
SSM2017P	£3.38	1N5401	£0.09
SSM2131P	£4.19	1N5402	£0.10
SSM2141P	£4.21	1N5404	£0.11
SSM2142P	£6.16	1N5406	£0.12
SSM2143P	£3.78	1N5407	£0.14
TBA120S	£0.90	1N5408	£0.15
TBA800	£0.70	BA157	£0.10
TBA810S	£0.64	BA158	£0.10
TBA820M	£0.40		
TDA1170S	£2.48		
TDA2002	£1.04		
TDA2004	£3.11		
TDA2030	£1.18		

BA159	£0.10	2SD1730	£1.44	BC328-16	£0.10	BDX32	£1.78
BAT85	£0.17	AC126	£0.44	BC337	£0.10	BDX33C	£0.56
BY126	£0.13	AC127	£0.50	BC337-25	£0.12	BDX34C	£0.50
BY127	£0.18	AC128	£0.40	BC338	£0.10	BDX53C	£0.47
BY133	£0.10	AC187	£0.48	BC338-25	£0.10	BDX54C	£0.50
OA47	£0.28	AC188	£0.48	BC348B	£0.14	BF180	£0.31
OA90	£0.07	ACY17	£3.84	BC357	£0.25	BF182	£0.31
OA91	£0.10	AD149	£1.67	BC393	£0.73	BF185	£0.58
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4.7	---	---	£0.05	£0.05	£0.05	---	---	---	£0.13	---	---	£0.41
10	£0.05	£0.05	£0.05	£0.05	£0.09	£0.12	---	£0.12	£0.13	£0.17	£0.40	£0.51
22	£0.05	£0.05	£0.05	£0.07	£0.11	£0.12	£0.13	£0.14	£0.15	£0.21	£0.52	£1.06
33	£0.05	---	£0.05	---	---	---	---	---	---	---	---	---
47	£0.05	£0.05	£0.07	£0.10	£0.19	£0.13	£0.13	£0.15	£0.19	£0.32	£0.57	---
100	£0.06	£0.06	£0.10	£0.13	£0.26	£0.14	£0.16	£0.19	£0.26	£0.44	---	---
220	£0.08	£0.09	£0.13	£0.25	---	£0.19	£0.20	£0.27	£0.39	£0.48	---	---
330	£0.09	---	£0.19	---	---	---	---	---	---	---	---	---
470	£0.12	£0.17	£0.24	£0.33	---	£0.24	£0.28	£0.43	£0.53	---	---	---
1000	£0.15	£0.33	£0.34	---	---	£0.33	£0.43	£0.59	£1.08	---	---	---
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COMPUTING CONUNDRUM

The *Colossus Recreated* article by Barry Fox in this issue raises some interesting points about the future of computers. We naturally tend to feel that modern PCs are way ahead of anything built more than fifty years ago using valves, so why can the world's first electronic computer still outperform a Pentium PC? It all comes down to single task computing.

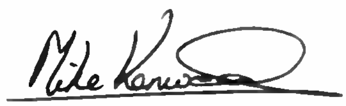
If you build a computer to perform a single task – like cracking a secret code – then you can make it do that task very efficiently and therefore very quickly. If you build a multi-tasking machine and then write volumes of software to give it the most user friendly interface possible for all those tasks, then you need masses of computing power, speed and memory to achieve a result and, of course, you slow down the process with overblown software.

PCs running Windows are not the most efficient answer to most tasks and if you use one professionally for a single task you will soon realise that Windows is an unnecessary inconvenience. It may be that Colossus will change the future of computing in a number of areas.

Isn't it fascinating how much we can learn from the past, and isn't it rather worrying how we quickly assume that what we have recently developed is best? It's nice to have the latest, fastest machine and we regularly come across people who look down their noses at less fortunate, or simply less interested, individuals, but surely there is much to be said for the minimalist approach. Why use a computer when it is not necessary, and why use a 200MHz Pentium PC with a Gigabyte of hard disk and massive RAM just to maintain a simple database, do a few calculations or for wordprocessing? The word "bloat" is used by Barry Fox and it is easy to see why.

BLOAT

We are probably as guilty of "bloat" as anyone else. You could say that our *PIC-olo Music Maker* uses unnecessary technology to produce a few notes – PIC chips are not in fact well suited to music making – but it is an excellent and instructive exercise in programming and the resultant instrument (if that is not too grand a word for it) is very simple to build and great fun. Besides, to keep everyone happy, we have a simple organ design based on an RC oscillator coming in a few months.



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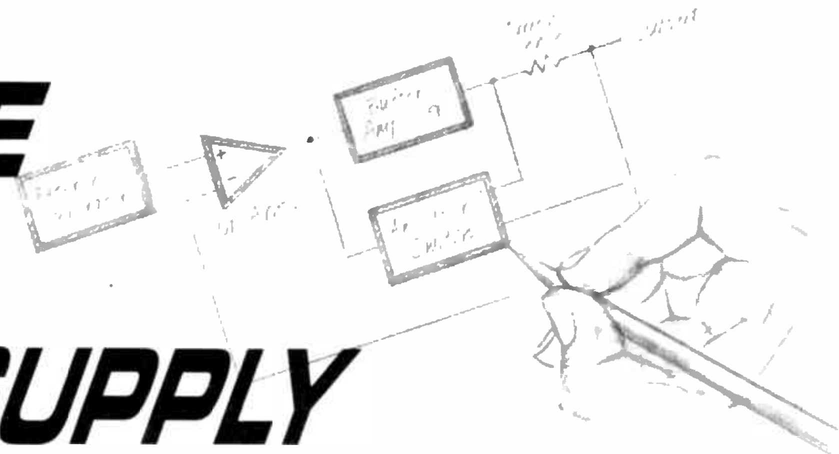
VARIABLE BENCH POWER SUPPLY



ROBERT PENFOLD

A low-cost, regulated 1·2V to 12V supply with four switched current ranges from 20mA to 500mA.

A REGULATED mains power supply unit is undoubtedly one of the most useful pieces of equipment for the electronics experimenter. Ideally the supply should have a wide output voltage range, and be capable of providing high currents, but a high specification is invariably accompanied by a high price.

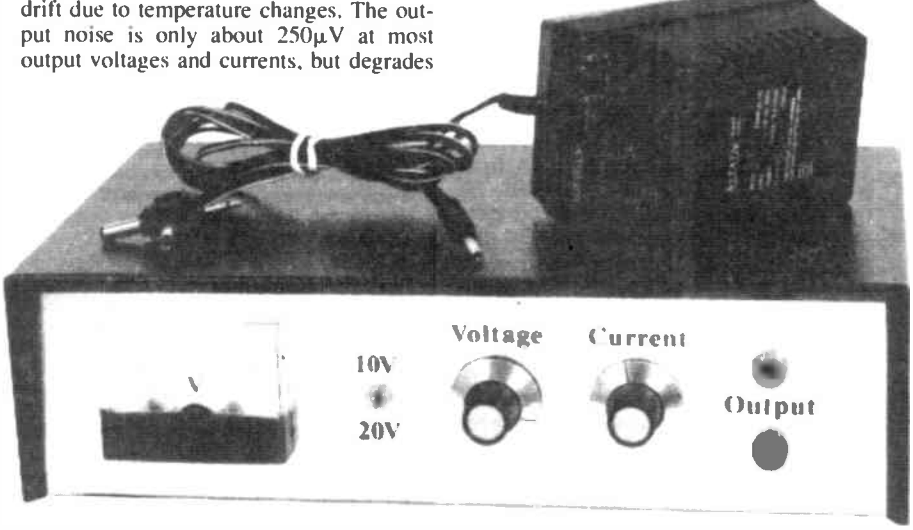
Fortunately, for most purposes a supply unit having a modest specification will suffice. Most projects require a supply of between about 3V and 12V, at output currents that are usually no more than a few hundred milliamps.

The mains power supply unit featured here has an output voltage range of 1·2V to 12V d.c., and it can supply output currents of up to 500mA. Despite the simplicity of the circuit, it provides excellent regulation. In fact, the output potential varies by no more than a few millivolts when the output current is taken from zero to full load.

A high quality reference voltage generator ensures that the circuit is free from drift due to temperature changes. The output noise is only about 250µV at most output voltages and currents, but degrades somewhat at higher voltages with output currents of more than about 400mA.

Current limiting at an output current of 500mA protects the circuit against the inevitable short circuits and overloads on the output. As 500 milliamps is a fairly high current that is capable of damaging many semiconductors, additional limit currents of 20mA, 50mA, and 200mA are available.

An optional voltage meter enables the output potential to be set with reasonable precision, but a significant saving in cost can be made if the voltmeter is omitted and the output voltage is set with the aid of a multimeter.



SAFE OPERATION

Normally a project of this type would not be suitable for beginners, as it would involve wiring carrying the dangerous mains supply. This power supply unit is perfectly safe for beginners as it uses a ready-made 12V "battery eliminator" as the power source. There is no mains wiring to contend with, and the maximum voltage in the circuit is a safe 20V or thereabouts.

Also, the double insulation in the "eliminator" power source ensures that the unit is well isolated from the mains supply.

It aditionally means that the unit has "floating" outputs i.e. neither output socket is earthed. This can be helpful in avoiding short circuits and "hum" loops when using the unit with equipment that has an earthed chassis.

SYSTEM OPERATION

There are two standard approaches to providing a variable voltage supply, and one of these is to use a potentiometer to provide a variable voltage source from a fixed regulator circuit. A buffer amplifier is then used to effectively boost the maximum output current from the potentiometer to a suitable level.

An alternative is to use a voltage regulator to provide a fixed voltage, plus an amplifier which multiplies the output voltage to the required figure, and also boosts the maximum output current to the required level. This second method generally offers better voltage regulation, and is the one adopted in this design.

The final circuit uses the arrangement shown in the block diagram of Fig. 1. It is based on an operational amplifier (op.amp) which is used in the non-inverting mode. An accurate and highly stable reference voltage is supplied to the non-inverting (+) input of the amplifier. The choice of reference voltage is important, since the minimum output voltage cannot be less than the reference potential. In this case a 1·2V reference source is used, and this enables the unit to be used in place of a single "dry" cell or nickel-cadmium battery.

OUTPUT CURRENT

Maximum output current from a normal operational amplifier is only a few milliamps, or possibly a few tens of milliamps. This is insufficient for a bench power supply unit, and a buffer stage at the output of the amplifier is therefore used to boost the maximum output current.

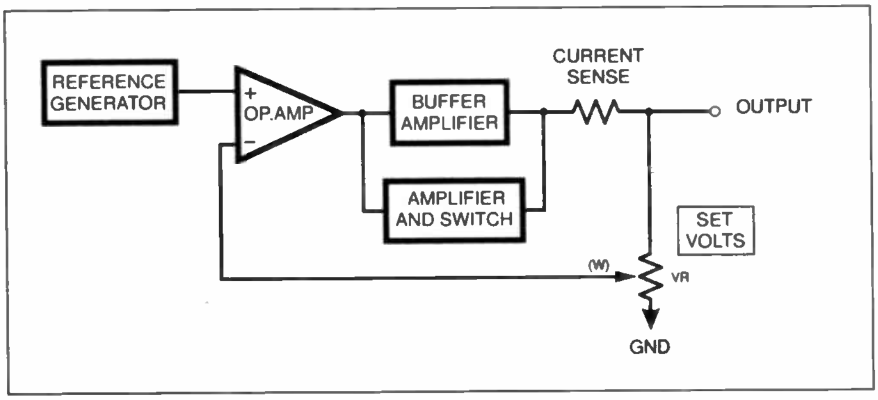


Fig. 1. Block diagram for the Variable Bench Power Supply.

A severe overload on the output could cause a very large current flow, which could damage the buffer amplifier and the power source before a conventional fuse would "blow." So, some form of electronic "fuse" has to be regarded as mandatory in a circuit of this type.

A low value resistor in series with the output of the circuit enables a current limiting circuit to detect an excessive current flow. The voltage developed across this resistor is proportional to the output current.

Provided the output current does not exceed about 500mA, the voltage across the current sensing circuit will not be sufficient to activate the amplifier and electronic switch. The circuit then works normally, providing a well regulated output voltage.

If the output current exceeds much more than about 500mA, the voltage across the current sensing resistor exceeds about 0·6V. The "electronic" switch then starts to turn on, and it connects the output of the op.amp through to the final output.

On the face of it, this will not have much effect, but the crucial factor here is that there is a voltage drop of more than one volt through the buffer amplifier. The switch therefore tends to pull the output of the op.amp lower in voltage, which in turn reduces the final output voltage. The switch then pulls the output of the op.amp to an even lower voltage.

Any attempt to draw more than the limit current simply results in the output voltage rapidly diminishing, with no significant increase in the output current. Even with a short circuit across the output terminals, the circuit will provide an output current of only about 600 milliamps or so. This form of current limiting responds almost instantly to any output overloads, and is fast enough to ensure that the supply's output stage and the power source are not damaged.

FEEDBACK

The closed loop voltage gain of a non-inverting amplifier is controlled by a negative feedback network connected between the output and the inverting (−) input. In this circuit the feedback network is a potentiometer (VR).

An operational amplifier amplifies the voltage difference across its inputs, and its innate (open loop) voltage gain is extremely high at d.c. and low frequencies. In fact, it is typically in excess of 100,000.

Taking the non-inverting input positive of the inverting input sends the output to a higher potential. Taking the inverting input to the higher voltage has the opposite effect, with the output going to a lower voltage. In the non-inverting mode the input potentials are balanced by a negative feedback action from the output to the inverting input.

With the potentiometer's wiper (w) at the top end of the track the inverting input is connected direct to the output of the supply. If the output should go above 1·2V, the inverting input will also be taken above this level, causing the output potential to be reduced.

If the output potential is pulled below 1·2V, this will again unbalance the input levels to the op.amp, this time causing the output to increase in voltage to correct matters. Note that the feedback is taken via the buffer amplifier and the current sense resistor, so that it will compensate for any increased voltage drop through these when the output loading is increased.

If the potentiometer's wiper is taken down its track, the negative feedback action still balances the input voltages to the op.amp. However, the voltage drop through the potentiometer means that the output settles at a higher voltage.

For example, suppose that the wiper is at the mid-point of the track, it will be at half the output voltage, which means that an output voltage of 2·4V is needed in order to deliver 1·2V to the inverting input of the amplifier.

The further down the track the wiper is taken, the greater the voltage drop through the potentiometer, and the higher the output voltage. The potentiometer therefore acts as the output voltage control.

CIRCUIT OPERATION

The full circuit diagram for the simple Variable Bench Power Supply appears in Fig. 2. The unregulated input voltage supply connects to socket SK1, and the actual voltage here is nearly 20V with no load connected at the output of the regulator circuit. With an output current of 500mA the input voltage is still almost 16V.

There are voltage drops through the regulator and current limiting circuits, but the circuit can just about maintain an output potential of 12V at 500mA. Fuse FS1 protects the battery eliminator if a serious fault should occur in the regulator circuit. C1 is the supply decoupling capacitor.

The regulator diode D1 provides the 1·2V reference source. This is used much like a Zener diode, but it has a much higher level of performance than a Zener diode. It will operate efficiently with currents from 50µA to 5mA, and in this case resistor R1 sets the current flow at about 500µA. Capacitor C2 filters any noise generated by D1.

Operational amplifier IC1 is a type that will operate properly with its inputs and output at low voltages. Most other op.amps will not operate properly in this circuit.

A Darlington power device TR1 operates here as an emitter follower buffer stage at the output of IC1. The very high current gain of TR1 ensures that the circuit can easily accommodate output currents of up to 500mA.

Current limiting is controlled by transistor TR2, and R3 to R6 are the four current sensing resistors. These bring the current limiting into action at approximate threshold currents of 20mA, 50mA, 200mA, and 500mA respectively.

Note that the short circuit output currents are somewhat higher than these figures, particularly at the lower limit

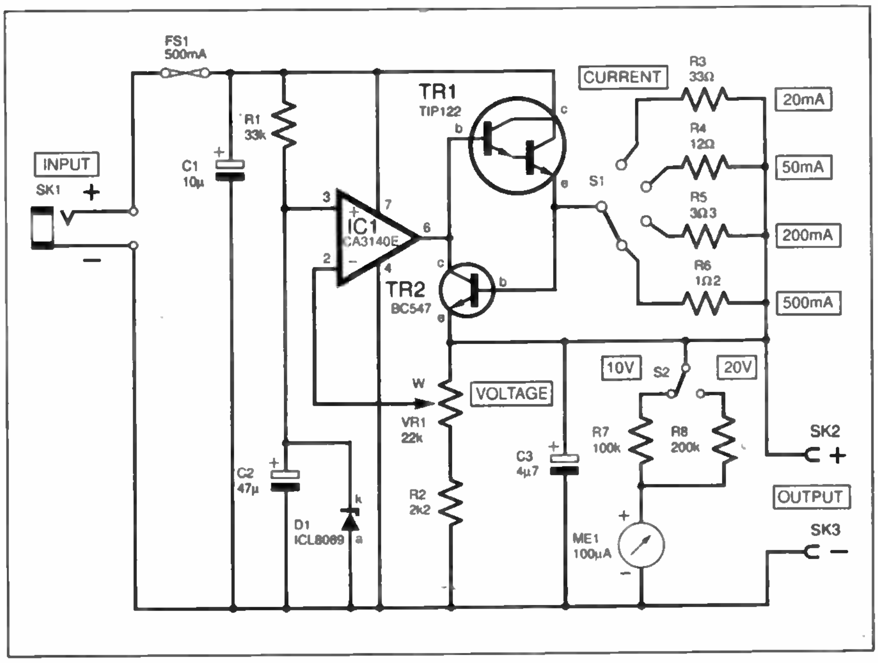


Fig.2. Complete circuit diagram for the Variable Bench Power Supply.

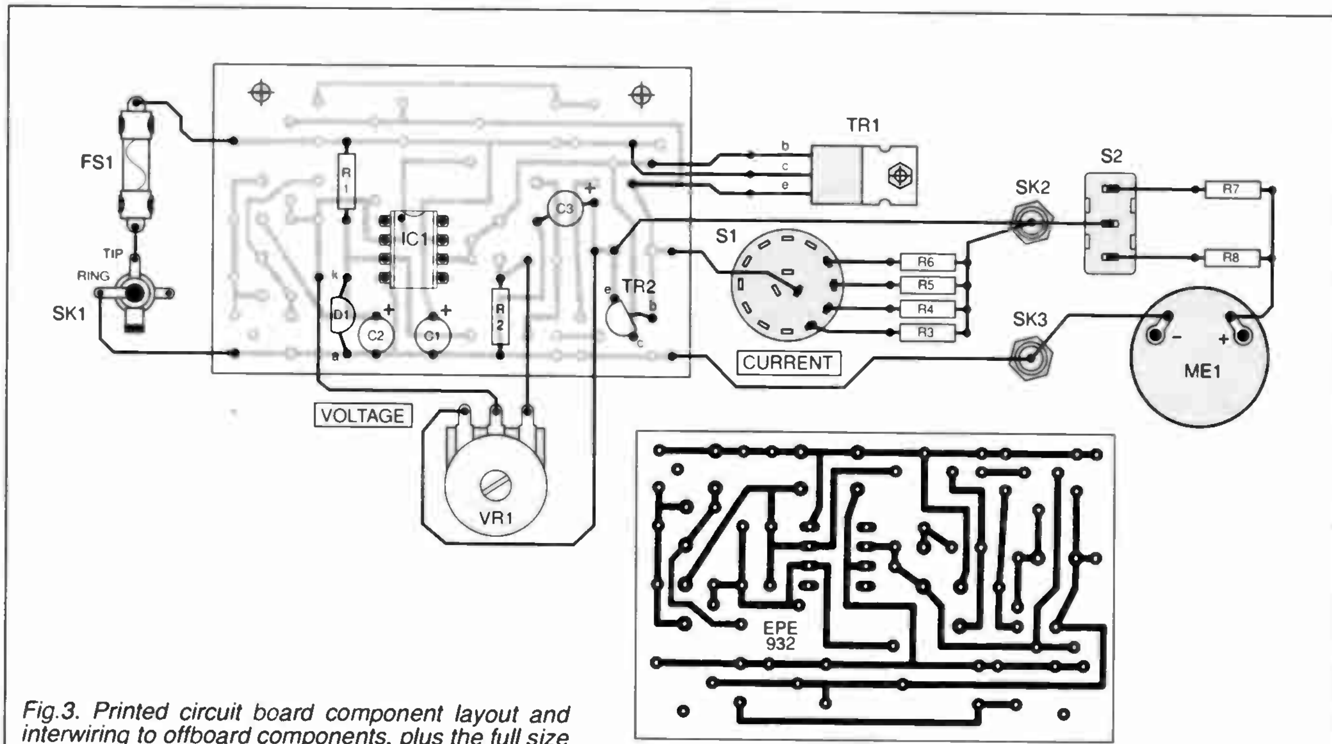


Fig.3. Printed circuit board component layout and interwiring to offboard components, plus the full size underside copper foil track master pattern.

COMPONENTS

Resistors

See SHOP TALK Page

R1	33k
R2	2k2
R3	33Ω
R4	12Ω
R5	3Ω3
R6	1Ω2
R7	100k
R8	200k

All 0·6W 1% carbon film

Potentiometer

VR1	22k rotary carbon, lin

Capacitors

C1	10μ radial elect. 25V
C2	47μ radial elect. 16V
C3	4μ7 radial elect. 50V

Semiconductors

D1	ICL8069 1·2V precision reference
IC1	CA3140E PMOS op.amp
TR1	TIP121 or TIP122 *npn* power Darlington transistor
TR2	BC547 *npn* silicon transistor

Miscellaneous

FS1	500mA 20mm "quick-blow" fuse, with chassis mounting fuseholder
ME1	100μA moving coil panel meter
SK1	3·5mm mono jack socket
SK2	4mm socket, red
SK3	4mm socket, black
S1	3-pole 4-way rotary switch, make-before-break
S2	s.p.d.t. min toggle switch

Multiple printed circuit board available from the *EPE PCB Service*, code 932; metal instrument case or box, size to suit – see text; 12V 750mA or 800mA unregulated mains (adaptor) power supply; control knob (2 off); TO220 insulating kit; 8-pin d.i.l. holder; nuts and bolts; output leads, wire, solder, etc.

Approx Cost Guidance Only £13
Excluding mains adaptor, meter & case

currents where the output current from IC1 becomes a significant factor.

VOLTAGE CONTROL

Potentiometer VR1 is the output voltage control. Resistor R2 limits the maximum output voltage to a little over 13V, but remember that currents of up to 500mA can only be maintained at output potentials of about 12V or less. Meter ME1 is the optional voltmeter.

With resistor R7 selected, using toggle switch S2, the full scale voltage is 10V, but this is increased to 20V with R8 selected. This second range is needed to accommodate output potentials of 10V to 13V.

Capacitor C3 is needed in order to ensure good stability at high output currents. Without this component the circuit has a tendency to oscillate.

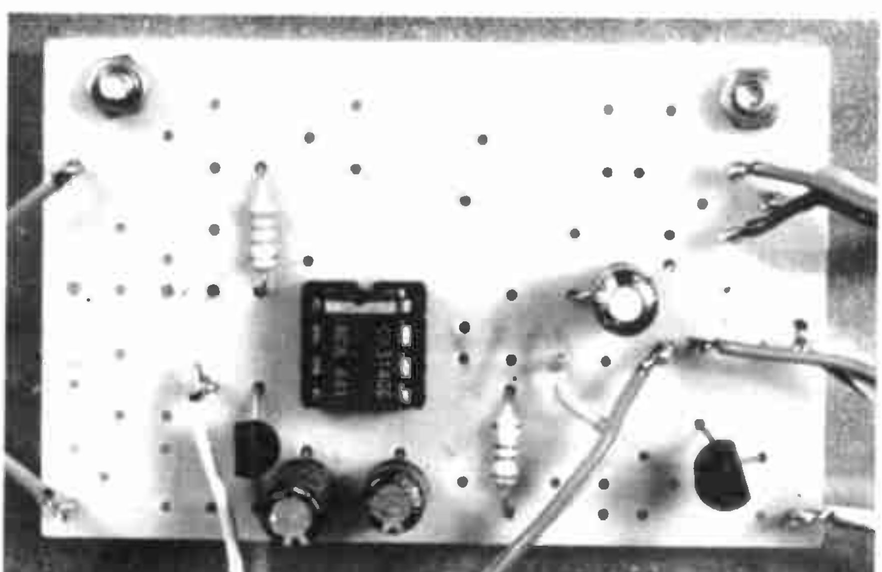
CONSTRUCTION

This project, like last month's *IR Repeater* circuit, is constructed using the *EPE* multi purpose printed circuit board (p.c.b.), but a fair percentage of the small components are not mounted on the circuit board. This p.c.b. is available from the *EPE PCB Service*, code 932.

The component layout for the printed circuit board, together with the hard wiring and copper track pattern is shown actual size in Fig. 3. Start construction by fitting the appropriate components onto the p.c.b. in the usual size order, working up to largest.

The CA3140E used for IC1 has a PMOS input stage, and the normal anti-static handling precautions must be observed when dealing with this component. In particular, it must be fitted in a holder, but it *should not* be fitted in place until the board and *all* the wiring have been completed. When fitting IC1 try to touch its pins as little as possible, and be careful to fit it the right way round.

The leads of transistor TR2 need a small amount of manipulation before they will fit



this layout, but TR2 should then drop into place quite easily. Reference diode D1 has a standard TO92 transistor style encapsulation, but it only has two leadout wires.

At this stage only fit single-sided solder pins at the points where fuse FS1, rotary switch S1, etc. will connect to the board.

Before mounting the p.c.b. in its case, remember that less than 50 per cent of the copper pads on the board are used. This makes it essential that the board be double-checked for any component positioning errors.

OFF THE BOARD

The completed circuit board is mounted in the metal case using plastic stand-offs or 6BA bolts. If bolts are used, spacers about 6mm long must be used to keep the soldered joints on the underside of the board well clear of the metal case.

Darlington transistor TR1 is mounted on the base panel of the case, which *must* be a metal type so that it acts as an efficient heatsink.

A comparatively small case will suffice if the voltmeter is omitted, but a much larger case will be needed if the meter is included.

This is due to the increased front panel area required for rotary switch S2 and the meter. Make sure you select a case that has a large enough front panel to comfortably accommodate everything, even if this means choosing one that is substantially over-size in other respects.

Note that TR1's heat-tab connects internally to its collector (c) terminal, and it must be insulated from the case using a standard TO220 insulating kit. This kit consists of a mica (or plastic) washer which insulates TR1 from the case, plus a plastic bush. The latter fits over and inside the metal heat-tab of TR1, so that it is insulated from the 6BA mounting bolt.

This arrangement ensures that there is no direct connection between TR1 and the case, or an indirect connection via the mounting bolt. Fig. 4 shows how everything fits together. It is advisable to use a continuity checker to ensure that TR1's

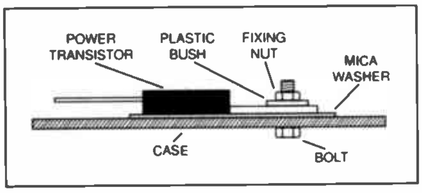
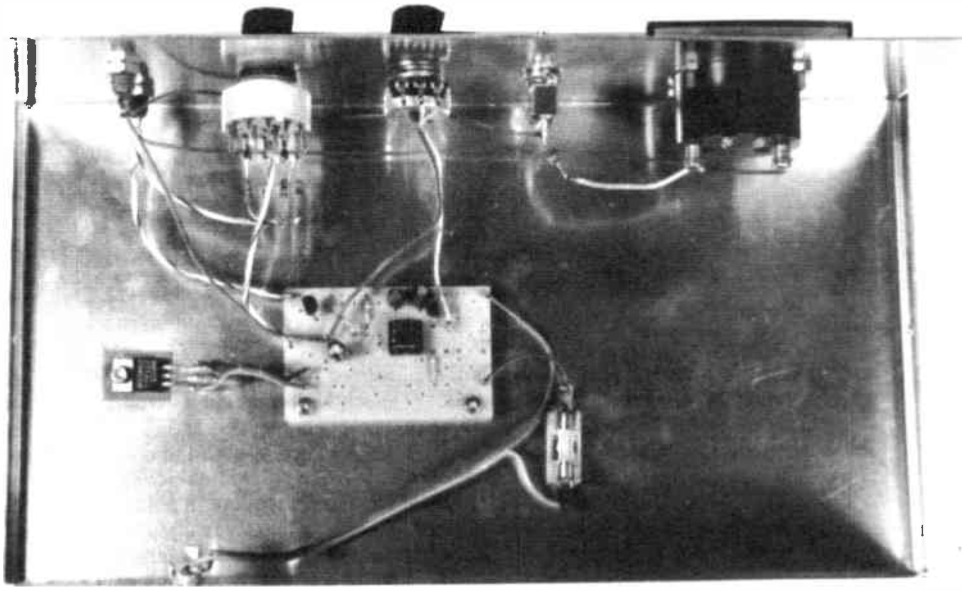


Fig.4. Isolating TR1 from the case.



heat-tab is reliably insulated from the case.

MAINS ADAPTOR

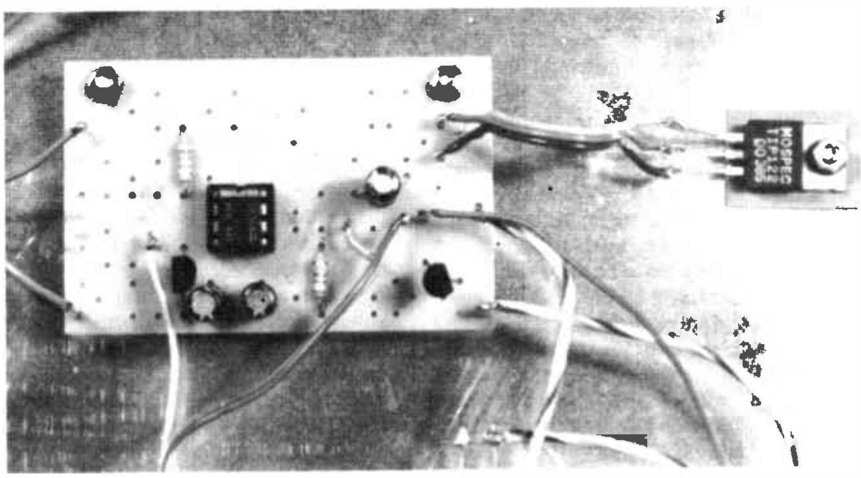
The battery eliminator used with the prototype has no less than five different types of plug on its output lead. Obviously, the power input socket SK1 must be a type that matches one of the plugs on the power source, and a 3·5mm jack plug is probably the best choice where this option is available.

The wiring for a socket of this type is shown in Fig. 3, and the battery eliminator set so that the *tip* of the plug is positive. Socket SK1 is mounted on the rear panel of the case. Note that the battery eliminator must be a *non-regulated* 12V d.c. type, and that no other type is suitable.

CASE DETAILS

Fuse FS1 is fitted in a chassis mounting fuseholder mounted at any convenient place on the base panel of the case. The front panel layout is not critical from the electronic viewpoint, but try to have the meter and voltage setting potentiometer VR1 reasonably well separated so that the meter is not obscured when VR1 is adjusted.

Most panel mounting meters require a large circular cutout plus four small mounting holes. The normal diameter for the large cutout is 38mm, but check this point before cutting the hole.



Probably the easiest way of making the cutout is using a brace plus a device known as a "tank cutter", or simply as a "hole cutter." Alternatively, use a coping saw, miniature round file, "Abrafile", or any similar tool. Whatever method is used, it is advisable to make the hole slightly undersize initially, and then enlarge it to precisely the correct size using a half round file.

The meter itself can then act as a improvised template to aid accurate positioning of the four small mounting holes. These holes should have a diameter of about 3·2mm, and are for the threaded rods that are built into the rear of the meter. The meter should be supplied complete with four fixing nuts and washers.

FINAL ASSEMBLY

With everything now fitted to the case, the unit is completed by adding the hard wiring. This is mainly straightforward, but be careful to get TR1 wired to the board correctly. TR1's leadout wires should be bent upwards slightly to ensure that they are kept well clear of the metal case.

Resistors R3 to R8 are easily mounted on switches S1 and S2, provided the tags of the switches and the ends of the leadout wires are both tinned with solder prior to making the connections.

IN USE

Most 12V battery eliminators also offer a range of lower output voltages, so make sure that the voltage selector switch is at the correct setting. Also double-check that the polarity switch has the correct setting (the tip of the plug being positive).

With the power source connected to input socket SK1 and plugged in at the mains, it should be possible to vary the output voltage over a range of 1·2V to at least 12V. If not, unplug the battery eliminator from the mains supply immediately, and recheck the wiring.

It is advisable to check that the current limiting circuit is functioning correctly. Set rotary switch S1 to the 500mA setting (R6), and adjust Voltage control VR1 for an output potential of around 12V. With a 4·7 ohm 2W resistor connected across the output sockets (SK2 and SK3) the output voltage should fall to about 3V.

New Technology Update

For some time, digital chips and their design uses have been benefitting from new lower operating voltages; now analogue chips are being given similar treatment – Ian Poole reports.

RECENTLY, there has been a lot of information in the technical press about the transfer from 5V to 3V logic. This change has been mainly brought about by the increase in the number of portable systems being used, as well as the need for higher speeds and lower heat dissipations. Most of the major processors have "road maps", or planned developments which show them increasing the speed of their operation and migrating to the 3V standard if they have not already done so.

One of the major problems in this migration is that a number of the more specialist i.c. functions are not yet available at the lower voltage. This gives rise to difficulties in using two voltage levels.

Fortunately, in many cases it is possible to drive a 3V chip from a 5V one without any damage or operating problems. This has helped the acceptance of the new standard, because, without being able to interface the two standards, very few pieces of low-voltage equipment could have been designed. Now, many new computers and other logic driven circuits use the lower voltage standard.

The "glue" logic used to perform some of the functions outside the chips is also available. A range of 74 low voltage HCMOS chips are fabricated by the main manufacturers, including Texas, National Semiconductor, Philips, etc. However, the range of functions is less than that which was available in the more familiar 5V series of HCMOS.

The reason for this reduction in choice is that some of the less well used functions are unlikely to be needed in sufficient quantities to make their production viable. Instead, it is more likely that these functions will be included in the VLSI chips or within programmable gate arrays.

Analogue Chips

Although the main thrust for low voltage development seems to have been focused on the digital side, analogue electronics has not been left behind. Although there may not be as much analogue electronics in items such as personal computers, there is still a vast requirement for analogue circuits in cellular phones, and this sector of the electronics industry is booming as much as any other. Accordingly, there is a need for very low voltage and low current analogue circuits.

One of the most versatile analogue circuits is the operational amplifier. Some of us can remember the introduction of the famous 741, some 30 years ago. Whilst these chips seemed like the ultimate in technology at the time, developments have moved well on from this. New chips offer much higher speeds as well as lower voltage operation, lower noise, higher input impedance and a host of other advantages.

As with digital chips, there is a major emphasis on trying to reduce the operating voltage of analogue circuits. Just as in the case of the digital circuits, there is a need to reduce the power requirements of equipment to enable battery sources to be used more easily. The fact that heat dissipation is lower has less impact on the design of the chip itself because the levels of integration are lower.

For VLSI digital chips running at 150MHz and more, on-chip heat dissipation is a major problem. For analogue chips, where levels of integration are less, this problem is not as acute. Nevertheless, this does not mean to say that, in the future, integration levels will not rise to the extent where it will become a major issue.

Lower-voltage Op.amps

In response to the needs for lower voltage analogue chips, a number of manufacturers are now introducing new devices. Motorola has recently launched an op.amp which is specified to function with a rail-to-rail voltage of just 1V! Previously, the lowest operating voltage for an op.amp was around 1·8V. This represents a major reduction.

Achieving the low voltage operation required the use of a number of interesting techniques. Most low voltage op.amps use a bipolar input. For those using CMOS technology, the lowest rail-to-rail operating voltages are around 2·5V or more.

To achieve the very low operating voltages, Motorola has employed depletion mode f.e.t.s. These are normally *on* when no bias is applied and enable low voltage operation. However, they have been designed so that they switch to enhancement mode as the voltage increases. This offers advantages in terms of higher transconductance and speed for the same drain currents.

Also included in the design, are *n*-channel MOSFETs fabricated using the SMARTMOS process and vertical *pnp* and high frequency *npn* devices. Further improvements have been added to the fabrication process to enable the required level of performance to be achieved.

Very tight control on the process stages, along with thinner layers of oxide and buried channels, have enabled the noise to be considerably reduced. In fact, it is in the area of the silicon-oxide interfaces where major improvements in noise performance can be made. By refining the process, noise levels can be reduced by as much as a factor of three.

Input Concentration

Much of the design effort for the low voltage operation has been placed into the input stages. Here ion implantation techniques are used to create the negative threshold devices which are required for low voltage operation. The way in which these devices operate is quite complicated.

There is a highly doped *p*-well in the structure to allow operation from very low voltages up to the specification limit by changing the mode of operation. Also, the drain area is lightly doped to ensure a sufficient breakdown voltage.

The input circuit itself is configured using high impedance current mirrors to provide high levels of gain. These mirrors must be very well balanced to ensure that the offsets are kept to a minimum.

This was a challenge to the design team because it was necessary to ensure that this parameter was met even down to the lowest supply voltages. It was particularly important at lower voltages because any increase in offset would manifest itself as a larger proportion of the available output swing.

Boosting Output

Apart from the input stages, development was also required for the output. In view of the very low voltages involved, the normal Darlington configuration could not be used. Instead, a configuration with a bass boost amplifier for the *npn* side of the output is used. This bass boost gives additional current drive for lower frequencies where a sustained current is required. A complementary circuit is then used for the *pnp* output device.

The performance of the MC33502, a new op.amp from Motorola, for example, is quite remarkable. Operating between 1V and 5V, the performance changes are relatively small. In addition to this, it boasts a unity gain bandwidth of greater than 4·8MHz, as well as a maximum operating voltage of 7.5V.

This is just one op.amp from one manufacturer. It is likely that other manufacturers will follow the lead taken by Motorola because the industry is fast moving towards the use of much lower rail voltages. Not only will the operating voltages of the future be much lower, but other features will be more easily available, making the compromise which often faces today's analogue designers less of an issue.

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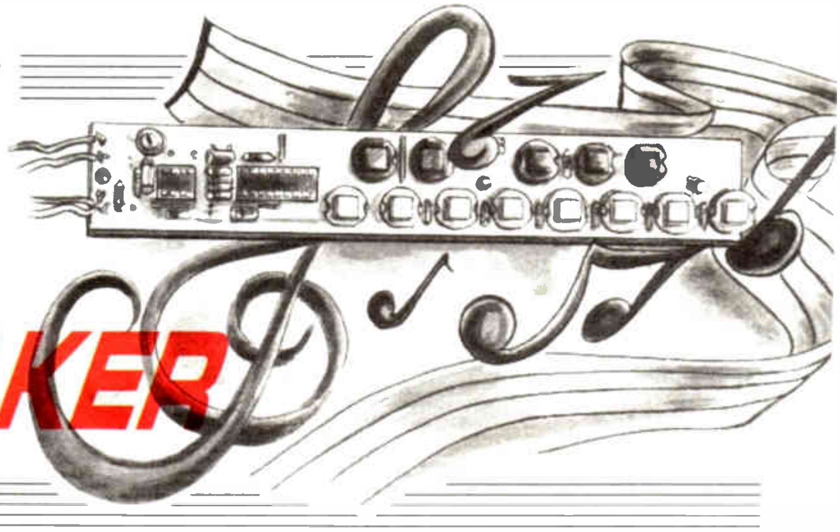
Constructional Project



PIC-OLO MUSIC MAKER

JOHN BECKER

How to make electronic music simply for the fun of it, and have a mini-lesson in PIC programming logic.

BOURNEMOUTH Symphony Orchestra is renowned as source of inspiration, but normally in matters of music. It might, then, come as a surprise to learn that two *EPE* constructional projects have also been inspired by their playing.

The first was the *EPE PIC-A-Tuner* of May '97. On numerous occasions the author has watched the timpanist tune his timpani while using an electronic tuning aid, obviously assured of its accuracy. So came the notion that as a professional musician finds tuners useful, then let's design a DIY one – and so it came about!

On another occasion, the melodic talents of the Piccolo player and her instrument took prominence. Suddenly, sparks of association leaped across the author's brain cells – *piccolo*? *PIC*colo? . . . PIC-olo! – musical instrument designed around a PIC, the microcontroller with which we have become well acquainted.

Here it is, then, PIC-olo Music Maker, another electronic design inspired by the BSO!

PRELUDE

However, don't expect to build PIC-olo and hear an electronic simulation of the real piccolo wind instrument (incidentally, *piccolo* is Italian for *small*). PIC-olo is electronic in nature and electronic in sound, simply generating thirteen harmonically related notes that are basically square waves with the corners lopped off.

Up to four of these notes can be played simultaneously, that is, chords can be played – it's not a "single-note" instrument as some of its historic predecessors were – remember the *Stylophone* of the 1970s made famous by Rolf Harris (currently of *Animal Hospital* fame)? That extraordinary (for its time) little musical instrument had a stylus which had to be touched on metal pads in order to create the notes.

Over the years, there have been several imitations and enhanced versions. Unashamedly, *PIC-olo* is the latest. But, it takes the original idea a triplet of logical steps forward: it uses a PIC16C84 microcontroller, thirteen press-button switches arranged in piano keyboard style (*C* to *C1* including sharps) and it is polyphonic.

PIC-olo is housed in a slim plastic case and can be used with headphones, a small speaker, or plugged into the hi-fi system. Not a stylus in sight! Allowing for inflation, it might also be described as the hi-tech evolution of the "penny whistle"!

How you obtain the software, and pre-programmed PICs, is detailed later.

CIRCUIT NOTES

As will be seen from the circuit diagram in Fig.1, there is not much in the way of electronics involved with PIC-olo Music Maker. Basically, just microcontroller IC1, small power op.amp IC2a, and the bank of switches S1 to S13.

The microcontroller detects which switches are pressed and generates square wave outputs of appropriate frequencies on its Port A pins RA0 to RA3. Via resistors R11 to R14 and a.c. coupling capacitor C3, the output frequency signals are mixed by op.amp IC2a, which is capable of supplying an output current of up to 500mA.

MUTING

The gain, or rather the *attenuation*, of the circuit around IC2a is preset by potentiometer VR1. The range of attenuation attainable is between about ×1/2 and ×1/100.

It may seem unusual to provide *attenuation* rather than *amplification* in the output stage, but there are two considerations which require this action.

First, the square waves arriving at IC2a have an amplitude of 5V. Since a.c. coupled mixing produces an output level which is the sum of the input amplitudes, the sum of the four input signals could, theoretically, be calculated as 20V peak to peak.

The op.amp, which is powered at 5V, cannot handle that amount of swing on its output. Indeed, at this powering voltage, its output will probably have a maximum swing of about 3·5V. Any signal trying to achieve a greater swing will be severely clipped.

This would not matter for a single square wave, but with more than one being processed, "head-room" is needed to allow four notes to sound louder than just one. That is, a single note must have an output amplitude that is no more than a quarter of that allowable for four notes.

Consequently, attenuation is essential and is determined by the ratio of the resistors feeding into the input (R11 to R14) and the total feedback resistance (R17 plus VR1).

The other consideration is that when PIC-olo is used with headphones, attenuation is required to protect ear drums! With the prototype and using 40Ω headphones, an attenuation to one-fifth was found to be preferable.

OUTPUT COUPLING

The output signal from IC2a is a.c. coupled by capacitor C5 and fed to socket SK1. Even though the signal is monophonic (in the sense that it uses one

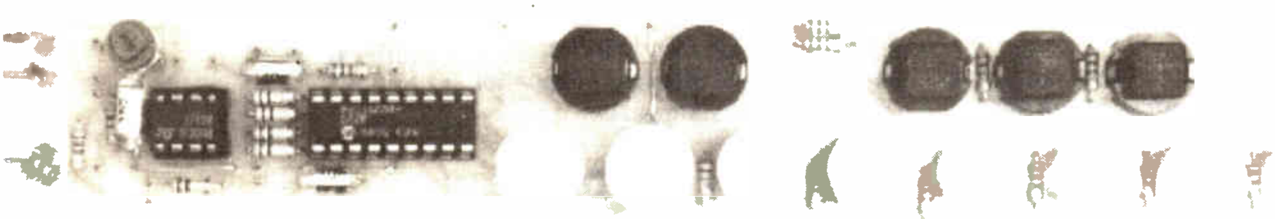
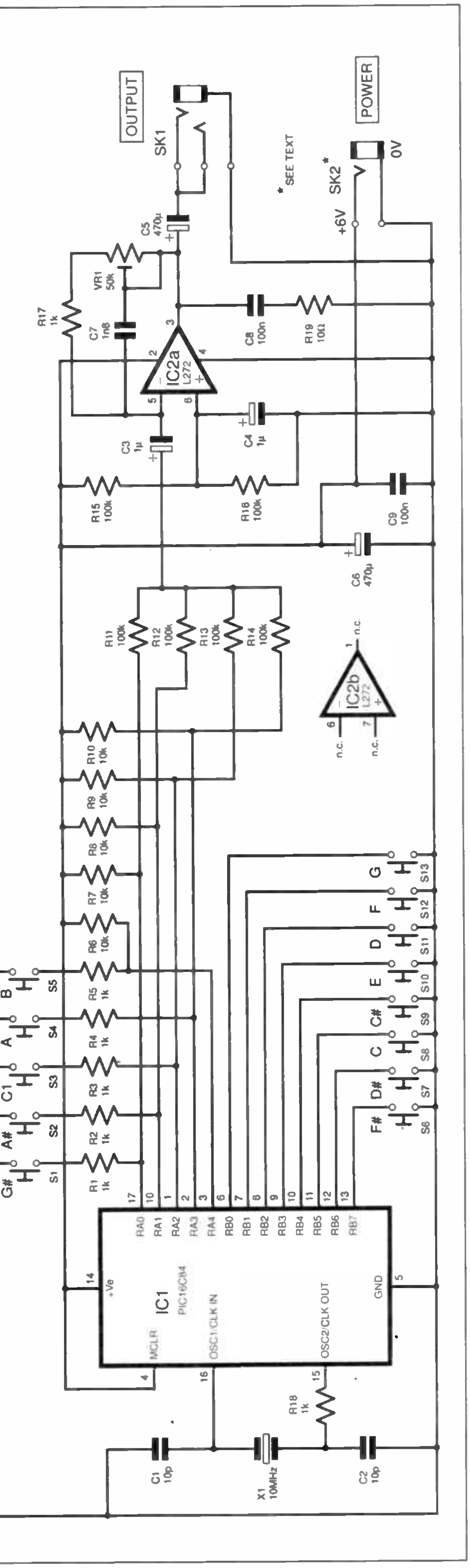


Fig.1. Complete circuit diagram of the PIC-olo Music Maker.



channel only and is not *stereophonic* – note-wise it is *polyphonic*), it is suggested that SK1 should be a 3·5mm stereo socket, allowing "personal" stereo headphones to be used.

The use of a stereo socket, though, means that a loudspeaker or amplifier lead must be terminated with a stereo plug. Alternatively, a mono socket could be used, though this would mean that stereo headphones would only produce a single-sided sound.

Capacitor C8 and resistor R19 are included in the output circuit according to the L272 data sheet recommendations regarding signal stability. Capacitor C7, in the op.amp feedback path, smooths off the corners of the square wave signals, making them sound slightly less harsh. The capacitor may be omitted if a harsher sound is preferred.

The second op.amp, IC2b, which is in the same package as IC2a, is not used. Note that the L272 has unusual pinouts and replacement by an "ordinary" op.amp is not practical without printed circuit board changes being made.

SWITCHING

Switches S1 to S13 are push-to-make types which provide a signal path (in this case to 0V) only when they are pressed. Consequently, for the microcontroller to respond as though the switches were change-over types producing either 0V or 5V (logic 0 or logic 1), positive biasing of the "open" side of the switches is required.

All of IC1's 13 port pins (RA0 to RA4 and RB0 to RB7) are used for switch monitoring. Port B's pins (RB0 to RB7) are only used for inputting data and, as they have pull-up resistors included internally, switches S6 to S13 do not need additional biasing resistors.

However, since Port A's pins (RA0 to RA4) are used for both input and output, the internal biasing resistors on those pins cannot be used (RA4 is actually an open-collector pin and is not internally biased). Consequently, switch biasing is provided by resistors R6 to R10.

Also, because of the dual function for the Port A pins, resistors R1 to R5 are inserted to prevent electrical conflict when switches S1 to S5 are pressed. Whilst it may seem that "clicks" would be heard when these switches are used, in reality, this does not seem to be the case.

(In retrospect, resistor R5 could have been omitted had the software not been programmed to set pin RA4 as an output – it's never actively used as such here. Programmers try to think of every eventuality, but don't always spot the obvious until later!)

SPEED AND POWER

Microcontroller IC1 is operated at a clock frequency of 10MHz, as set by crystal X1 in association with capacitors C1 and C2, and resistor R18. It is *essential* that only the *10MHz* version of the PIC16C84 is used in this circuit. Although the author has run the standard 4MHz version at 10MHz, this condition is likely to be unreliable, and possibly unrepeatable.

The circuit can be powered at between 5V and 6V d.c. A 6V battery supply is perfectly acceptable. Whilst IC1 will tolerate a supply of 7V, it is recommended that this level of voltage should not be used.

Although a 3·5mm mono jack socket (SK2) is shown as the power input, any other type of connector can be used. Indeed, the use of a "proper" power supply connector is probably a better way to do things.

Capacitors C6 and C9 provide power line smoothing. Resistors R15, R16 and capacitor C4 set a mid-way bias level (3V with a 6V power supply) for IC2a.

SOFTWARE

It may appear that the circuit could have been designed so that each of the 13 outputs from IC1 could each have sent a different frequency to a 13-input mixer around IC2a. Switches would then be inserted into each of the mixer lines, pressing them in order to connect the desired frequency to the mixer.

This, though, would have meant that each line would be constantly generating a frequency having an amplitude of 5V. Inevitably, all 13 signals would "leak" into the op.amp circuit by a small amount even when the switches were unpressed. As a result, PIC-olo would never seem to be silent.

To avoid this undesirable situation, the software has been written so that an output from IC1 is only active when the switch for that line is pressed. This complicated the software program a bit, but not significantly so. It all still takes place

within 236 bytes of the 1024 bytes of program space available.

PROGRAM FLOW

A listing of PIC-olo's program source code is available as stated later. Studying the listing, you will see that the program starts with a one-off routine that sets the basic initialisation parameters, after which it enters a perpetual loop.

In this loop are 15 principle "cells" of instructions. The first cell, named GET-KEY, is principally responsible for reading which keys, if any, are pressed. First, a "note quantity detected" counter is primed (BSF LOOPA,2). This limits the number of pressed keys which will be actioned to a maximum of four.

Next, all of Port A pins (RA0 to RA4) are set for input, the status of these pins is read and stored in a register (REG2). Port A is then reset for output mode.

Immediately following this, a register (REG1) which holds the contents of any previously detected keynote action (zero on the first time round the loop) is loaded into Port A for outputting to mixer IC2a, via pins RA0 to RA3 (pin RA4, although active as an output, is not used in this context). REG1 is then reset to zero.

Following the first processing cell are 13 cells which are allocated individually to separate notes. All 13 cells have identical formats but read their data from different sources and have different counter values assigned to them.

Cells one to eight read directly from Port B (which is always set for input mode) and deal with the "natural" notes, *C, D, E, F, G, A, B* and *C1* (the latter being one octave higher than *C*). Cells nine to thirteen read from the register (REG2) which holds the last key status at Port A. They deal with the "sharp" notes, *C#, D#, F#, G#* and *A#*.

Each of the 13 cells has two counters. One counter decrements (counts down by one) from a preset value each time the main program loop is repeated. The other increments (counts up by one) each time the first counter reaches zero. The first counter is, at this point, then reset to a starting value which depends on the note being generated by that cell.

In effect, the first counter generates a pulsed waveform at twice the required audio frequency. The second counter divides the frequency by two and "squares" the waveform that is to be output to the mixer.

In the software example shown in Table 1, which details the cell routine for note *C*, NOTEC1 is the down-counter, and NOTEC2 is the up-counter:

Table 1. Software example

NC:	BTFSC PORTB,5	bit test PORT B pin RB5 for "clear" (zero)
	GOTO ND	go to cell for Note D
	DECFSZ NOTEC1	decrement counter NOTEC1 and check for zero
	GOTO AC	go to note C sub-address A
	MOVLW 58	move decimal 58 into register W
	MOVWF NOTEC1	move W into counter NOTEC1
	INCF NOTEC2,F	increment counter NOTEC2
AC:	RRF NOTEC2,W	rotate right counter NOTEC2 into register W
	RLF REG1,F	rotate left register REG1
	DECFSZ LOOPA,F	decrement counter LOOPA and check for zero
	GOTO ND	go to routine for note D
	GOTO PAD1	go to timing compensation routine named PAD1

Taking the cell instructions in detail:

NC
this is the address name allocated to the start of this cell (standing for Note C)

BTFSC PORTB,5
tests the status of Port B pin RB5; is its key pressed (is Port B pin RB5 low/clear – logic 0)? Only one of the next two instructions will be actioned, depending on the "truth" of the answer. If it is "true" that Port B pin RB5 is low, a logic 1 occurs and is added to the microcontroller's program counter (PCL), causing the program to jump to the second instruction rather than the first. If the answer is "false", a logic 0 is generated which does not affect the program address value, and so the "GOTO ND" instruction is actioned.

GOTO ND
to reach this instruction, the key has been found to be unpressed, and so the rest of this cell is bypassed, the program jumping to cell ND (Note D).

DECFSZ NOTEC1,F
to reach this instruction, the key has been found to be pressed, therefore this note's first counter (NOTEC1) is decremented and checked if it is now zero. If it is "true" that the counter is zero (answer = logic 1) the next instruction (*GOTO AC*) is bypassed (same reasoning as with *BTFSC* above).

GOTO AC
to reach this instruction, the counter NOTEC1 has been found not to be zero, so now jump to the part of routine commencing at address AC:.

MOVLW 58
to reach this instruction, the counter has been found to be zero, so load the W (Working) register with the value of 58 (the frequency setting value for Note C – other note cells have different values set here).

MOVWF NOTEC1
now transfer the contents of W into counter NOTEC1.

INCF NOTEC2,F
and increment counter NOTEC2.

AC
this is the sub-address jumped to from four instructions above, and the address to which the *INCF* instruction immediately above automatically moves.

RRF NOTEC2,W
the contents of NOTEC2 are now copied into the W register and shifted right by one place. This shifting moves the contents of the W register's bit 0 into a Carry register (actually, a Carry *flag* since only a single bit of a Status register is used). At the same time, the previous contents of the Carry register are shifted into the left hand bit (bit 7) of the W resister. This is irrelevant here, but is an automatic part of the process.

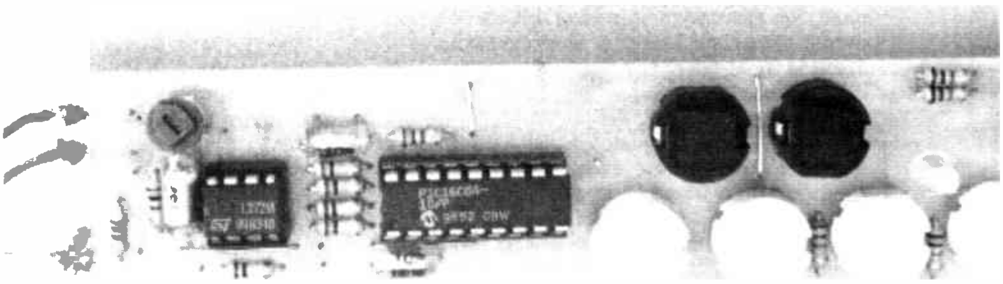
RLF REG1,F
all eight bits of register REG1 are now shifted left by one place, an action which automatically shifts the contents of the Carry register (now holding a copy of the value of NOTEC2's bit 0) into bit 0 of REG1. (Bit 7, the far left bit, drops out of REG1 – in fact, it is shifted into the Carry register, but that fact is also irrelevant here).

DECFSZ LOOPA,F
decrement the keypress counter (LOOPA) and observe if it is now zero. As with the previous *DECFSZ* instruction, only one of the next two instructions will be actioned, depending on the "truth" of the answer.

GOTO ND
as counter LOOPA is not zero, jump to the cell starting at address ND: (Note D).

GOTO PAD1
as counter LOOPA is zero, bypass the other note cells and jump to the synchronisation routine at address PAD1

Each of the note cells are actioned in the same way, either until the counter LOOPA reaches zero (four keypresses have been detected), or until all 13 note cells have been processed in the search for keypresses.



SQUARE WAVE FORMATION

The data bit value (logic 0 or logic 1) which is shifted into register REG1 each time a cell's keypress is detected, changes at the rate at which that cell's first counter reaches zero.

This rate depends on the starting value repeatedly loaded into that counter. The starting value thus determines the rate at which the second counter increments.

The second counter can be regarded as a divide-by-2 counter, or flip-flop, whose output (bit 0) is alternating between high and low at an evenly spaced rate all the time that the relevant key is pressed. In other words, the second counter can be regarded as a square wave generator.

It is the contents of this generator which are being shifted (transferred) into bit 0 of REG1. For each new bit shifted in, the other bits that have already been set are shifted left by one place, eventually being shifted out and lost.

NOTE ROUTING

Once the entire main loop has been completed (*GOTO GETKEY* later on in the listing) and restarted at GETKEY, the current contents of REG1 are transferred to Port A, whose first four pins (RA0 to RA3) output the data to the mixer stage around IC2a. Only the first four bits of REG1 are important in this program.

The actual Port A pin which is output to by each note generator (via REG1), will depend on where that note is in the sequence of keys being pressed. If only one note key is pressed, say note *G*, the output for that single note will always appear on Port A pin RA3. The other pins, RA1 to RA3, will be set at logic 0.

If four notes are pressed, say *C*, *E*, *G* and *C1*, then *C* will be shifted into RA3, *E* into RA2, *G* into RA1 and *C1* into RA0. The order in which the notes will occur on Port A is the order in which the key cell routines are accessed, which is a fixed order within the program. Natural notes will always precede sharp notes.

This fact, though, is only of academic interest and will not be apparent to the listener. If no keys are pressed, then the contents of register REG1 will be zero, and thus all four Port A output lines will be "silent". There is a bit more on this point later.

PHASE RELATIONSHIPS

An interesting side-effect of the frequency generating technique, which may sometimes be apparent, is the changing phase relationship between multiple notes played at different moments.

Since the note frequencies are not generated by constantly running oscillators, but are turned on and off when required, notes will commence and end at different points in their counter's cycles. Examination on an oscilloscope will clearly display this situation. The phases between the notes depend entirely on the starting and ending values of their counters.

The effect is not detrimental to the character of the sound produced. In fact, it enhances it. It is not especially pronounced, but when it is apparent, it adds a bit of "colour" to the sound.

NOTE FREQUENCY

Of additional interest to the ear is the slightly imprecise tuning of the "oscillators". This is due to the counters having to count in whole numbers (integers) rather than in fractions. It, too, adds character to PIC-olo's sound.

Even though the circuit is being run at 10MHz, because of the time it takes to perform each instruction, and thus the total time that elapses between each trip round the program loop, the counter starting values cannot be very large, and so cannot be "corrected" by small amounts. A much higher clock rate than 10MHz (which is impossible with a PIC16C84) would have allowed higher count values to be used, resulting in greater frequency precision.

A selection of frequencies and cell count values, as established when test-programmed into PIC-olo, is shown in Table 2. It will be seen that the use of integer values cannot result in absolute note precision, but the tuning is near enough for all but the most critical ears.

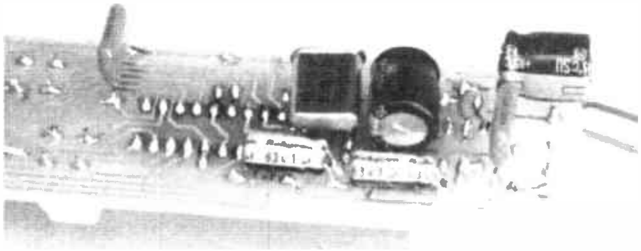
Table 2. Frequency and cell count value relationships

Note	Ideal freq in Hertz	Count	Measured Freq in Hertz	Chosen value
C	261.625	59	255.3	
		58	259.6	Yes
		57	246.2	
C#	277.182	55	273.8	
		54	278.8	Yes
		53	284.1	
D	293.66	52	289.6	
		51	295.3	Yes
		50	301.2	
D#	311.126	49	307.3	
		48	313.7	Yes
		47	320.4	
E	329.627	47	320.4	
		46	327.3	Yes
		45	334.6	
F	349.229	44	342.3	
		43	350.2	Yes
		42	358.5	
F#	366.994	42	358.5	
		41	367.2	Yes
		40	376.4	
G	391.995	39	386.1	
		38	396.2	Yes
		37	406.9	
G#	415.304	37	407.0	
		36	418.2	Yes
		35	430.1	
A	440.00	35	430.2	
		34	442.8	Yes
		33	456.2	
A#	466.163	33	456.3	
		32	470.4	Yes
		31	485.6	
B	493.883	31	485.6	
		30	501.8	Yes
		29	519.2	
C1	523.251	30	501.8	
		29	519.2	Yes
		28	537.6	

It will also be seen that there is little room for manoeuvre if raising PIC-olo's overall frequency range is contemplated. There is room, though, to *lower* its range; doubling the count value will halve the frequency.

From this it will be spotted that all halved frequencies would have even count value numbers, which would allow the actual frequency to be shifted closer to the ideal by changing some numbers to the nearest odd number.

Two photos showing the components mounted on the underside of the PIC-olo p.c.b.



PROGRAM BALANCE

A final, but most important point about the software for PIC-olo, is that it has been "balanced". Obviously, the time taken to process each cell will depend on the action required:

If no keypress occurs for a cell, the cell's software routine takes only two instructions to perform (e.g. *BTFSC PORTB,5* and *GOTO ND*). It can take nine instructions if the key is pressed. Such disparities in timing require additional time to be added later in the loop, otherwise the frequency generated by *all cells* will vary, depending on which keys are pressed.

Consequently, towards the end of the program loop, another cell contains a series of "pads" (a *padded cell*? – curtail that humour!). The "pad" to which the program will jump depends on the position from which the jump occurs.

If, for example, notes *C, D, E* and *F* are pressed, all four allowable keypresses will have been registered and so the jump occurs from the end of cell NF: down to PAD4. The dummy actions within PAD4 through to PAD12 are then processed, each instruction increasing the total timing of the whole loop.

If, though, the fourth keypress is on note *A#*, the jump is to PAD12, the final pad. In both four-key cases, the total timing for the loop's completion remains the same.

All "pads" are identical in function and format. They simply test a dummy bit of a dummy register (REG3), simulating the action that would have occurred if each key that has *not* been checked *had* been checked. As an example, PADs 1 and 2 are simply:

```
PAD1:    BTFSC REG3,0
         GOTO PAD2
         NOP (no operation)
PAD2:    BTFSC REG3,0
         GOTO PAD3
         NOP
```

Had the remaining keys *actually* been checked, undesirable time penalties would occur if they were found to be pressed. Remember that the PADs are only actioned if all four permitted keypresses have occurred. Any further keypresses are unwanted.

In reality, PADs 1 to 3 will never be accessed, but they are retained to preserve the author's sense of program uniformity!

MORE TIME WASTING

Should *fewer* than four keys be pressed, additional timing compensation needs to take place. This is carried out in a loop named CHKIT, its processing count being related to the actual number of keys pressed: once round the loop for three keypresses, twice for two, three times for one.

As with the PADs, actions within loop CHKIT are basically time wasters, they are simply there to delay matters by a predictable amount. One useful action does occur, though, register REG1 has its contents shifted left by one place each time round the CHKIT loop.

This makes Port A pin RA3 the dominant output line. The dominance of the other lines decreases in order of RA2, RA1, RA0. If a key is pressed, RA3 will always have a frequency on it, whereas RA0 will only carry an output frequency if four keypresses have occurred.

CAUTION

Under no circumstances should the balance of the main loop be upset by making amendments to any of the instructions within it, other than to change the counters' reset values. All frequencies will be upset if any one cell's instruction timing is changed in any way.

Resist the temptation to simplify the program by using a look-up table for the count values. The use of a table will slow down the rate at which the main loop is processed.

ROUND AGAIN

Once any timing compensation has been performed and one of the commands *GOTO GETKEY* has been reached, the program jumps back to the first cell at GETKEY:, whereupon the software again reads Port A and transfers the contents of register REG1 to it.

The speed with which the whole cycle occurs results in notes being generated at the rate shown in Table 1 and marked with "Yes".

CONSTRUCTION

Details of PIC-olo's printed circuit board (p.c.b.) component layout and full size copper foil master are shown in Fig.2. This board is available from the *EPE PCB Service*, code 164.

Fit the three on-board link wires first, followed by the resistors, capacitors C1 and C2, and then the i.c. sockets.

Crystal X1 and the remaining capacitors (C3 to C9) are all mounted on the back of the board and horizontal to it (see photographs). All these latter components should be as close to the board as possible to minimise the board's overall assembled thickness (its *profile*).

Observe the correct polarity for the electrolytic capacitors (C3 to C6). Use a piece of insulating tape below crystal X1 to prevent its metal case from shorting across the p.c.b. tracks.

Now mount the switches, S1 to S13, ensuring that the indents in their sides are aligned as shown in Fig.2. If different switches are used, check their correct orientation using a multimeter on a resistance range.

A word of caution about the switches: those used in the version of PIC-olo published here are not the cheapest available. Cheap switches were used on an earlier prototype but their operation left much to be desired in a unit that relies heavily on their repeated use. As a result, more expensive ones were chosen and the board redesigned to accept them.

The type of sockets you choose for SK1 and SK2 depends on the equipment with which PIC-olo will be used. Consequently, the inclusion here of socket wiring guidance would be inappropriate. If in doubt, again check matters with a multimeter.

The socket wires may be soldered directly to p.c.b. tracks or to single-sided terminal pins (flat side on the track side).

Before applying power or plugging in the i.c.s, check all your soldering thoroughly

COMPONENTS

See SHOP TALK Page

Resistors

R1 to R5, R17, R18	1k (7 off)	
R6 to R10	10k (5 off)	
R11 to R16	100k (6 off)	
R19	10Ω	

Potentiometer

VR1 50k preset, sub-min, round

Capacitors

C1, C2	10p polystyrene (2 off)
C3, C4	1μ elect, radial, 10V (2 off)
C5, C6	470μ elect, radial, 10V (2 off)
C7	1n8 polystyrene
C8, C9	100n polyester (2 off)

Semiconductors

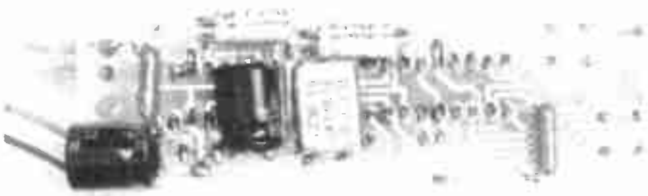
IC1	PIC16C84-10 microcontroller, 10MHz version, pre-programmed (see text)
IC2	L272 dual power op.amp

Miscellaneous

S1 to S13	single-pole push-to-make switches, p.c.b. mounting (5 black, 8 white – see text) (13 off)
X1	10MHz crystal
SK1	3.5mm stereo jack socket (see text)
SK2	3.5mm mono jack socket (see text)

Printed circuit board, available from the *EPE PCB Service*, code 164; 18-pin d.i.l. socket; 8-pin d.i.l. socket; plastic electrical conduit (see text); end caps for conduit (2 off); nuts (12 off); bolts (4 off), size to suit conduit; connecting wire; solder, etc.

Approx Cost Guidance Only £28 plus case



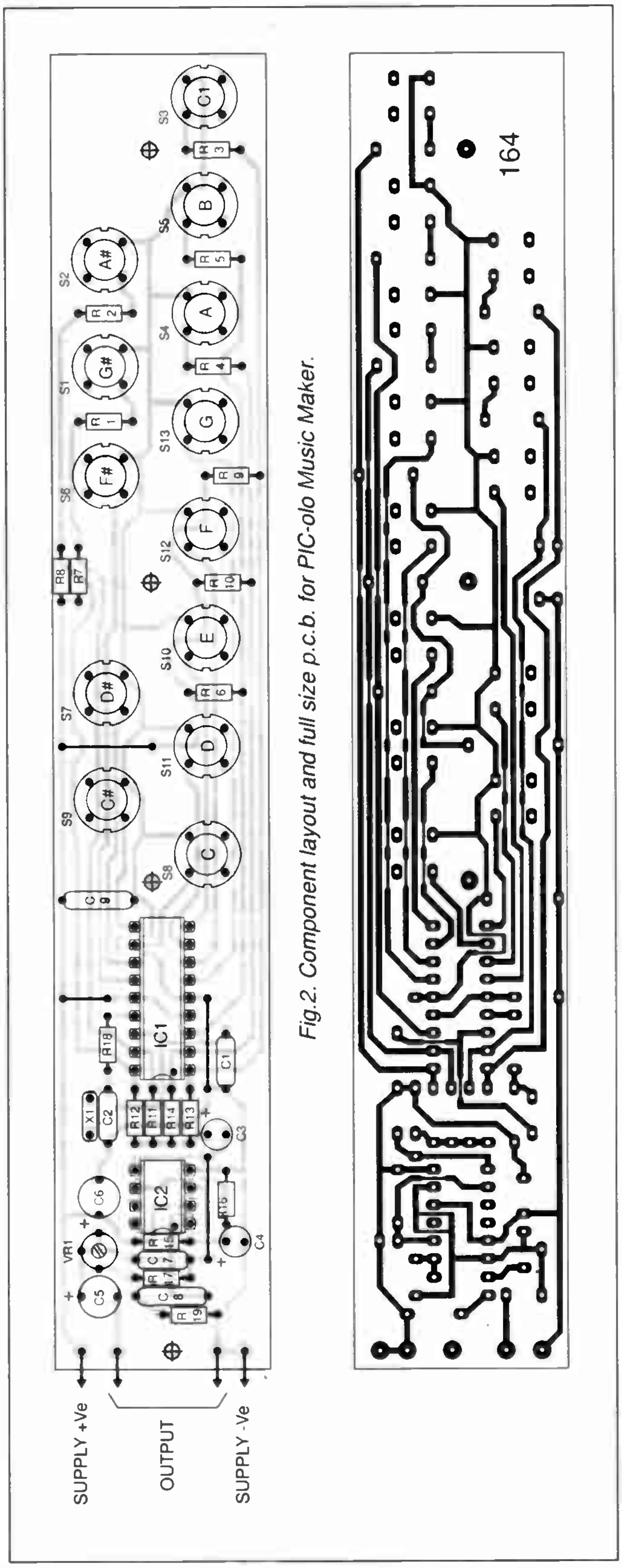


Fig.2. Component layout and full size p.c.b. for PIC-olo Music Maker.

and double check the correctness of the component positioning and polarity of the electrolytic capacitors.

Correctly insert the i.c.s (IC1 has to be pre-programmed, of course, as detailed in a moment). Connect up to a power supply and to something that allows you to hear what is happening – headphones, speaker or amplifier.

Press the keys in turn and check that each results in a different note being heard, and then that up to four notes can be played simultaneously.

All right? Good, now you can make music!

But, you'll want a case first.

HOUSING PIC-OLO

Originally, a narrow plastic *plumbing* pipe seemed likely to be the ideal housing for PIC-olo: nice and slender, shape reminiscent of a real wind instrument. Regrettably, the finished construction was just a bit too big to fit in such a pipe. Additionally, it was recognised that the curvature of the pipe would make adequate protrusion of the two rows of switches a difficult matter.

However, the *electrical* trade uses plastic conduit of a rectangular shape and in several sizes. It was a length of conduit (240mm × 37mm × 25mm – internally 35mm × 21mm) which was chosen for PIC-olo. It should be available from specialist electrical stores, and possibly from some major DIY stores. Ensure that you get the type which has one side which can be easily removed.

The internal measurements must be no less than those stated, but may be more; the length is not so critical. The size of the components used, especially the electrolytic capacitors, will also determine the conduit size that can be used. It is recommended, in fact, that the conduit is only bought *after* PIC-olo has been fully constructed.

SWITCH HOLES

Care must be taken over the position of the holes through which the switches must protrude. First remove the detachable side of the conduit. Put that to one side for the moment.

Take a photocopy of the p.c.b. track layout in Fig.2 and securely tape it to the broadest surface of the other (U-shaped) part of the conduit. Accurately mark the central position of each switch, and the points at which the securing bolts will pass through, then carefully drill small diameter holes at each point using a power drill. Use larger drill sizes to enlarge each hole as appropriate.

It is likely to be found that the switch holes required are a larger diameter than the largest standard drill size. If so, *very carefully* enlarge each hole using a counter-sink bit or cone-shaped hole-enlarging tool. Beware that both tools are likely to " snatch" at the hole, making it jagged, so take extreme care. The use of a drill stand for this process is essential.

Ensure that the holes become the right size to allow the switches to pass through, permitting them to be pressed smoothly, and to release without friction. It may be necessary to trim off parts of any plastic ridges within the conduit to let the p.c.b. be positioned satisfactorily.

Using the four bolt holes provided (only two were used on the prototype, but two have since been added to the p.c.b. artwork), pass round-headed bolts through the conduit, heads on the outside. Tighten nuts down onto each bolt.

Fit another nut to each bolt, positioning it so that the p.c.b. will rest on it, allowing the switches to pass through their holes. Now fit nuts to secure the p.c.b. in position, and tighten them down. Double check that all the switches can still be used freely.

Drill holes in one of the conduit's plastic end caps (available from the conduit supplier) to suit the sockets used for SK1 and SK2. Secure the sockets in position.

Now press the detached conduit side back into position and push on the end caps. That's the case finished, unless you want to add legends to it, saying what it is and what the note names are. Rub-down lettering will do the job.

As an alternative to this case, PIC-olo could be housed in a large colourful case more suited to encourage a child's visual interest. To this end, coloured switches could be chosen instead of the black and white ones used in the author's model.

PROGRAMMED PIC

Software for PIC-olo Music Maker can either be obtained on disk from the editorial office or down-loaded from our web site. There is a nominal handling charge for the former; we make no charge for the latter. See *Shoptalk* page for details.

It is again stressed that the *10MHz* version of the PIC16C84 has to be used with PIC-olo. Before loading it with the software, it must be initialised for 10MHz use, with Watchdog and Power-on-Reset both off.

The software was written using TASM, the shareware (Public Domain Shareware Library, Version 3.0 originating from Speech Technology Inc.) PIC programming software first made available when the *EPE Simple PIC Programmer* of Feb '96 was published. This software continues to be available from the editorial office on disk, and from our web site.

Whilst knowledgeable programmers will be able to translate the TASM coding to suit other programming software, such as MPASM, neither *EPE* nor the author can advise on this.

Pre-programmed PICs are also available from our regular programmed-PIC source, Magenta Electronics, again see *Shoptalk* for details.

The web site address (including sub-directory) is **ftp://ftp.epemag.wimborne.co.uk/pub/PICS/PIColo**

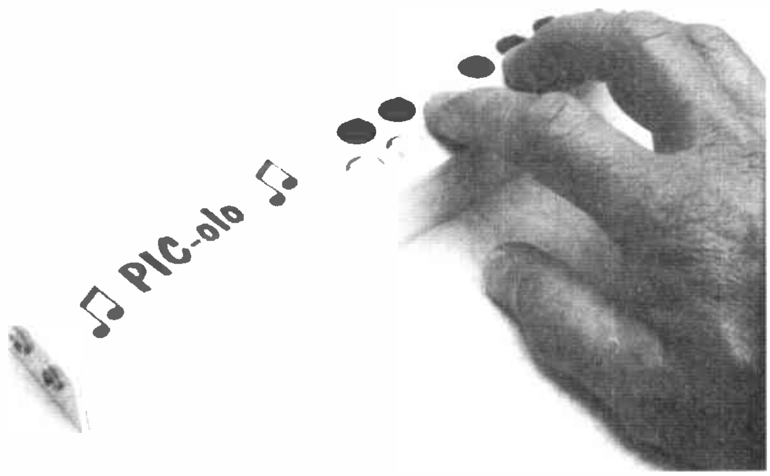
Readers who wish to know more about PIC programming should refer to the *Back Issues* page where previous *EPE* PIC-based project articles are listed and available as stated. You should also obtain PIC data books from Arizona Microchip, Unit 6, The Courtyard, Meadowbank, Furlong Road, Bourne End, Bucks SL8 5AJ. Tel: 01628 851077. Fax: 01628 850259.

CONCLUSION

For the author, designing PIC-olo Music Maker was an interesting exercise in finding out how a PIC could cope with music making. As it turns out, an instrument like PIC-olo seems to be just about all that this particular microcontroller can handle. It is a powerful microcontroller in many applications, but sophisticated music making is not its *forte*.

PIC-olo is a lot of fun and will not only provide enjoyment, but could also offer children early steps in understanding how to make music. It is not a precision musical instrument, but it was never intended to be. More elegant electronic musical instruments need much greater processing power and a lot more circuitry. Nonetheless, we believe you will enjoy PIC-olo.

The thought occurs, though, could another *EPE* PIC project be inspired by the Bournemouth Symphony Orchestra? Although the author would like to honour, say, the harp section, the project title *HarPIC* might be misunderstood!



SHOP TALK
with David Barrington

Variable Bench Power Supply

The only item that stands out as likely to possibly cause sourcing problems for those undertaking the *Variable Bench Power Supply* project is the 1·2V temperature compensated voltage reference type ICL8069. If it is unobtainable from your usual local supplier, it can be purchased from **Maplin,** order code YH39N.

It is important to use the specified PMOS op.amp type CA3140E as it is capable of handling the low input and output voltages associated with this circuit. It was found that most other "similar" op.amps will not work properly in this circuit. The CA3140E is generally available from most of our components advertisers.

The case *must* be an *all-metal* type as the base also acts as a heatsink for the Darlington transistor. Also, as the "heat-tab" is connected to its collector terminal the Darlington must be isolated from the case using a standard TO220 insulating kit, consisting of a washer and plastic bush.

The battery eliminator used to power the circuit *MUST* be a *non-regulated* 12V d.c. type – no other type is suitable. Most mains eliminators offer a range of low output voltages, so make sure the selector switch is set to the correct setting and check that the tip of the plug is the positive voltage connection. The eliminator used with the model is an Altai 750mA version which many of our advertisers may stock.

This project is built on the *EPE* Multiple Project PCB, this is available from the *EPE PCB Service*, code 932.

PIC-olo Music Maker

It is essential that only the 10MHz version of the PIC16C84 microcontroller be used for the *PIC-olo Music Maker* project.

The dual power op.amp. type L272 is listed by two sources, namely: **Maplin,** code UJ36P and RS outlet **Electromail *(☎01536 204555),*** code 635-167.

Turning to the "keys", the pushbutton switches used in the model are not the cheapest, but cheaper ones used in an early prototype soon showed up defects after repeated use. As a result, it is recommended that constructors stick to the specified (push-to-make release-to-break) RS types. These are obtainable through their mail order outlet Electromail, codes 334-915 (black) and 334-886 (white).

For those readers who do not have their own facilities to program PIC chips, a ready-programmed PIC16C84 can be purchased from **Magenta Electronics *(☎ 01283 565435)*** for the sum of £15, including post and packing.

However, if you wish to do your own programming, the software listing (TASM) is available on a 3·5in disk from the Editorial Offices – see *PCB Service* page for details. If you are an Internet user, it is available *Free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk/pub/PICS/PIColo.**

The PIC-olo printed circuit board is available from the *EPE PCB Service*, code 164.

Micropower PIR Detector – Control Board

The dual-in-line switches, used on the *Control* board for the *Micropower PIR Detector*, are described as being sub-miniature s.p.d.t. types and a quad (S1 to S4) and a single version are used here. These switches are carried by most component stockists, but, be warned, the minimum spacing between banks is 0·15in. so a 4-switch d.i.l. package must be used for S1 to S4 if it is to fit on the p.c.b.

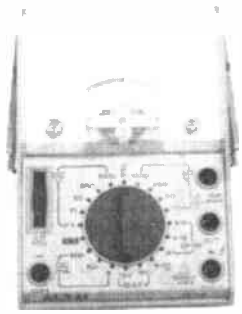
The BUZ11 power MOSFET came from **Maplin,** code UJ33L. Note that the suffix L should be quoted when ordering the BC184L transistor, as other versions have a different pin-out line-up.

The printed circuit board is available from the *EPE PCB Service*, code 163.

Universal Input Amplifier

The NE5532 i.c. is classified as being "suitable for use in high quality and professional equipment", and is the preferred choice of op.amp for the *Universal Input Amplifier* project. This dual low-noise op.amp should be widely available, but if problems locating it do arise, it is stocked by **Maplin,** quote code UH35Q.

The small printed circuit board is obtainable from the *EPE PCB Service*, code 146.



Multimeter Offer

If you're looking for a good low-cost analogue multimeter (everyone should have one as well as a digital meter), you will most likely find just what you want from **Squires Model & Craft Tools.** The Altai HM102BZ multimeter in our photograph is being offered to *EPE* readers at just £14.95 inclusive of VAT; postage within the UK is free.

If you think the meter measures up to what you are looking for, contact **Squires Model & Craft Tools, Dept. EPE, The Old Corn Store, Chessels Farm, Hoe Lane, Bognor Regis, West Sussex, PO22 8NW. (☎ *01243 587009*).**

PLEASE TAKE NOTE

Infra-Red Remote Control Repeater *July '97*

A suitable substitute for the BP103B phototransistor is the SFH300, which is available from RS/Electromail, code 585-220.

PIC Digilogue Clock *June '97*

Reverse the polarity of capacitor C1 in Fig.5. Notches in switches S1 and S2 align vertically.If instability of the display occurs (e.g. erratic "rotation" of the hours l.e.d.s), decrease the value of R1 to 1k.

Cut off pins 6 and 7 of X2 display d.i.l. holder (units of minutes – bottom right-hand two pins) ensuring that they cannot touch the p.c.b. track (this is an easier solution than cutting and re-routing the associated p.c.b. tracks).

RE-USABLE CDs – AT LAST

A Stop-Press report from Barry Fox

They've done it – achieved the reality of re-writable CDs for the consumer!

HEWLETT PACKARD, Mitsubishi, Philips, Ricoh, Sony and Yamaha are launching the product consumers have been wanting for the last ten years. CD-ReWritable looks like an ordinary CD but behaves like a giant floppy disc, with 500 times the capacity. The disc records and plays back any kind of digital data, including back-up files from a PC, hi-fi sound or video. It can then be erased and reused.

CD-RW discs play back on CD-RW recorders or a new generation of CD-ROM drives. But unbeknownst to their owners, some recently purchased CD-ROM drives already contain "Multiread" circuitry which self-adjusts for CD-RW playback. Anyone buying a new ROM drive should now insist that it is Multi-read capable.

Conventional CDs and CD-ROMs are pressed from plastics, with a spiral of pits in the surface, and covered with reflective material. The player reads the disc with a laser beam whose reflection is affected by the pits.

Write-once CDs are pressed from plastics without pits, and coated with a dye which absorbs laser light during recording. The dye gets hot and permanently deforms into pit-like marks. The disc has a "pre-groove" which is formed during pressing and serves as an optical guide for the laser during recording.

CRYSTAL GAZING

The new CD-RW discs are coated with an alloy of silver, indium, antimony and tellurium. In its natural state, the alloy is crystalline and reflects light efficiently. During recording, the laser heats spots on the surface to around 600°C, so that the alloy melts. The spot then cools so quickly that the alloy does not have time to re-crystallise. It "freezes" into an amorphous state which is much less efficient at reflecting light. So the readout laser sees the spots as pits.

To erase the recording, the laser again heats the alloy but more slowly and to a lower temperature, which lets the alloy re-crystallise.

The coating can be erased at least a thousand times and is protected by a transparent lacquer which is sufficiently robust to let the user handle the disc. So CD-RWs do not need a protective caddy and can thus fit any conventional CD drive.

Existing CD-audio players and CD-ROM drives have a light sensor designed to read pressed or write-once discs which reflect 70 per cent of the laser light from the lands between the data pits, and around 30 per cent from the pits. The difference represents digital ones and zeros. Although it is possible to make an alloy which matches these optical characteristics, the recording laser must be very powerful to melt the alloy. The system is then too expensive for consumer use.

NEW MULTIREAD STANDARD

Recently, Philips and HP agreed a standard for CD-RW with 20 per cent reflection from the alloy in its crystalline state and five per cent in its amorphous state. The recorder can use an inexpensive 10mW laser. But the player must have a more sensitive sensor.

The new standard defines a Multiread player with automatic gain control in the circuit which amplifies the signal from the light sensor. If the disc is a pressed CD or CD-R, the amplifier gain is turned down; if the disc is a CD-RW with lower reflection, the gain automatically increases.

The Multiread standard has now been endorsed by all the major manufacturers of CD-ROM drives. Around one third of the latest models in the shops, known as 12x drives which run at 12 times normal speed, already have AGC. Once makers have sold off their old stock, all new drives will conform. Some old ROM drives and even CD audio players may, by happy chance, have sufficiently sensitive optics to play CD-RW recordings.

Philips' CD-RW recorder will cost $900, with 650Mbyte blank discs costing $25. Hardware and disc prices should soon fall to around half. The Philips recorder looks like a CD player and connects to a PC to copy files on its hard disc. The control software already lets it copy music files. Philips expects standalone audio recorders "this year or next".

SEMICON INDEX

IT was with pleasure that we recently received the latest edition of the Semicon Index. For many years we have benefitted from various editions of this authoritative source of semiconductor information and are pleased to receive the latest. If there is a more comprehensive single source, we have yet to learn of it.

The Semicon Index comprises three volumes, each dedicated to a specific group of semiconductors. Volume One covers transistors, Volume Two details diodes and thyristors, and Volume Three covers integrated circuits.

Each volume is around 35mm thick, with pages measuring about 175mm × 246mm. Device listings are split to reflect general type categories, and in each category the devices are itemised in alphanumeric order. The essential characteristics for the devices are then presented in tabulated form, complete with a cross-reference to outline and pinout details displayed in a later section. A guide to each device's manufacturer(s) is also given.

Details of the manufacturers, complete with their distributors' details, are given in another section. A further section of each volume gives guidance on possible substitutions where appropriate. Surface mount devices are included.

Anyone seriously into electronics will find that once these volumes have had their data riches probed, you will never want to be without them.

Each volume is available separately and may be purchased soft-bound, or loose-leaf in a sturdy ring binder. Loose-leaf updating packs are released periodically to keep you abreast of the latest device introductions. Devices are never *dropped* from the Semicon Indexes and so you will have access to historical data as well as the very latest.

To find out more about these invaluable data source volumes, contact Semicon Indexes, PO Box 470, Lee, London SE12 8AF. Tel/fax: 0181 852-2309. E-mail: Semidex@aol.com.

Sinclair Tunes in Again

Alan Winstanley has the details

THE irrepressible British inventor, Sir Clive Sinclair, is at the forefront again with a gadget harking back to his origins in electronics, in the form of the imaginatively-named *X1 Button Radio*, which he dubs "the world's smallest radio". The size of a 10 pence coin, the miniaturised mono X1 in-ear device weighs in at just 15 grams and is powered by a lithium cell which offers up to a year's usage.

A special "sure grip" feature is incorporated into the custom ABS moulding, and it includes its own antenna. Sinclair's X1 Button Radio automatically seeks and tunes in to FM stations, using pushbuttons to scan the 88 to 108MHz FM band, in the same way a car radio and some personal stereos search for and lock on to radio broadcasts. The X1 is only available by mail order in the UK and is supplied complete with battery.

Back in 1962, the fledgling inventor, aged 22, formed Sinclair Radionics and marketed his first AM-band miniature radio, the Sinclair Micromatic, which retailed at 49 shillings and sixpence (under £2.50) in kit form. He soon established a reputation for miniaturised, novel gadgets utilising new technology.

The Sinclair name subsequently adorned a wide variety of sleek products, including the Cambridge calculator, slim-line audio products and speakers, the best selling ZX81 and Spectrum computers, digital test equipment, the Microvision pocket television, the Sinclair QL ("Quantum Leap") and Z88 computers, before he sold the brand name to Alan Sugar's Amstrad in 1986.

Sir Clive is better known these days for his electric transport accessories, notably the "Zike" electric cycle and "Zeta" electric drive add-on for bicycles. We are promised another major innovation from Sinclair later this year in the electric transport market.

Most of Sinclair's former products were the subject of stylish advertising campaigns for mail order kits, and were a regular feature in the pages of *Everyday Electronics* and sister magazine *Practical Electronics* at the time.

Not all of his products were successful, and reliability was sometimes a problem as he "pushed" the technology, but Sinclair's visions were still ahead of their time and pace setting, nevertheless. His remarkable inventive genius was rewarded with a knighthood in June 1983.

With the X1, maybe his creative yearning for electronics technology has awakened once again.

The Sinclair X1 Button Radio is available for £10 inc. P&P by mail order only, from Sinclair Research Ltd., Vector Services Division, 13 Dennington Road, Wellingborough, Northants NN8 2RL. Tel: 01933 279300.

B.A.E.C. NEWS

LAST time we received a British Amateur Electronics Club (B.A.E.C.) newsletter, we were dismayed that they appeared to be having difficulties finding a replacement for their retiring editor, Alf Denison. We are pleased to learn in the latest newsletter that all appears to have been resolved.

In a nutshell, a team of B.A.E.C. members is now jointly carrying out the necessary compilation, editing and production involved. Other members, of course, continue to supply the material.

The B.A.E.C. is a club which encourages the enjoyment of doing electronics and of learning about it. We have always supported it, believing in its aims. If you would like to be directly involved with like-minded electronics enthusiasts, join the Club!

For more information, contact the Secretary, J. F. Davies, B.A.E.C., 70 Ash Road, Cuddington, Northwich, Cheshire, CW8 2PB. Tel: 0106 883742. E-mail: john@fdavies.u-net.com.

SINGULARITY

IN an age when it is customary to cram as many functions as possible into a single i.c. package, the developing news of an opposite concept comes as something of a surprise. The news, received from two companies independently, Texas Instruments and Fairchild, announces the latest single gate i.c.s to be released.

As most of you will be aware, it has been conventional for many years for functional gates such as AND, NAND, NOR etc., to be housed as four of a type in a single package. Now, in what seems to be an about turn, chips comprised of just one gate are finding a use where board space is at a premium. Normally, if one wants a single gate, the quad package is used and the other three gates ignored. But why take up extra space if you don't need to seems to be the concept now being catered for by i.c. manufacturers.

The gates from Fairchild and TI are all surface mount devices and cover the functions NAND, NOR, AND, OR, NOR, inverter and Schmitt inverter. Fairchild call their range the TinyLogic family (HST series); TI's form the MicroGate family.

Fairchild's web site is: http://www.fairchildsemi.com. Texas are at http://www.ti.com.

ARE PCs TO REPLACE TVs?

It may seem an heretical thought to avid programmers, but you could soon be using your PC to watch TV – Barry Fox explains

THE latest Homefront study, from electronics market research company Odyssey in San Francisco, shows how people are buying computers and using them instead of watching TV. But computers are now widely known to be difficult to use and sales to new customers are drying up.

Odyssey interviewed 4,500 consumers, across the country, and found that repeat purchases dominate the market. Only 32 per cent of consumers are now first time buyers, compared to 49 per cent a year ago. So home penetration now remains stable, with PCs in 37 per cent of US homes.

Odyssey's President, Nick Donatiello predicts that, "You won't see PCs in more than 50 per cent of US homes until the manufacturers figure out how to make them easier to buy, set up and use".

Odyssey's study also shows that 46 per cent of US households with computers (equivalent to 17 per cent of all US households) are now online. On average they spend 9·4 hours a week sending electronic mail or surfing the Internet.

By far the most successful Service Provider in the USA is America On Line, which now has 22 per cent of the market, compared with nearest rival, Compuserve, which has four per cent.

Particularly interesting is Odyssey's finding that 30 per cent of the PC users who surf the Internet say they are doing so instead of watching TV. Furthermore, 23 per cent of them are sending electronic mail, instead of mailing letters.

All this helps explain why computer giants Microsoft, Compaq and Intel have now formed an alliance to develop and sell a new generation of PCs that will receive digital TV programmes and digital data transmitted over the airwaves. The announcement, made at the *National Association of Broadcasters Convention* in Las Vegas early in April, follows the decision, made last December by the Federal Communications Commission in the USA, on digital broadcasting.

The FCC has not defined a TV standard, instead it has set a range of digital standards, which range from current TV picture quality up to high definition pictures, with low cost receivers still able to receive high definition transmissions, and display them in standard definition.

The Microsoft/Compaq/Intel Alliance believes that adding digital TV reception to a PC will put only $100 on the price. The first sets should be available in the second half of 1998 and the Alliance predicts that by the year 2000 all new PCs will be digital TV receivers.

COLOSSUS RECREATED

BARRY FOX

The world's first electronic computer, built in secret during World War II, has been recreated and outperforms the latest Pentium PC.

EVERY other weekend a group of volunteers welcomes visitors to a cluster of decaying huts in the grounds of a stately home near Bletchley, in Buckinghamshire. Despite what the British security services would wish, and thanks to the accidental publication of top secret documents in the US, the Bletchley volunteers can, for the first time, recreate the technology used during World War II to crack the codes used by the German military.

The surprise discovery, which raises questions on the best future for computing, is that the wartime technology can still outperform the latest Pentium PC.

Fifty years ago 12,000 people were working at Bletchley Park in three shifts round the clock. The Public Records Office has 320,000 messages which were successfully decoded. All the workers were bound by the Official Secrets Act and sworn to remain silent until the day they died. Some visitors are for the first time able to discover what it was their wives and husbands were doing there.

LOONEY BIN

The locals referred to Bletchley Park as the "looney bin" because it was populated by oddballs, obliged to live a lie. Most of the staff did not understand the jobs they were doing. Each worked on a tightly targeted task, with no knowledge of how it fitted into the overall strategy. Mechanical engineers made precision wheels, electricians connected wires and clerks used two million punch cards a week to build an index.

Only a handful knew that they were building and using the world's first computer. That handful also understood the need for secrecy to continue long after the normal 30 years. The principles used at Bletchley were so far ahead of their time that they apply equally well to modern code-breaking. The application of new technology just makes them more efficient.

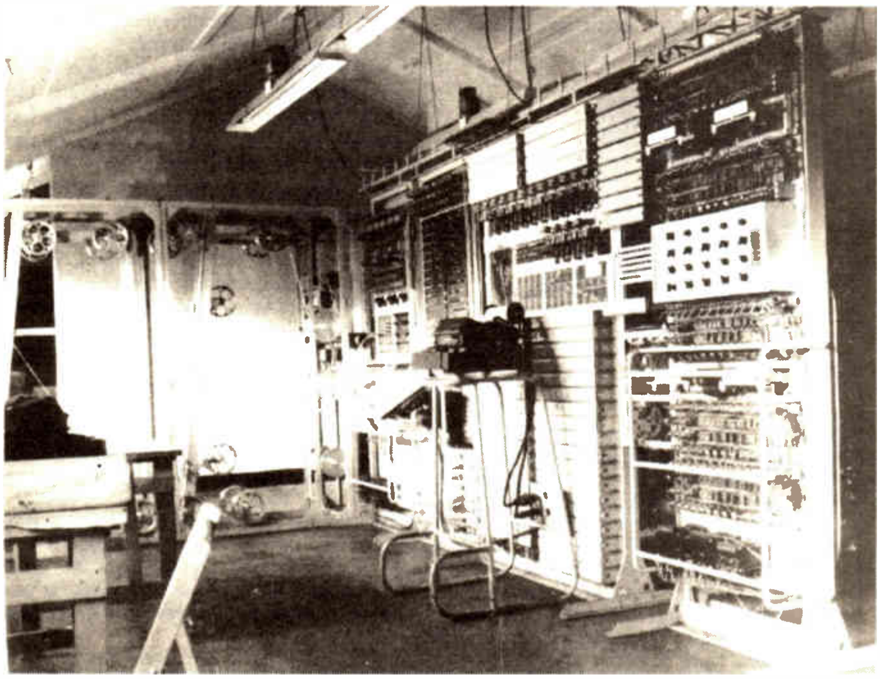
When the war ended, the equipment used by the codebreakers was all either spirited away by the security services, or physically destroyed on the orders of Winston Churchill. The blueprints were burned. Churchill wanted to make sure that the Russians did not know how the British broke codes. He feared, correctly as it turned out, that a Labour Government would oust him, and believed that the Labour Party of the day had an uncomfortably close relationship with the Soviet states. Soon after, in his famous speech given at Fulton, Missouri (March 1946) Churchill warned that "an iron curtain has descended across the Continent".

WORKING REPLICA

Although Britain's spymasters, at the Government Communications Headquarters near Cheltenham, have now allowed the publication of numerous books on Bletchley, the authors have always been censored, either directly by GCHQ or indirectly by restricted information. Much of what has been written glosses over simple truths, replaces hard facts with complex maths or omits essential details.

Until 1996, no-one was allowed to build a working replica of Colossus, the first electronic computer, even though enough unauthorised diagrams had survived to prod the memories of those of the original design team who were still alive. GCHQ only relented because the US Security services published papers which the UK had given them during the war. Colossus is now built, with its 2,500 valves glowing, and paper tape drive whirring, at Bletchley.

GCHQ has not needed to stop anyone trying to rebuild the codebreakers' other machine, known as the Bombe. After Churchill's order to smash the equipment at Bletchley, all that remained was one fuzzy photo of a machine in a hut, some machine tool plans for unspecified components and a handful of wiring. This wiring had survived only because one of the workers who was ordered to smash Bombes with a hammer had broken the



The Colossus of Bletchley Park, showing its "front panel", and punched-tape rollers in the background.

handle on his suitcase, and needed something for a makeshift repair when he went on leave at the weekend. He found it recently in his attic.

Even the huts in which the equipment was built and used are at risk. They are now owned by British Telecom who no longer need them for training telephone engineers. So BT's accountants would like to earn £10 million for the company's shareholders by raising everying to the ground and selling the site for housing.

ENIGMA

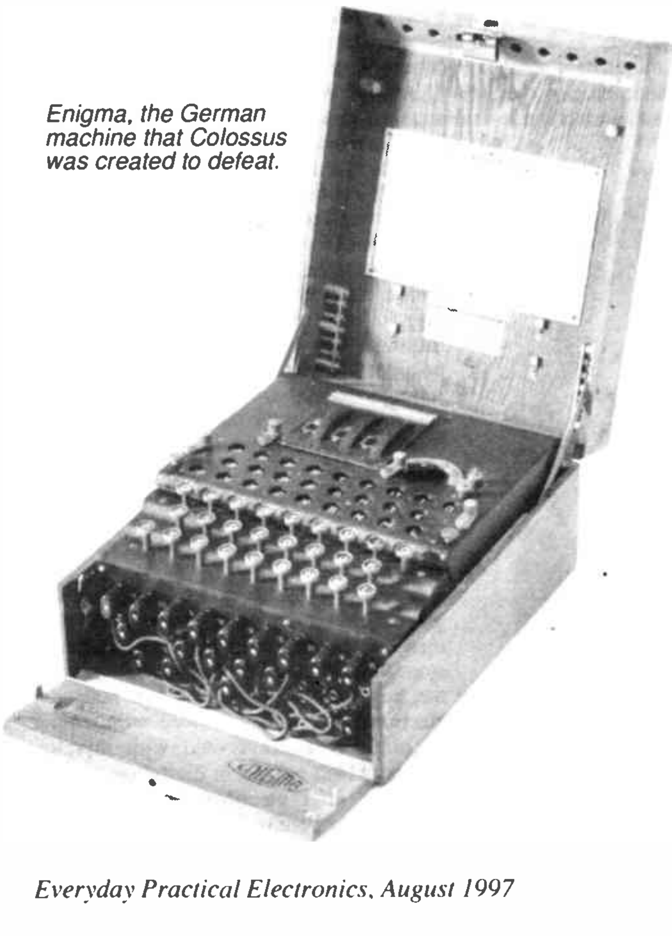
During the war, the Germans used two quite different coding systems to keep their radio messages secret. All operational radio traffic, such as orders to troops and ships, were fed through Enigma machines. These were clumsy to use so the High Command, Hitler and his generals, had a rather more user-friendly device made by electronics company Lorenz. The Allies knew how Enigma worked, but not how to crack the codes it used, which were changed every day. They did not know how the Lorenz machine was made so had to work that out before they could start on the codes.

Enigma was invented in Germany, in the 1920s. Patents gave full details of the mechnical design and the UK built a similar machine called TypeX. It looked like a mechanial typewriter and worked on the principle of substitution. I remember, during a time in the RAF as a service engineer, being taken to a securely guarded hut, told to sign the Official Secrets Act and shown a TypeX machine. As we left the hut, all the notes we had made to help us remember how to service TypeX, were taken from us and destroyed. Signing the Act was completely unnecessary. Within a couple of hours we had forgotten how the machine worked. Fortunately (for Britain) I was never asked to repair one.

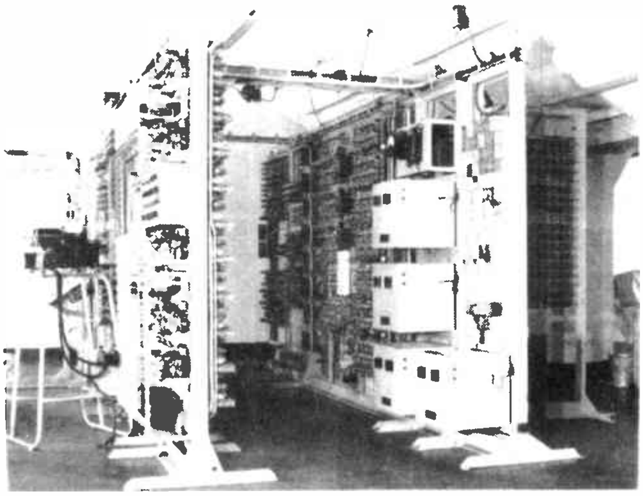
Visiting the Bletchley Museum recently reminded me of what I had forgotten. When the operator pressed a key, a lamp lit to signify a different letter. Typing an A could give a P; then typing another A might give a Z; typing a B could then give a P, or a Z, and so on.

The operator wrote down the signified letter and when a whole message had been keyed in and the corresponding lamp letters noted, a Morse Code operator tapped out the now gibberish message for transmission.

At the receiving end, another Morse Code operator noted the incoming letters, wrote them down and passed them to an operator of another Enigma machine. Keying in the gibberish text, lit lamps to spell out the original clear text message. But this only



Enigma, the German machine that Colossus was created to defeat.



A side-ways view of Colossus. Its valves consumed 4·5kW of power and were never switched off.

happened if both machines were set up in exactly the same way, and this was changed daily and was well nigh impossible to guess.

WHEELS AND PATCHES

Each Enigma machine had at least three rotor wheels, like cogs, which contained wires that connected the keyboard to the lamps. All the wheels were differently wired and the operator had a choice of five. Each wheel had a inner and outer circle of 26 contacts, and the circles could be turned through 26 alphabet settings to change the internal connection paths.

Each time a key was pressed, the wheels moved relative to each other, continually changing the relationship between the keyboard and lamps. To make things even more complicated, the connections passed through a Stekker board, a patchwork of wires and pins like a miniature telephone switchboard.

A secret list told all operators which wheels to choose, which alphabet settings to use and in which order to place the wheels side by side. This was known as the "ground setting".

The operator then turned the wheels at random into a starting position or "indicator setting". This setting, signified by whichever three alphabet letters were aligned with a marker line, was transmitted "clear" for anyone to receive. The operator at the other end used this information to set his wheels in the same starting position; but it was valueless to anyone who did not know the ground setting.

Together, these confusions piled on confusions gave a total of 150 million million million possible combinations of connection paths. It would take anyone with an Enigma machine, but no knowledge of the ground settings, literally years to decode a message by the "brute force" method of keying it through the machine, again and again, each time with a different setting.

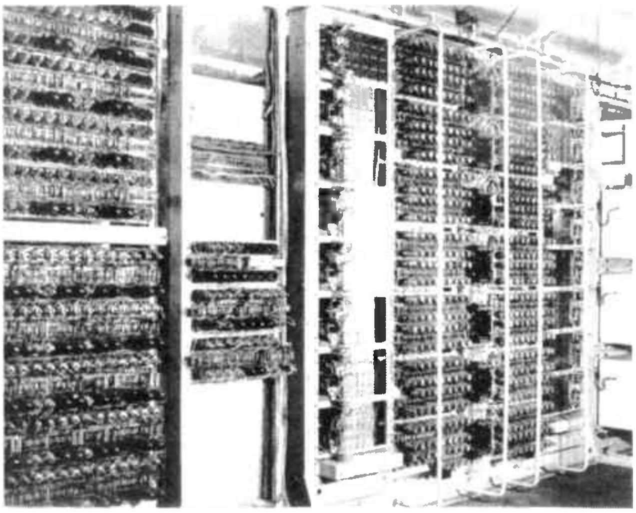
SCHLUSSELZUSATZ

The Schlusselzusatz, made by Lorenz, worked like a teleprinter or telex machine. Instead of changing one letter into another (like Enigma), the Lorenz machine generated pseudo-random text characters which were then added to the original text. So the clear text message was hidden in a forest of gibberish characters.

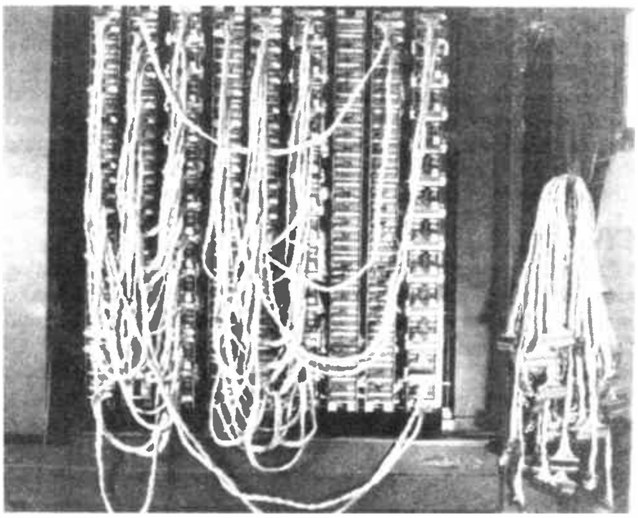
Lorenz, which Bletchley people called Tunny, had a keyboard into which the German operator typed a message. The keyboard converted letters of the alphabet into the world standard 5-bit International Teleprinter Code, also known as Baudot code. Each digital word is made up from five marks and spaces, in combinations which denote text characters. One word represents one character.

The 5-bit words were stored as punched holes on paper tape, then broken down into five separate bits, and each bit passed through two toothed wheels, similar to the rotary contacts used in an ordinary Strowger telephone exchange. The wheels were connected in series, and each with different internal wiring paths. This changed the marks into spaces, and vice versa, or left them unchanged, depending on the wiring and position of the wheel. So each bit was changed, or left unchanged, twice. Two drive wheels turned the ten wired wheels through ever-changing combinations, to give 10^{19} code possibilities.

The wheel bank thus created a "key stream" of gibberish 5-bit



Banks of valve circuits; Colossus Mk2 used 2,500 valves.



Interconnection wiring allowed circuit paths to be changed.

code words. These were then added to the stream of orginal "clear" text character words, to produce an encrypted stream of very heavily disguised text.

When the receiving machine had matching wheels and the same ground setting, it generated an identical stream of gibberish which could then be stripped out to leave the original message..

As was the case for Engima, the relative positions of the wheels were set, to a secret menu, every day. Then, for each message, their starting positions were set to a new order. The codebreakers at Bletchley first had to know how the wheels were wired, then find the daily wheel pattern and finally the starting order used for each message. Only then could they build a replica of the key stream and strip it from the message, to reveal the clear text.

The British forces did not capture a Lorenz machine until the last days of the war. It was thus up to the Bletchely codebreakers to try and work out how Tunny worked, from intercepted messages.

INTELLECTUAL FEAT

Mathematician Bill Tutte used a mistake made by an German operator in January 1942 to unravel the key stream for a single 4000 character message, subtract it from the gibberish stream and work backwards to deduce the wheel design. The task took him four months.

"Bill Tutte's work on Colossus was the greatest intellectual feat of the whole war" says Tony Sale, Director of the Bletchley Park Cryptology museum. "At Bletchley they knew nothing about the Lorenz machine and only six people ever understood the signficance of what Bill Tutte had achieved."

Tony Sale used to work for MI5, with Peter Wright, who later upset the government by writing a book about the security service. Sale then helped the Science Museum rebuild the Babbage Engine, the mechanical calculating machine which Charles Babbage designed but never finished. Three years ago he became fascinated by the computers used at Bletchley and the way the Lorenz mystery was unravelled.

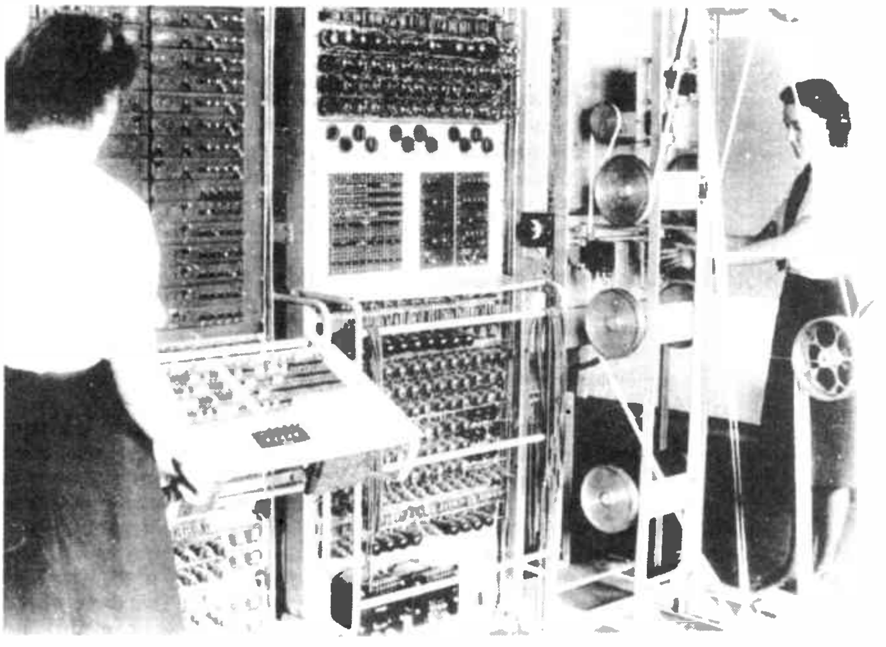
The Lorenz operator had sent the same 4000 character letter twice, because there was a fault at the receiving end – probably because the operator had dozed off. Because he was lazy, the sender used the same Lorenz wheel settings, and thus the same encryption code. Worse still he did not send exactly the same text. Fed up at the prospect of keying it all in again, he shortened some words, for instance using "nmr" for "nummer". This gave the codebreakers "depth", at least two identical or similar messages, sent with the same coding settings. With depth they were able to strip the key stream from the original messages. Tutte then worked backwards from the key stream to deduce the way the wheels on the Lorenz machine were made.

WORLD FIRST

As with Enigma, the Lorenz codes changed with the daily wheel settings. Even when the codebreakers knew how the Lorenz wheels were wired, it had taken them two months of trial and error, working through every possible relative position for the wheels, to decode a message. By then its content was worthless, and Britain's radio operators were intercepting thousands a day and sending them to Bletchley. What the codebreakers needed was a machine to automate the task. Colossus was the answer. It was the world's' first electronic computer, built by the Post Office Research Station at Dollis Hill under the direction of electronics engineer Tommy Flowers.

Colossus grew out of a primitive machine, jokingly called Heath Robinson, which used two loops of punched paper tape. One tape stored the encrypted message, the other held a selection of possible keys represented by wheel settings derived from the text in a crib. The machine ran the tapes at 30 mph while reading them by shining light though the punched holes onto photocells. All the time the electronics looked for possible matches which might tell what postions the wheels had been in when creating the gibberish.

The Heath Robinson tapes stretched and got out of synchronism. Tommy Flowers then had the idea of using just one tape, to store the encrypted message, while storing the key information inside the machine, electronically. This was done with a plug board of connections and with thyraton valves, which remain in digital on and off positions after electrical switching, like modern RAM chips.



Colossus operators at work – note the punched paper tapes running on the pulleys.

Colossus Mk 1 (with 1,500 valves) was working by mid 1943; Mk2 (which had 2,500 valves) was switched on 1 June 1944. The main difference was that Mk2 also had a refreshable memory, of more switched valves, that let it store some previous characters while processing new ones, and then compare the results.

CRIBS

Alan Turing, another mathematician recruited to Bletchley from Cambridge University, saw that there was no point in trying a brute force attack on the codes. Messages would be out of date long before they could be read. Instead he tried to predict text that would be found at some part of the message. The codebreakers called these known text strings "cribs". It is this kind of process that the security services would still like to keep secret because the principles are as valid today as they were in the war.

One crib trick was for British bombers to drop mines at carefully targeted longitude and latitude in the sea. The German Navy would then transmit a message which somewhere contained the known grid references. The same technique was used by British spy ships, disguised as fishing trawlers, to prod Russian spy ships, also disguised as trawlers, into sending messages during the Cold War.

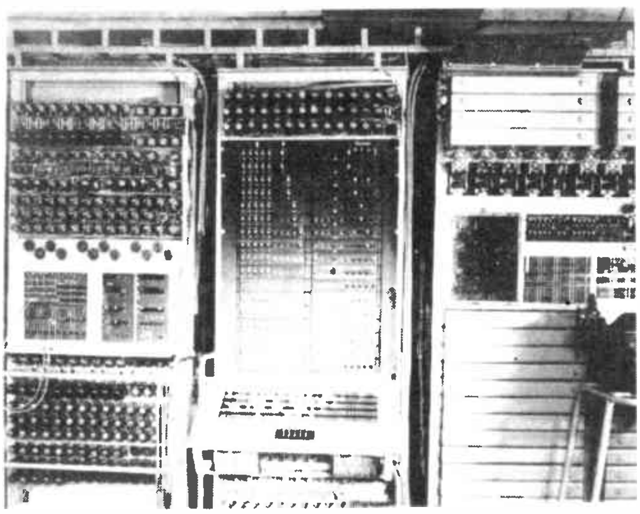
Keyboard data operators at Bletchley. None knew what purpose the data served.

The Germans also used Short Weather Codes, a lookup table of three-letter abbreviations for known weather conditions. If the weather was known, then the appropriate abbreviation would be buried somewhere in the coded message. Wireless operators used similar short codes to check tuning and report reception strength.

All round Britain, radio stations continually monitored the airwaves round the clock, writing down all the gibberish messages which the Germans transmitted. Although the wireless interceptors did not know it, what they wrote down was sent to Bletchley for analysis.

Colossus used Boolean logic to find wheel patterns that matched letters in the plain text crib with letters in the encrypted message. These wheel patterns thus might be the actual ones used to encrypt the entire message. On the other hand they might not. So Turing devised a system of probability scoring. Colossus continually printed out a list of numbers which represented the probability of a key being good for the whole message, rather than just a few characters.

Clerks then used a Bletchley-built machine which worked like the German Lorenz machine – a "virtual Tunny" – to check the key with the whole message. If it produced clear German, the key was the one used by the German operator. If most of the message came out as gibberish, with a only a few letters correct by pure chance, the key was wrong. The operators then had to go back to Colossus and look for the next highest probability score.



Details of Colossus' front panel, showing more valves, plus keyswitches and patch connector panels.

Precursing modern parallel processors, like the latest Pentium MMX chips, Colossus checked five paper tape tracks simultaneosly, to generate five pulse streams, each running at 5,000Hz. Colossus then performed 60,000 calculations a second, on each of the five tracks, making a total of 300,000 calculations a second.

The 2,500 valves consumed 4·5 kilowatts of power. PO designer Tommy Flowers told the codebreakers to leave them all running all the time. Valves fail when they are switched on from cold and pass a surge of current.

NOT FORGOTTEN

Tony Sale wants to ensure that Britain's remarkable technical achievements are not forgotten, as the original designers die. The US computer industry has made far more capital out of ENIAC, the Electronic Numerical Integrator and Computer, completed in 1946. ENIAC calculated the trajectory of shells in different wind and air conditions; it had 19,000 valves but was not completed until 1946.

Sale also believes that the work done fifty years ago has an important message for today's computer industry. A dedicated computer, like Colossus, performs one task extremely efficiently. A multi-purpose platform, like the ubiquitous PC, can perform a wide variety of tasks, none of them very well. To prove his point Sale has written a program for a Pentium PC which does what Colossus did. The Pentium still takes twice as long to come up with the right answer.

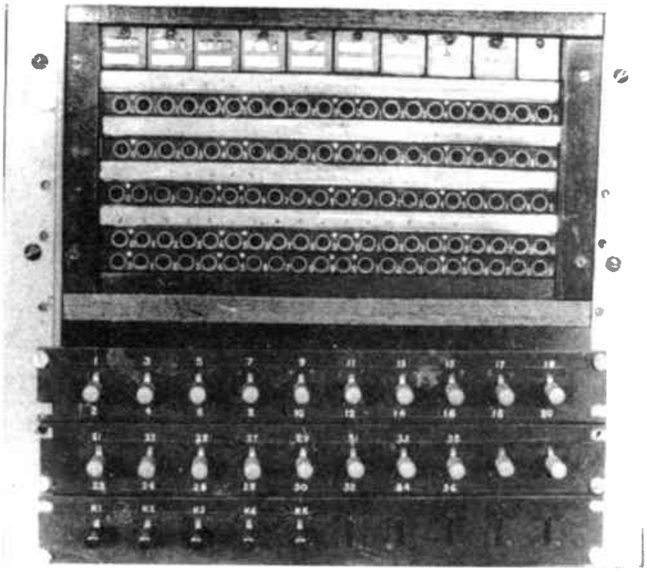
The orginal plans for Colossus no longer exist, because GCHQ told Tommy Flowers to burn them. But eight photos survived, along with a few circuit diagrams illegally kept by Bletchley staff.

"No-one believed we could do it", recalls Sale. But the Bletchley Park Trust, which rents the grounds from British Telecom, provided the hut rent-free. Sale spent £6,000 of his own money and ex-codebreakers chipped in another £2,000. When this money ran out, British electronics company Quantel gave £4,000 to buy the last valves.

But GCHQ was unhappy about the project.

"It was not the technology of the computers used to break the codes that worried the Government", says Sale. "It was the algorithms used by the codebreakers on those early computers. The work being done by Alan Turing and his team was so many light years ahead of its time that it is still being used in cryptoanalysis today. The Government saw it as a continuing security risk".

Until November 1993 GCHQ flatly refused to allow a rebuild. Sale then got "reluctant agreement" from GCHQ to let the public know what wires, resistors and valves the codebreakers were using. GCHQ released what information it said it still had, but this turned out to be very little. Sale was allowed to rebuild only the short-lived



A row of 4-digit electro-mechanical counters, five rows of patch sockets, and three rows of keyswitches.

Mark 1 Colossus, which had no memory. He was forbidden to connect any wires so that the machine could actually work.

GIFT FROM THE GODS

Without telling anyone Sale quietly rebuilt the Mark 2 version, complete with memory, connected the wires and got the machine running. A gift from the Gods saved him from prosecution under the Official Secrets Act. In March 1996, the National Security Agency in the USA handed a bundle of 5,000 secret documents on Bletchley to the US Government's National Archives and Records Administration library in Washington. The papers contain working plans for Colossus. The NSA had them because the US Army sent a security detachment to Eastcote during the war.

Insiders are sure that the NSA would never have released its papers without permission from GCHQ. They suspect that the Cheltenham organisation only gave permission because whoever it was who dealt with the request, did not understand the significance of what they were doing. Now it is too late. The documents cannot be unpublished and they for ever lift the threat of action on Colossus under the Official Secrets Act.

TURING BOMBE

Sale now wants to rebuild the electromechanical Bombe which Alan Turing, and fellow mathematician Gordon Welchman, designed to crack the Enigma codes. Again the wartime machine was a precursor to modern parallel processing, and far more efficient. When the Bombe's 15 minute search and match routine is simulated on a Pentium PC, it takes 18 hours.

"Unfortunately the world has gone for the general platform approach", says Sale. "It rules the world. But not always for the best".

The Turing Bombe had rows of contact wheels, mechanically and electrically analagous to the rotors of 36 Enigma machines. Together they worked like an electrical circuit tester. As the wheels turned, with a clockwork ticking sound (hence the nickname Bombe), they tried every possible connection path through the Enigma machine. Each Bombe tested 15,726 different paths every 15 minutes, registering those which connected to confirm a possible match between the original letter keyed into the Enigma machine and the quite different letter that came up as a lit lamp. Operators tried each of the possible settings on a TypeX machine to see if it translated gibberish into a crib.

When the Bombe found a match with a predicted fragment, this did not necessarily mean that the setting was correct, and could decode the complete message. It precluded a raft of other settings, which must be wrong. This narrowed the choice for a further search. The Bombe also took advantage of a design flaw in Enigma. It never encoded an A as an A, or B as a B, and so on. Applying high level maths to this, ruled out some possibilities.

The first Bombe was built in Hut 11 in 1940. Many replicas were later installed in sites in Wavendon, Eastcote and Stanmore.

"The Bombe was a dedicated parallel processor of immense power" says Sale. "Once a connection was made current travelled down the wires at the speed of light. There is no general purpose platform that can match that speed".

But Churchill's destruction was total. No useful plans or wiring diagrams survived, not even some measurements to put a size on the machine seen in the one remaining photo. GCHQ insists that it has nothing on file.

Most of the components were made by British Tabulating Machines of Letchworth, now swallowed by ICL. The high speed relays, which had to switch every 20 milliseconds as the drums stepped, came from the Post Office. The components meant nothing to their makers. The Bombe only took shape at Bletchley when all the components were assembled and connected by the few people who understood the overall plan.

BRITISH BOMB

Just before Christmas, Tony Sale visited the Washington library, while on a lecture tour in the US. There he found a file catalogued as the "British bomb". It turned out to be a complete description of the Turing Bombe, with 50 photographs of the original machine.

"We jumped a light year", says Sale who now has a full copy of the file. "We are already showing the photos to the 'wrinklies', people who worked on the project, and it is triggering all manner of lost memories".

Publication of the Bombe papers also insures the Bletchley volunteers against any threat of prosecution under the Official Secrets Act.

But even with the US papers, the rebuild will take three years and cost at least £150,000. It must be done fast while there are still wrinklies left to remember.

Quantel has started the ball rolling with a gift of £10,000. "We know the machines worked", says Quantel's Director of R and D, Paul Kellar, "because we won the war. We now want to see how they worked. The whole electronics industry owes its existence to the work done at Bletchley".

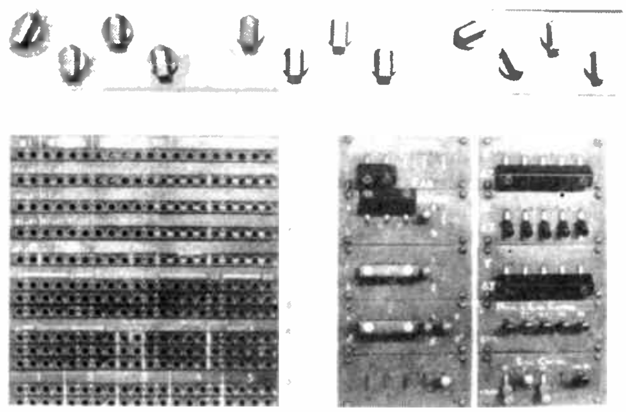
Quantel has a special reason to be interested in the rebuild. Quantel makes the special effects and editing equipment used by TV stations around the world and has stuck with an engineering policy which parallels Turing's. Colossus, like the Bombe, and ENIAC, was designed to perform a specific task, unlike today's computers which can be programmed to perform a wide range of tasks. Quantel's equipment uses dedicated electronics which perform one task only.

BLOAT

Paul Kellar believes that the Bombe carries an important message for today's computer industry. As the hardware for standard platforms, like DOS, Windows or the Apple Mac, becomes more powerful, programmers write software that needs more power, more memory and more disk space. So it runs at snail's pace speed on anything but the latest machine.

"We call it bloat", says Kellar. "And bloat soaks up advances in technology. At Bletchley they lived from hand to mouth. The way they did it would still be the best way to do it today."

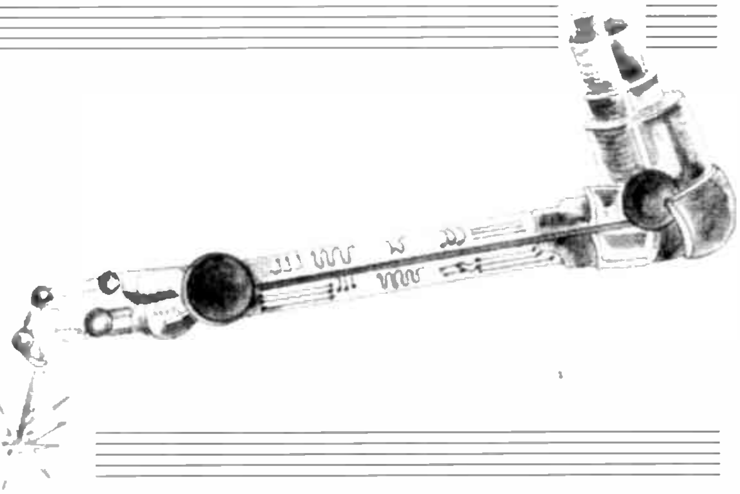
"If standard platforms had existed fifty years ago, some civil servant would have insisted that the Bletchley codebreakers use them. Then we would have lost the war and we would all now be speaking with German accents".



More patch connectors and switches, apparently associated with the counting procedure.

ACKNOWLEDGEMENT

The illustrations used in this article have been kindly supplied by The Science Museum, *London*.



CIRCUIT SURGERY

ALAN WINSTANLEY

This month, our regular "Surgery" deals with some obscure capacitor specifications, we also look at coin cell sizes, an alarm modification and answer a PIC query.

Capacitor ESR

Have you ever noticed a large electrolytic capacitor becoming warm in use? In an ideal world, capacitors are, well, just capacitors, and an ideal capacitor would not do any "work" and would not dissipate heat. After all, in theory they merely store charge and have no resistance.

But, in reality, they have further characteristics which aren't always obvious when you think of these components as "ideal" devices. Sometimes you need to dig more deeply into the data!

Electrolytic capacitors are often used as smoothing (or "reservoir") capacitors in power supplies. One capacitor parameter you might see in a catalogue is its *Equivalent Series Resistance* or *ESR*. Maybe you will see alternative specs, including *dissipation factor* or *ripple current* given instead. These can give you interesting pointers regarding the performance of the capacitor.

The physical construction of an electrolytic capacitor results in it having an inherent resistance (as well as inductance) which causes it to dissipate I^2R power in use, so it warms up. Therefore, this means that there is a limit as to how much "work" such a capacitor can be expected to do and still operate reliably at a given temperature. This becomes most relevant at higher currents (say, over a few amperes output).

Shown in Fig.1 is an ordinary full-wave rectified power supply used with a step-down transformer. Even if you don't feel the need to engage in heavy mathematics, there are several aspects which need to be borne in mind when picking a capacitor, even if the circuit is designed using a pretty standard combination of rules of thumb and educated guesstimates!

Firstly, the transformer secondary voltage may be higher when it's off-load, because output voltages are often quoted assuming a simple resistance *at full load*. Because of the transformer's regulation (or lack of it), the output voltage may be somewhat higher when a smaller load, or none at all, is placed across the output of the power supply.

Transformer regulation is calculated as:

$$\frac{(\text{Voff load} - \text{V full load})}{\text{V off load}} \times 100\%$$

Regulation specifications are not often quoted in mainstream catalogues, and it could be anything between, say, 7 and 33 per cent, depending on the transformer type. Let's assume 25 per cent for a small 6VA p.c.b. mounting type; if it has a 10V secondary (full load) rating, the actual off-load a.c. voltage could be 13·3V or so.

After full-wave rectification, this voltage will be 1·414 times higher, or about 19V d.c. (Incidentally, the bridge rectifier should, therefore, be able to withstand twice this figure as a peak-inverse voltage.) Hence, the capacitor must be rated for the higher, off-load voltage.

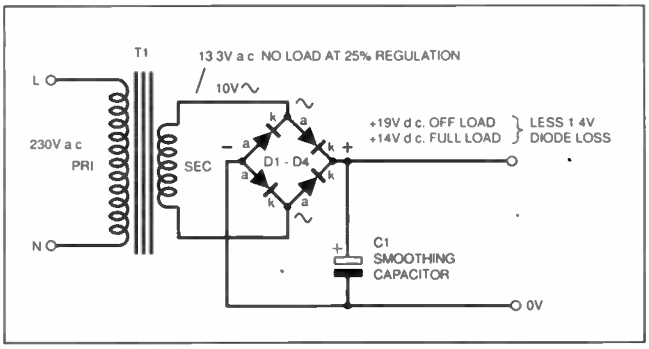


Fig.1. Regulation of a transformer determines the maximum voltage across the smoothing capacitor. (Assumes that the secondary voltage is quoted as 'full resistive load'.)

If we're honest, when we're designing those simple, impromptu power supplies, a rule of thumb is simply to use, say, a 1000µF or 2200µF smoothing capacitor along with a favourite bridge rectifier and transformer, and away we go! It has, after all, been done many hundreds of times before.

But, for heavier duty applications when things become more demanding, then those hidden specifications should be borne in mind. When shopping around, compare the ESR, ripple current and power factor ratings of the components on offer.

ESR will usually be quoted in milliohms; the lower, the better. Ripple current may be also quoted, indicating the maximum permissible current flowing "via" the smoothing capacitor at (usually) 100Hz at 20°C, although ripple at other frequencies may also be included (e.g. 10kHz).

Capacitors claiming to be *high ripple current* imply that they have a low ESR, and are better suited to heavy duty applications featuring high load currents. Other capacitor types may claim to have a low *ESL* (*effective series inductance*), as the spirally-wound foils of electrolytic capacitors produce an inherent inductance (*L*) effect. Even the length of the lead-outs can have an effect on this, and the leads should be kept as short as possible, especially at high frequencies.

A final rating which you may sometimes see is that of *dissipation factor* or *power factor*. This is calculated by dividing the ESR by the capacitive reactance (a.c. resistance) at a particular frequency. Without getting into power engineering, you can use this figure when making comparisons of different types of capacitor: the lower, the better.

Schade Graphs

When designing d.c. power supplies, probably the most accurate and elaborate design aids are the "Schade" graphs, of which advanced electronics enthusiasts will be aware. These have been reproduced in some past data books (e.g. I have them in certain Texas and National books) and even though they were drafted in 1943, they are still held in high esteem today. (O.H. Schade, *Proc.* IRE, Vol. 31).

Schade performed a total analysis of the relationship between all aspects of a capacitor-input filter section, resulting in him publishing a number of complex graphs which enable a designer to specify a transformer, rectifier and capacitor in half-wave and full-wave circuits.

Having used the Schade graphs, hobbyists can be forgiven for reverting to the time-honoured technique of using a 1,000μF capacitor together with a suitable transformer and bridge rectifier for all their low power projects!

However, at least when you're next checking through catalogues, you'll now have more of an insight into those capacitor specifications.

Finally, for the benefit of beginners, we would re-iterate that **it is extremely dangerous to misuse electrolytic capacitors.** It is safe to use a capacitor with a voltage rating *higher* than the one specified in the parts list, but it is potentially hazardous to utilise a *lower-voltage* device. You must always observe their maximum voltage rating.

Even more importantly, because electrolytics are polarised, you must always ensure that they are inserted into circuit the right way round. The polarity of electrolytics is always very clearly marked, so be sure to inspect them closely and double-check prior to powering-up for the first time.

Similarly ensure that you insert bridge rectifiers the correct way round, because sometimes this too could result in the smoothing capacitor being accidentally reversed. **Failure to observe any of these warnings could result in serious damage or injury.**

Burglar Alarm Modification

June 97's *Circuit Surgery* included a simple burglar alarm project which used a transistorised loop to trigger a thyristor. This provides a "latching" alarm which continues to sound even when the triggering signal is removed. **Ben Dias** of Bristol asked if it could be adapted to provide a further delay:

I'm interested in adapting it for one of my projects. I need the Normally Closed loop to reset itself after a delay of about 5 to 10 seconds if it is closed again – in other words, the thyristor would only fire after a break of 5 to 10 seconds on the N.C. loop. Could you suggest a modification?

Straightforward, this – simply add, say, a 100μF electrolytic capacitor to the circuit (Fig.3, p. 390) in place of capacitor C1. Also increase the value of R4 to, say, 47 kilohms. This will slow the response right down and (rule of thumb time) introduce a delay whose RC time constant is 4·7 seconds.

In practice, because of the leakage and tolerance of the electrolytic, expect variations of the timed period in individual cases. It will also affect the operation of the Normally Open loop, however, as it introduces a delay on that too.

Coin Cell Batteries

Recently, when I enquired at my local branch of a well known chemist for a replacement "coin cell" for my electronic organiser (which, in the event, conked out one week later), it brought forth the response, "Do you mean a *coin holder*?". Um, not quite.

Anyway, Tables 1 and 2 are reference table for the plethora of coin cells, button cells, silver-oxide and Lithium batteries, call them what you will. If you see something curious like "9,5 × 3,6" imprinted on the electronic calculator or watch in question - it's simply the continental way of writing the battery's dimensions in millimetres!

Table 1. Popular Silver Oxide Cells

IEC Ref.	Height (mm)	Dia. (mm)	mAh typ.	Varta Ref.	Duracell Ref.
SR41	3·6	7·9	45	V391	D392
SR42	3·6	11·6	100	V344	
SR43	4·2	11·6	120	V386	D386
SR44	5·4	11·6	170	V357	D357
SR45	3·6	9·5	78	V394	
SR48	5·4	7·9	70	V393	D393
SR54	3·1	11·6	80	V389	D389/390
SR55	2·1	11·6	43	V391	D391
SR57	2·7	9·5	42	V395	D395/399
SR58	2·1	7·9	22	V362	D361/362
SR59	2·6	7·9	30	V397	D397
SR60	2·1	6·8	16	V364	D364
SR62	1·6	5·8	8	V317	
SR63	2·1	5·8	12	V379	
SR64	2·7	5·8	16	V319	
SR65	1·65	6·8	13	V321	
SR66	2·6	6·8	27		D377
SR67	1·65	7·9	20	V315	
SR68	1·6	9·5	23	V373	
SR69	2·1	9·5	30	V370	D370/371

Table 2. Lithium Manganese Cells (3 Volt)

Type No.	Height (mm)	Dia. (mm)	mAh typ.
CR1216	1·6	12·5	25
CR1220	2·0	12·5	35
CR1616	1·6	16	50
CR1620	2·0	16	60
CR2016	1·6	20	90
CR2025	2·5	20	170
CR2032	3·2	20	230
CR2320	2·0	23	135
CR2330	3·0	23	260
CR2354	5·4	23	500
CR2430	3·0	24·5	280
CR2450	5·0	24	560

The tables quote dimensions of most common types, and in compiling them I checked the Duracell and the marvellous Varta sites on the World Wide Web (**www.varta.com** and **www.duracell.com**). It's also worth pointing out that it's much easier to use these cells on a home-brew p.c.b. these days, now that board-mounting holders for coin cells are available from the major mail order suppliers.

The "SR" prefix means silver oxide (1·55V). An "LR" prefix infers an alkaline (1·5V) type, but the dimensions would be the same. Mercury oxide ("MR") batteries are apparently being phased out for environmental reasons.

Note that it is always extremely important that coin cells are kept away from babies and children: if swallowed, a chemical reaction will produce a caustic solution, and such cases should always be treated as a medical emergency.

Which PIC?

A question cropped up from a reader concerning the choice of PIC microcontroller. **Joseph Zammit** of Malta asks:

I want to buy some PIC16C84s but the ones I have seen advertised have an "-04" suffix attached to the part number. Is there anything different? Secondly, I know quite a lot of theory about electronics but I'm a bit rusty when it comes to the constructional aspects. Since I need to budget well, how can I boost my confidence?

John Becker, our Technical Editor, advises that the "-04" devices are what we might call the "standard". They will operate at clock speeds up to 4MHz. The "-10" types will operate at clock speeds up to 10MHz. The PIC data books give more details of the two versions. Their pin-outs are identical.

As far as the practical aspects are concerned, first you could check out my own five-part series *Build Your Own Projects* which commenced in the November 1996 issue. Robert Penfold's periodic *Techniques – Actually Doing It* series also provides practical hints and tips for constructors.

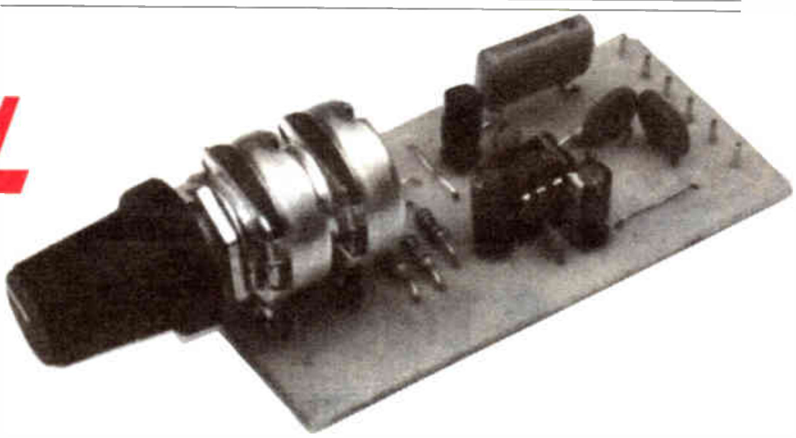
My advice is always to get some straightforward projects "under your belt" to gain confidence and practical experience, prior to tackling more advanced subjects where there is the risk of running into difficulty if you've been too ambitious, too soon. That alone could damage your confidence irreparably.

Preferably, purchase the printed circuit board from the *EPE PCB Service* rather than make your own. The use of p.c.b.s eliminates a huge scope for wiring errors.

The other main subtle causes of problems are transistor substitution errors (especially if the pinouts differ from the original), component value errors, and problems with soldering technique.

● If you have any queries or comments, please write to Alan Winstanley, *Circuit Surgery*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom.

UNIVERSAL INPUT AMPLIFIER



ANDY MILLAR

A versatile little front-end amplifier with an impressive performance.

It is unfortunate that the sound quality of many items of low cost PA and recording sound equipment are let down by the performance of their input amplifiers. This is because the demands placed on a PA or recording input amplifier are really quite heavy. Ideally it should be able to cope with input signals ranging from the quietest microphone to the output of a CD player, whilst having low distortion and low noise at all times.

The circuit described here is designed to replace the input stage of a mixer or pre-amp and will provide a gain adjustable over a very wide range with low noise. It is also a straightforward task to assemble several of these circuits into a simple mixer, as will be shown later.

HIGH GAINS

The most critical part of a high gain low noise amplifier is the choice of amplifying component. Despite the vast quantities of new op.amps which have been launched over the past few years, the single 5534 and dual 5532 still seem to be by far the best general purpose audio op.amps for the money in terms of gain range available and input noise.

On the downside is their d.c. performance, which is pretty poor compared with more modern devices, and so some care was required in the design of this circuit to prevent d.c. offset problems. However, the noise performance, even of the noisier 5532, is still very good. At full gain the Universal Input Amplifier circuit will have an output noise of about −60dBu over the audio band.

Since the maximum output level with ±15V power rails will be about 20dBu, this gives a signal-to-noise ratio at maximum gain of 80dB – plenty good enough for Rock-and-Roll. At minimum (unity) gain the noise will be at about −96dBu giving a signal-to-noise ratio of 116dB, rather better than digital!

The Universal Input Amplifier circuit diagram shown in Fig. 1 provides a voltage gain continuously variable from one (0dB or unity) suitable for tape machine, CD, and some musical instruments, to 1000 (60dB) suitable for low sensitivity microphones. Almost any music signal will fall somewhere between these two extremes. The frequency response is flat to within 0·5dB between 20Hz and 20kHz.

One of the most difficult parts of designing an amplifier with a wide range of gain settings is to achieve a sensible law or "feel" to the control. The human ear is sensitive to logarithmic changes in level, that is if you keep doubling the level of a signal it will sound as though it is increasing in equal steps, which is why we use the dB scale for measuring audio levels.

An ideal gain control would vary the level steadily in dB, but it turns out that for most circuits this requires a "reverse log" potentiometer (pot.). Although reverse log pots. are made the author has never found a retail source for them.

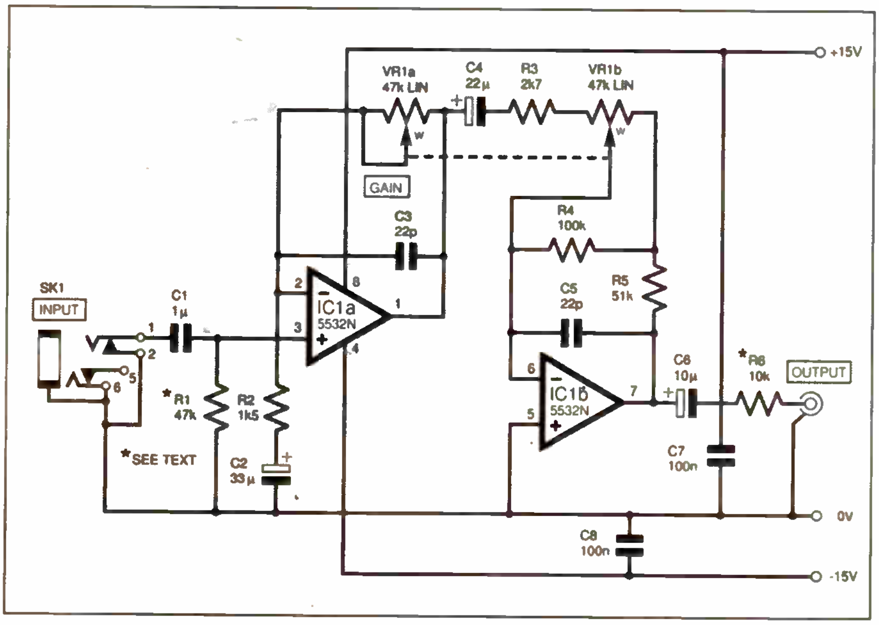


Fig. 1. Full circuit diagram for the Universal Input Amplifier.

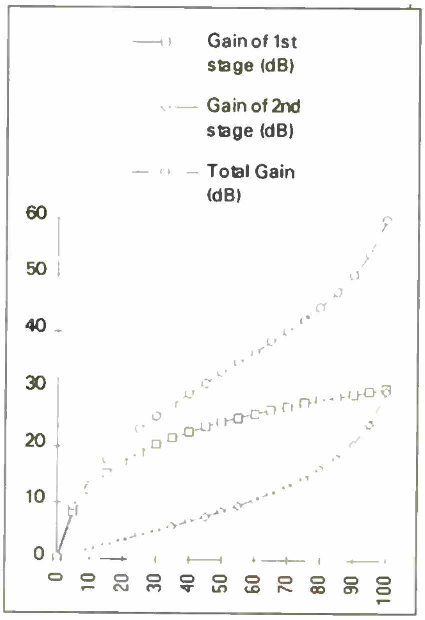


Fig. 2. Gain laws for the amplifier stages.

CIRCUIT DESCRIPTION

The Universal Input Amplifier circuit (Fig. 1) uses a combination of two different gain configurations to give a reasonably good gain law – see Fig. 2 graph. To achieve this, the gain control is split into two stages around IC1a and IC1b. Note that VR1a and VR1b are connected such that if their wipers (a) come off their tracks, as tends to happen when pots get old and dirty, there is still a feedback path for the op.amps to help prevent unpleasant bangs and crackles.

Another reason for splitting the gain between two stages is so that neither op.amp is overworked. If distortion, noise, and offset are to be kept under control then the gain that is required from an op.amp must always be considerably less than that available.

The gain available from an op.amp at any particular frequency is given by the gain-bandwidth product, always clearly given in the op.amp data, which for a 5532 is 10MHz. The op.amp will have its lowest gain at the highest frequency.

For audio equipment 20kHz is normally taken as the highest operating frequency, so to find the gain available in the op.amp we divide the gain-bandwidth product by 20kHz, giving us 10MHz/20kHz which is 500. A good rule of thumb is that the gain of the circuit should never be more than one-tenth (1/10) of the gain available, so we should keep the gain of each stage of this circuit below 50 (34dB).

In fact, the highest gain required in each stage is 32 (30dB). This leaves plenty of gain available in the op.amp to counteract its internal distortion and noise.

Capacitors C2 and C4 keep the d.c. gain of each stage at unity to prevent large offsets, whilst C3 and C5 prevent oscillations. Capacitors C1 and C6 a.c. couple the input and output respectively.

Resistor R1 sets the input impedance. It was found that 47 kilohm (47k) is suitable for most signal sources, but for an input that will be used with a Guitar this should be changed to 470 kilohms. Note that contrary to popular belief both "low impedance" and "high impedance" microphones can be fed into an impedance of 10k or higher with no problems.

The value of the output resistor R6 depends on the circuit application. Normally this would be a 100 ohm resistor, which ensures the circuit will not oscillate when a capacitive load, for example a screened cable, is connected to its output. However, by fitting a 10k resistor in this position it is possible to make a simple mixer by feeding the output of several Universal Input Amplifier circuits together as described later.

INPUT SCREENING

The input connector type will also depend on the application, however jack type connectors are recommended as these are available with an extra contact to "short out" the input when the mating jack plug is removed (see Fig. 3). With other types of connector the high input impedance of the input may pick up unwanted signals (particularly mains hum) if the gain is set high when the input is removed.

The input connections should be made with screened wire and the screen of the input connector must be connected to the 0V connection of the p.c.b. for lowest noise operation. If the input jack socket is a plastic bodied type or otherwise *insulated* from any "grounded" metalwork then the other 0V connection should be made to the power supply. If the screen of the input socket will make a connection to the power supply through the metal chassis then no other 0V connection should be made to the board as this would make an earth loop, which could pick up hum.

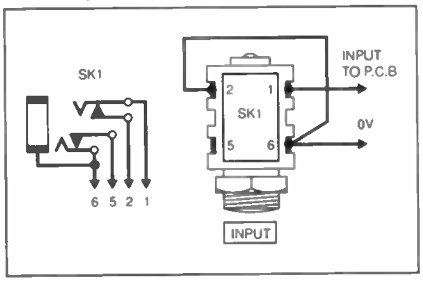


Fig. 3. Circuit symbol and wiring to "switched" input jack socket.

POWER SUPPLY

A suggested optional Power Supply circuit diagram is shown in Fig. 4. Although it shows dual plus and minus 15V power rails, the circuit will operate from any dual supply rails from ±18V down to about ±5V. This will normally allow it to use the existing supplies when wired as a replacement into an existing piece of equipment.

The power supply should be well smoothed, preferably with voltage regulators. Due to the 5mA current drain, it is not recommended that the circuit be run from batteries.

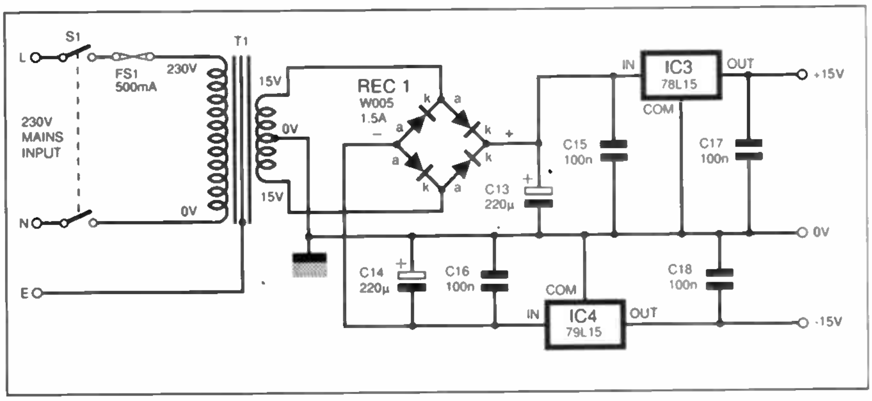


Fig. 4. Suggested dual voltage power supply circuit diagram.

COMPONENTS

INPUT AMP

See SHOP TALK Page

Resistors

R1	47k (see text)
R2	1k5
R3	2k7
R4	100k
R5	51k
R6	10k (see text)

All 0·25W 5% carbon film

Potentiometer

VR1 47k dual rotary carbon, linear

Capacitors

C1	1µ polyester
C2	33µ radial elect. 35V
C3, C5	22p disc ceramic (2 off)
C4	22µ radial elect. 25V
C6	10µ radial elect. 63V
C7, C8	100n disc ceramic (2 off)

Semiconductors

IC1 NE5532N dual low noise op.amp

Miscellaneous

SK1 6·35mm (¼in) plastic bodied jack socket, with break contacts

Printed circuit board available from *EPE PCB Service*, code 146; metal case, size to choice – see text; 8-pin d.i.l. socket; screended cable; multi-strand connecting wire; solder pins (6 off); solder etc.

MONO MIX AMP (Optional)

Resistors

R7	10k
R8	100Ω

All 0·25W 5 % carbon film

Potentiometer

VR2 10k rotary carbon, log.

Capacitors

C9	82p disc ceramic
C10	10µ axial elect. 63V
C11, C12	100n disc ceramic (2 off)

Semiconductors

IC2 TL071CN low noise op.amp

Miscellaneous

Stripboard, size 11 strips x 10 holes approx; 8-pin d.i.l. socket; multistrand connecting wire; solder pins (5 off); solder etc.

POWER SUPPLY (Optional)

Capacitors

C13, C14	220µ radial elect. 35V (2 off)
C15 to C18	100n disc ceramic (4 off)

Semiconductors

REC1	W005 1·5A bridge rectifier
IC3	78L15 +15V 100mA voltage reg. (see text)
IC4	79L15 –15V 100mA voltage reg. (see text)

Miscellaneous

S1	d.p.d.t. mains toggle switch
T1	mains transformer: 230V a.c. primary; 15V-0V-15V 300mA secondary
FS1	0·5A anti-surge fuse, with holder

Approx Cost Guidance Only £16 excluding power supply

If you do need to provide an additional power supply then use the one in Fig. 4, this will power up to *six* Universal Input Amplifier circuits with a mix amplifier (Fig.7). For more circuits replace the 78L15/79L15 regulators with 7815/7915 types, change the mains transformer to one with a 1A rating, and change the values of capacitors C13 and C14 to 470µF.

CONSTRUCTION

Details of the Amplifier printed circuit board (p.c.b.) component layout, wiring and full size underside copper foil master are shown in Fig. 5. This board is available from the *EPE PCB Service*, code 146.

Commence construction by mounting the 8-pin d.i.l. socket for the op.amp, these i.c.s do occasionally fail, in particular they may become noisy. Also, this will allow you to check that the voltage rails are the correct way round before plugging in the op.amp – even highly experienced engineers get this wrong sometimes!

Follow this up by inserting the resistors and capacitors, taking care with the polarities of C2, C4 and C6. Also, don't forget the single wire link.

With the p.c.b. layout given, the board is fixed to the chosen metal enclosure, size will depend on set-up finally selected, using the pot. mounting bush and nut of the Gain control VR1, which, being a dual device, will provide plenty of support for the small p.c.b. If the circuit is built using another method, such as stripboard, then care should be taken to prevent oscillation by keeping the pot. connections as short as possible and the input and output of the circuit well separated.

TESTING

Testing the circuit is simply a matter of connecting a signal source to the input with the output connected to an amplifier and speaker – remembering to start with the Gain control right down (anti-clockwise). A suitable signal source for testing low gain settings would be a CD or cassette player, whilst the high gain settings would be best tested with a microphone.

If the Universal Input Amplifier is used to replace an existing input stage then some investigation will be required to find the best place to tap the signal in. This will probably involve tracing out the existing circuit, which 99 times out of 100 will have the form of Fig. 6 – if it doesn't then you may require expert help!

The existing coupling capacitor should be removed and the output of the Universal Input Amplifier connected to the

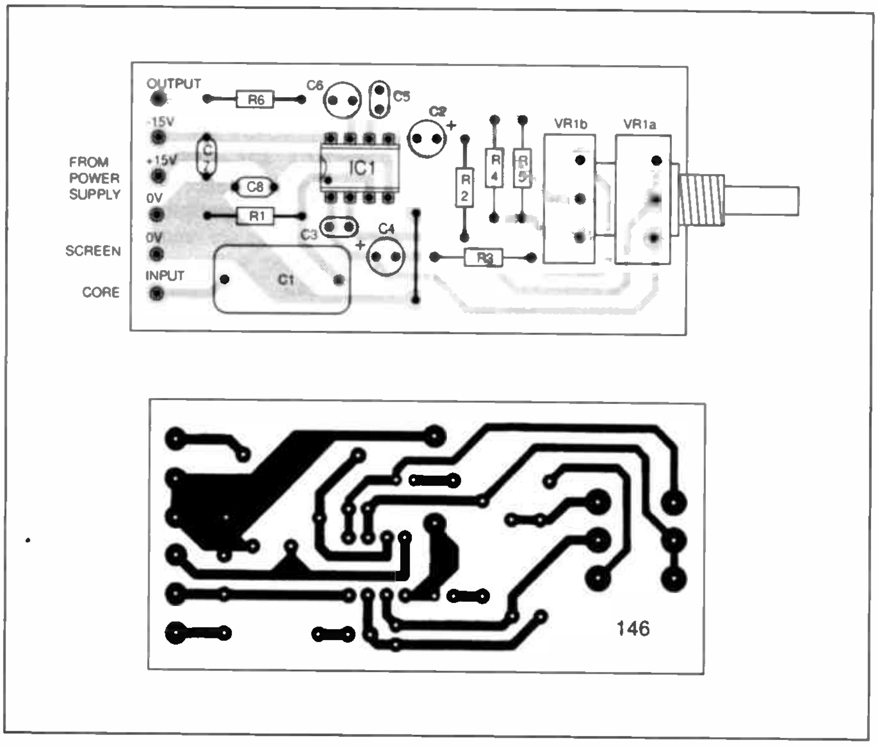
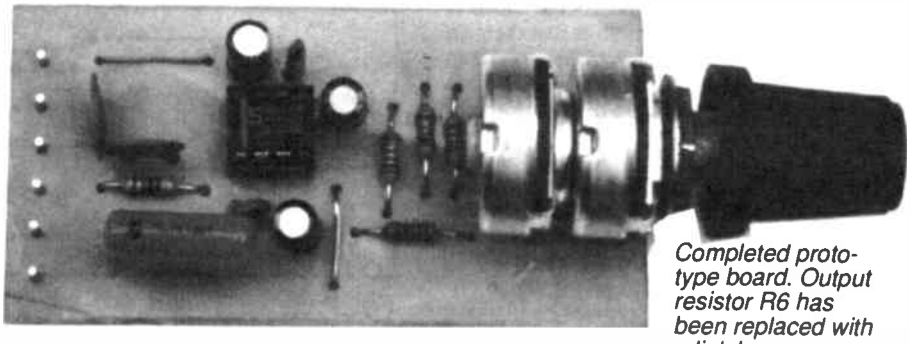


Fig. 5. Input Amplifier printed circuit board component layout and full size copper foil master pattern.



Completed prototype board. Output resistor R6 has been replaced with a link here.

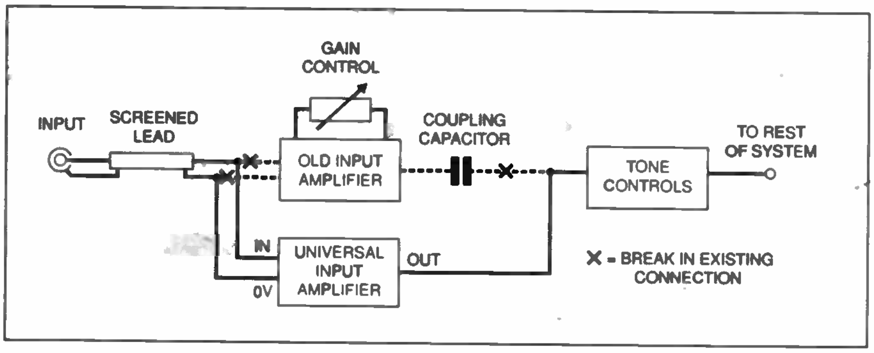


Fig. 6 (above). Linking the Universal Input Amplifier into an existing system.

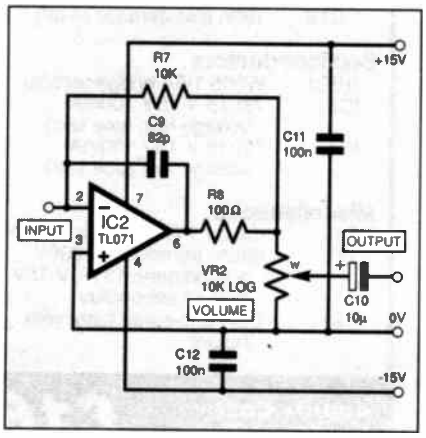


Fig. 7. Circuit diagram for a Simple Mono Mixer.

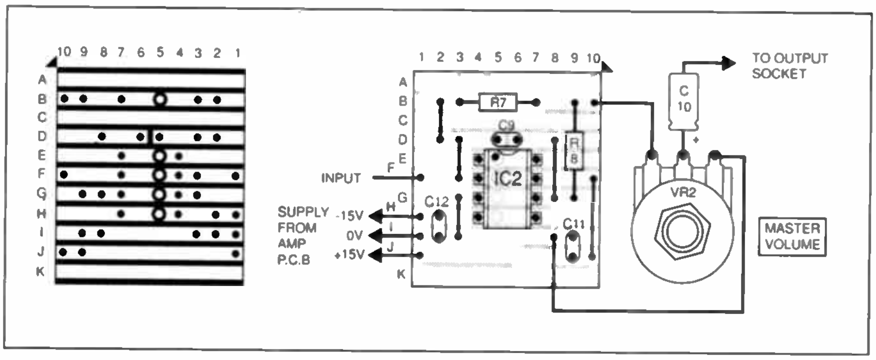


Fig. 8. Suggested stripboard component layout and wiring for the Mono Mixer.

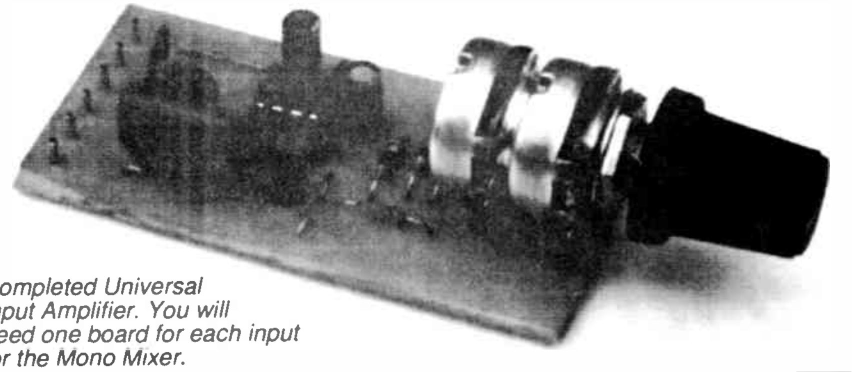
"output" side (right) of the capacitor. The signal input feed *must* be completely isolated from the old circuit.

Alternatively, if your equipment has a "Line" audio input you could build the Universal Input Amplifier into a separate box and connect its output to the "Line" input. The screen of the output connector should then connect to the 0V of the Universal Input Amplifier.

MONO MIXER

To make the circuit into a simple self-contained Mono Mixer, you will need as many Universal Input Amplifier circuits as inputs are required, with a 10k resistor being used for R6 as mentioned earlier. The outputs of all the Universal Input Amplifiers are then simply wired together and connected to the input of the single i.c. Mono Mixer circuit shown in Fig. 7. Potentiometer VR2 will give a Master Volume control if required.

A stripboard component layout for the Mono Mixer is given in Fig. 8. "Busbars" of tinned copper wire can be used to join the outputs and the supply rails of the Universal Input Amplifiers to simplify wiring as shown in Fig. 9. Again, the 0V connection should NOT be made to the power supply if it will connect through the metal front panel and input connectors.



Completed Universal Input Amplifier. You will need one board for each input for the Mono Mixer.

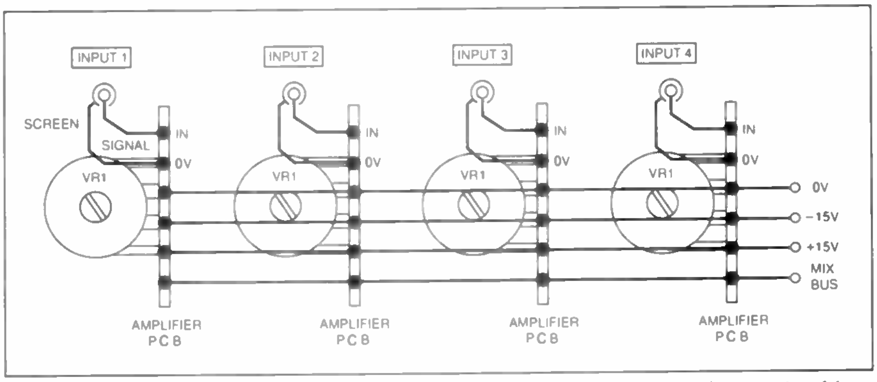


Fig. 9. Wiring together several Input Amplifier boards for connection to the Mono Mixer stripboard.

MEXPRESS - BASIC FOR ENGINEERS

ROB MILES

Examining the latest in data manipulation and presentation software offered by Quickroute Systems.

MEXPRESS is officially described by software distributors Quickroute Systems as "BASIC" for scientists and engineers. The wording on the *MExpress* box describes it as a "Technical Fourth Generation Language with Flexibility and Power". In this review, we examine the program, what it can do, and why it may be so useful to engineers. First, let's look at some maths!

MATHS AND MEXPRESS

If you have a lot of calculations to perform, you will probably want to use a calculator, possibly a programmable one; you may perhaps resort to a computer and maybe a spreadsheet in which you can work out totals and averages, plot graphs and a whole lot more.

However, there are many tasks which engineers and mathematicians would like to perform with ordinary numbers that spreadsheets cannot do easily, and this is where software tools like *MExpress* come in. *MExpress*, though, is *not* a "super-spreadsheet", instead it might be regarded as a tool on the next level up.

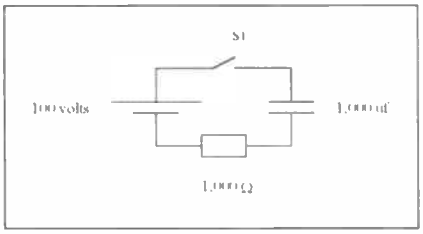


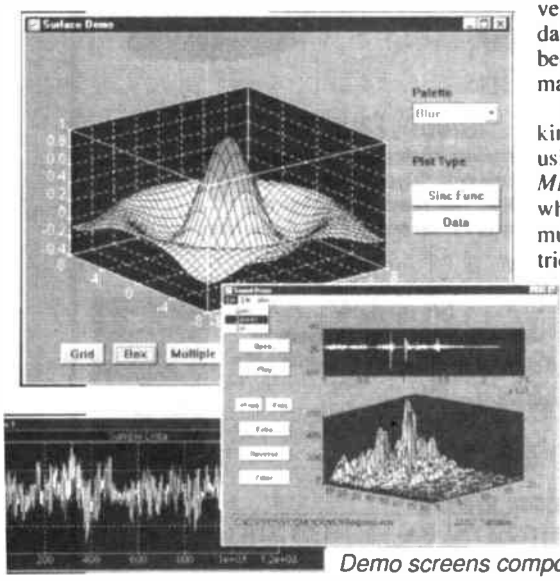
Fig.1. Circuit diagram for a simple RC network

You can certainly use it to perform calculations, but you can also apply it to build programs which are able to perform very complex tasks on large amounts of data. These programs can then be embedded into other systems and "do the maths" for them.

Whilst there are already tools of this kind available and engineers have been using them for some time, the promise of *MExpress* is that it will not only deliver what other programs do, but do so at a much-reduced cost. It also has a few extra tricks up its sleeve.

VECTORS AND MATRICES

Numbers are the raw data that calculators and spreadsheets work with, and *MExpress* can indeed work with ordinary numerical data. The *real* power of the program appears when you start playing with vectors and matrices.



Demo screens composite supplied by Quickroute Systems.

A number is a single value, perhaps the voltage across two terminals, and you can manipulate simple numbers with *MExpress*. A vector, though, is a *set* of values, perhaps the voltage across a capacitor as it charges. *MExpress* can accept a range of values and then treat them as a single vector. Take for example, the circuit in Fig.1.

When the switch is closed, the capacitor will charge up via the resistor, and there is an equation which, for any given time, will give us the voltage across the capacitor.

The numbers in Fig.2 represent the instantaneous charging voltage on a 1,000μF capacitor in series with a 1kΩ resistor when connected across a 100 volt source.

The voltages were calculated at quarter second intervals, starting at time zero, and were then input to *MExpress* as a vector.

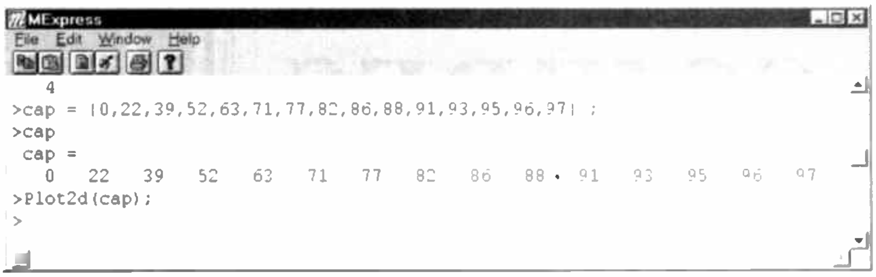


Fig.2. Data for the voltage across a charging capacitor.

The last instruction *plot2d(cap);* tells it to plot a graph. Fig.3 shows the result.

This is the curve we would expect, with the rate of change slowing down as the voltage on the capacitor approaches the supply voltage. The values could, in this instance, have been worked out using a spreadsheet, but, to give you an idea of the power of *MExpress*, consider the data shown in Fig.4.

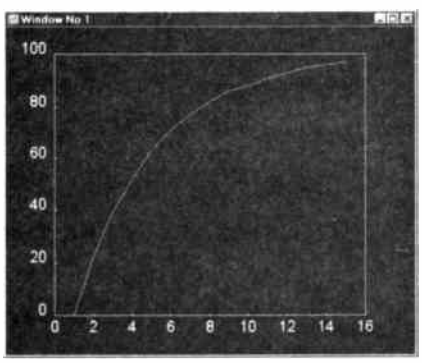


Fig.3. Resultant exponential curve, plotted as a 2-dimensional graph.

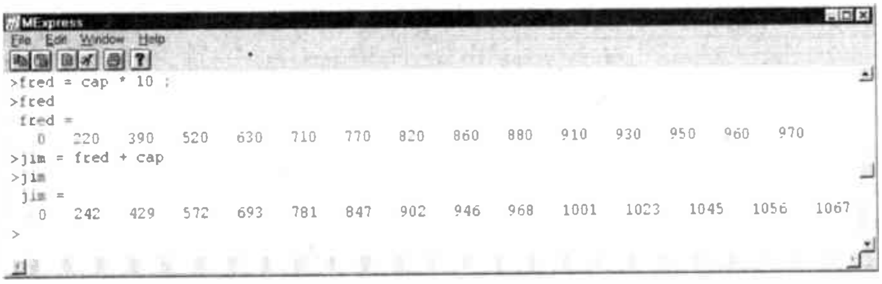


Fig.4. More complex treatment of multiple vectors.

A single statement has been performed, and that has created a new vector, "Fred", and then made a third vector, "Jim", by adding "Fred" and "cap" together. This shows that vectors can be treated as single variables, and played with accordingly.

The technique can now be expanded to handle matrices, and this is where the fun really starts!

A vector is treated by *MExpress* as a special kind of matrix: one having a single row. A matrix is a set of values of a particular size. Matrices can hold many kinds of data; you can even regard the screen of your computer as a matrix, with a number giving the colour and brightness of each of the arrays of dots (pixels) on it.

MExpress lets you work with matrices in the same way that calculators let you handle simple numbers. You can add them, subtract them and multiply them together.

In addition, there is a range of built-in mathematical tools which can be used to analyse and process matrices, as well as displaying them graphically. This means that you can directly manipulate this form of data without having to write a program specifically to handle the complicated variables.

PROGRAMMING

It is possible to write *scripts*, which are programs that *MExpress* will execute for you. For example, rather than manually work out each value in turn for the capacitor in Fig.1, the five-line program in Fig.5 was typed in and used instead, resulting in the figures shown below the program. It looks a lot like BASIC.

Programs can be saved in files and you can create libraries of functions that can be used in even more demanding applications.

Once you get the hang of programming you can go on to produce full-blown Windows applications which have buttons, pointers, sliders and all the gadgets which Windows users seem to like!

The example shown in Fig.6. is an implementation of a calculator using *MExpress*. At this point, we have probably come full circle!

If you use the Developer version of *MExpress*, you can create freestanding programs that can then be distributed without needing to make extra royalty payments to the designers of *MExpress*.

You can also use the system to generate components that can be made part of "C" programs. In this way you can integrate the mathematical abilities of *MExpress* in your own software.

Programs can additionally import and export audio samples in the standard Windows .WAV format, so that you can perform signal processing and analysis using it (although you'd need a pretty fast machine to do this in real time).

It is also able to manipulate bitmaps and images, so that you can perform image processing, or just enhance the appearance of your programs.

INSTALLATION

MExpress requires an IBM-compatible PC running Windows 3.1 or later. However, since *MExpress* is a 32-bit program, you will obtain the best results if you run under Windows 95 or NT, particularly if you want to use the Developer version.

It is, perhaps, regrettable that *MExpress* is supplied on three floppy disks. Whilst it is impressive that something of this power and complexity can be fitted onto *only* three disks, it is a nuisance to keep swapping them during installation.

Furthermore, the designers have saddled the program with a rather clumsy key mechanism, which updates a special file onto the distribution disk each time you install or remove the program.

This can not only be annoying, but any damage to your initial floppies might mean that you could have difficulties when moving the program from one machine to another. You might also get problems when you back up and restore the key files.

Quickroute Systems say they will replace damaged disks if you send them the originals, but even so, if the software had come on a CD-ROM, as so many packages do these days, life could have been easier.

In fact, the program *was* transported over a number of machines during the review test and without problems, except that the Install program made rather a hash of modifying a particular *autoexec.bat* file. You do have the option, though, to make the changes manually, or to make no changes at all – which seemed to work.

Once running, the program did everything the manual said it would, and behaved itself during testing with no nasty crashes or hangups.

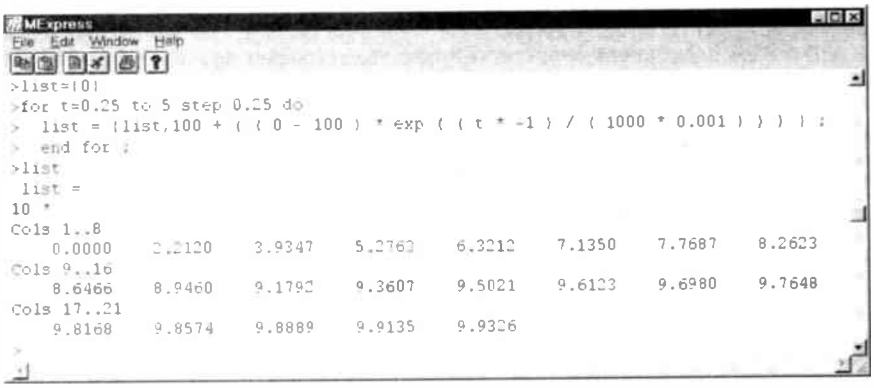


Fig.5. User-written MExpress script.

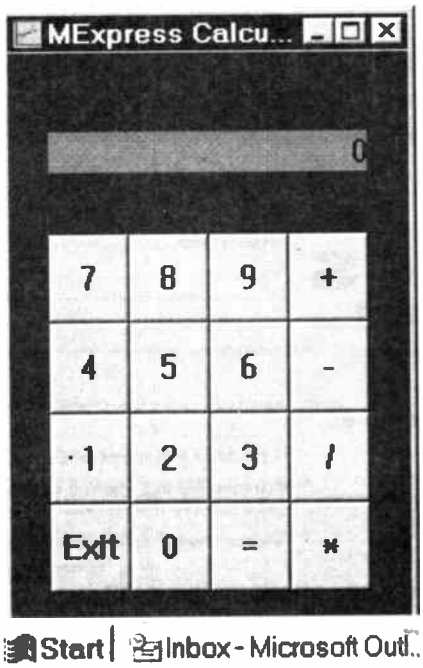


Fig.6. Windows Calculator application written in MExpress.

FLAVOURS

There are two flavours of *MExpress*, the Standard and the Developer versions. The Standard version costs £99 plus postage and VAT. The Developer version costs £299 plus postage and VAT. There is a 30-day money-back guarantee.

The Standard version *interprets* the programs that you write, which means that it looks at each line of the program as it reaches it while running, figures out what is required and then does it.

The Developer version produces programs that are *compiled* (by itself) while being written. Thus, when run, the system does not have to spend time interpreting each line as it occurs. This means that programs can run several times faster.

You would really need the Developer's version if you wanted to make freestanding programs, and it is also useful if you need *MExpress* programs to run as quickly as possible.

Note that to use the Developer version, you also need a "C++" compiler, the Microsoft or Borland versions being the ones that are recommended.

The bottom line is that, unless you specifically want speed, or want to give your programs away, the Standard version will probably suit you.

IN CONCLUSION

MExpress is a good product. To go back to the description "Technical Fourth Generation Language with Flexibility and Power," it seems possible to agree with most of it; *MExpress* is undoubtedly a technically-orientated tool for engineers.

Whilst the meaning of "Fourth Generation" is, perhaps, ambiguous when it is applied to programming languages, in this case, it probably means that you can write programs which are very Windows-like in operation, down to event-driven buttons and sliders.

MExpress is probably as flexible as a programming language can be, with the added benefit of its mathematical abilities. It is unlikely you would write a word processor using *MExpress*, but you can construct design, simulation or analysis programs with this tool.

It provides similar facilities to other systems already in the marketplace, but its price makes it highly competitive, and the ability to make freestanding executable programs when using the Developer's version is a great asset.

The manual is well written and comprehensive – and no errors were spotted! It will not teach you to program, nor will it make you a mathematical genius, but it will tell you how to use the system in a comparatively painless way. There is also a useful set of examples and demonstration programs.

Future versions of *MExpress* will be able to make dynamic link libraries for use with Microsoft Windows. These "DLL" files are the key to how Windows applications actually integrate together, and this should make it even easier to integrate *MExpress* into existing programs.

Quickroute have also developed a tool to aid porting of *Matlab Level 4M* files to *MExpress*, which will become available in beta-release form free from their WWW site in the near future.

MExpress is a highly cost effective software package that will enable you to perform complex data analysis and presentation functions, and to create custom design and analysis tools. If this is what you are looking for, it is strongly recommended that you examine it. It is also great fun to play with!

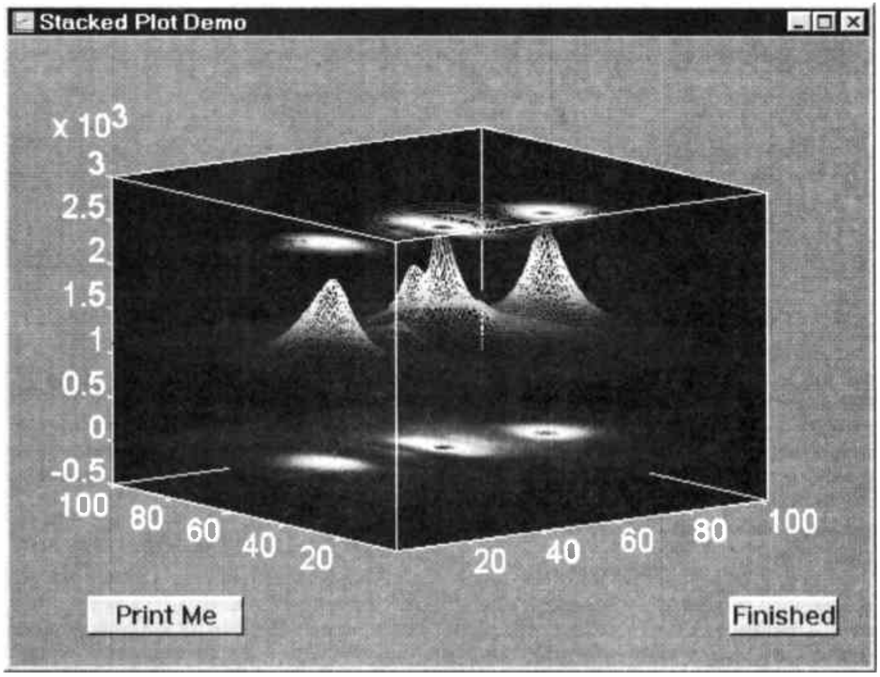


Fig.7. Demonstration of 3-dimensional data display.

MEXPRESS DEMOS

The screenshot in Fig.7 shows *MExpress* in action from the demonstration package that is provided with it. It illustrates a graph containing multiple representations of the same data, in this case a matrix containing height information. Note also the buttons on the screen, which activate functions in the program to perform the designated tasks.

Compiled versions of *MExpress* demonstration programs have been placed on the *EPE* FTP site: **ftp://ftp.epemag.wimborne.co.uk/pub/software/mexpress.zip**

For more information about *MExpress*, contact Quickroute Systems Ltd., Dept. EPE, Regent House, Heaton Lane, Stockport, SK4 1BS. Tel: 0161 476 0202. Fax: 0161 476 0505.

E-mail: **info@quicksys.demon.co.uk.**
Web: **http://www.quickroute.co.uk.**

THE REVIEWER

Rob Miles is a lecturer in the Department of Electronic Engineering, University of Hull. E-mail: **r.s.miles@e-eng.hull.ac.uk.** He thanks Dr. Tony Wilkinson for also assessing the software.

READOUT

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

PIC-TICK TIMING

Dear EPE

I restore and repair clocks and recognise in your *PIC-a-Tuner* (May '97) a possibly economical method of timing clocks. However, to do this it would be necessary to read frequencies of 1Hz (as in the case of a grandfather clock). Can the software be modified to do this?

J. J. McClure, Omagh, N. Ireland

It could be modified if you are familiar with PIC programming (I can't offer to do it for you). But, although it can be done, in all honesty, it would not be the ideal way to achieve what you want. PIC-a-Tuner *is very accurate for musical tuning, but there is a wider degree of acceptable tuning range in music than there is in horology. A fraction of a Hertz difference in musical tuning accuracy is unlikely to be noticed, especially in the very low frequency range. Clock timing, though, requires far greater accuracy (as I know you know!). A fraction of a Hertz inaccuracy for a clock can mount up to several seconds of significant deviation over several months, or even weeks.*

To tune a clock to the required accuracy using counting techniques, a digital readout of the time periods should be used, not an analogue bargraph as used in PIC-a-Tuner. *You would then need to use a circuit which could count the number of "system" clock pulses occurring between each clock tick, and the greater the number, the greater the accuracy of the count.*

Crystal controlled PICs can do the task, up to a count rate of, perhaps, at least ten times less than the crystal frequency (the control command instructions processed by the PIC to do the counting task slow down the sampling rate). It would be critical, however, that the circuit which detects the sound of each clock tick should rapidly respond to each tick and produce a pulse with a very fast leading (or trailing) edge. This edge needs to trigger the counter routine at identical points in the changing amplitude of the tick sound; not such an easy task for a comparatively slow changing audio source.

A more accurate pulse could be generated in the case of grandfather clock by using opto-electronics, the pendulum repeatedly swinging between a sharply focussed light source and a sensor, so creating sharply defined electrical pulses. Even that, though, could be subject to error due to the slowness of the pendulum; in this case an averaging technique would have to be used, taking a given number of ticks over a given period of time, and averaging the total microsecond (or even nanosecond) count assessed by the PIC. It's all more complex than PIC-a-Tuner *is designed for.*

*There is, though, a non-counting technique that could be used, requiring a dual-trace oscilloscope, frequency generator, small amplifier and a microphone. Set the frequency generator to **exactly** 1Hz. Monitor its output on one scope channel, setting the sync trigger to this channel. Connect mic to amplifier, and the amplifier output to the scope's second channel. Set the scope sampling rate so that one pulse of the 1Hz sig-gen signal can be clearly and stably seen. Arrange the mic and amp controls so that the clock ticks can be seen on the scope at a reasonable amplitude.*

Observe at which point on the screen each tick pulse is being displayed (the pulse need not be particularly "clean" – as would be needed for a counting technique). At each tick, the pulse will change its position relative to the 1Hz pulse trace. If the pulse appears to be moving to the left, the ticks are occurring too rapidly (the clock is "fast"); if they move to the right, the clock is "slow". Adjust the clock's tick rate until the tick pulse appears to be stationary. The clock is then accurately set. For clocks ticking at more than one pulse per second, set the sig-gen frequency accordingly (e.g. 2Hz for two ticks per second). JB

RAILWAY SHORTS

Dear EPE

I have taken *EPE* since it began, but mainly due to lack of time I find I never make the larger projects, plus the fact that I have found no use for them.

Because my other hobby of a Garden Railway takes much of my time, I would like simple projects like timers, flashers, light level controls, proximity switches, speed controllers for small motors, noise makers, temperature level controllers, and so on. Don't tell me I can get all these from books (*and from back issues of EPE. JB*). I do already if required, but I like to make different "simple" projects. Simple, in this sense, means fairly easy and quick to make and use in my situation. I do already buy your p.c.b.s and find this helps.

Eric Goodley, Doncaster

Between Jan '90 and Jun '97 we have published four railway-type projects (plus numerous related discussions in Interface*), 25 timers, three flashers, 35 other lights projects, 18 switching designs, four motor controllers, countless noise makers, seven temperature controllers, and the "so ons" probably run into hundreds! These are, hopefully, what's helped to keep you with us over the years. Nice to hear from you.*

On a personal note, let's hear from readers in favour of larger projects; all of us author/designers love designing, coming up with an idea and seeing how it can be achieved electronically (or just in software on a PC), but for many of us it's the more complex design challenges we prefer – something to get teeth and brain cells into. Please, people, encourage us with some supportive replies!

BULLY FOR BULL (AND OTHERS)!

Dear EPE

Reading your piece on Bull Electrical (*Innovations*, Jun '97) has prompted me to tell you of a drill speed controller kit I bought from them. This was based on thyristor circuitry, which is "old hat" today, but this was in '62 or '63 and was fairly advanced for its time. What's more, it's still in perfect working order. Even older was the multimeter kit that I bought from Bull's (albeit under one of their former names). This was possibly '59 or '60, but someone borrowed it and found it so useful that they forgot to return it.

I was also one of Greenweld's first customers, giving them one of their first big orders, for about 100 "Talking Book" machines, and that was around 30 years ago.

My progress in electronics owes a lot to these two firms who have made it possible for those of limited means to get some hands-on experience of electronics which they could not otherwise afford. We should all be grateful to them.

Alan J. Gamble, Burscough, Lancs

Despite the (now retreating) recession, there are still a fair number of electronics companies whose history goes back in time and to whom many are grateful. Being EPE *staff, I can't mention my own favourites, but we'll be pleased to hear about other readers' Company accolades. Many newer companies are also setting similar quality and service trends for the current generation.* JB

PIC OR CHOOSE?

Dear EPE

As an avid reader of *EPE* since 1987, I enjoy the projects and articles (although not being in the UK some flavour is lost for me). I have a suggestion/problem that might revive the constructional heydays:

I get the impression that the market in microcontrollers is fairly biased to the PIC and its derivatives. Seeing that the projects published (and the technology used) are largely beyond your control, why not generalise the part of the project involving the microprocessor? This will mean that the project can be built by, for example, an enthusiast of the 8051 and its derivatives, or any of the other current microcontrollers available. More generic info in the article will assist the constructor to get the project going without having to relive all the development problems the original designer had!

Louis Kirstein, Johannesburg, South Africa

A stunned intake of breath and astonishment from yours truly! (Half an hour later:) It's not the electronics that takes the design time in a microprocessor/controller based project, it's the software *writing!*

In a sense, any µcontrolled project can be regarded as a generalised electronics base for which a variety of µcontrollers could be used. But, and this is a big BUT, each µcontroller type could well have different language/dialect requirements and interface facilities. There is no way that most readers could take an electronics base and a detailed program flow-chart and readily write their own software to suit the electronics presented in the magazine. Such projects have to be tailored to suit specific processors for which proven software is also available as part of the published article.

Even experienced programmers can have difficulty translating between languages; expecting readers to create their own software from flow charts would be unrealistic. It's not just the concept of the software which is important, it's the implementation *through the commands available for a particular processor.*

As an example, I've been writing machine code for various projects and µprocessors for around 20 years. One of the projects (about 1989) was a bike computer based on a 6502 processor, plus Eprom, interface chip and separate memory. It might seem, therefore, that my PIC-Agoras Wheelie Meter, *which I designed to replace it, would have required a mere translation from 6502 to PIC. Not so! The end products are largely identical in function, but because of the significantly differing command structures of the two processors, a total software rewrite was required. Apart from the fact that I knew what the design could and should do, it was as though the 6502 design had never existed*

No, by their very nature, published µC projects must be designed for specific controllers.

Finally, we do have control over what designs we publish! JB

ENGINEERING RECOGNITION (2)

Continuing to share with you the anonymous document circulating as multiple generation photocopies (*Readout*, June '97), another way to recognise engineers is by their attitudes towards gadgets:

"To the engineer, all matter in the universe can be placed into one of two categories:

1. things that need to be fixed, and
2. things that will need to be fixed after you've had a few minutes to play with them.

"Engineers like to solve problems. If there are no problems handily available, they will create their own problems. Normal people don't understand this concept; they believe that if it ain't broke, don't fix it. Engineers believe that if it ain't broke, it doesn't have enough features yet. To the engineer, the world is a toy box full of sub-optimised and feature-poor toys."

Mind you, an engineer is also likely to observe that life is too short to bother with mending things; why waste time on the obsolete when there's so much else that needs to be invented? JB

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?

FEB '96 Photostats Only (see below)

PROJECTS ● Simple PIC16C84 Programmer ● Mains Signalling Unit – 2 ● PIC Electric Meter – 1 ● Vari-Speed Dice ● Analogue Frequency Meter.
FEATURES ● Teach-In '96 Part 4 ● Circuit Surgery ● Making Your Own P.C.B.s ● Techniques – Actually Doing It.

MARCH '96

PROJECTS ● Mind Machine Mk III Part 1 ● High Current Stabilized Power Supply ● Multi-Purpose Mini Amplifier ● Infra-Zapper ● PIC-Electric Meter – 2.
FEATURES ● Teach-In '96 Part 5 ● Ingenuity Unlimited ● Flight PAL Trainer Review.
FREE ● Headphones (UK copies only).

APRIL '96 No Free Booklets left

PROJECTS ● Bat-Band Converter ● Event Counter ● Mind Machine Mk III Part 2 – Programmer ● Hearing Tester.
FEATURES ● Teach-In '96 Part 6 ● Circuit Surgery ● Thermionic Valves Part 1.

MAY '96

PROJECTS ● Midi Analyser ● Mind Machine Mk III Part 3 – Tape Controller ● Versatile PIR Detector Alarm ● Countdown Timer ● Bat Band Converter B.F.O.
FEATURES ● Teach-In '96 Part 7 ● Ingenuity Unlimited ● Thermionic Valves Part 2 – The C.R.T.

JUNE '96

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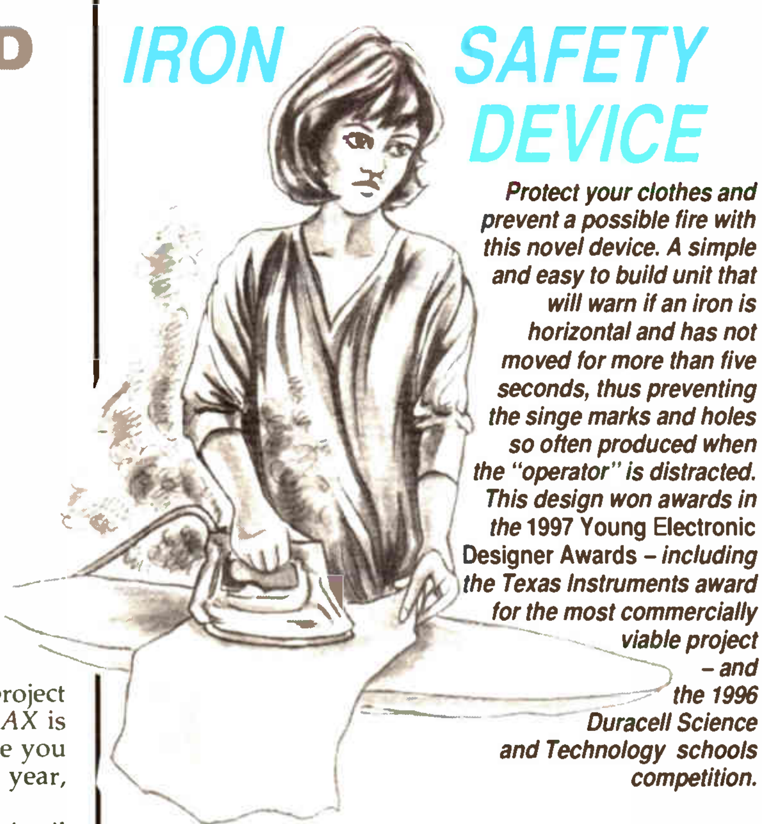

Protect your clothes and prevent a possible fire with this novel device. A simple and easy to build unit that will warn if an iron is horizontal and has not moved for more than five seconds, thus preventing the singe marks and holes so often produced when the "operator" is distracted. This design won awards in the 1997 Young Electronic Designer Awards – including the Texas Instruments award for the most commercially viable project – and the 1996 Duracell Science and Technology schools competition.

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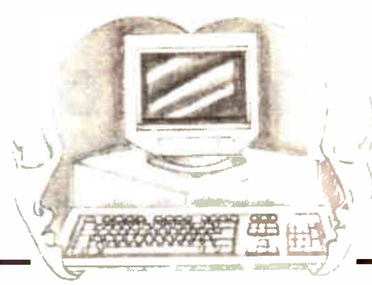
INTERFACE



Robert Penfold

AUDIO FREQUENCY METER INTERFACE

IN RECENT *Interface* articles we have considered a number of test instruments based on a PC, and we continue in the same vein this month with an Audio Frequency Meter Interface.

This is a function that could probably be achieved largely in software, either by counting the number of pulses in a given period of time or by measuring the period of one cycle. Either way, it would probably require a machine code routine to handle things with adequate accuracy, but these are interesting approaches that I will investigate in the future.

The current design relies largely on hardware to do the work, with the computer providing the display and control logic. The interface is still quite simple, and it is designed to connect to a bi-directional parallel printer port. It should also work properly with any computer port that can provide eight input lines plus two handshake outputs and one handshake input.

However, the software will obviously need some adjustment for operation with a different input port. The 8-bit resolution of the system means that it will not achieve the same degree of accuracy as an expensive digital frequency meter (d.f.m.), but it is still adequate for many purposes, and is at least as good as an analogue frequency meter.

The block diagram of Fig.1 shows the general scheme of things used in this frequency meter. It operates on the normal pulse counting method with gate periods of 10 milliseconds, 100 milliseconds, and one second. In conjunction with an 8-bit counter, these provide full scale frequencies of 25·5kHz, 2·55kHz and 255Hz.

The gate periods are controlled by a monostable which has three switched resistors to provide the three gate times. The monostable is activated by way of a handshake output of the printer port. A trigger circuit is used ahead of the gate, and this provides a pulse output signal that is compatible with the logic circuitry regardless of the input level or waveform.

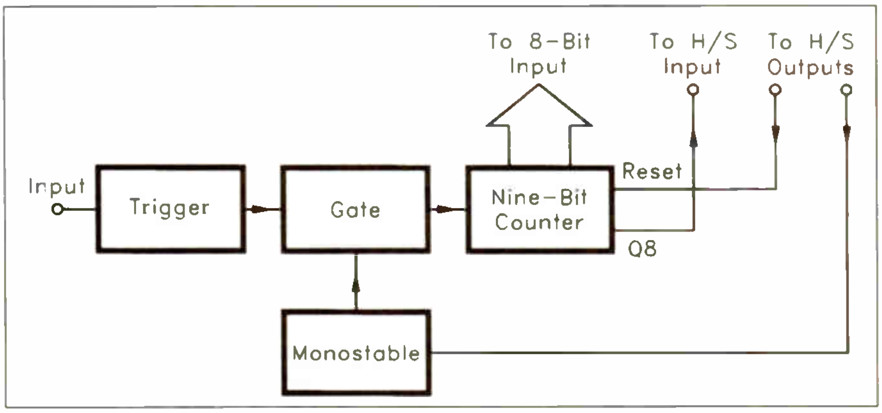


Fig. 1. The Audio Frequency Meter Interface block diagram.

A minimum input level of about 150 millivolts r.m.s. is needed in order to operate the trigger circuit and produce a reading.

The counter is a 9-bit type, but only eight bits are used to provide readings. The ninth bit is read by a handshake input and is used to provide a warning to the user if the counter overruns.

A handshake output is used to control the reset input of the counter and this must be activated to clear the counter before a new reading is taken. The basic sequence of events when taking a reading is for the counter to be reset, the monostable to be triggered, and then after a suitable delay the reading is taken.

The delay is provided in software and is a little over one second on all three ranges (i.e. slightly longer than the longest gate time). The ninth bit of the counter is checked repeatedly while the count is in progress, and a suitable warning produced if this bit is set.

The Circuit

The circuit diagram in Fig.2 shows the trigger, gate, and monostable stages of the Audio Frequency Meter Interface. Transistor TR1 is used as an emitter follower buffer stage which provides the unit with an input impedance of about 250 kilohms.

Capacitor C3 couples the output from the buffer stage to a simple trigger circuit based on transistors TR2 and TR3. This drives the signal gate which is one of the four 2-input NOR gates in IC1, a

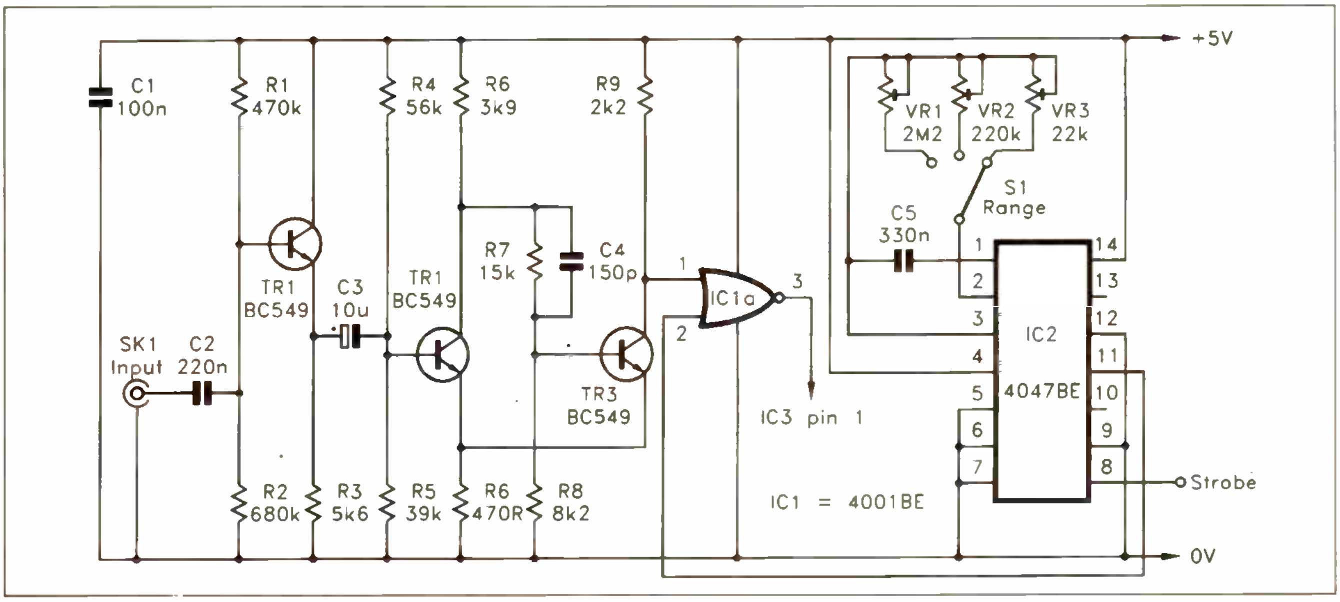


Fig.2. The circuit diagram for the trigger, gate and monostable stages.

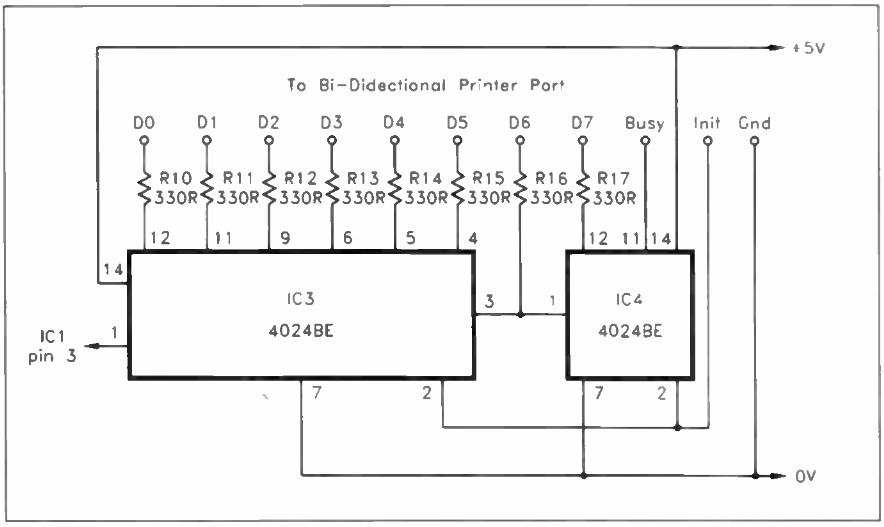


Fig.3. The circuit diagram for the counter stages. Only nine of the fourteen stages are actually used.

CMOS 4001BE. The other three gates of this package are left unused.

A high control signal to pin 2 of IC1a blocks the output signal at pin 3, and a low control level enables the input signal to pass through to the output. The signal undergoes an inversion through IC1a but this is of no practical consequence.

Component IC2 is a CMOS 4047BE astable/monostable, which in this circuit is connected to operate as a positive edge-triggered monostable. The duration of the output pulse is governed by capacitor C5 and whichever of the three presets (VR1 to VR3) is selected using switch S1.

The three presets provide the unit with its three measuring ranges, with the 255Hz, 2·55kHz, and 25·5kHz ranges being provided by VR1 to VR3 respectively. Each preset must be adjusted for good accuracy on its range, and a source of calibration frequencies is therefore needed in order to set-up this project ready for use.

A crystal calibrator having low frequency output signals is ideal, but a calibrated audio signal generator or function generator should provide signals of adequate accuracy. Preferably, each calibration frequency should be more than 50 per cent of the full scale frequency for the range it will be used to calibrate.

The circuit diagram for the counter stages appears in Fig.3. Two CMOS 4024BE 7-stage binary counters are used in series to provide a 14-stage counter, but only the first nine stages are actually utilised.

The outputs of the first eight stages drive the data inputs of the computer's printer port via current limiting resistors R10 to R17. These resistors are needed because the data lines of the printer port will default to behave as outputs at switch-on, which results in two sets of outputs connected together.

These resistors are high enough in value to prevent damage to either set of outputs, but are low enough in value to ensure that they do not have a detrimental effect on the circuit's performance.

Bit 9 of the counter is read by the busy handshake input of the printer port and the reset input of the counter is driven by the initialise handshake output.

The Software

The GW BASIC/QBASIC listing shown in Listing 1 provides a frequency readout in Hertz. It prints the range in use on the screen, and the required range is selected by pressing keys 1, 2, and 3. The program is set to range 1 initially (the 255Hz range).

The range must be set separately on the interface and on the computer, but it would be possible to use an extra pole on switch S1 to indicate the range in use to the computer. This type of thing has been covered in previous *Interface* articles.

After some initial setting up, line 50 sets the data lines of the printer port as inputs (see *Interface* Feb. '97 for more information on bi-directional printer ports). The next three lines then generate the pulses which reset the counter and trigger the monostable.

A delay of about 1·2 seconds is then provided with the aid of the TIMER function, and this gives the hardware time to take a reading. At the same time, bit 9 of the counter is repeatedly checked by line 120, and the program exits the loop if an overload occurs and this bit is set.

The routine at line 360 onwards prints a warning message on the screen, provides a delay of 1·2 seconds, and then loops back to line 60 where a new reading is commenced.

If no overload is detected, the program checks to see if a range selection key has been pressed and, if an appropriate key has been pressed, the program goes into one of three subroutines that change the range message printed the on-screen.

The value assigned to variable "M" is also altered. After the range checking routine the counter is read, the returned value is multiplied by "M", and the frequency in Hertz is then printed on the screen. The program then loops back to line 60 and starts taking a new reading.

A continuous stream of readings are therefore taken and displayed at approximately 1·2 second intervals. There is no built-in provision to break out of the program, but the usual Control-Break combination will bring the program to a halt.

Listing 1: Audio Frequency Meter Program (GW BASIC/QBASIC)

```
5   REM FREQUENCY METER PROGRAM
6   REM REQUIRES PC WITH
    BI-DIRECTIONAL PRINTER PORT
10  CLS
20  LOCATE 7,30
30  PRINT "RANGE 1"
40  M = 1
50  OUT &H37A,32
60  OUT &H37A,33
70  OUT &H37A,37
80  OUT &H37A,33
90  T! = TIMER
100 T! = T! + 1.2
110 X! = TIMER
120 IF (INP(&H379)) < 128 THEN GOTO
    360
130 IF X! < T! GOTO 110
150 A$ = INKEY$
160 IF A$ = "1" THEN GOSUB 240
170 IF A$ = "2" THEN GOSUB 280
180 IF A$ = "3" THEN GOSUB 320
190 LOCATE 5,30
200 F = (INP(&H378))
210 F = F * M
220 PRINT F "HERTZ "
230 GOTO 60
240 LOCATE 7,30
250 PRINT "RANGE 1"
260 M = 1
270 RETURN
280 LOCATE 7,30
290 PRINT "RANGE 2"
300 M = 10
310 RETURN
320 LOCATE 7,30
330 PRINT "RANGE 3"
340 M = 100
350 RETURN
360 LOCATE 5,30
370 PRINT "OVERLOAD "
380 D = 1
390 T! = TIMER
400 T! = T! + 1.2
410 X! = TIMER
420 IF X! < T! GOTO 410
430 GOTO 60
```

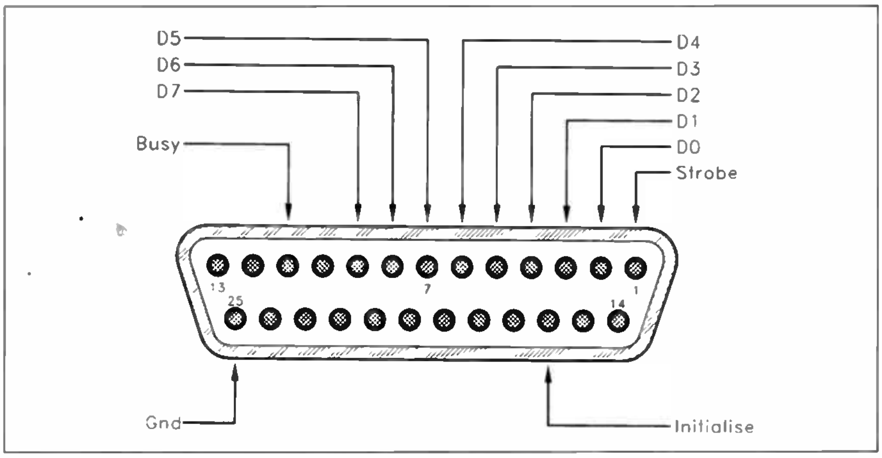


Fig.4. Connection details for the printer port. The connections to the port are via a 25-way male D-type connector.

Constructional Project

MICROPOWER PIR DETECTOR

ANDY FLIND

Part 2

A three module integrated intruder deterrent. The PIR is a self-setting, stand-alone, battery powered module for boats, caravans, garages or garden sheds.

As mentioned last month, the construction of an effective intruder alarm system requires more than just the µPIR Detector. A means of adjusting sensitivity is often needed, together with a timer for setting the alarm duration when triggered. A facility for resetting this timer is usually necessary, and of course a power output stage is needed to operate a siren, flashing beacon or other warning device.

For use with the µPIR Detector unit (last month) these control functions should use very little current so that a complete battery-operated system can be built for use in remote locations where mains power is not available. Fortunately, using CMOS components it is possible to construct a Control circuit that draws *no current* at all in the "standby" condition. Power is only required during operation following a signal from the Detector.

PULSE COUNTING

An effective way to adjust the sensitivity of a PIR detector is to use a "pulse counting" technique. A simple PIR circuit, such as that shown last month, responds to changes in the level of infra-red radiation, producing a series of pulses as the intruder's body moves around the detection area. These pulses are counted by the circuit and, should a sufficient number occur without a reasonably long interval between them, the alarm is triggered.

There are two main reasons why sensitivity may need to be reduced in this way. One is that an alarm that responds to a single pulse may be triggered by all sorts of spurious inputs, caused by animals, birds or even insects crossing its field of view. The other is that the installation may cover an area where, perhaps, the occasional passer-by is to be expected, even though this may only be the owner moving around the protected property.

As an example of the efficiency of this type of system, the author uses one to protect a garage door facing onto a footpath occasionally used by the public. The pulse count is set to fifteen and requires a seven-second interval before restarting from zero, and it hardly ever gives false alarms. Loitering in front of it for around ten seconds sets it off without fail however, and apart from preventing burglary it has proved very useful in deterring local children intent on destroying a nearby earth bank.

CIRCUIT DESCRIPTION

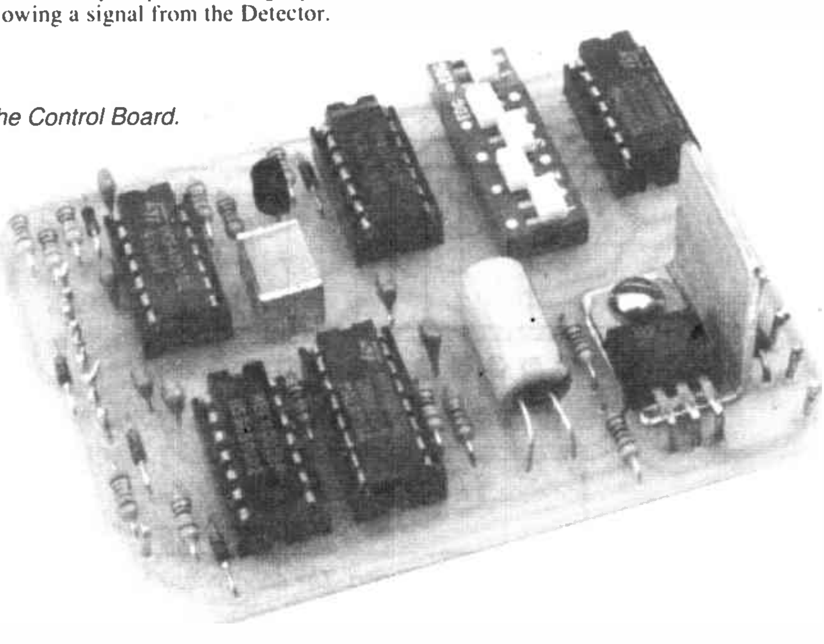
The full circuit of the PIR Control System is shown in Fig.1. It is designed to be used with a separate power supply with a nominal value of 12V d.c., a practical source being a pack of eight "C" or "D" cells which will also be capable of supplying a few hundred milliamps to a siren.

The output of the µPIR Detector is connected to the input points *A* and *B*. On detecting a signal, the detector sinks current from the "pull-up" resistor R1, so the "active" input condition is "low".

Using the "Schmitt" gate IC1d, one of four contained in a 4093B device, together with low-pass filtering from resistor R2 and capacitor C1, ensures that glitch-free pulses with rapid rise and fall times are applied to the "Clock" input, pin 1, of the 4024B counter IC2. The input is inverted by IC1d so that the pulses from its pin 11 are positive-going.

These pulses also turn on transistor TR1 which discharges capacitor C2 to take the Reset connection pin 2 of IC2 low, this being the counter's "enabled" state. The count advances on the negative edge of the clock so it actually counts on the trailing edge of each input pulse.

The first five outputs (Q1 to Q5) are connected through five two-way d.i.l. switches to inputs of the 4068B NAND gate IC3, allowing selection of any combination between 1 and 31 pulses as the number that will cause the output of



The Control Board.

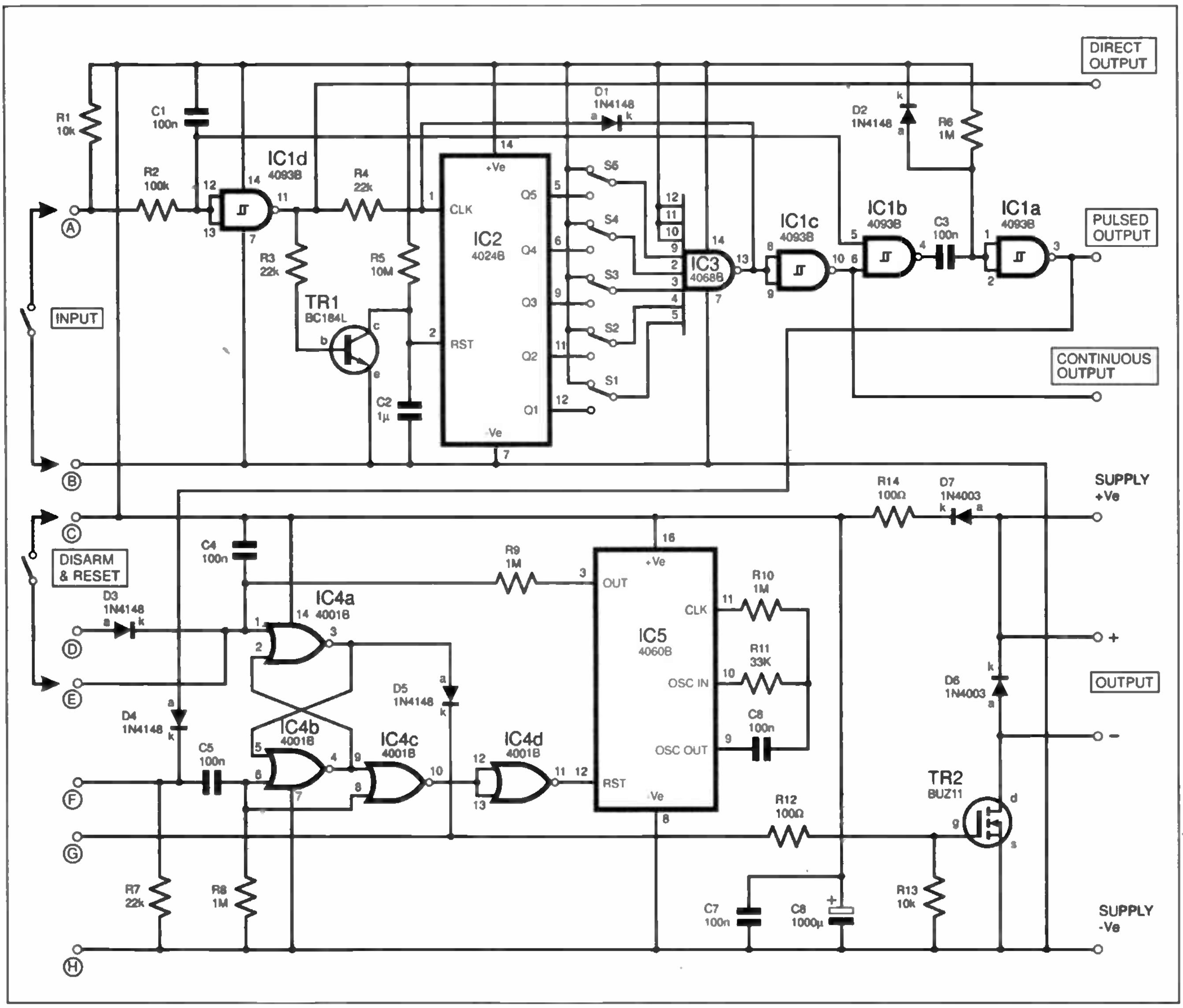


Fig.1. Circuit diagram for the Micropower PIR Controller.

IC3 to go low. When it does so, it holds the clock to IC2 low via diode D1, so that the circuit remains in the "operated" condition.

When the input is not active, transistor TR1 is "off" and capacitor C2 is charged by resistor R5. It takes about seven seconds to reach a high enough value to reset IC2, so a gap of this length is required to restart the count or to reset the circuit once it has operated.

OUTPUT SELECTION

Three outputs are available from this part of the circuit. IC1c inverts the output from IC3 to give a Continuous Output which goes high on operation and remains high until IC2 is reset. This is combined with the input through NAND gate IC1b and passed through the time constant of capacitor C3 and resistor R6 to the inverting gate IC1a, to generate a brief pulse at the Pulsed Output for each further input pulse from the detector after the counter has operated.

This "pulsed" output is the one that is normally used for triggering the timer to sound the alarm. A Direct Output that goes high for each pulse from the detector is also available for readers wishing to monitor the system or experiment with it.

TIMER CIRCUIT

The output timer is built from the 4001B quad NOR gate IC4, and the 4060B counter, IC5, which has an internal oscillator. Gates IC4a and IC4b are connected to form a "set-reset" flip-flop.

A positive voltage applied to capacitor C5, either from IC1a through diode D4 or from an external input connected to point *F*, results in a pulse at pin 6 of IC4b which sets it to the state where its output pin 4 is low and IC4a output pin 3 is high. The positive voltage from pin 3 turns on TR2, an inexpensive power MOSFET which can switch several amperes if the power supply can deliver it, via diode D5 and resistor R12.

All positive input pulses are also applied to input pin 8 of IC4c, resulting in negative pulses from this gate and positive ones from IC4d which reset the counter to zero each time. When IC4c pin 8 returns to the low state with a low also set on pin 9, the Reset input to IC5 becomes low which allows its internal clock to run and counting commences.

If there are no further input pulses, following a period set by the values of the clock components C6 and R11, the output from IC5 pin 3 goes high. This resets the flip-flop, which then turns off TR2 and resets IC5 ready for further triggering.

A positive voltage applied to pin 1 of IC4a at any time will also reset the flip-flop to turn off TR2. Holding this point positive prevents the circuit from operating to provide a "disarmed" condition.

An input, such as a switch, that is either positive or floating can be applied directly to input point *E*, but one that has an active low state such as a CMOS output must be connected through point *D* so that diode D3 will allow resistor R9 to take pin 1 of IC4a high. Diode D3 also allows the "disarm" connections of several boards to be connected in parallel.

USEFUL FEATURES

This timer circuit has some useful features that may not be immediately obvious. The timing period is easily set by changing the value of resistor R11, which gives about a minute for each 33 kilohms of resistance. Timing begins from the end of the last input pulse, so it will not "time-out" whilst the intruder remains within range of an associated PIR detector.

The Disarm inputs always override the signal input so TR2 is always "off" whilst one of these is active. Capacitor C5 ensures that it will time-out if a fault results in a permanently high input. In the "standby" condition it draws no current at all, so prolonged use from battery supplies is possible (unless it is triggered very frequently!)

Although the complete board can be used to make an effective alarm with a single PIR input, additional inputs are provided for building up a more complex system where this is required. Extra control board(s) are needed for this, but usually only part of the circuit will be needed for the additional features.

As triggering is effected by positive pulses through diode D4 with the "pull-down" resistor R7, multiple inputs can be connected so long as they consist of pulses applied through diodes to point *F*. For a second PIR detector only the counter would be required, and the output from D4 of this could be connected to this input to use the existing timer and power stage.

To add a second timer with a longer period, perhaps for use with a doorswitch or a glass-break detector, only the timer part of the circuit is required as the arrangement of D5 and R13 allows the second timer to use the output stage of the first, simply by connecting the points *G* in parallel.

The circuit power supply is available from points *C* and *H* for use by external circuits, although the current available is limited by resistor R14. Multiple Disarm connections can be connected to points *D* or *E*, though this is not really advisable as one of them might inadvertently be left active.

CONSTRUCTION

Despite the many features and the flexibility of this circuit, it is compact and simple to construct. As with the µPIR Detector, care should be taken to avoid contamination of the p.c.b. from excessive handling as some of the impedances used are fairly high. This applies especially around components R5 and C2.

Precautions to prevent damage by static electricity should also be observed as all the i.c.s are CMOS types. The use of d.i.l. sockets is advised for these.

All components for the µPIR Control System are mounted on a single-sided printed circuit board (p.c.b.) and the component layout and full size copper foil master are shown in Fig.2. This board is available from the *EPE PCB Service*, code 163. The usual construction procedure of fitting resistors and diodes, followed by the smaller capacitors, then the i.c. sockets, d.i.l. switches and the electrolytic capacitor C9 should be followed.

The value of 33 kilohms (33k) shown for resistor R11 gives the timer a period of about a minute but this may easily be altered. For example, 330k will give about 10 minutes.

The switches S1 to S5 are described as "sub-miniature s.p.d.t. dual-in-line", and are available in banks of 1, 2 or 4. For this circuit, a bank of four is used for S1 to S4 and a single one is used for S5. Be warned, the minimum spacing between banks is 0·15in, so two "2's" cannot be used to replace the "4", they won't fit on the board!

Internally they consist of two switches physically coupled together and closing in opposite directions. In this design, the lower one of each pair is on and so "active" when moved towards IC2. Each switch is marked with two dots to indicate which is "on" for the current slider position.

It is, of course, possible to omit the switches and fit wire links instead, but this would reduce the ease of adjustment.

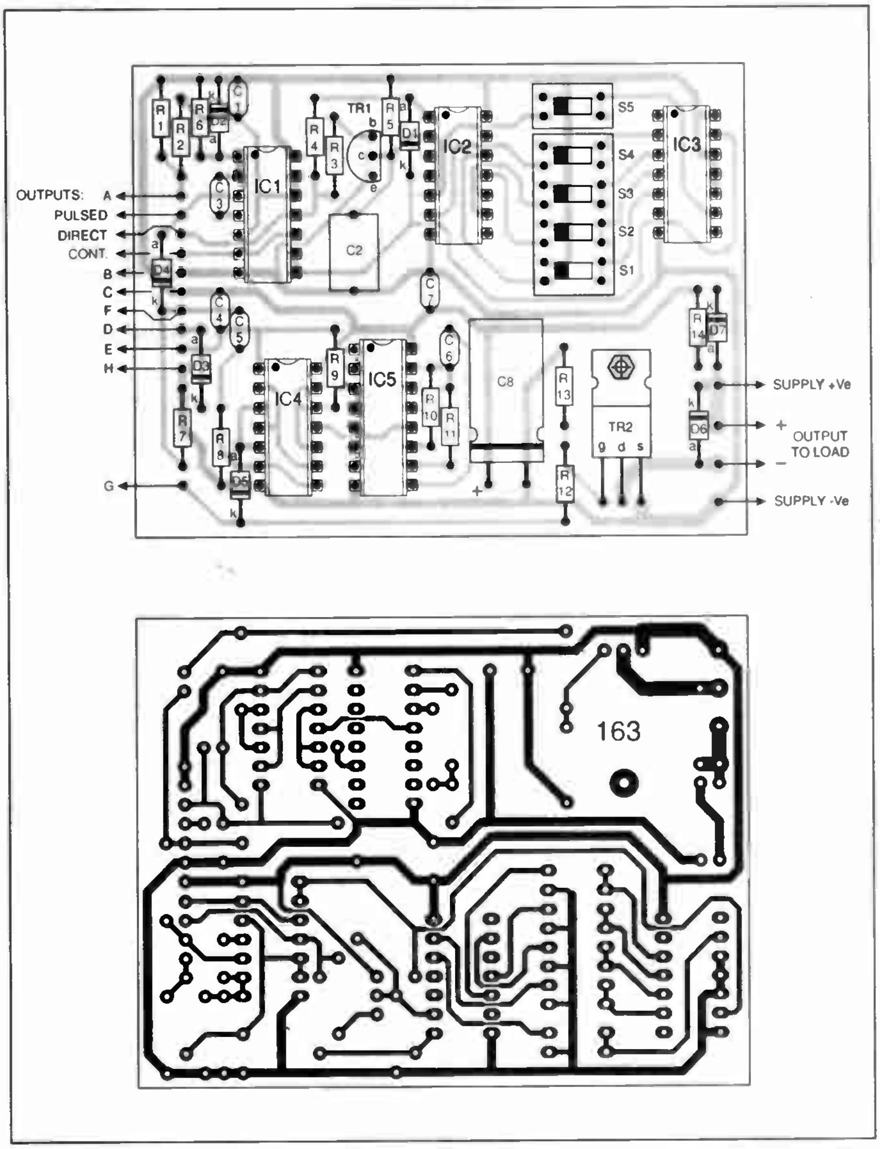


Fig.2. Printed circuit board component layout and full size copper foil track master pattern for the µPower PIR controller.

COMPONENTS

µPIR Controller

See SHOP TALK Page

Resistors
- R1, R13 10k (2 off)
- R2 100k
- R3, R4, R7 22k (3 off)
- R5 10M
- R6, R8, R9, R10 1M (4 off)
- R11 33k (see text)
- R12, R14 100Ω (2 off)

Capacitors
- C1, C3, to C7 100n resin-dipped ceramic (6 off)
- C2 1µ polyester layer
- C8 1000µ/16V radial lead electrolytic

Semiconductors
- D1 to D5 1N4148 silicon signal diode (5 off)
- D6, D7 1N4003 silicon rectifier diode (2 off)
- TR1 BC184L *npn* silicon transistor
- TR2 BUZ11 power MOSFET
- IC1 4093B CMOS quad Schmitt NAND gate
- IC2 4024B CMOS 7-stage ripple counter
- IC3 4068B CMOS 8-input NAND gate
- IC4 4001B CMOS quad NOR gate
- IC5 4060B CMOS 14-stage ripple counter with internal oscillator

Miscellaneous
- S1 to S4 sub-miniature s.p.d.t. dual-in-line switch, p.c.b. mounting, quad
- S5 sub-miniature s.p.d.t. dual-in-line switch, p.c.b. mounting, single.

Printed circuit board available from *EPE PCB Service*, code 163; optional case, size and style to choice – see text; 14-pin d.i.l. socket (4 off); 16-pin d.i.l. socket; strip of aluminium for heat-sink, see text; multistrand connecting wire; solder pins; solder etc.

Approx Cost Guidance Only £19 excluding case

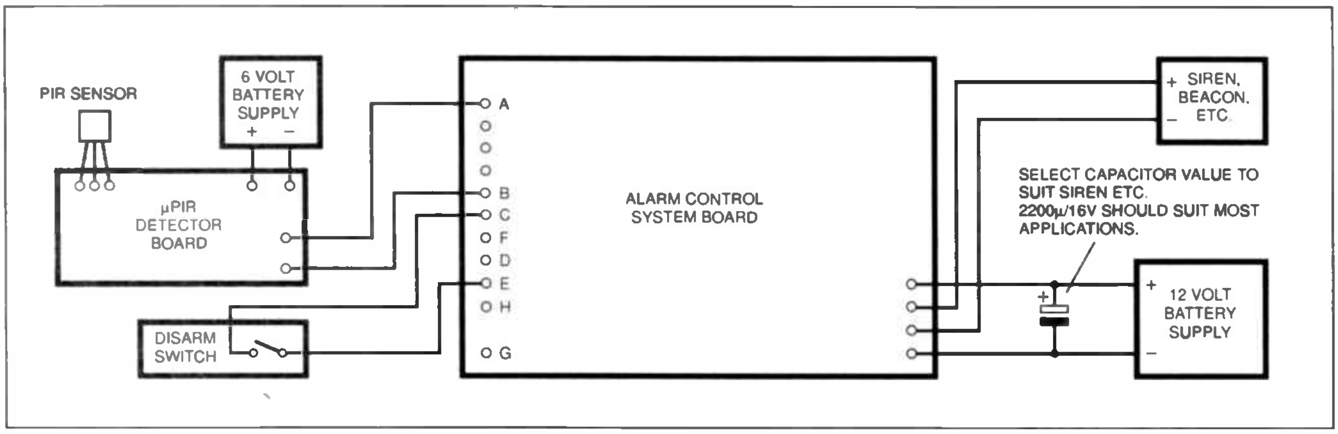


Fig.3. Basic system connections.

In the prototype MOSFET TR2 was fitted with a small heatsink made from an L-shaped piece of aluminium. However, subsequent tests have shown that this is not really necessary as the "on" resistance of the BUZ11 is so low that even when passing a couple of amps it is unlikely to dissipate more than a couple of hundred milliwatts. Most sirens use much less than this, the one used by the prototype draws around 300mA.

TESTING

Providing construction is carried out with reasonable care, it is unlikely that problems .will be experienced with this circuit. However, if it does malfunction, a logic tester is the best instrument for investigating the circuit, though a meter could be used instead.

The pulse counter stages should be checked first by inserting IC1, IC2 and IC3 in their respective sockets and the circuit powered-up. It will operate from any voltage between 6V and about 15V, although it is really intended for use with a 12V supply.

For testing, a microswitch can be connected between points *A* and *B*, this being preferable to a pushbutton as it will normally have less contact "bounce". Switches S1 to S5 can be set for a low count of, say, "5". They have a binary weighting of 1, 2, 4, 8 and 16, so "5" means d.i.l. switches S1 and S3 on, all others off.

Various points can be checked as the microswitch is operated. Each time it is closed the Direct Output should go high. On releasing it for the fifth time (if this value has been set) the Continuous Output should go high and remain high for about seven seconds.

The Pulsed Output may be difficult to see as the pulses are brief, but pin 4 of IC1 can be easily observed. It should be high until the preset number of pulses is reached, then go low each time the input switch is released. Following the final pulse it will remain low until capacitor C3 charges sufficiently to reset IC2.

An additional check that may be useful is that if S1 to S5 are all "off", all the inputs to IC3 should be high, so output pin 13 should be low and pin 10 of IC1 should be high. If the input is then left open, IC1 pins 11, 4 and 3 should be low. If the input is taken low, pins 11 and 4 should go high.

Testing of the Timer section can be carried out by inserting IC4 and IC5 and applying brief positive inputs to "*F*" (Start) and "*D*" (Stop). Once again, a logic tester is the best tool for locating problems around the Timer circuit.

Operation of the Clock in IC5 can be checked at pin 9 of this i.c. This oscillates at a relatively high frequency whilst timing is taking place, around 130Hz for a one minute output period, and remains low at other times.

It should be remembered that when the timer is triggered by the pulse counter through diode D4, about seven seconds will have to elapse before the full count can take place again. Until this time has passed, if the timer is reset, it will be triggered by just one input pulse to the counter.

CASE DETAILS

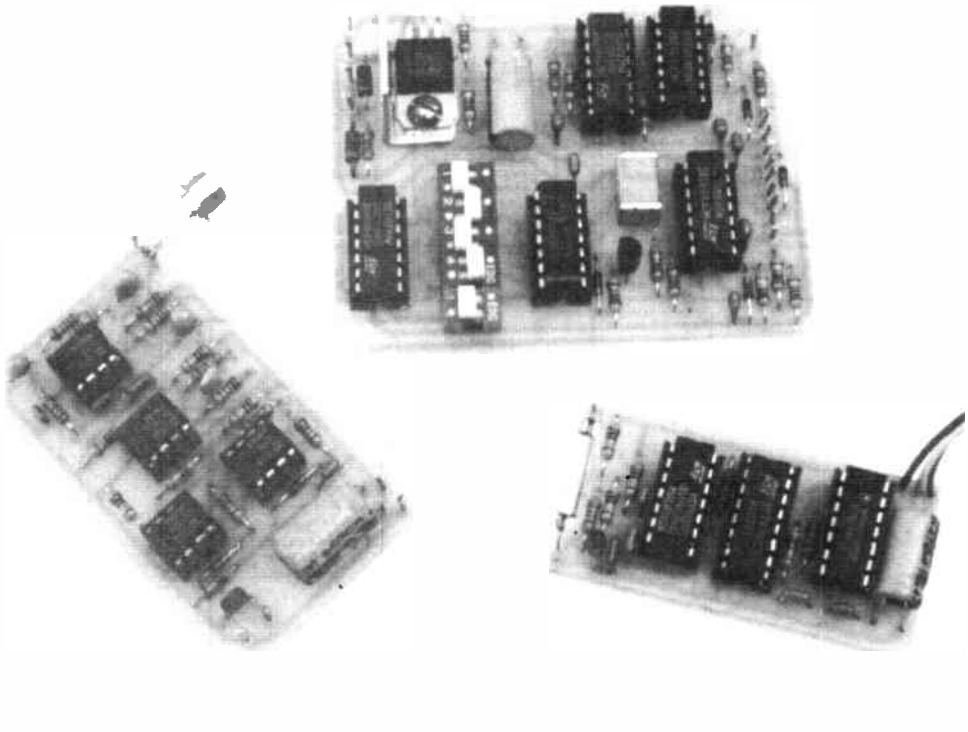
Like the µPIR Detector, this board can be fitted into any case of the constructor's choice, though a fairly large one containing a pack of eight "C" or "D" cells and perhaps even the alarm siren itself may be the best arrangement. The less external wiring there is, the less chance of an intruder managing to disable the system by damaging it.

The siren used by the author is a "Miniature Piezo Siren" which takes 300mA of supply current and is quite loud enough for most applications. Connections to make a simple and effective system are shown in Fig.3.

The Disarm switch could be concealed in some way, and may be an ordinary s.p.s.t. switch of any type, or perhaps a reed switch. The only difficulty is making it inconspicuous enough whilst still accessible from outside the protected premises.

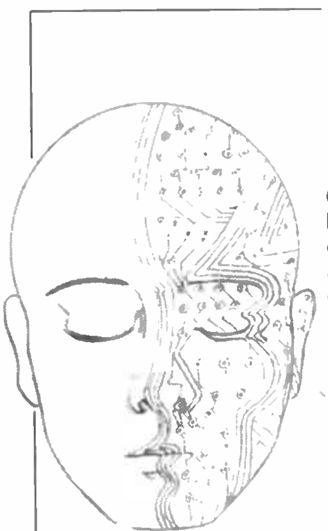
If it is inside, it may be difficult to unlock and enter before the pulse counter triggers the alarm. There is also the minor difficulty of resetting the system into the "Ready" state without setting it off whilst locking up and leaving.

Next month, the concluding article in this series will present a neat solution to these problems when we discuss the Disarm/Reset system.



Left to right: µPIR Detector, Control Board and Disarm/Reset Board.

INGENUITY UNLIMITED



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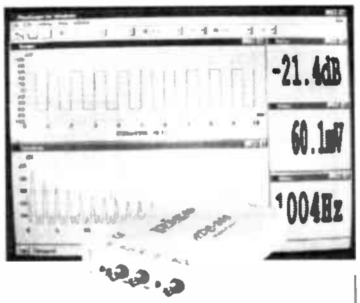


IR Camera Shutter Trigger – explore nature pictorially

INSPIRED by professionals' photographs of birds in flight, I decided to have a go myself and attempt to take dynamic photos of the same subject. The resultant circuit of Fig.1 is an interrupted beam type of trigger design which operates the shutter of motor-driven cameras at the appropriate moment to photograph the bird.

The system comprises an infra-red transmitter and a receiver which drives the camera shutter mechanism for a short trigger period.

The transmitter is based around IC1, a 7555 astable driving an IR emitter l.e.d. D1. It has a 10µs "on time" and 200µs "off time" at a frequency of about 4·8kHz.

The receiver is formed around IC2, a Sharp IS1U60 IR remote control receiver (available from RS Components or Electromail, Code 577-897 – *A.W.*) in a 3-pin housing. Received IR pulses appear at the output of IC2 and, being negative-going, are rectified and smoothed by D2, R5 and C3.

The resulting d.c. voltage is then compared against a reference voltage of half the supply rail, derived by R6 and R7. A 7611 op-amp (IC3) acts as a comparator whose output is low whenever there is no signal (i.e. when the IR beam is broken by the bird in flight).

In order to provide a consistent shutter triggering signal, the comparator's output is coupled by C5 to IC4, a 7555 monostable which is triggered when IC3 output goes low, and which times for a period of about 300ms.

The output of IC4 drives a solenoid (L1), or alternatively fires the camera's remote release directly, via the MOSFET power transistor TR2. The solenoid must be mechanically linked to a remote manual shutter release, and may need to be adapted to suit.

When IC4 times out, a negative-going trigger signal is sent via C7 to IC5, another

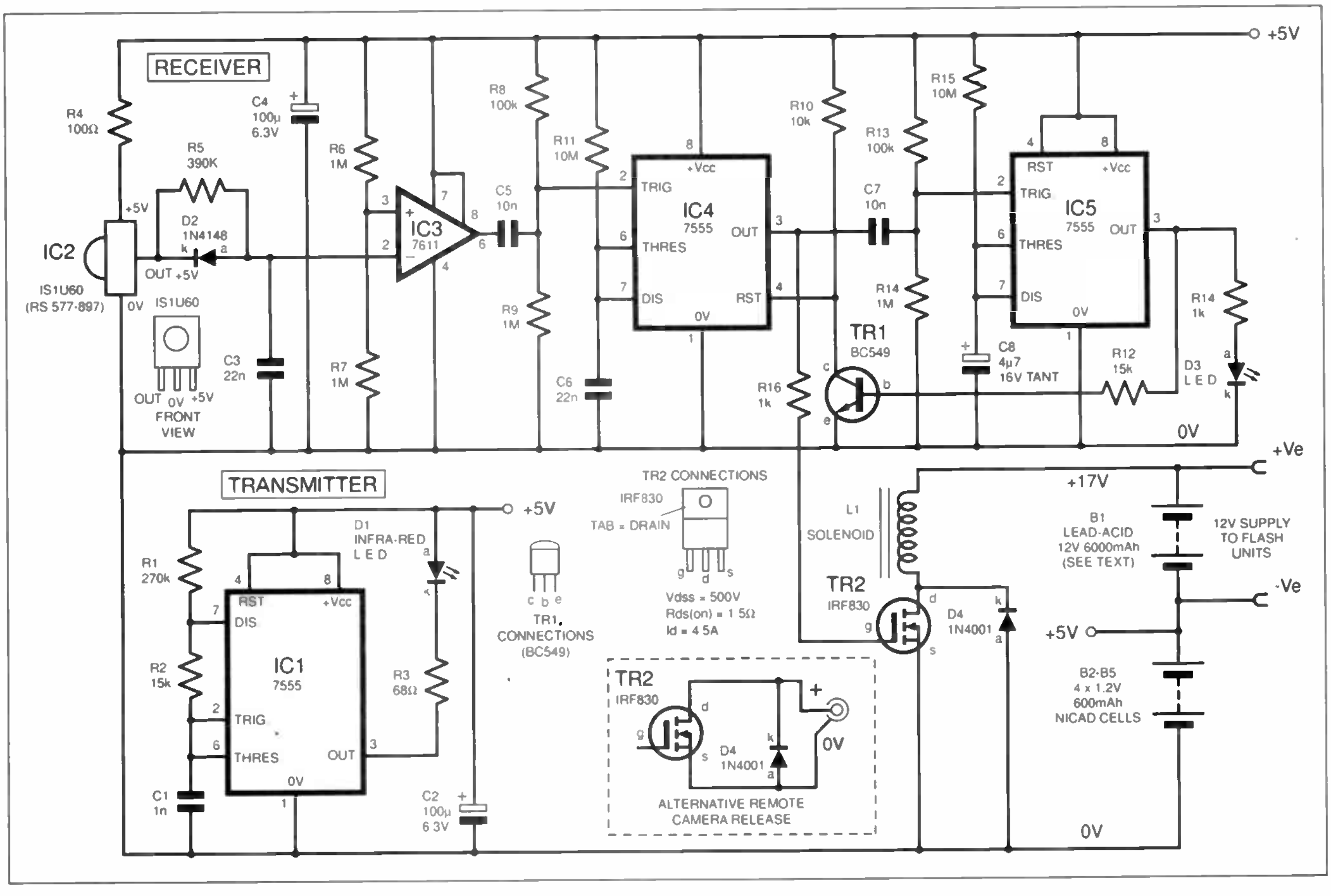


Fig. 1. Circuit diagram for an IR Camera Shutter Trigger.

7555 monostable with a period of approximately 50 seconds. IC5 drives transistor TR1 and this holds IC4's reset pin at 0V, disabling it from timing in the interim period.

The purpose of this is to provide a delay timer which prevents any further operation of the shutter solenoid/trigger (and wasting film) when the flash gun is recharging; l.e.d. D3 illuminates to indicate that resetting is in progress. After 50 seconds or so, the system is ready to take another photo.

A split rail supply voltage is derived from a series of batteries, as also shown in Fig.1. A 12V 6Ah lead acid battery, B1, powers the flash units. A 5V rail for the transmitter and receiver is provided by four 1·2V 600mA Ni-Cad cells (B2 to B5) in series. These are also placed in series with B1 as shown, and the resulting 17V d.c. supply was found to be sufficient to power the solenoid.

The circuit could, perhaps, be adapted with more ingenuity to provide a method of time-lapse photography for other applications.

Stephen Browne,
Carrickfergus,
Northern Ireland.

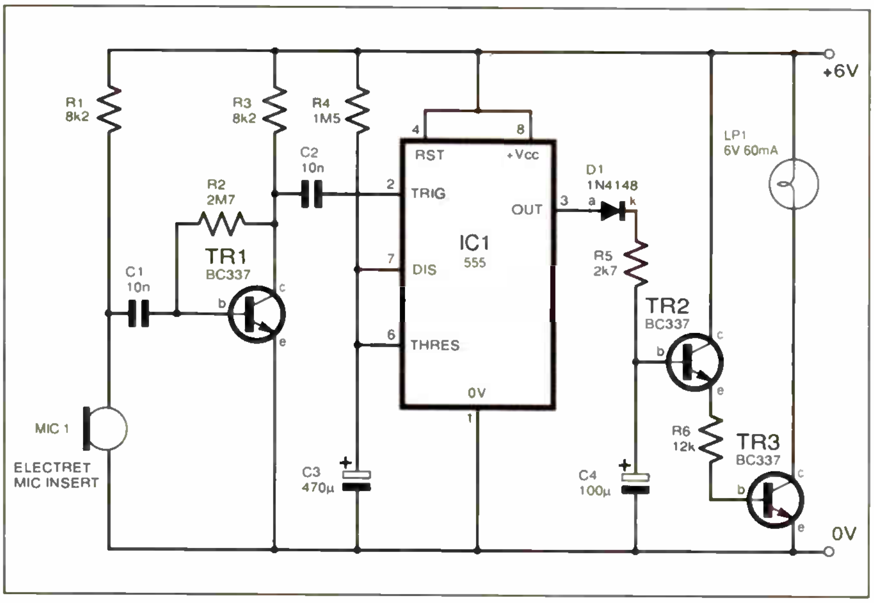


Fig.2. Camper's Night-Light controller.

Camper's Night-Light – for comfortable camping

GOING on a camping holiday with very young children often means some form of night-light is required. However, it's impractical to leave a lamp switched on throughout the night, and so I designed the circuit of Fig.2, which is a sound-operated night-light that gradually fades in brightness to save batteries.

This circuit will cause a low voltage bulb to shine at full brightness for approximately 12 minutes, and then cause it to gradually fade out. A dimming lamp is also less likely to wake a dozing child than being suddenly being plunged into total darkness. However, the lamp can be switched on again by making a sound, such as a child's cry or the clicking of fingers – much more convenient than fumbling around for an on/off switch in the dark.

A miniature electret microphone, MIC1, with integral f.e.t. amplifier, is used to monitor sound. Transistor TR1 amplifies any sounds, and the relatively low values of coupling capacitors make the circuit quite insensitive to low frequencies, e.g. quiet talking after "lights out", but responsive to high-pitched sounds (a clicking of the fingers up to two metres away!).

The amplifier's output triggers IC1, a 555 monostable, with R4 and C3 providing a 12 minute delay. Via D1 and R5, its output charges C4, turning on the transistors TR2 and TR3. This completes the circuit to LP1, a 6V bulb, which illuminates.

When the 555 times out, C4 maintains the base current but slowly discharges through the transistors to 0V and gradually dims the bulb. D1 prevents the capacitor from discharging back into the 555 output pin. The overall current consumption is approximately 5mA when the bulb is not illuminated.

Peter Bush,
Colchester, Essex.

Car Electrics Tester – buzz off on time

THE DESIGN shown in Fig.3 was evolved to enable some basic tests to be made on a car's electrical system, producing an audio tone when in use. It has two basic functions:

1. With two test leads plugged into SK1 and SK3, a "go/no-go" test for the presence of voltage may be made, e.g. at the pins of a bulb holder or a fuseholder.

2. If SK1 and SK2 are used, a continuity tester is formed to aid the testing of bulbs, fuses, wiring, etc.

The circuit is simply an audio oscillator form around a 555 astable, its frequency set by R1, R2 and C1. The oscillator drives a small loudspeaker (LS1) having an impedance of 35 ohms or more. Four diodes, D1 to D4, are used as a bridge rectifier on the input supply, making the circuit immune to reverse voltages.

All sockets are standard 4mm types for use with ordinary test leads. Power is supplied by a miniature 12V "No.23A" cigarette lighter battery (Maplin JG91Y).

David Allen,
Cheltenham, Glos.

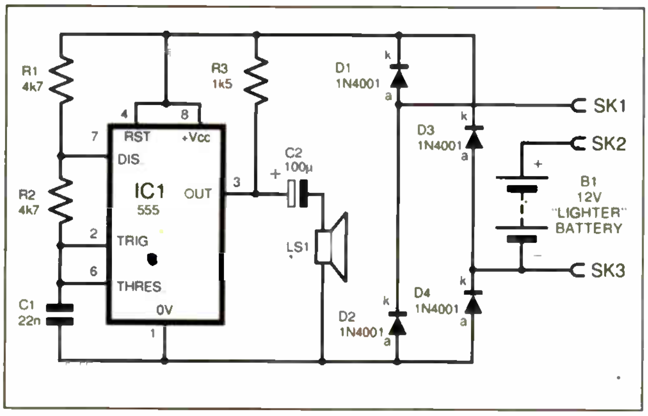
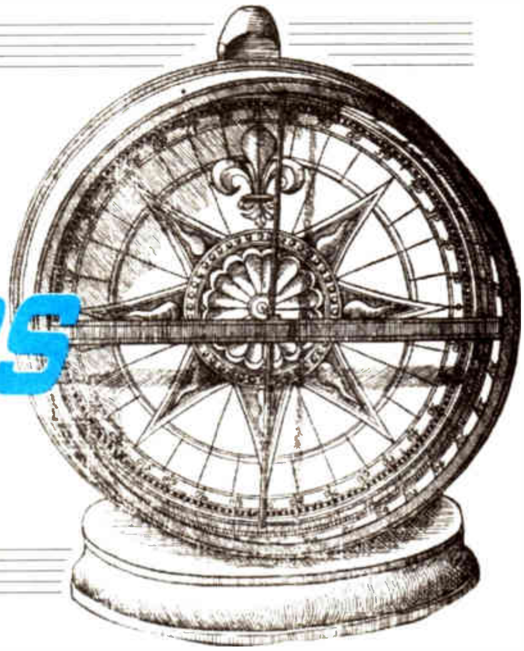


Fig.3. Car Electrics Tester circuit.

Special Feature



THE GREAT EXPERIMENTERS

A short history - Part Four

STEVE KNIGHT

Although poorly educated, Faraday began to solve the mysteries of magnetic induction and capacitance, laying firm foundations for future theoreticians.

THIS MONTH we turn to the man who was arguably the greatest experimental physicist of them all, Michael Faraday. Like many of those before him, and many of those contemporaneous with him, he came from a poor family and had a meagre upbringing along with three other children, of which he was the third.

His father, a Yorkshireman of frugal parentage, was a skilled blacksmith by trade having at that time what might be called an elementary education, followed by an apprenticeship. His mother was without any form of education, but what she lacked in literacy she made up for in love and care for her offspring so that, in spite of their poor circumstances, the children were as well looked after as their straitened situation allowed.

Michael Faraday (1791-1867)

So this was the atmosphere in which Michael Faraday spent his childhood and early adolescence. He did not show any particularly ability for, or promise of a scientific career; he seemed just an average kind of lad, and as he himself said later: "My education at a common day-school was of the most ordinary kind, consisting of little more than the rudiments of reading, writing and arithmetic. My time otherwise was passed at home and in the streets".

The extraordinary thing about the achievements of his later career was that he knew practically no mathematics beyond the arithmetic he had picked up at the common day-school. He once remarked that he was not a mathematician in any shape or form and had never made a mathematical calculation in his life, except for one occasion when he had cranked the handle of a primitive calculating machine.

It may have been that his self-confessed ignorance of mathematics made him the great practical experimenter that he became; we can only surmise. Experimenters there have been who, applying their mathematics for the meaning of a theory, have successfully reached their goal by the test of experiment to that theory; the works of Ampere and Ohm are examples of this.

Faraday, however, did not have this approach; he had an instinctive feel for what was a plain physical truth, and rarely did he fail to hit the nail squarely on the head. This innate ability he applied to the testing ground of his laboratory work, nearly always with remarkable success. The mathematical foundations of his discoveries were left to later workers, particularly James Clerk Maxwell of electro-magnetic wave theory, who produced a treatise on the electrical achievements of Faraday a few years after the latter died in 1867.

EARLY YEARS

When he was thirteen, Michael was apprenticed to a book seller and book binder, initially as an errand boy. This work brought him into contact with books and he wasted no time in studying some of these as they passed through his hands.

Among the books he read in this way were a number on chemistry and the section on Electricity which he discovered in the *Encyclopedia Britannica*. This period sparked his interest in science.

In 1812, when he was twenty-one and completing his apprenticeship with the book binder, his slender resources prevented him from gaining more information and instruction than he could obtain simply by reading books. He soon grew tired of the humdrum routine of the work he now found himself doing for a new employer, as most of us do at one time or another, particularly as he now had an ill-tempered boss and long hours.

At this stage he had the temerity (as it no doubt was) to write a letter to Sir Humphrey Davy of the miners' safety lamp fame, who had been seen by Michael at

Sir Humphrey Davy (1778-1829)

a series of lectures at the Royal Institution through the kindness of a bookshop customer who appreciated the embryonic physicist's enthusiasm for science. With his letter, Michael also included the notes he had made of Davy's lectures.

Davy showed some immediate interest in the letter's appeal and the ability that Michael had displayed in the taking of the lecture notes and the observations he had appended to them. He (Davy) asked one of the former managers of the London Institution (who was a descendent of the great diarist, Samuel Pepys) what he should do about Faraday's appeal.

"What should you do?", replied Pepys. "Put him to wash bottles and keep the laboratory tidy. If he is good for anything he will do these jobs straightaway; if he declines he is good for nothing".

But Davy felt that Michael deserved something better than being a mere handyman, and he sent Faraday a letter explaining that he would do the best he could to find him a worthwhile job somewhere within the scientific establishment.

LUCKY APPOINTMENT

A particular piece of luck now came Faraday's way. The position of a laboratory assistance happened to fall vacant shortly after, and at the Royal Institution, to boot. Davy put Faraday's name forward for the position and as a result Michael was appointed to the job at a meeting of the managers of the Royal Institution held on the first day of March, 1813. So Faraday began his famous career.

His main work at the early stages of his new employment was to assist the lecturers and to maintain the apparatus in good condition, which probably included the washing of a few bottles! Faraday quickly established himself to the full satisfaction of the Institution members, and it was not long before he was assisting with minor experiments, initially in chemistry, and in acting as a note copyist for Davy himself.

When Davy set out in October 1813 on an eighteen month European tour, he invited Faraday to accompany him as a general assistant; this tour gave Faraday an irregular but valuable scientific education, together with the privilege of meeting many of the great names of European physicists who were in later years to become his own close and admiring friends.

Over the next ten years, Faraday established himself as a physicist of a very high order, performing experiments on the alloys of steel (of which "he was accustomed in later years to present his friends with razors made from them"), followed by researches into the liquefaction of gases.

He was made a Fellow of the Royal Society, and in 1825 was promoted to the position of Director of the Laboratories. One of his first acts in this new capacity was to organise Friday evening meetings of those members who were interested in science, and these meetings soon developed into those weekly discourses which became a hallmark in the activities of the Institution, and do so to this day as television entertainment round about Christmas time.

Faraday married a Miss Sarah Barnard in 1821, in a ceremony which was, by his own wish, a quiet and simple affair. So he just married the lady and took her home to his rooms at the Royal Institution. It turned out to be a long and happy union.

ELECTRO-DYNAMICS

Out of all the literature Faraday produced over the period we have covered above, his greatest work was the series of "*Experimental Researches into Electricity*", where he described his many discoveries, among which were the principles of electromagnetic induction in 1831, the laws of electrolysis in 1833 and the effect of a magnetic field on the rotation of polarized light in 1845.

Our main interest in this short series will lie in the first of these headings, though we will first have a look at an experiment in electro-dynamics which is the fundamental feature of the electric motor.

The study of electro-dynamics is, along with his work on electromagnetic induction, accepted as being Faraday's greatest contribution to electrical science. We have already looked at the work of Christian Oersted in which the magnetic effect of an electric current was discovered, so leading to the knowledge that there was a close relationship between these two phenomena; and to that of Andre Ampere's extension of the Oersted effect, culminating in the discovery of the electromagnet.

Faraday, from about 1830, effectually took over the study of electromagnetism from Ampere and was successful in making an experiment which had previously been attempted, without success, by a colleague at the Royal Institution and which foreshadowed the electric motor.

Oersted's experiments had demonstrated that a magnetic needle in the vicinity of a current-carrying conductor tends to move so that it is at right-angles to the conductor. This, as we now know, is due to the fact that an isolated north pole tends to move along the "lines of force" (as Faraday visualized in his field theory of magnetism) of a magnetic field in which the pole is placed. This is illustrated in Fig.1.

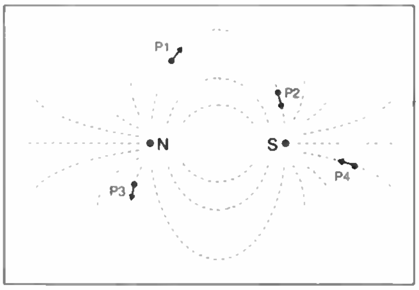


Fig.1. The movement of an isolated N pole at points such as P_1 P_2 etc. will be along a line of magnetic force.

It is important to realise here that the lines of force do not have an identity as such; they do not "flow" in any way such as an electric current (of electrons) flows in a conducting medium. It is simply that an isolated pole (if we could get one) would move along a particular route to the oppositely signed pole.

It was general knowledge at the time, and Faraday was aware of it, that the magnetic field surrounding a current-carrying conductor took the form of concentric circles; you have probably illustrated this for yourself by arranging a wire to be vertical and passing through the centre of a horizontal piece of card, see Fig.2.

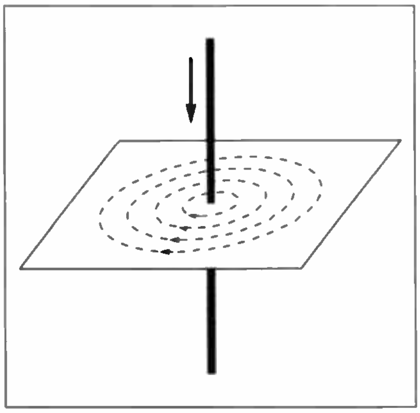


Fig.2. The magnetic field lines surrounding a current-carrying conductor.

Then if iron filings are sprinkled on the card and the edges gently tapped, the filings will arrange themselves in concentric circles which indicate the direction in which the magnetic force is acting at any point. An isolated pole, placed in this field, would move around one of the circles if free to do so.

Now Faraday argued that since an action and a reaction are equal and opposite, then if an isolated pole tends to move around a current-carrying wire, there must be a tendency for the wire to rotate around a magnetic pole; it was simply a matter of relative motion, depending upon which element was free to move and which was fixed and unable to move. Faraday's experiment to see if his argument was sound is shown in Fig.3.

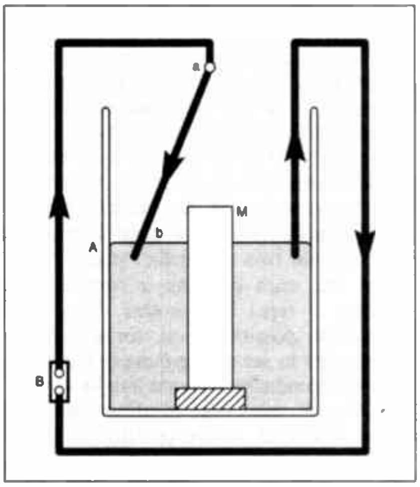
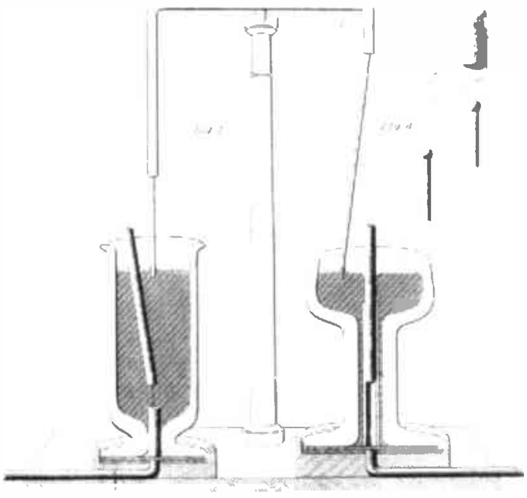


Fig.3. Faraday's experiment on the mutual rotation of a wire carrying current and a magnet.

He arranged a container of mercury *A* so that it formed a part of an electric circuit made up of battery *B* and the connecting wires. A magnet *M* was fixed centrally and vertical in the mercury container, and a portion of the wire, *a-b*, forming the circuit was pivoted at *a* so that it was free to move in any direction about the pivot point. Hence the apparatus formed a practical test of the surmised rotation of a free conductor *a-b* round a fixed pole which existed at the upper end of the magnet and acted effectually as an isolated pole.

The experiment was a complete success and a story goes that on seeing his apparatus work, Faraday danced about in childlike excitement exclaiming "There it goes, there it goes". He later repeated the experiment with the wire fixed and the magnet moveable, with similar results.



Faraday's rotation apparatus.

ELECTROMAGNETIC INDUCTION

Faraday's most far reaching discovery happened in about 1831 when he demonstrated that electricity could be produced from magnetism; we know this effect today as *electromagnetic induction*.

Although the American physicist Joseph Henry discovered electrical induction independently of Michael Faraday and constructed the first electromagnetic motor, the achievements of Faraday are in no way diminished. The unit of inductance, the Henry, was named after the American.

What was the general nature of the investigation as Faraday would most probably consider it? From the work of earlier experimenters he would know that a current-carrying wire is surrounded by a magnetic field; he had already made use of this fact in the construction of his electric "motor". Additionally, he knew that Ampere had shown that two conductors placed side by side and each carrying a current, would attract or repel one another. Why should it not be possible, then, for a current of electricity to set up (or *induce*) a current in another conductor brought into its vicinity?

What Faraday was in effect asking was why it should not be possible to produce a current from magnetism, seeing that Oersted and Ampere had demonstrated the opposite effect.

At the beginning of his research into this possibility, he arranged two wires in close proximity to each other, as Fig.4 shows; one wire he connected to a battery *B* so that this first wire carried a current, and the other he connected to a galvanometer (*G*) so that he could detect the presence of a current flowing in this second wire.

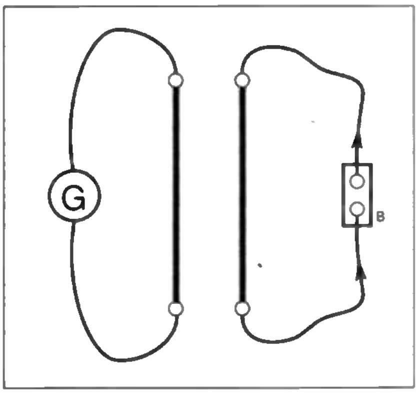


Fig.4. Faraday's first attempt at producing an induced current.

He obtained no result in spite of a number of changes in the disposition of the wires and the strength of the current. He abandoned this line of enquiry for a number of years because much of his time was then taken up with research into the properties of optical glass; when he returned to the problem again in 1828 he still failed to get any sort of result. It was a classical case of being so near and yet so far.

It was not until 1831 that Faraday met with success, and what followed was probably the most outstanding achievement of his entire career. We recall that Ampere had shown that a solenoid carrying a current behaved exactly as a bar magnet, and that if a rod of iron was placed in the solenoid, the rod became magnetized.

Building on this foundation, Faraday made an important change in the form that the solenoid took. He obtained a soft iron ring or toroid, about 150mm in diameter, and around each half of the ring he wound coils *P* and *Q*, as Fig.5 depicts.

Coil *P* was connected to a battery *B* and switch *S*; coil *Q* was connected to galvanometer *G*. On pressing the switch, Faraday observed that the galvanometer needle swung completely around a number of times before coming to rest in its initial position. On releasing the switch, the deflection of the needle was repeated but in the opposite direction.

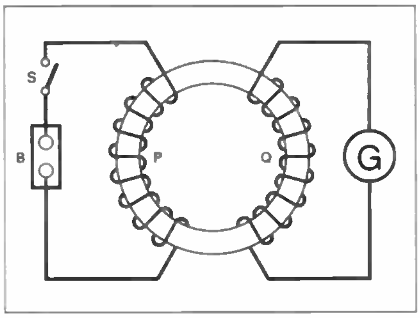


Fig.5. The experiment from which Faraday discovered electro-magnetic induction.

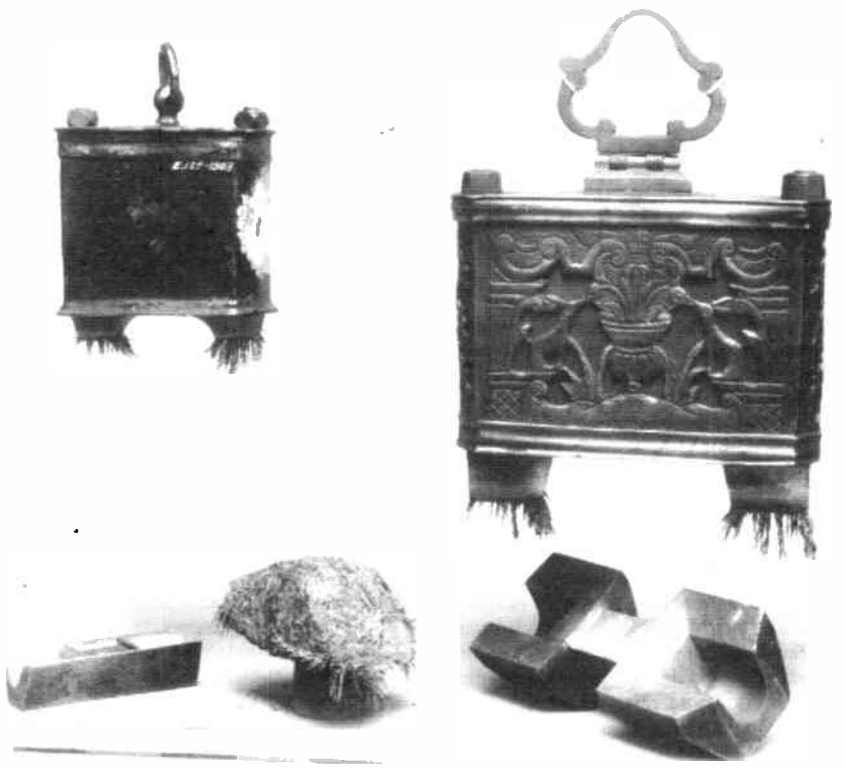
Although what he had actually done was to invent the toroidal transformer, we must forgive Faraday for not immediately appreciating the significance of what his experiment was saying to him; it appeared that the magnetism set up by the battery current in coil *P* was the cause of the *momentary* current which appeared in coil *Q*, but why did it flow only at the moments when the current in coil *P* was started or stopped?

He wrote in his notes "I think I have got hold of a good thing, but cannot say. After all my labours it may be a weed that I pull up instead of a fish".

To verify that it was indeed the magnetism of the iron core which produced the electricity, Faraday repeated the experiment using a non-magnetic material in-place of the iron. The galvanometer deflection again occurred but the movement of the needle was greatly reduced. This satisfied him that the magnetization was the responsible agent and that the greater the magnetic field strength, the greater was the induced current, and consequently the magnetism produced the electricity.

He wrote about this experiment: "When the contact was made, there was a sudden and very slight effect at the galvanometer and there was also a similar slight effect when the contact with the battery was broken. But while the voltaic current was continually passing through the one helix, no galvanometer appearance nor any effect like induction upon the other helix could be perceived, although the active power of the battery was very great".

Faraday now did a number of experiments replacing the magnetism that he had so far derived from a battery supply of



Loadstone used by Faraday with a coil and iron bar.

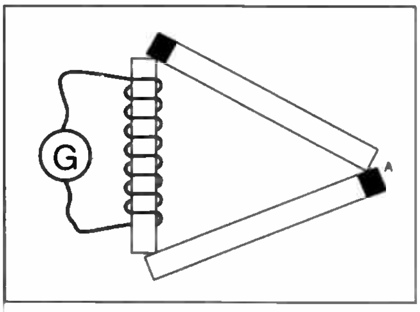


Fig.6. A further demonstration of electro-magnetic induction.

current with a permanent magnet. In one of these he wound a coil around a short rod of soft iron and connected its ends to a galvanometer as we see in Fig.6.

He then took two bar magnets and placed them so that opposite poles were in contact with the ends of the iron rod. When the contacting ends of the magnets were brought together (or separated) at point A, the galvanometer needle was deflected, the effect being as in the earlier experiments, not permanent but a momentary "kick" each time the bar magnets were separated or brought together.

From this, Faraday had thus demonstrated the converse of Oersted's effect: Oersted had found that a magnet was influenced by an electric current; Faraday that an electric current could be generated by a magnet.

In another experiment, Faraday plunged a bar magnet directly into a solenoid and found that the galvanometer deflected as the magnet entered the coil and again when he withdrew it, but again there was no deflection when the magnet was stationary.

It now became clear to him that the vital factor for the production of an induced current in any given conductor was that there had to be a relative *change* of conditions between the inducing field and the current generating circuit and that any change in conditions followed from a movement of one part relative to another.

This fact had to follow, of course, from the principle of the conservation of energy. No induced current could be obtained from a stationary field or a stationary magnet; it doesn't matter whether the magnet moves relative to the coil, or the coil to the magnet. If things were otherwise and an electric current (and hence electrical energy) could be generated by simply placing a magnet at the centre of a solenoid, then sitting back to enjoy the free output, all the trials and tribulations of the "perpetual motion" addicts would be over, and electricity bills would have never been invented.

To get energy out of a system (in the case of the induced current here) energy has to be supplied to the system. This supplied energy comes from the work done in establishing the exciting field or from the muscle power in pushing a magnet into or pulling it out of a solenoid. We do not get any "free" energy.

LENZ'S LAW

A Russian born physicist, Heinrich Lenz, besides being credited with the effect of temperature on electrical resistance, supplemented in 1834 the work of Faraday by pointing out what is now known as Lenz's Law; that is, in every case of induced current flow due to a relative change in the magnetic conditions, *the direction of the induced flow is always such that it tends to oppose the change in the conditions which are bringing it about.*

When we consider Lenz's Law, we have to realise that what is actually induced in a solenoid directly or in a winding adjacent to the field (what we now call the "secondary" winding in transformer action) by the change in conditions somewhere in the system, is an e.m.f. (electromotive force); this e.m.f. causes a current to flow in the winding *if* the circuit is completed through a galvanometer or whatever.

Lenz's Law therefore applies only to induced currents and these can only flow in a closed circuit. If you push a magnet into a solenoid, you have to provide a little more muscle power when a galvanometer is connected to the solenoid than you do when the solenoid is unconnected.

Faraday also discovered for himself how to determine the directions of induced voltages and currents, but he did not express his results so neatly as Lenz.

FARADAY'S LAW

Faraday had the insight to see that the induced e.m.f. appears no matter whether the change in the magnetic field strength is provided by moving the coil or by moving the magnet relative to each other. Although much of the required mathematical treatment of Faraday's work was carried out by Clerk Maxwell, the resulting law is known as Faraday's Law of Magnetic Induction. It can be expressed as:

Induced e.m.f.

$$= \frac{\text{change in the field density (or flux)}}{\text{time the change takes place}}$$

= the rate of change of the field density

So the faster a magnet is plunged into a coil, for instance, the greater is the induced e.m.f.

A negative sign is usually given to this expression as a consequence of Lenz's law which indicates that the induced e.m.f. acts against the direction of the inducing agent.

FURTHER RESEARCHES

Not all of Faraday's achievements were associated with electromagnetism. After some years investigating electrolysis and the analysis of compounds by use of an electric current (with which many of us are no doubt familiar), he turned to electrostatics and demonstrated that the electricity derived from friction (on various machines) was identical with that obtained from the voltaic cell, and from this he turned his attention to electrostatic induction.

Charles Coulomb, the French physicist, had in 1777 shown that Newton's law of inverse squares for gravitation was as true for electric and magnetic attractions and repulsions, something that Ampere also demonstrated for the force acting between parallel wires. Coulomb had assumed from his experiments that the force acting between two charges was also, as Newton believed for gravity, a case of "action at a distance" and that the intervening medium had no effect on this.

Faraday did not see eye to eye with this argument, saying that the medium

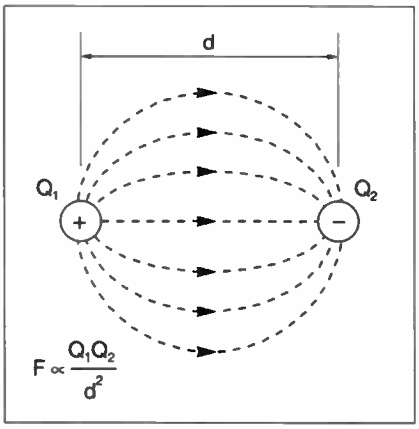


Fig.7. Electrical force field between oppositely signed charges.

between the charges (which he called the "dielectric") did have an influence on the force. Action at a distance implied that the mutual attraction between charges took place along a straight line, but his own experiments had shown him that the force lines were curved, after the fashion of Fig.7.

This sketch reminds us of the field around a bar magnet where charges are replaced by poles, but with the important difference that the electrostatic lines of force *terminate* on the surfaces of charged bodies whereas magnetic lines form closed loops. Electric force is taken to act from the positive charge to the negative, so that if an isolated positive charge is placed in the field it will tend to move towards the negative charge.

Faraday experimented with concentric metal spheres and parallel plates in search of a verification of his suggestion about the effect of the dielectric medium on the force between electric charges, and of the mechanism of the charge induced in an insulated uncharged body by the presence of a near-by charged body.

In his own words: "The question may be given thus: suppose an electrified plate of metal (*A*) is suspended in air, and *B* and *C* two exactly similar plates are placed parallel to and on each side of *A* at equal distance and insulated, *A* will then induce equally towards *B* and *C*, that is, equal charges will appear on these plates". His experiment is illustrated in Fig.8.

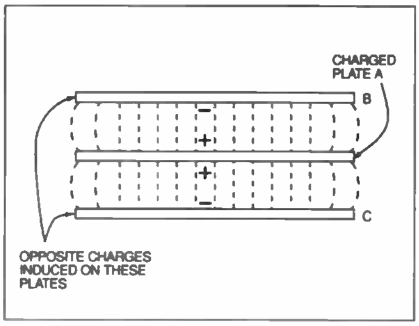


Fig.8. Faraday's capacitor experiment.

The induced charges appear on *B* and *C* because the lines of force from *A* terminate on their surfaces, in just the same way as a magnet will induce magnetism in a near-by piece of iron. Faraday goes on: "If in this position of the plates some other dielectric than air, such as shellac, be introduced between *A* and *C*, will the induction between them remain the same?"

He answered this question by

constructing two identical plate arrangements (what we now call a capacitor), in one of which he placed a dielectric, the other containing air only, as shown in Fig.9. When both systems were charged by the same potential difference, Faraday found by experiment that the charge on the one containing the dielectric was greater than that on the other, that is, the field between the plates was increased by a factor k ($k > 1$) by the introduction of a dielectric.

In this way Faraday discovered the property which he termed the "dielectric constant" of the medium and which we now call the permittivity; the ability of a conductor to hold a charge is increased by the presence of a solid dielectric, hence it exhibits a greater "capacity". So did Faraday's work lead us to the capacitor.

Faraday died on August 25th 1867 at the age of 76. John Tyndall, who was the friend and biographer of the great experimenter, in his book *Faraday as a Discoverer* said of him: "Underneath his gentleness was the heat of a volcano. He was a man of excitable and fiery nature; but through high discipline he had converted the fire into a central glow and motive power of life, instead of permitting it to waste itself in useless passion."

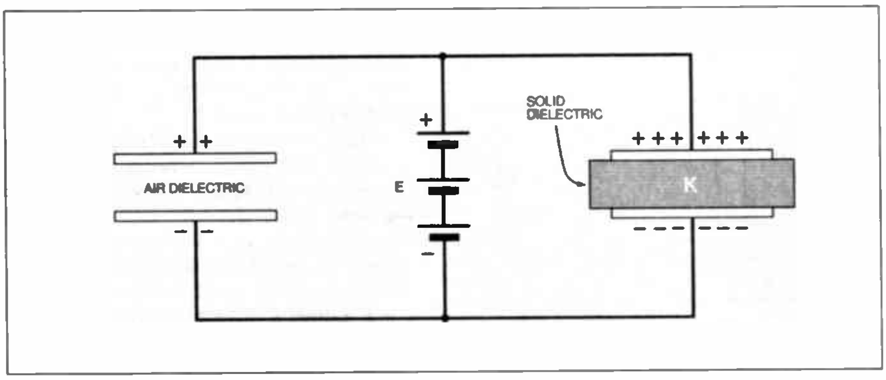


Fig.9. The effect of a solid dielectric is to increase the electric field by a factor k.

Faraday is remembered in the unit of capacitance, the Farad. You will find his portrait on the back of a £20 note.

PART FIVE

In next month's concluding article, we look at the work of William Thomson whose pioneering researches led to the advent of wireless telegraphy.

ACKNOWLEDGEMENT

The illustrations used in this article have been kindly supplied by The Science Museum, *London*

Ohm Sweet Ohm

Max Fidling

Mouse Trouble

Flicking through some of the many colour prints which were on sale in a local picture-framing gallery, up popped – lo and behold – "*Mouse Trouble*" – a cartoon print from the 1944 *Tom & Jerry* movie of the same name! This immediately struck a chord with my latest death-defying attempts at electronic maintenance, back at the shack.

You see, readers, over the last few months, far from retiring into my workshop never to be heard of again, I have in fact been tussling with technology. What with Pentiums, RAMs, ROMs, floppies, mice, software, hardware, firmware, liveware, and all that jazz, I fear I have joined the ranks of my babbling computer friends.

Even the most resistant of my friends seem to have got this computer bug too, so eventually I had no choice but to relent and purchase a personal computer. So far, the main benefit has been that I can now print the Boss's shopping lists at 600 dots per inch, in a variety of those typeface things. Somehow, the list is longer, too.

Royal Command

The past few months have seen intense activity *Chez Fidling* because it isn't easy to get to grips with these things if all you've ever known has been a 1947 "Royal" typewriter with sticking letters (or missing altogether – the letter "P" flew off one day) and a ribbon which was permanently stuck at half mast, printing half red, half black as a consequence.

Always one to keep up with the elite, however, the Boss had decided that the Fidlings would join the computer age, and all I had to do was pay for it. The dining room table was thus buried under half a hundredweight of menacing machinery.

Aided by my know-all computer-literate 10-year-old nephew (swine), I had persevered, and eventually I managed to make progress with this word-processing malarkey.

At my command, the printer churned out all sorts of colourful invitations, adverts for the local Women's Institute meetings, not to mention more stuff for the local vicar and his fund-raising activities, notably the Reverend's awe-inspiring *Church Bells Mobile Disco*. Great things, computers.

Rogue Rodent

At least they were until one day, the mouse started to behave in a most unrodent-like way. Try as I might, I could not get the pointer to move on the television screen. It was stuck firmly at the bottom. No amount of cajoling, muttering, threatening it with the cat or anything would free the darn thing. The pointer would not point.

There was nothing in the "Help" screens about *Pointers, Sticking*. There was nothing for it, I would have to operate on the deceased mouse using my trusty multi-purpose colour coded screwdriver set, which was always poised above the bench in the shack, ready for action. So Piddles the cat and I skittered down the garden path and into the workshop, accompanied by the said Sticking Mouse.

On the underside of the dead mouse were some screws - nothing high-tech about that, I thought! – and so these were off in a twirl. Typically, one of them rolled onto the floor and under the bench never to be seen again, but there was nothing wrong that a big self-tapping screw wouldn't cure, I told the cat, as I proceeded to dissect the electronic, decidely-dead mouse.

The fault soon became apparent, because the innards were glued solid with what resembled dried marmalade, probably a souvenir from the breakfast table! A quick polish with a soggy rag soon removed the desiccated condiment.

Blasted Mouse!

This left me with the problem of how to dry out the soggy mouse, as I twirled the rotating innards freely, waiting for inspiration. *No problem!* I told Piddles, who was munching a rubbery marshmallow (our favourite candy) on the floor. I spotted my can of Air Duster, which was used mainly for knocking bluebottles and wasps senseless and splatting them on the window during these summer months.

I grabbed the can, and gave the mouse a quick blast. The innards rotated gratifyingly, as I squirted the opto-isolator slotted wheels a bit more. They whizzed round at a dizzying speed, though Piddles, who'd seen it all before, was duly unimpressed. One more blast for luck, I thought, and I jabbed the button hard down!

This produced an awe-inspiring jet of gas of supersonic proportions which obviously caught the electronic rodent unawares – as it blasted the mouse clean out of my hand and smacked it against the wall behind the bench!

The mouse fell to the bench with a clatter, looking decidedly the worse for wear. Holding it up by its cable, I tutted as I picked over its broken circuit board with my screwdriver. So much for computer technology! Now, where's my hot melt glue gun and 100W soldering iron?

VIDEOS ON ELECTRONICS

A range of videos selected by EPE and 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.

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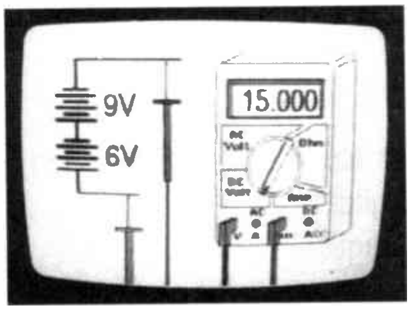

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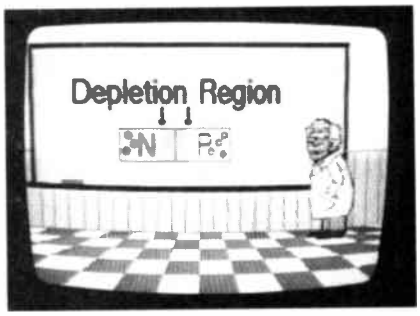

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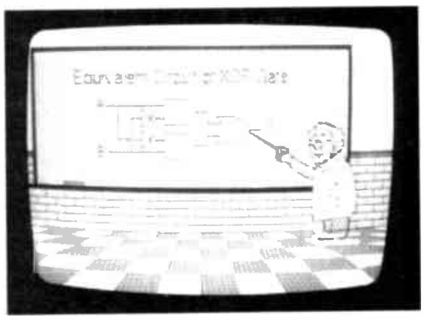

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INTRODUCING MICROPROCESSORS
Mike Tooley B.A. (published by *Everyday Practical Electronics*)
A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc.

Sections cover Microcomputer Systems, Microprocessors, Memories, Input/Output, Interfacing and Programming. There are various practical assignments and eight Data Pages covering popular microprocessors.

And excellent introduction to the subject even for those who do not wish to take the City and Guilds assessment.

80 pages **Order code TI-88/89** **£2.45**

ELECTRONICS TEACH-IN No.6
DESIGN YOUR OWN CIRCUITS
(published by *Everyday Practical Electronics*)
Mike Tooley B.A.
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 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 **Order code TI6** **£3.45**

TEACH-IN No. 7, plus FREE SOFTWARE
ANALOGUE AND DIGITAL ELECTRONICS COURSE
(published by *Everyday Practical Electronics*)
Alan Winstanley and Keith Dye B.Eng(Tech)AMIEE
This highly acclaimed *EPE 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 DISKC 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 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.

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ELECTRONIC PROJECTS BOOK 1
(published by *Everyday Practical Electronics* in association with Magenta Electronics)
Contains twenty projects from previous issues of *EE* each backed with a kit of components. The projects are: Seashell Sea Synthesizer, 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, Mainstester 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 **Order code EP1** **£2.45**

RADIO / TV / VIDEO

ELECTRONIC PROJECTS FOR VIDEO ENTHUSIASTS
R. A. Penfold
This book provides a number of practical designs for video accessories that will help you get the best results from your camcorder and VCR. All the projects use inexpensive components that are readily available, and they are easy to construct. Full construction details are provided, including stripboard layouts and wiring diagrams. Where appropriate, simple setting up procedures are described in detail; no test equipment is needed.

The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.

109 pages **Order code BP356** **£4.95**

SETTING UP AN AMATEUR RADIO STATION
I. D. Poole
The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.

Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

An essential addition to the library of all those taking their first steps in amateur radio.

86 pages **Order code BP300** **£3.95**

EXPERIMENTAL ANTENNA TOPICS
H. C. Wright
Although nearly a century has passed since Marconi's first demonstration or radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour.

The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc. These materials are, in general, cheap to obtain and easily worked with simple tools, encouraging the trial-and-error philosophy which leads to innovation and discovery.

Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.

72 pages **Order code BP278** **£3.50**

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E. M. Noll
Many people live in flats and apartments or other types of accommodation where outdoor aerials are prohibited, or a lack of garden space etc. prevents aerials from being erected. This does not mean you have to forgo shortwave listening, for even a 20-foot length of wire stretched out along the skirting board of a room can produce acceptable results. However, with some additional effort and experimentation one may well be able to improve performance further.

This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers.

Much information is also given on shortwave bands, aerial directivity, time zones, dimensions etc.

50 pages **Order code BP136** **£1.75**

PROJECT COSTRUCTION

TEST EQUIPMENT CONSTRUCTION
R. A. Penfold
This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

The following designs are included:–

AF Generator, Capacitance Meter, Test Bench Amplifier, AF Frequency Meter, Audio Mullivoltmeter, Analogue Probe, High Resistance Voltmeter, CMOS Probe, Transistor Tester, TTL Probe.

The designs are suitable for both newcomers and more experienced hobbyists.

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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 slected. 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 BP285** **£4.99**

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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 BP121** **£2.50**

AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold
The purpose of this book is to provide the reader with a wide range of preamplifier and power amplifier designs that will, it is hoped, cover most normal requirements.

The preamplifier circuits include low noise microphone and RIAA types, a tape head preamplifier, a guitar preamplifier and various tone controls. The power amplifier designs range from low power battery operation to 100W MOSFET types and also include a 12 volt bridge amplifier capable of giving up to 18W output.

All the circuits are relatively easy to construct using the p.c.b. or stripboard designs given. Where necessary any setting-up procedures are described, but in most cases no setting-up or test gear is required in order to successfully complete the project.

100 pages **Temporarily out of print**

DESIGN YOUR OWN CIRCUITS
See ELECTRONICS TEACH IN No 6 above left.

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Owen Bishop
Explains electronic control theory in simple, non-mathematical terms and is illustrated by 30 practical designs suitable for the student or hobbyist to build. Shows how to use sensors as input to the control system, and how to provide output to lamps, heaters, solenoids, relays and motors.

Computer based control is explained by practical examples that can be run on a PC. For stand-alone systems, the projects use microcontrollers, such as the inexpensive and easy-to-use Stamp BASIC microcontroller. These projects are chosen to introduce and demonstrate as many aspects as possible of the programming language and techniques.

198 pages **Order code BP377** **£5.99**

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B. B. Babani
A complete book for the home constructor on "how to make" RF, IF, audio and power coils, chokes and transformers. Practically every possible type is discussed and calculations necessary are given and explained in detail. Although this book is now twenty years old, with the exception of toroids and pulse transformers little has changed in coil design since it was written.

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R. M. Marston
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R. A. Penfold
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A BEGINNERS GUIDE TO CMOS DIGITAL ICs
R. A. Penfold
Getting started with logic circuits can be difficult, since many of the fundamental concepts of digital design tend to seem rather abstract, and remote from obviously useful applications. This book covers the basic theory of digital electronics and the use of CMOS integrated circuits, but does not lose sight of the fact that digital electronics has numerous "real world" applications.

The topics covered in this book include: the basic concepts of logic circuits; the functions of gates, inverters and other logic "building blocks"; CMOS logic i.c. characteristics, and their advantages in practical circuit design; oscillators and monostables (timers); flip/flops, binary dividers and binary counters; decade counters and display drivers.

The emphasis is on a practical treatment of the subject, and all the circuits are based on "real" CMOS devices. A number of the circuits demonstrate the use of CMOS logic i.c.s in practical applications.

119 pages **Order code BP333** **£4.95**

AUDIO AND MUSIC

INTRODUCTION TO DIGITAL AUDIO (Second Edition)
Ian Sinclair
Digital recording methods have existed for many years and have become familiar to the professional recording engineer, but the compact disc (CD) was the first device to bring audio methods into the home. The next step is the appearance of digital audio tape (DAT) equipment.

All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.

This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product.

128 pages **Order code PC102** **£7.95**

PROJECTS FOR THE ELECTRIC GUITAR
J. Chatwin
This book is for anyone interested in the electric guitar. It explains how the electronic functions of the instrument work together, and includes information on the various pickups and transducers that can be fitted. There are complete circuit diagrams for the major types of instrument, as well as a selection of wiring modifications and pickup switching circuits. These can be used to help you create your own custom wiring.

Along with the electric guitar, sections are also included relating to acoustic instruments. The function of specialised piezoelectric pickups is explained and there are detailed instructions on how to make your own contact and bridge transducers. The projects range from simple preamps and tone boosters, to complete active controls and equaliser units.

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R. A. Penfold
This book provides practical circuits for a number of electronic musical effects units. All can be built at relatively low cost, and use standard, readily available components. The projects covered include: Waa-Waa Units; Distortion Units; Phaser; Guitar Envelope Shaper; Compressor; Tremolo Unit; Metal Effects Unit; Bass and Treble Boosters; Graphic Equaliser; Parametric Equaliser. The projects cover a range of complexities, but most are well within the capabilities of the average electronics hobbyist. None of them require the use of test equipment and several are suitable for near beginners.

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Vivan Capel
This book contains all that a working musician needs to know about loudspeakers; the different types, how they work, the most suitable for different instruments, for cabaret work, and for vocals. It gives tips on constructing cabinets, wiring up, when and where to use wadding, and when not to, what fittings are available, finishing, how to ensure they travel well, how to connect multi-speaker arrays and much more.

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For a further selection of books see next month's issue.

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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. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749; Fax 01202 841692 (NOTE, we cannot reply to orders or queries by Fax); E-mail: editorial@epemag.wimborne.co.uk** . 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.

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PROJECT TITLE		Order Code	Cost
* EPE Met Office – Computer Interface (double-sided)	JAN'96	964	£7.69
Audio Signal Generator		969	£6.58
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Analogue Frequency Meter	FEB'96	957	£6.70
Vari-Speed Dice (Teach-In '96)		974	£5.69
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* PIC-Electric Meter – Sensor/PSU–Control/Display		977/978 (pr)	£9.90
Multi-Purpose Mini Amplifier	MAR'96	976	£6.12
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PROJECT TITLE		Order Code	Cost
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Theremin MIDI/CV Interface (double-sided p.t.h.)	FEB'97	130 (set)	£40.00
Pacific Waves		136	£9.00
PsiCom Experimental Controller		137	£6.78
Oil Check Reminder	MAR'97	125	£7.16
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– Interface		148	£5.91
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* PIC-olo		164	£7.02

EPE SOFTWARE

Software programs for the *EPE* projects marked above with an asterisk (*) are available altogether on a *single* 3.5 inch PC-compatible disk, or as needed via our Internet site. The same disk also contains the following additional software: Simple PIC16C84 Programmer (Feb '96). The disk (order as "PIC-disk") is available from the *EPE PCB Service* at £2.75 (UK) to cover our admin costs (the software itself is *free*). Overseas £3.35 surface mail, £4.35 airmail. Alternatively, the files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

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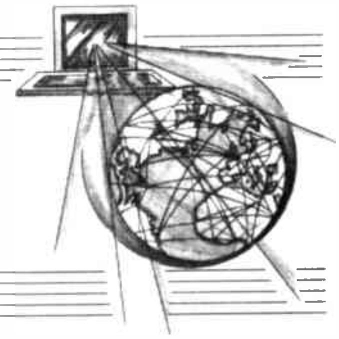
SURFING THE INTERNET

NET WORK



ALAN WINSTANLEY

FTP Et Al!

EPE Net Work is our monthly column which updates readers having Internet access with the latest news about our World Wide Web site (**http://www.epemag.wimborne.co.uk**) and our FTP site (**ftp://ftp.epemag.wimborne.co.uk**). This month's *PIC-olo* project is at **ftp://ftp.epemag.wimborne.co.uk/pub/PICS/PIColo**.

Regular readers will recall last month's large addition to our site in the form of the fully fledged demonstration version of the CD-ROM *Parts Gallery + Electronic Circuits & Components – An Introduction.*

Follow the link on our *Home Page*, or FTP (file transfer protocol) it directly from our FTP site at **/pub/software/eccdemo.exe** (4·2Mb). The demo will be there until the end of August, after which you can fetch it from the site of Matrix Multimedia (**http://www.matrixmultimedia.co.uk**).

With large FTP transfers like this, I prefer the full control of "proper" FTP software as found in my favourite *Procomm for Windows*. The transfer is intelligently handled, in that you can specify a variety of configuration options to cope with any crashes which happen during the transfer.

If, for example, the line drops during an FTP download using *Netscape*, you have to start again from scratch and overwrite the existing file; however, decent FTP software will enable you to carry on where you left off, instead.

The *Net Work* page is the most popular of all our web site pages and something new is the *Net Work A-Z Index* (**../netwkaz.htm**) of all the *Net Worked* links I've provided in the past year. Through the miracle of Windows Cut and Paste, all the URLs to which I've linked are now also available in strict alphabetical order – enough to keep even the most ardent surfer occupied for ages! Remember that I welcome details of any URLs you find interesting yourself.

Junk, and More Junk

You know the feeling as a large window envelope crashes onto your door mat – six lucky numbers visible through an opening, and your name in big letters? Yes, "junk" mail has been a fact of life for many decades, as a myriad of paper passes over your breakfast table en route to the waste paper bin.

Mailing lists are now much more refined and "intelligent" these days, though, and in the UK, one way of cutting down on the latest offers from the *Reader's Digest* and others is to contact the Mailing Preference Service (Freepost 22, London W1E 7EZ, incidentally).

The service is there more to stop direct mailers from wasting their resources sending unwanted mail, rather than trying to preserve your sanity.

While we're on the subject, junk phone calls are also a bane, so try the Telephone Preference Service, 6 Reef House, Plantation Wharf, London, SW11 3UF. Both services will help reduce unsolicited contact from firms you've never dealt with.

If only such a free service were available for Internet users! An interesting comparison: up to 75 per cent of my incoming E-mail at any one time can be unsolicited junk mail. However, my colleagues back at HQ in Wimborne never receive any at all! How so, I wonder? Well, the answer seems to be *Usenet* or *News*.

There are some 25,000 newsgroups available to anyone having the software (an off-line newsreader) capable of "subscribing" to them. News, in spite of its name, has nothing to do with current affairs, bulletins or news flashes. Each newsgroup is a topical chat area and in theory relates to one particular subject which is defined in the newsgroup's charter.

When you think about the millions of E-mail messages openly circulating within newsgroups (and news archives), each message contains something which is a prized commodity in the junk-mailing community – your active E-mail address! Your address is contained in the header of the message, and it may be in the signature (.sig) too. Usenet is scoured by "bots" which are specially trained to sniff out E-mail addresses in news messages circulating the globe.

Junk mail then starts to drift in from nowhere (**nowhere.com**, anyway) – often along the subject lines of "Earn $$$$! Not MLM!" (Multi Level Marketing); "Teach Your Baby To Swim with Our New Video!"; "Sell Cosmetics from home!"; "Cut $$$ from your AT&T Phone Bill!"; "Hi! End all your money worries instantly!!"; and it goes on.

Some Internet Service Providers will suspend the account of any customers who send UCE – Unsolicited Commercial E-mail or bulk E-mail – like this, so the so-called "spammers" who "spam" this garbage across the planet hide behind strange E-mail addresses such as *anybody@nowhere.com*.

It is an American menace, it can be intensely annoying when you're busy dealing with your E-mail, it is likely to get worse, and it costs you connection time and money.

Replying with an expression of your annoyance may be fruitless because of the dummy E-mail address set up by the spammer. In fact, if anything, it just proves that they've hit the target and that your address is indeed active!

The same may be said if you send the standard "Remove" (me from your mailing list) message: you're likely to attract even more junk. The most irritating junk mail is probably that which has a meaningless but intriguing subject – such as "Hi!" or "Hello again!". Some E-mail has been received which is of a deeply offensive and disturbing nature, but this is, thankfully, extremely rare.

Junk mail presently defeats the most refined of kill-file rules, so it's seemingly impossible to block it, though I did notice quite a reduction when I stopped posting to Usenet for a time. Interestingly, Usenet users are increasingly fighting back by forging their own E-mail addresses too; it is not uncommon these days to see a posting by, say, **bob@no.spam.mycompany.com**, thus frustrating any attempt for a mail-bot to send him some junk mail.

Human beings know to remove the "no.spam" from the address if replying by E-mail. Unfortunately, my own version of this ruse is currently unprintable.

Hot Links

Here are this month's selection of notable links – and ready-made for you to click on the *Net Work* page of our web site. Do share any worthwhile electronics sites with us and you'll receive a mention on our web pages.

To tie in with this month's *Circuit Surgery*, don't forget to visit the excellent Varta Batteries site at **http://www.varta.com**. More battery-related info is at Duracell New Products & Technology Division **http://www.duracellnpt.com/techref.d** and **http://www.car-go.com** (Car-Go Inc.)

An on-line US version of the Mailing Preference Service anti-junk E-mail site – which costs US $19·95 to subscribe to – is maintained by Donna Troy Enterprises at **http://www.spnt.com/~d_troy/page2.html**.

E-Lab Digital Engineering Inc. manufacture several highly-functional i.c.s. (they say here) for use by the "electronics design community". More news on **http://www.netins.net/showcase/elab**, worth checking for the Java applet moving l.e.d. display alone!

Information on educational software for teaching electricity and electronics (at $395 per licence), with downloadable demos, can be checked out at **http://etcai.pair.com**. A comprehensive Emulator Page for Spectrum, Commodore C64, BBC, Atari 2600, NES, Sega etc. is at Legion's Emulator Page on **http://www.tcp.co.uk/~legion/emul.htm** whilst an Amiga emulator page is also under construction at Crasher's Home Page **http://www.tcp.co.uk/~marios**.

Sinclair's name pops up again: to find out what a Sinclair ZX80/81 looked like and how to build one out of standard components, you just *must* go to the ZX80/81 Hardware Page at **http://www.babytalk.demon.co.uk/zx80/zx80.html**.

Join me next month for more *Net Work*. My E-mail address is **alan@epemag.demon.co.uk**. My *Home Page* is **http://ourworld.compuserve.com/homepages/alan_winstanley**.

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AUDIO LEAD CHECKER KIT LU26D £19.99
Construction details: Audio Lead Checker Leaflet XZ20W 80p
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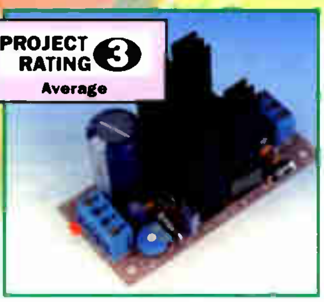

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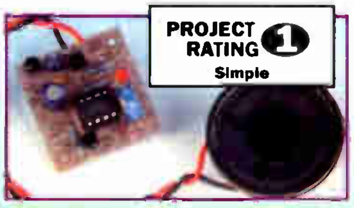
IDEAL FOR:

- Audible warning devices
- Sirens and alarms
- Children's toys

PROJECT RATING 1 Simple



Kit includes all components, PCB, LED, piezo sounder and full instructions. Enclosure, loudspeaker, switch/touch pads, battery, etc., are dependant on user's intended application and therefore not included in the kit.

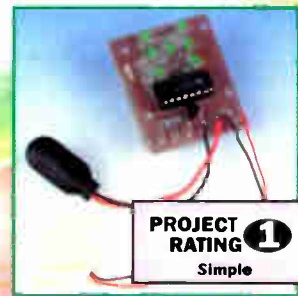
CAR ALARM SIREN KIT LU85G £7.99 USA POLICE SIREN KIT LU88V £7.99
WAILING POLICE SIREN KIT LU89W £7.99
Construction details: Siren Sound Generator Leaflet XZ42V 50p
Issue 112 / April 1997 Electronics & Beyond XD12N £2.25

These kits are:

- Supplied with high-quality fibre-glass PCBs – pre-tinned, with printed legend and solder resist
- Supplied with comprehensive instructions and a constructors' guide
- Covered by the Maplin Get-You-Working Service and 12-month warranty

Kits do not include tools or test equipment. Kits may require additional components or products, depending on application, please refer to construction details or contact the Maplin Technical Support Helpline (Tel: 01702 556001) if in doubt.

ELECTRONIC DICE KIT



PROJECT RATING 1 Simple

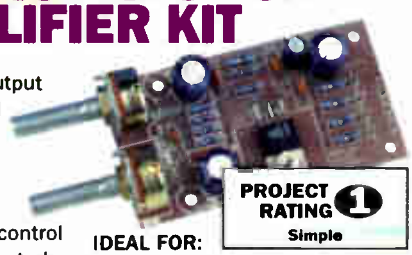
FEATURES:

- Easy to build – ideal beginners' project
- Auto power-off for long battery life
- Low quiescent current (typically 1μA)
- 3V supply voltage (2 x 1.5V cells ideal)
- Touch, switch contact or digital input to 'roll' dice
- 'Rolling dice' sound effect
- Dice can be interlinked for games requiring more than one dice
- EMC / CE Compliant

Kit includes all components, PCB, LEDs, piezo sounder and full instructions. Enclosure, fixing hardware, switch/touch pads, battery, etc., are dependant on user's intended application and therefore not included in the kit.

ELECTRONIC DICE KIT LU78K £7.99
Construction details: Electronic Dice Leaflet XZ43W 50p
Issue 112 / April 1997 Electronics & Beyond XD12N £2.25

VIDEO DISTRIBUTION AMPLIFIER KIT



PROJECT RATING 1 Simple

FEATURES:

- Composite video input/output
- Four outputs as standard
- Units can be cascaded for multiple outputs
- Easy to build and use
- Compact dimensions
- Video gain (0dB to 8dB) control
- HF boost (0dB to 8dB) controls
- Wide bandwidth: 20Hz to 50MHz
- 75Ω or high impedance input
- 75Ω outputs
- Single +12V DC @ 50mA Supply
- EMC / CE Compliant

IDEAL FOR:

- Video signal distribution
- Video dubbing/duplication
- CCTV/Security

Kit includes all components, PCB, potentiometers and full instructions. Enclosure, knobs, coaxial cable, connectors, etc., are dependant on user's intended application and therefore not included in the kit.

VIDEO DISTRIBUTION AMPLIFIER KIT LU79L £14.99
Construction details: Video Distribution Amplifier Leaflet XZ38R 50p
Issue 111 / March 1997 Electronics & Beyond XD11M £2.25

CONTINUITY TESTER KIT

FEATURES:

- Easy to build – ideal beginners' project
- Audible continuity indication
- Can discriminate between semiconductor junctions and 'true short-circuits'
- Compact, lightweight and portable
- Battery powered
- No setting up required
- EMC / CE Compliant

IDEAL FOR:

- Tracing faults on PCBs
- Checking components
- Tracing wiring

PROJECT RATING 1 Simple

Kit includes all components, PCB, box, box label, sockets, wire, speaker, test leads, etc., and full instructions. Requires Alkaline PP3 battery (not included in kit).

CONTINUITY TESTER KIT JA13P £19.99
Construction details: Continuity Tester Leaflet XZ39N 50p
Issue 111 / March 1997 Electronics & Beyond XD11M £2.25

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Or Tel: 01702 554002 for details of your nearest Maplin or Mondo store.
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