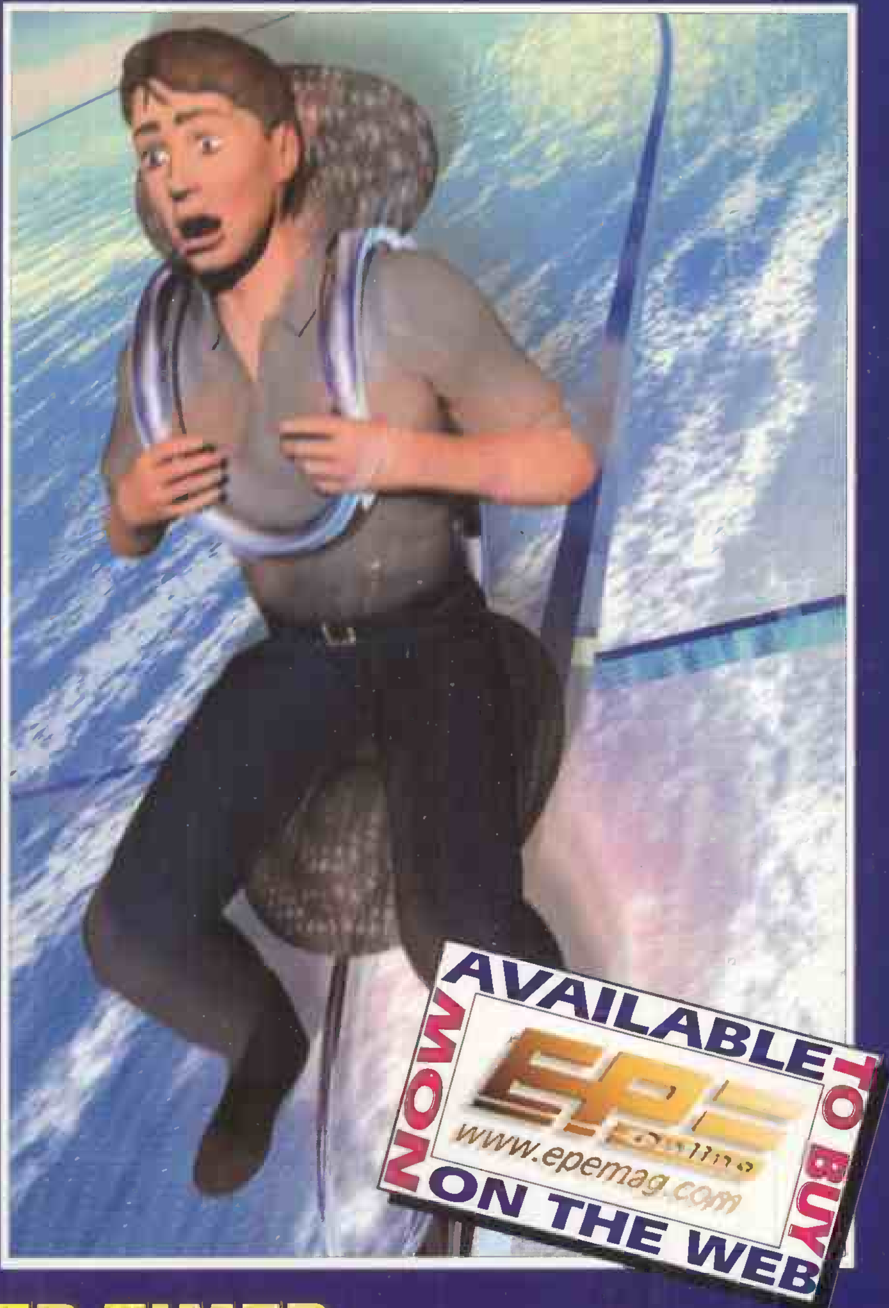
THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EVERYDAY PRACTICAL ELECTRONICS

JULY 2000

INCORPORATING ELECTRONICS TODAY INTERNATIONAL £2.65

g-METER
Measure the forces your body endures



PIC-GEN
PIC controlled Frequency Generator and Counter

Starter Project

CAMERA SHUTTER TIMER
Simple but accurate tester

PLUS

Ingenuity Unlimited

Circuit Surgery • News

http://www.epemag.wimborne.co.uk

12v 18Ah SEALED LEAD ACID BATTERIES, new and boxed, unused pack of 4 £39.95 ref CYC7 or £15 each ref CYC6

AUTOMATIC CHARGER For the above batteries, charges 2 at once, charge level indicator circuitry, 6 hour charge. £10 ref CYC8

A new range of 12v to 240v INVERTERS

IV400S (400 watt) £89

IV800S (800watt)£159

IV1200S (1200 watt) £219

ECG MACHINES?/6v 10AH BATTS/24V 8A TX Ex government ECG machines! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear including video out etc. On the front panel are two DIN sockets for connecting the body sensors to. Sensors not included, Inside 2 x 6v 10AH lead acid batts (not in good condition), pcb's and a 8A? 24v torroidial transformer (mains in). sold as seen, may have one or two broken knobs etc due to poor storage £15.99 ref VP2

SODIUM LAMP SYSTEMS £75.70 **Complete system with 250w or 400watt SON-T Agro bulb, reflector with bulb holder and remote ballast and starter(uncased) all you need is wire. 250W system ref SLS1, 400W system SLS2.**

PC SUPPORT HANDBOOK **The ultimate technical guide to building and maintaining PC's. Over 460 A4 pages packed with technical data and diagrams just £10 ref PCBK. If you want 4 copies for £33 ref PCBK2. Also available is a CD packed with diagnostic programmes to use with the book £5 ref PCBK1**

D SIZE NICADS **Tagged, 1200mA, 1.2v pack of 4 for £6 ref CYC9 or as a pack of 24 for £22 ref CYC10**

D SIZE SEALED LEAD ACID BATTERIES 2v 2.5ah rechargeable sealed lead acid battery made by Cyclon 60x45mm (standard D size) supplied as a pack of 12 or 20 giving you options for battery configerations eg 12v at 5ah, 24v at 2.5ah, 6v at 10ah. These batteries are particularly useful in that you can arrange them in your project to optimise space etc (eg boat ballast etc) Pack of 12 £10 ref CYC4, pack of 20 £16 ref CYC5

HYDROPONICS DO YOU GROW YOUR OWN? We have a full colour hydroponics catalogue available containing nutrients, pumps, fittings, enviromental control, light fittings, plants, test equipment etc Ring for your free copy.

PC COMBINED UPS AND PSU The unit has a total power of 292 watts, standard mother board connectors and 12 peripheral power leads for drives etc. Inside is 3 12v 7.2aH sealed lead acid batteries. Backup time is 8 mins at full load or 30 mins at half load. Made in the UK by Magnum, 110 or 240vac input, +5v at 35A, -5v at .5A, +12v at 9A, -12v at .5A outputs. 170x260x220mm, new and boxed £29.95 Ref PCUPS2

ALTERNATIVE ENERGY CD, PACKED WITH HUNDREDS OF ALTERNATIVE ENERGY RELATED ARTICLES, PLANS AND INFORMATION ETC £14.50 REF CD56

AERIAL PHOTOGRAPHY KIT This rocket comes with a built in camera! it flies up to 500 feet (150 m) turns over, and takes an aerial photograph of the ground below. The rocket then returns with its film via its paracute. Takes 110 film. Supplied complete with everything including a launch pad and 3 motors (no film) £29.98 ref astro

PROJECT BOXES Another bargain for you are these smart ABS project boxes, smart two piece screw together case measuring approx 6"x5"x2" complete with panel mounted LED. Inside you will find loads of free bits, tape heads, motors, chips resistors, transistors etc. Pack of 20 £19.95 ref MD2

TELEPHONES Just in this week is a huge delivery of telephones, all brand new and boxed. Two piece construction - Illuminated keypad, tone or pulse (switchable), recall, redial and pause, high/low and off ringer switch and quality construction. Off white colour and is supplied with a standard international lead (same as US or modems) if you wish to have a BT lead supplied to convert the phones these are £1.55 each ref BTLX **Phones £4.99 each ref PH210 off £30 ref SS2**

3HP MAINS MOTORS Single phase 240v, brand new, 2 pole, 340x180mm, 2850 rpm, builtin automatice reset overload protector, keyed shaft (40x16mm) Made by Leeson. £99 each ref LEE1

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

CHIEFTAN TANK DOUBLE LASERS 9 WATT+3 WATT+LASER OPTICS Could be adapted for laser listener, long range comms etc Double beam units designed to fit in the barrel of a tank, each unit has 2 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 freq. The units also contain a receiver to detect reflected signals from targets. £99 Ref LOT4.

MAGNETIC CREDIT CARD READERS AND ENCODING MANUAL £9.95 Cased with flyleads, designed to read standard credit cards! complete with control elctronics 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

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

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

BRAND NEW MILITARY ISSUE DOSE METERS Current NATO issue Standard emergency services unit Used by most of the worlds Military personel New and boxed Normal retail price £400, BULLS bargain price just £99 The PDRM 82 M is a portable, lightweight, water resistant gamma radiation survey meter to measure radiological dose rate in the range 0.1to 300 centigrays per hour in air. The Geiger Muller (G.M.) tube detecting unit is energy and polar response corrected. The radiation level is displayed on a Liquid Crystal Display. The microcomputer corrects for the non-linearity of the G.M. tube response. The Instrument is powered by three international C size batteries giving typically 400 hours operation in normal conditions. The dose rate meter PDRM 82M, designed and selected for the United Kingdom Government, has been fully evaluated to satisfy a wide range of environmental conditions and is nuclear hard. The construction enables the instrument to be easily decontaminated. The instrument is designed for radiation surveys for post incident monitoring. Used in a mobile role, either carried by troops or in military vehicles for rapid deployment enabling radiation hot spots to be quickly located. Range 0 - 300 cGy/h in 0.1 cGy/h increments. Over-range to 1500 cGy/h - Indicates flashing 300. Accuracy f20% of true dose rate +0.1 cGy/h, 0 - 100 cGy/h. f30% of true dose rate, 100 - 300 cGy/h. Energy Response 0.3 MeV to 3 MeV - within f20% (Ra 226). 80 KeV to 300 KeV - within i40% (Ra 226). Detector Energy compensated Halogen quenched Geiger Muller Tube. Controls Combined battery access and ON/ OFF switch. Batteries 3 International standard C cells. Weight 560 grms. Operating Temperature Range -30deg C to +60 degC. Indications High contrast 4 digit LCD. Battery low indication Dose rate Rising/Falling £99 ref PDRM.

Hydrogen fuel cells **Our new Hydrogen fuel cells are 1v at up tp 1A output, Hydrogen input, easily driven from a small electrolosis assembly or from a hydrogen source, our demo model uses a solar panel with the output leads in a glass of salt water to produce the hydrogen! Each cell is designed to be completely taken apart, put back together and expanded to what ever capacity you like, (up to 10 watts and 12v per assembly. Cells cost £49 ref HFC11**

PHILIPS VP406 LASER DISC PLAYERS, SCART OUTPUT, JUST PUT YOUR VIDEO DISK IN AND PRESS PLAY, STANDARD AUDIO AND VIDEO OUTPUTS,. £14.95 REF VP406

SMOKE ALARMS Mains powered, made by the famous Gent company, easy fit next to light fittings ,power point. Pack of 5 £15 ref SS23, pack of 12 £24 ref SS24

4AH D SIZE NICADS pack of 4 £10 ref 4AHPK

SENDER KIT Contains all components to build a A/V transmitter complete with case £35 ref VSXX2

10 WATT SOLAR PANEL Amorphous silicon panel fitted in a anodized aluminium frame. Panel measures 3' by 1' with screw terminals for easy connection. . **3' x 1' solar panel £55 ref MAG45**

12V SOLAR POWERED WATER PUMP Perfect for many 12v DC uses. from solar fountains to hydroponics! Small and compact yet powerful,works direct from our 10 watt solar panel in bright sun. Max hd:l7 ft Max flow = 8 Lpm,1 .5A Ref AC8 £18.99

SOLAR ENERGY BANK KIT **50x 6"x12" 6v solar panels(amorphous)+50 diodes £99 ref EF112**

PINHOLE CAMERA MODULE WITH AUDIO! Superb board camera with on board sound! extra small just 28mm square (including microphone) ideal for covert surveillance. Can be hidden inside anything , even a matchbox! Complete with 15 metre cable, psu and tv/vcr connnectors. £49.95 ref CC6J

SOLAR MOTORS Tiny motors which run quite happily on voltages from3-12vdc. Works on our 6v amorphous 6" panels and you can run them from the sun! 32mm dia 20mm thick. £1.50 each

WALKIE TALKIES 1 MILE RANGE £37/PAIR REF MAG30

LIQUID CRYSTAL DISPLAY Bargain prices, 40 character 1 line 154x16mm £6.00 ref SMC4011A

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

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

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

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

MINATURE TOGGLE SWITCHES These top quality Japanese panel mount toggle switches measure 35x13x12mm, are 2 pole changeover and will switch 1A at 250vac, or 3 A at 125vac. Complete with mounting washers and nuts. Supplied as a box of 100 switches for £29.95 ref SWT35 or a bag of 15 for £4.99 ref SWT34

VOICE CHANGERS Hold one of these units over your phone mouth piece an you can adjust your voice using the controls on the unit! Battery operated £15 ref CC3

BULL ELECTRICAL

250 PORTLAND ROAD, HOVE, SUSSEX . BN3 5QT. (ESTABLISHED 50 YEARS).

MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £4.00 P&P PLUS VAT.

24 HOUR SERVICE £6.50 PLUS VAT.

OVERSEAS ORDERS AT COST PLUS £3.50

(ACCESS, VISA, SWITCH, AMERICAN EXPRESS)

'phone orders : 01273 203500

FAX 01273 323077

Sales@bull-electrical.com

30 WATTS OF SOLAR POWER for just £69, 4 panels each one 3'x1' and producing 8w, 13v. PACK OF FOUR £69 ref SOLX

200 WATT INVERTERS plugs straight into your car cigarette lighter socket and is fitted with a 13A socket so you can run your mains operated devices from your car battery. £49.95 ref SS66

THE TRUTH MACHINE Tells if someone is lying by micro tremors in their voice, battery operated, works in general conversation and on the 'phone and TV as well! £42.49 ref TD3

INFRA RED FILM 6" square piece of flexible infra red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infra red output only using standard light bulbs Easily cut to shape. 6" square £15 ref IRF2

33 KILO LIFT MAGNET Neodynium,32mm diameter with a fixing bolt on the back for easy mounting. Each magnet will lift 33 kilos, 4 magnets bolted to a plate will lift an incredible 132 kilos! £15 ref MAG33 Pack of 4 just £39 reg MAG33AA

HYDROGEN FUEL CELL PLANS Loads of information on hydrogen storage and production. Practical plans to build a Hydrogen fuel cell (good workshop facilities required) £8 set ref FCP1

STIRLING ENGINE PLANS Interesting information pack covering all aspects of Stirling engines, pictures of home made engines made from an aerosol can running on a candle! £12 ref STIR2

ENERGY SAVER PLUGS Saves up to 15% electricity when used with fridges,motors up to 2A,light bulbs,soldering irons etc. £9 ea ref LOT71, 10 pack £69 ref LOT72.

12V OPERATED SMOKE BOMBS Type 3 is a 12v trigger and 3 smoke cannisters, each cannister will fill a room in a very short space of time! £14.99 ref SB3. Type 2 is 20 smaller cannisters (suitable for mock equipment fires etc) and 1 trigger module for £29 ref SB2 Type 1 is a 12v trigger and 20 large cannisters £49 ref SB1

HI POWER ZENON VARIABLE STROBES Useful 12v PCB fitted with hi power strobe tube and control electronics and speed control potentiometer. Perfect for interesting projects etc 70x55mm 12vdc operation. £6 ea ref FLS1, pack of 10 £49 ref FLS2

NEW LASER POINTERS 4.5mw, 75 metre range, hand held unit runs on two AA batteries (supplied) 670nm. £29 ref DEC49J

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. £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.

IR LAMP KIT Suitable for cctv cameras, 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&r earwaveguides, 1.1"x2.7"x4.6" fits on visor or dash £149

LOPTX Made by Samsung for colour TV £3 each ref SS52

LAPTOP LCD SCREENS 240x175mm, £12 ref SS51

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

ELECTRONIC SPEED CONTROLLER KIT For the above motor is £19 ref MAG17. Save £5 if you buy them both together, 1 motor plus speed controller rrp is £41, offer price £36 ref MOT5A

INFRA RED REMOTE CONTROLS made for TV's but may have other uses pack of 100 £39 ref IREM

RCB UNITS Inline IEC lead with fitted RC breaker. Installed in seconds. Pack of 3 £9.98 ref LOT5A

On our web sites you can

1. Order online.
2. Check your premium bonds.
3. Enter our auction or build your own.
4. Add E-commerce to your own site.
5. Discover our software site, optical site, hydroponics site, holiday home exchange site, inkjet site, hotels site.
6. View our web camera.
7. Invest in our future.

http://www.bullnet.co.uk

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

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

STEPPER MOTORS Brand new stepper motors, 4mm fixing holes with 47.14mm fixing centres, 20mm shaft, 6.35mm diameter, 5v/phase, 0.7A/phase, 1.8 deg step (200 step) Body 56x36mm. £14.99 ea ref STEP6, pack of 4 for £49.95. PIC based variable speedcontroller kit £15 ref STEP7

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

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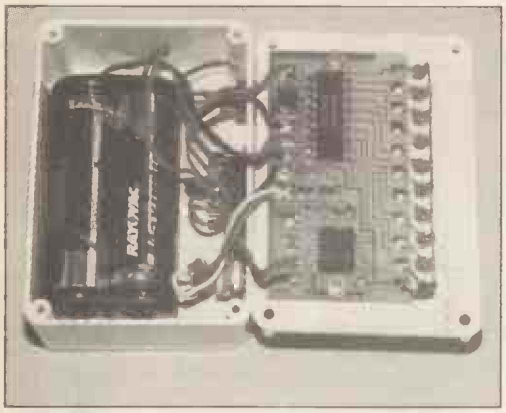
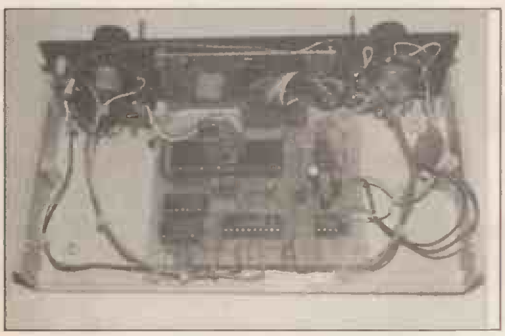


Projects and Circuits

Series and Features

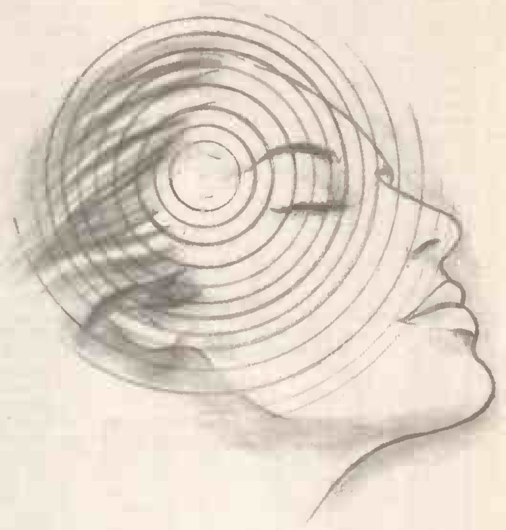


Regulars and Services

Our August 2000 issue will be published on Friday, 7 July 2000. See page 483 for details

NEXT MONTH

EPE MOODLOOP



Various ways of encouraging the brain to generate specific electrical frequencies exist, one of which is exposure to a suitable alternating magnetic field. Opinions on how this works vary, but one likely method seems quite simple. An alternating magnetic field induces electrical currents in conductive material within range and brain tissue is such a conductor. It seems likely that the production of weak currents of suitable frequency within the brain will either tend to produce the desired mental state directly, or it may do so by encouraging the brain to "synchronise" to the frequency. Either way, the effect is one many people find worthwhile as shown by the interest in the two projects published so far in EPE*.*
Both of these produce tiny localised magnetic fields. This one represents an attempt to increase the effect by delivering a much larger current into an inductive loop system which may be placed right around a small room (or around a bed in the case of insomnia!) to permeate a whole area with the desired field. Roughly speaking, it can saturate an area of up to four metres square with a field of intensity equal to that of one of the previous designs at a range of about three centimetres. This should be sufficient for the most ardent enthusiast of the system.

New Series

TOP TENNERS

This short collection of projects, some useful, some instructive and some amusing, can be made for around the ten pounds mark. The estimated cost does not include an enclosure, for many of them work just as well as an open board.
All of the projects are built on stripboard, and have been designed to fit on to boards of standard dimensions. All of the projects are battery-powered, so are safe to build.

DOOR PROTECTOR

Our first Top Tenner *is a simple* Door Protector*. Even if you already have a system installed in your home or workplace, there is likely to be a use for this project. With any security system, or even with none, it is important that all doors and windows should be protected by bolts, bars, grids or other physical means. Unfortunately, there is nearly always one weak point. This is the Exit Door, the door by which you normally leave the house when you are going out. This unit will provide timed entry and exit whilst protecting this or any other door or window.*

HANDY AMP

This easy to build "bench" amplifier has an in-built loudspeaker, it also has the facility for connecting personal stereo type headphones or an external loudspeaker. It will accept both high-level and low-level input devices. Magnetic record player cartridges and dynamic microphones provide a low-level output while the "line output" socket fitted to many pieces of consumer equipment (such as compact disc players and video recorders) provide a high level.
Many readers will, no doubt, wish to construct the amplifier for experimental and test purposes. However, it could have a variety of other applications. Examples include a small practice amplifier for electronic musical instruments and as the basis for an intercom or toys and games. Being battery-operated, it may be set up outdoors and, with just a microphone (possibly with an extension lead) and a pair of headphones connected, it could be used to listen to wildlife etc.

PLUS: ALL THE REGULAR FEATURES

NO ONE DOES IT BETTER

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INCORPORATING ELECTRONICS TODAY INTERNATIONAL

DON'T MISS AN ISSUE – PLACE YOUR ORDER NOW!
Demand is bound to be high

AUGUST ISSUE ON SALE FRIDAY, JULY 7

SIMPLE PIC PROGRAMMER

INCREDIBLE LOW PRICE! **Kit 857 £12.99**

INCLUDES 1-PIC16F84 CHIP SOFTWARE DISK, LEAD CONNECTOR, PROFESSIONAL PC BOARD & INSTRUCTIONS

Power Supply £3.99

EXTRA CHIPS:
PIC 16F84 £4.84

Based on February '96 EPE. Magenta designed PCB and kit. PCB with 'Reset' switch, Program switch, 5V regulator and test L.E.D.s, and connection points for access to all A and B port pins.

PIC 16C84 DISPLAY DRIVER

INCLUDES 1-PIC16F84 WITH DEMO PROGRAM SOFTWARE DISK, PCB, INSTRUCTIONS AND 16-CHARACTER 2-LINE **LCD DISPLAY**

Kit 860 £19.99

Power Supply £3.99

FULL PROGRAM SOURCE CODE SUPPLIED – DEVELOP YOUR OWN APPLICATION!

Another super PIC project from Magenta. Supplied with PCB, industry standard 2-LINE × 16-character display, data, all components, and software to include in your own programs. Ideal development base for meters, terminals, calculators, counters, timers – Just waiting for your application!

PIC 16F84 MAINS POWER 4-CHANNEL CONTROLLER & LIGHT CHASER

- WITH PROGRAMMED 16F84 AND DISK WITH SOURCE CODE IN MPASM
- ZERO VOLT SWITCHING MULTIPLE CHASE PATTERNS
- OPTO ISOLATED 5 AMP OUTPUTS
- 12 KEYPAD CONTROL
- SPEED/DIMMING POT.
- HARD-FIRED TRIACS

Now features full 4-channel chaser software on DISK and pre-programmed PIC16F84 chip. Easily re-programmed for your own applications. Software source code is fully 'commented' so that it can be followed easily.

Kit 855 £39.95

LOTS OF OTHER APPLICATIONS

PIC TOOLKIT V1

• PROGRAMS PIC16C84 and 16F84 • ACCEPTS TASM AND MPASM CODE
Full kit includes PIC16F84 chip, top quality p.c.b. printed with component layout, turned-pin PIC socket, all components and software*
*Needs QBASIC or QUICKBASIC

KIT 871 . . . £13.99 Built and tested **£21.99**

PhizzyB

ALL PARTS FOR SERIES INCLUDING PCBs, PROGRAMMED CHIP, CD-ROM AND DISPLAYS

MAIN BOARD – FULL KIT	£131.95	BUILT	£149.95
I/O PORT KIT	£16.99	BUILT	£24.99
L.C.D.	£12.49	POWER SUPPLY	£3.99
8-BIT SWITCH/LATCH	£7.95	INT. MODULE.	£10.45

68000 DEVELOPMENT AND TRAINING KIT

KIT 621
£99.95

- NEW PCB DESIGN
- 8MHz 68000 16-BIT BUS
- MANUAL AND SOFTWARE
- 2 SERIAL PORTS
- PIT AND I/O PORT OPTIONS
- 12C PORT OPTIONS

• ON BOARD 5V REGULATOR
• PSU £6.99
• SERIAL LEAD £3.99

Mini-Lab & Micro Lab Electronics Teach-In 7

As featured in *EPE* and now published as Teach-In 7.
All parts are supplied by Magenta.
Teach-In 7 is £3.95 from us or EPE
Full Mini Lab Kit – £119.95 –
Power supply extra – £22.55
Full Micro Lab Kit – £155.95
Built Micro Lab – £189.95

EPE PIC Tutorial

At last! A Real, Practical, Hands-On Series

- **Learn Programming from scrach using PIC16F84**
- **Start by lighting l.e.d.s and do 30 tutorials to Sound Generation, Data Display, and a Security System.**
- **PIC TUTOR Board with Switches, l.e.d.s, and on board programmer**

PIC TUTOR BOARD KIT

Includes: PIC16F84 Chip, TOP Quality PCB printed with Component Layout and all components* (*not ZIF Socket or Displays). Included with the Magenta Kit is a disk with Test and Demonstration routines.

KIT 870 .... £27.95, Built & Tested £42.95

Optional: **Power Supply – £3.99, ZIF Socket – £9.99**
LCD Display .... £7.99 LED Display £6.99
Reprints Mar/Apr/May 98 – **£3.00 set 3**

PIC TOOLKIT V2

- SUPER UPGRADE FROM V1 • 18, 28 AND 40-PIN CHIPS
- READ, WRITE, ASSEMBLE & DISASSEMBLE PICS
- SIMPLE POWER SUPPLY OPTIONS 5V-20V
- ALL SWITCHING UNDER SOFTWARE CONTROL
- MAGENTA DESIGNED PCB HAS TERMINAL PINS AND OSCILLATOR CONNECTIONS FOR ALL CHIPS
- INCLUDES SOFTWARE AND PIC CHIP

KIT 878 . . . £22.99 with 16F84 . . . £29.99 with 16F877

SUPER PIC PROGRAMMER

- READS, PROGRAMS, AND VERIFIES
- WINDOWS® SOFTWARE
- PIC16C6X, 7X, AND 8X
- USES ANY PC PARALLEL PORT
- USES STANDARD MICROCHIP • HEX FILES
- OPTIONAL DISASSEMBLER SOFTWARE (EXTRA)
- PCB, LEAD, ALL COMPONENTS, TURNED-PIN SOCKETS FOR 18, 28, AND 40 PIN ICs

• SEND FOR DETAILED INFORMATION – A SUPERB PRODUCT AT AN UNBEATABLE LOW PRICE.

Kit 862 £29.99

Power Supply £3.99

DISASSEMBLER SOFTWARE £11.75

PIC STEPPING MOTOR DRIVER

INCLUDES PCB, PIC16F84 WITH DEMO PROGRAM, SOFTWARE DISC, INSTRUCTIONS AND MOTOR.

Kit 863 £18.99

FULL SOURCE CODE SUPPLIED
ALSO USE FOR DRIVING OTHER POWER DEVICES e.g. SOLENOIDS

Another NEW Magenta PIC project. Drives any 4-phase unipolar motor – up to 24V and 1A. Kit includes all components and 48 step motor. Chip is pre-programmed with demo software, then write your own, and re-program the same chip! Circuit accepts inputs from switches etc and drives motor in response. Also runs standard demo sequence from memory.

8-CHANNEL DATA LOGGER

NEW!

As featured in Aug./Sept. '99 *EPE*. Full kit with Magenta redesigned PCB – LCD fits directly on board. Use as Data Logger *or* as a test bed for many other 16F877 projects. Kit includes programmed chip, 8 EEPROMs, PCB, case and all components.

KIT 877 £49.95 inc. 8 × 256K EEPROMS

MAGENTA

All prices include VAT. Add **£3.00** p&p. Next day **£6.99**

Tel: 01283 565435 Fax: 01283 546932 E-mail: sales@magenta2000.co.uk

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ROUGH MEASUREMENTS

Measuring a change in capacitance of 10^{-18}F or a movement of 0·2 angstroms – about a tenth of an atomic diameter – in a hobbyist project seems to be next to impossible and certainly unthinkable a year or so ago. But with the development of specialist i.c.s such technology is now available to all. Why would we want to measure such small valves, well if you use a mass of just 0·1 micrograms to measure g-force then it is necessary to record movements of this nature.

An i.c. with a two micrometre beam etched into it, along with the necessary detector electronics, forms the basis of our *g-Meter* project this month. When you realise that the whole thing, including the interconnections, is housed in a plastic package measuring just 10mm by 8mm you begin to realise just how far technology has advanced in what was previously an electromechanical device – I suppose it still is, even though it is now etched into a single silicon chip.

Devices like this are what keeps our hobby interesting. One small chip plus a handful of passive devices and some form of readout and you have a fascinating, highly sensitive piece of equipment whose output can also be fed to a data logger or computer for analysis and recording.

When you realise that what you are using is right at the forefront of technology and you can buy this for less than £20 it seems even more amazing. Gone are the days of weights on pendulums or inside bolt-on steel housings, now you can stick your accelerometer on with tape.

BLASÉ

I guess we should not be too surprised since we just accept that a Pentium chip contains seven million active devices, but it always seems to me that miniaturisation of mechanical items of this nature is somehow a greater achievement. Maybe it's because we are so used to electronics getting smaller and smaller that we simply accept it, but find it harder to believe that a pump, gearbox or mechanical beam can be miniaturised in the same way.

Mike Kenward

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Starter Project

CAMERA SHUTTER TIMER

ROBERT PENFOLD

An easy-build project that will check your camera shutter speeds. Four switched ranges up to: 5ms; 50ms; 500ms and 5 seconds.

ALTHOUGH digital cameras have been progressing rapidly in recent years, and most of the photographs in this magazine are now produced without the aid of film, most people are still using traditional cameras. It seems likely that they will continue to do so for some years yet.

The quality of the finished result with traditional photography is dependent on a number of factors. One of these is the accuracy of the shutter, which is particularly important when using certain types of film. There is very little exposure latitude with any form of transparency film, and also with certain negative films.

Modern SLR cameras mostly have electronically timed shutters, and in terms of accuracy they are generally superior to the purely mechanically shutters of older designs. Electronically timed shutters are also less prone to creeping out of adjustment over a period of time, but things can obviously go awry with shutters of either variety.

ON TIME

It is not essential to use a complex digital timer to test camera shutters, and a very basic analogue timer circuit is capable of providing accurate measurements in this application. The simple design featured here has four measuring ranges having full-scale values of 5ms, 50ms, 500ms, and 5 seconds. It can therefore be used to measure the full range of speeds covered by most cameras.

Some of the more modern cameras have manual shutter speeds of up to around 30 seconds or so, which takes the longer shutter speeds beyond the maximum range of this unit. However, these longer shutter times of around 8 seconds to a minute are easily tested using a stopwatch, and do not really need a shutter timer.

Although this unit is primarily designed for testing shutters, it should be possible to modify it for use in some other automatic timing applications. The light level on a sensor going above a certain threshold level activates the timer, but it can also be controlled by switch contacts.

INTEGRATOR

The circuit is based on an operational amplifier (op.amp) connected as an integrator. The basic integrator circuit is shown in Fig.1. Like most basic operational amplifier building blocks an integrator requires dual (positive and negative) supply rails with a central (zero volt) earth rail. The inputs and outputs can therefore have negative as well as positive voltage levels.

An operational amplifier amplifies the voltage difference at its two inputs, and the output voltage is positive if the non-inverting (+) input is at the higher potential. The output voltage is negative if the inverting (–) input is at the higher voltage. The voltage gain is extremely high at d.c. and low frequencies, with a figure of around 200000 being unexceptional.

Under standby conditions the non-inverting (+) input is biased to the 0V rail, and there is no charge on capacitor C_a. A negative feedback action stabilises the inverting input at the 0V bias level fed to the non-inverting input.

If the output was at a positive potential, the coupling through C_a (which has no charge voltage) would take the inverting input positive, unbalancing the input voltages and taking the output negative. With the output at a negative voltage the feedback through C_a again unbalances the input levels, and this time sends the output positive. Any drift in the output voltage is therefore corrected by the feedback.

With a real world op.amp the output will not be stabilised at precisely 0V, since the gain of the amplifier is very high rather than infinite. Also, imperfections in the op.amp's circuit can produce small offset voltages at the output, but in practice any errors are normally very small.

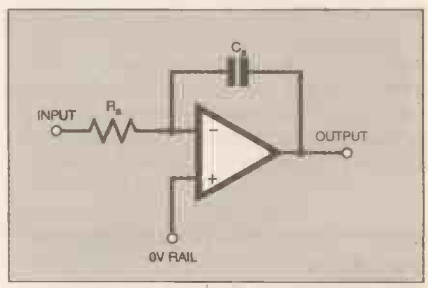


Fig.1. The basic integrator circuit.

ON CHARGE

So far we have only considered the circuit with the input "floating" or at 0V. Suppose that the input is taken a few volts positive. Capacitor C_a then charges through resistor R_a, and the voltage at the inverting input starts to rise.

This sends the output negative in order to keep the inverting input at 0V. As C_a charges, the inverting input remains at 0V and the output of the circuit goes steadily more negative.

The important point to note here is that the voltage across resistor R_a remains constant, and is equal to the input voltage. The current flow through R_a, and therefore the charge current for C_a, is also constant.

If a capacitor is simply charged from a resistor via a voltage source, the voltage rises quickly initially, but then gradually slows down. This is due to the fact that there is initially the full voltage across the resistor, giving a high charge current. As the voltage across the capacitor rises, the voltage across the resistor falls, giving an ever-decreasing charge rate.

The constant current flow into C_a results in the output of the circuit going negative at a linear rate. If the output is at –1V after one second, it will be at –2V after two seconds, –3V after three seconds, and so on.

An integrator is therefore ideal as the basis of a simple timer. It is just a matter of using a voltmeter circuit at the output and adjusting the scaling so that the meter readings are easily converted into times.

SPEED AND SIZE

The block diagram of Fig.2 shows the general scheme of things used in the Camera Shutter Timer project. The integrator drives a moving coil panel meter, with the later directly indicating shutter timers over the four ranges stated previously. Using four input resistors, giving four different charge rates for the capacitor, provides the four ranges.

The integrator is driven from a photodiode or a phototransistor via an electronic switch. It is essential to use a photocell that has a fast response time since most cameras have a faster shutter time of one millisecond or less. Photo-resistors are too slow, but phototransistors and photodiodes have suitably fast response times.

In theory there is some advantage in using a photodiode due to its faster response time. In practice a photodiode seems to provide little improvement in accuracy in this application. Also, a photodiode has the drawback of being far less sensitive than a phototransistor. This design incorporates a simple transistor switching stage to ensure that the integrator receives a proper switching signal whether a photodiode or a phototransistor is used.

On the face of it, the size of the sensor is unimportant, but in this application it is a case of "small is beautiful". The design of mechanical shutters has to take into account the fact that it takes a certain amount of time for the shutter to open and close.

At the slow speeds this factor does not matter because the opening and closing times are very short relative to the shutter time. At the fastest shutter speeds the opening and closing times can actually be longer than the nominal shutter speed. This may seem to be impossible, but all becomes clear when the action of a focal-plane shutter is examined.

CURTAIN CALL

There are two shutter curtains that are made from metal or rubberised cloth. One of the curtains blocks light from the film until the shutter is fired, and then it slides out of the way to one side to expose the film. After the appropriate time, the second curtain moves across the film gate and blocks light from reaching the film again. The two curtains are then pulled back to their original positions, and they move together in such away that light is always blocked from the film. The shutter is then ready to operate again.

As it takes several milliseconds for each curtain to traverse the film gate, the only way of achieving fast shutter speeds is to start the second shutter curtain before the first one has completely moved out of the way. This effectively gives a slit that travels across the film, exposing it a bit at a time. The faster the shutter speed, the narrower the slit is made. Although it may take something like 10 milliseconds for the shutter to complete an exposure, by making the slit narrow enough each part of the film can be exposed for a millisecond or even less.

Here we are measuring the shutter time by having a light source in front of the shutter, and the sensor positioned behind it and quite close to the film plane, see Fig.2. The unit responds to the pulse of light produced when the shutter is fired.

If the sensor has a large diameter its size effectively increases the size of the slit

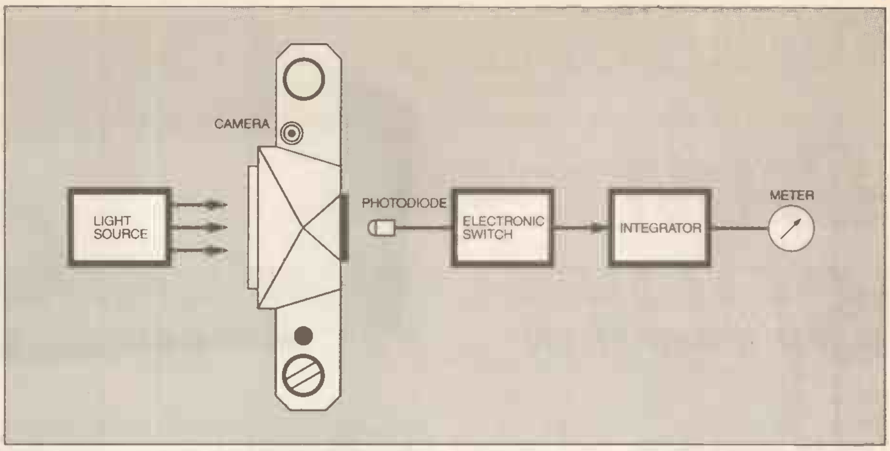
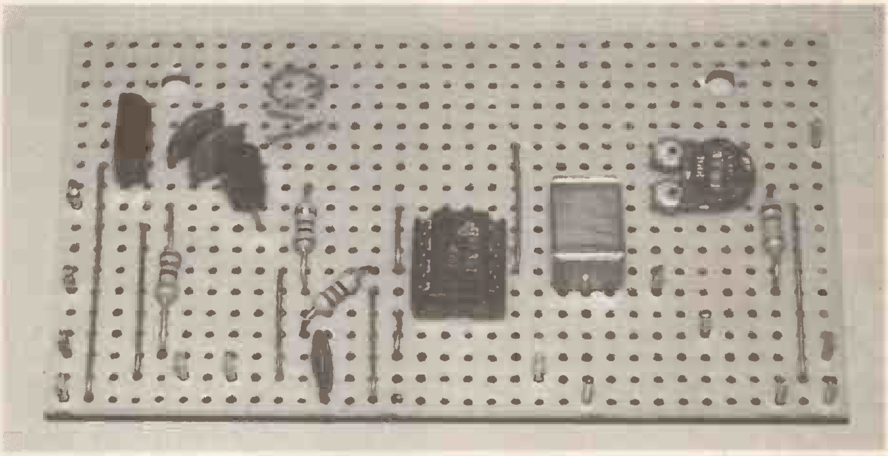


Fig.2. Block schematic diagram for the Camera Shutter Timer.



COMPONENTS

Approx. Cost Guidance Only £12 excluding meter, case, batts.

Resistors

R1	1k	
R2	2k2	
R3	2k7	0·6W 1% metal film
R4	27k	0·6W 1% metal film
R5	270k	0·6W 1% metal film
R6	2M7	0·6W 1% metal film
R7	22Ω	
R8	120k	

All 0·25W 5% carbon film except where noted

See SHOP TALK page

Potentiometers

VR1	220k rotary carbon, lin.
VR2	100k min. carbon preset, horizontal

Capacitors

C1, C2, C4	100n disc ceramic (3 off)
C3	1µ polyester, 10mm lead spacing

Semiconductors

D1	SFH309/5 phototransistor or other small photodiode or phototransistor (see text)
TR1	BC559 *pnp* transistor
IC1	78L05 +5V 100mA voltage regulator
IC2	LF351N b.j.f.e.t. op.amp

Miscellaneous

S1	4-way 3-pole rotary switch (only one pole used)
S2	pushbutton switch, push-to-make, release-to-break
S3	d.p.s.t. min. toggle or rotary switch
ME1	50µA f.s.d. moving coil panel meter
B1, B2	9V battery, PP3 size (2 off)

Metal instrument case, size about 200mm wide; stripboard, 0·1in. matrix 33 holes by 18 copper strips; 8-pin d.i.l. holder; battery connector (2 off); control knob (3 off); screened lead; multistrand connecting wire; single-ended solder pins; solder; M2.5 or 6BA fixings, etc.

when the shutter is used at fast speeds, giving elongated shutter timings. For this type of measurement the sensor would ideally be only a fraction of a millimetre in diameter, but it also needs to be reasonably sensitive.

In practice a diameter of about one millimetre is a good compromise. Photodiodes and phototransistors as small as this seem to be unobtainable these days, but a larger device is easily masked to produce an effective diameter of about one millimetre.

CIRCUIT OPERATION

The full circuit diagram for the Camera Shutter Timer is shown in Fig.3. Operational amplifier IC2 is used in the integrator mode, and capacitor C3 is the integration capacitor. Resistors R3 to R6 are the input Range resistors, and the required resistor is selected using Range switch S1.

Meter ME1 is driven from the output of IC2 (pin 6) via the series resistance of R8 and calibration preset potentiometer VR2. Operating Reset switch S2 discharges capacitor C3 through current limiter resistor R7 so that the meter is zeroed and a new reading can be taken. Resistor R7 prevents excessive discharge currents that would otherwise shorten the operating life of switch S2.

Under dark conditions, photodiode D1 operates much like any other semiconductor diode. When reverse biased, as it is here, only a minute leakage current flows. Under bright conditions the leakage level increases, and the leakage current is roughly proportional to the received light level.

If the leakage current is high enough, transistor TR1 is biased into conduction and it applies +5V to the input of the integrator. In practice, sensitivity or Level control VR1 is adjusted so that TR1 is switched off when the shutter is closed, and turned on when the shutter is open. Potentiometer VR1 enables the unit to function properly under a wide range of ambient light levels.

Operation using a phototransistor is much the same, and Fig.3 shows the correct method of connection for a component of this type. Under dark conditions the collector (c) to emitter (e) leakage current is the low level associated with ordinary silicon transistors, but at high light intensities it rises to a milliamp or more. This again gives the required on/off switching action from TR1.

Finished unit showing front panel layout and lettering. Note the phototransistor/diode light sensor is attached to the free end of the screened cable.

It is important that the integrator is fed with a stable input potential since any changes in this voltage will alter the charge current of the integration capacitor and degrade the accuracy of the unit. A monolithic voltage regulator (IC1) is therefore used to produce a well stabilised +5V supply for the input circuitry.

The integrator, IC2, does not require a stabilised supply and is powered direct from two small (PP3 size) 9V batteries. The current consumption is only a few milliamps from each supply rail.

CONSTRUCTION

Most of the components are assembled on a piece of stripboard that has 33 holes by 18 copper strips. The component layout, interwiring and details of the breaks required in the underside copper strips are shown in Fig.4.

Construction of the board follows along normal lines, with a board being trimmed down to the correct size using a hacksaw, the two 3mm dia. mounting holes then being drilled, after which the 12 breaks in the copper strips are cut. The breaks can be made using a handheld twist drill bit of about 5mm dia. or so.

The board is now ready for the components and link wires to be added. The LF351N specified for IC2 is not a static-sensitive component, but it is still a good idea to use a holder for this component. Do not overlook any of the eight link wires.

The shorter links can be made from the wire trimmed from resistors, but some 22s.w.g. or 24s.w.g. tinned copper wire is needed for the longer links. At this stage only fit single-sided solder pins to the board at the positions where connections to the meter, controls, etc. will eventually be made.

BOXING-UP

When choosing a case for this project bear in mind that a fair amount of front panel space is required for the meter and four controls. This precludes the use of small and most medium size cases. A metal instrument case about 200mm or so wide is probably the best choice and was used for

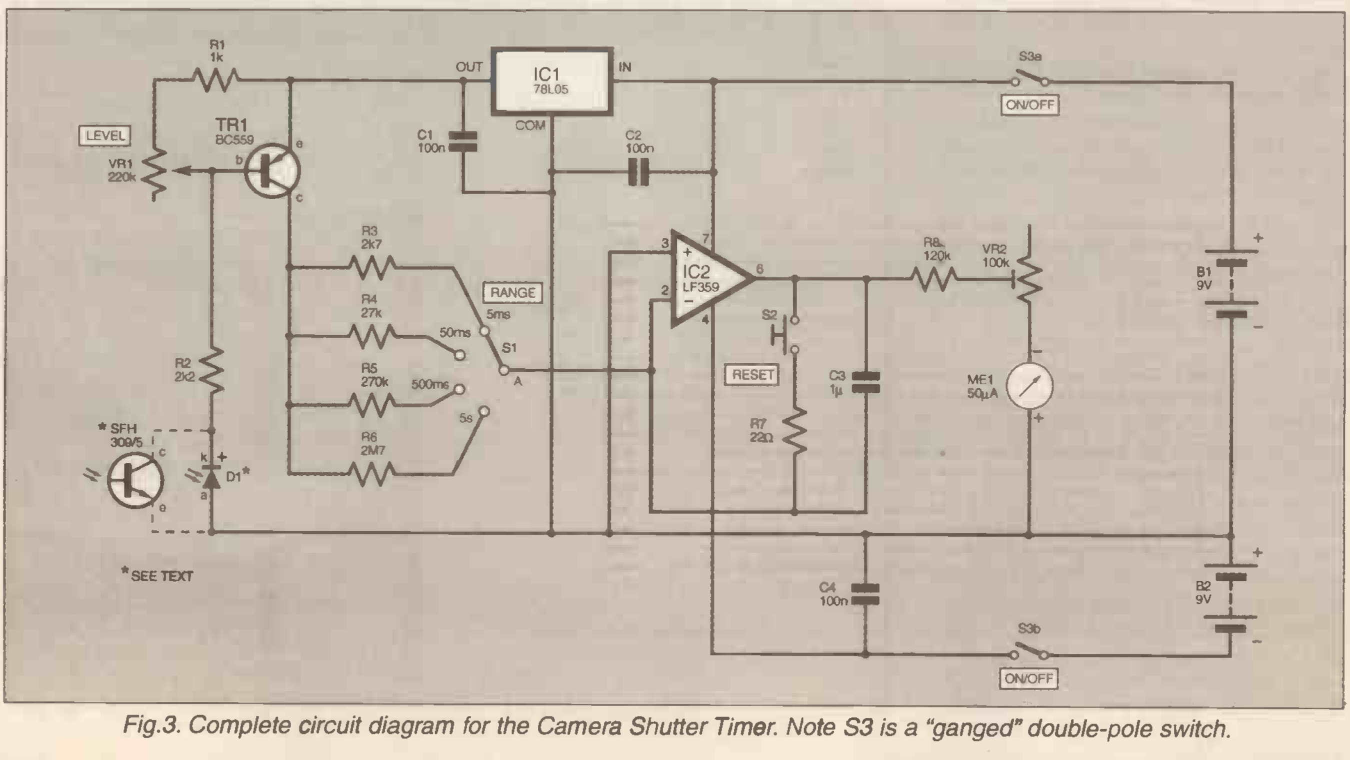


Fig.3. Complete circuit diagram for the Camera Shutter Timer. Note S3 is a "ganged" double-pole switch.

the prototype, but one of the larger plastic boxes would also be suitable.

The exact component layout used is not important from the electrical point of view, since the circuit operates at d.c. and is not prone to problems with stray feedback or noise pick up. However, try to use a sensible layout that makes the unit easy to use.

PANEL METER

Fitting the meter on the front panel is potentially difficult, as it requires a large round mounting hole. This is 38mm in diameter for most of the smaller meters, but it is clearly advisable to check this before cutting the hole.

The quickest way of making this cutout is to use a hole-cutter of the appropriate diameter, or to use one of the adjustable cutters that are available from most do-it-yourself superstores. Alternatively, cutting carefully using a coping saw, Abrafile, or any similar tool will produce the cutout, albeit rather slowly.

Four 3mm dia. mounting holes are required for the threaded rods built into the meter. These are normally at the corners of a square having 32mm sides and the same centre as the main mounting hole. Again, it is advisable to make some measurements on the meter itself to check its mounting arrangements prior to drilling any holes.

LIGHT SENSOR

Photodiode D1 can be connected to the main unit via a two-way plug and socket such as a 3·5mm jack type, but it is cheaper and easier to simply hard wire it to the circuit board. A hole for the connecting cable must be drilled in the case, and the hole should be fitted with a grommet to protect the cable if the case is a metal type.

A piece of two-way cable about 0·5 metres long is used to connect light sensor D1 to the circuit board, and low cost screened cable is probably the best choice. Use the outer braiding to connect the anode (or emitter) to the 0V rail, and the inner lead to connect the cathode (or collector) to resistor R2.

The unit worked when tried with various photodiodes and phototransistors, but as explained previously, results will be more accurate at faster shutter speeds if a sensor having a diameter of 3mm or less is used. Results will be even better if the sensor is masked down to a diameter of about one millimetre, and the easiest way of doing this is to apply a ring of black paint around the front of the diode.

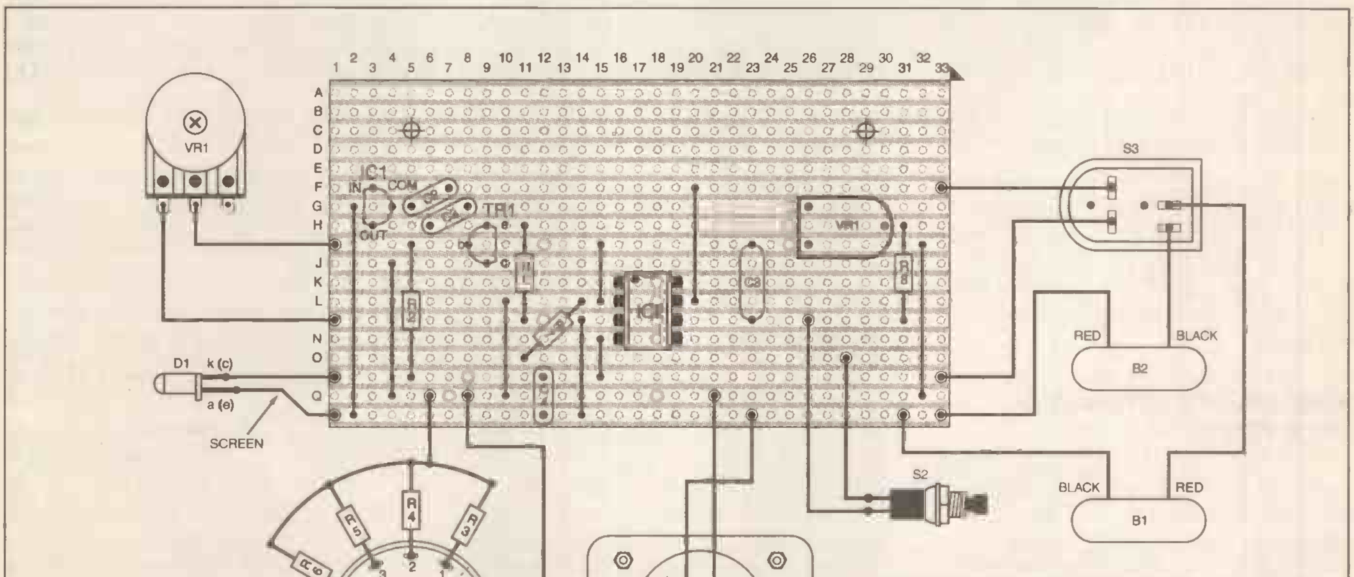
FINAL ASSEMBLY

The circuit board is mounted on the base panel of the case, well towards the right-hand side, as viewed from the rear, so that there is sufficient space for the batteries to its left, see photograph. Mounting bolts are preferable to plastic stand-offs when using stripboard, and both 6BA and metric M3 bolts are suitable. Include spacers at least 6mm long to hold the underside of the board well clear of the case.

All the hard wiring is included in Fig.4 and is largely straightforward. Be careful to connect meter ME1 and the two battery connectors with the correct polarity. If sensor D1 has a standard l.e.d. style case, the shorter leadout wire will be the cathode or the collector. For diodes having other case styles the manufacturer's or retailer's literature should be consulted.

The base terminal is not normally accessible on small phototransistors, but if there is a base lead it is simply ignored.

The four range resistors (R3 to R6) should be mounted directly on the rotary Range selector switch S1. It is best to



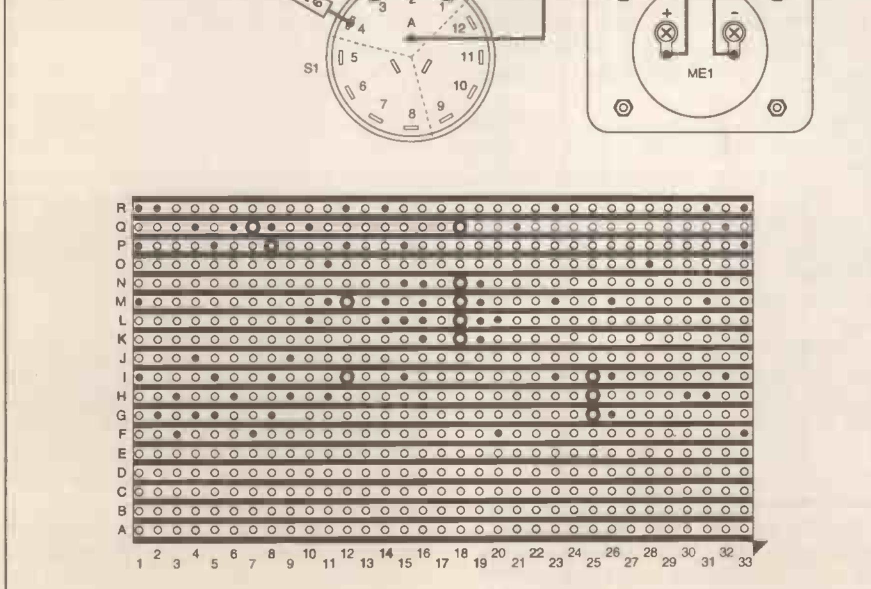
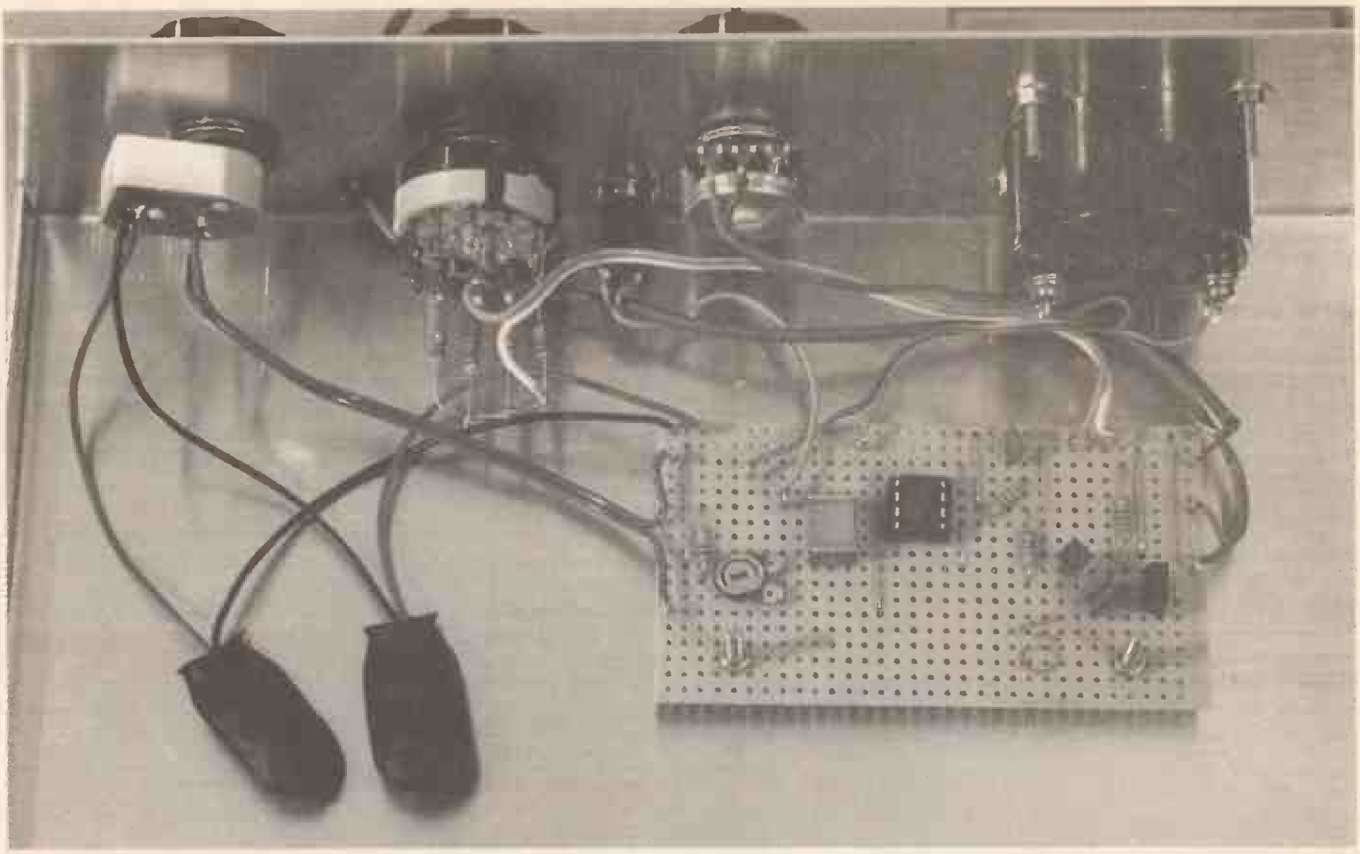


Fig.4. Camera Shutter Timer stripboard component layout, interwiring and details of breaks required in the underside copper strips. (Right) Mounting the Range resistors directly on the switch tags before it is fitted in the case will help with the final wiring.



Layout of components inside the prototype metal case. The circuit board is bolted to one side of the case to make space for the batteries. The board should be bolted on 6mm spacers to keep the copper underside well clear of the metal case.

solder the resistors on the switch tags before it is fitted in the case front panel.

Try to complete the soldering fairly swiftly so that the resistors do not overheat. It takes quite a lot of heat to destroy them, but relatively small amounts to impair their accuracy.

CALIBRATION AND TESTING

Start calibration/testing with Range switch S1 set to the five-second range (R6 switched into circuit) and preset VR2 adjusted to roughly middle setting. When the unit is first switched on the meter ME1 may read other than zero, but briefly pressing pushswitch S2 should zero the meter.

With the sensor (D1) aimed towards a light source, which can simply be bright daylight coming through a window or light from a table lamp, the meter reading should slowly advance. However, it may require some adjustment to Level control VR1 before this happens. Clockwise adjustment of VR1 reduces the light level needed to activate the unit. If the sensor is a photodiode a reasonably strong light source will be required.

With a little trial and error it should be possible to find a setting that results in the meter reading advancing when the sensor is aimed towards the light source, and stopping when it is not. If the unit seems to be malfunctioning in any way, switch off immediately and recheck the entire wiring, etc.

It might be possible to check automatic exposure times with some cameras, but the unit was only designed to check manual speeds. Obviously the timer is only usable with cameras that have removable or hinged backs, which means the vast majority of 35mm models.

The main exceptions are some of the older Leica models and copies of these such as the early Fed and Zorki cameras. The timer was not designed to test "leaf" shutters, but it seemed to work quite well when used with shutters for large format lenses and when tried with some "golden oldies", such as an Agfa Rangefinder model.

Testing is easier if the lens is removed from the camera, but it is possible to make accurate measurements with cameras that have fixed lenses. A large light source such as a window is then preferable. This minimises any dark areas where there will be insufficient light to activate the sensor.

Results are best with the sensor positioned quite close to the shutter curtains, but great care must be taken to avoid getting the sensor in contact with any part of the shutter. These days the cost of having damaged shutters repaired is so high that the sums involved are higher than the value of the repaired cameras. Therefore, it is better to err on the side of caution and have a gap of several millimetres between the shutter and the sensor.

The best way of calibrating the unit is to use a recently manufactured or serviced camera as the calibration source. Set the timer to the 500-millisecond range and the camera for a shutter speed of 0·5 seconds (500 milliseconds).

Press Reset switch S2 to zero the meter, take a reading, and then adjust preset VR2 for precisely full-scale reading on the meter. In the absence of a suitably reliable camera, calibrate the unit on the five-second range using the camera set to "bulb" or "B", and a stopwatch to help generate a five second shutter time.

The 0 to 50 scaling of the specified meter produces readings that are easily converted into shutter times, and it is not worthwhile doing any recalibration. Cameras use shutter times expressed as fractions of a second rather than in milliseconds, which slightly complicates matters. However, Table 1 shows the equivalent times in milliseconds for the standard shutter speeds.

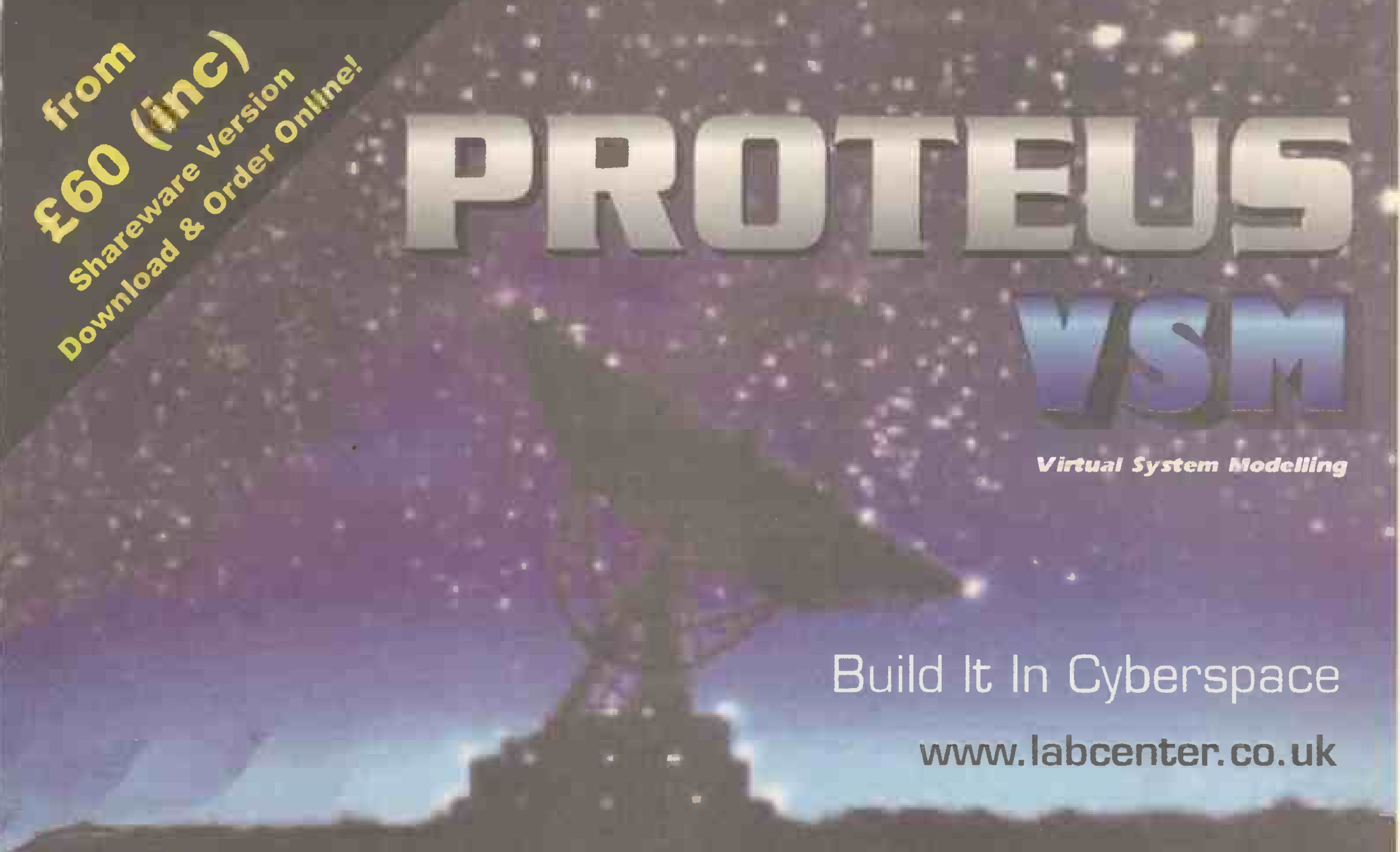
Table 1: Equivalent times in milliseconds for shutter speeds

Marked Speed	*Equivalent in ms*
1/4000	0·25
1/2000	0·5
1/1000	1
1/500	2
1/250	4
1/125	8
1/60	16·66
1/30	33·33
1/15	66·66
1/8	125
1/4	250
1/2	500
1	1000

IN USE

It is only fair to point out that the generally accepted camera standards allow for quite large margins of error, especially on the faster shutter speeds. An error of something like +50 per cent is clearly not good, but it does not indicate a faulty shutter, just one having mediocre accuracy.

With older cameras do not be surprised if checking the same shutter setting produces a fairly wide range of times. Unless the variations are very wide this does not indicate that the shutter is faulty, but it does suggest that it is long overdue for cleaning and recalibration. □



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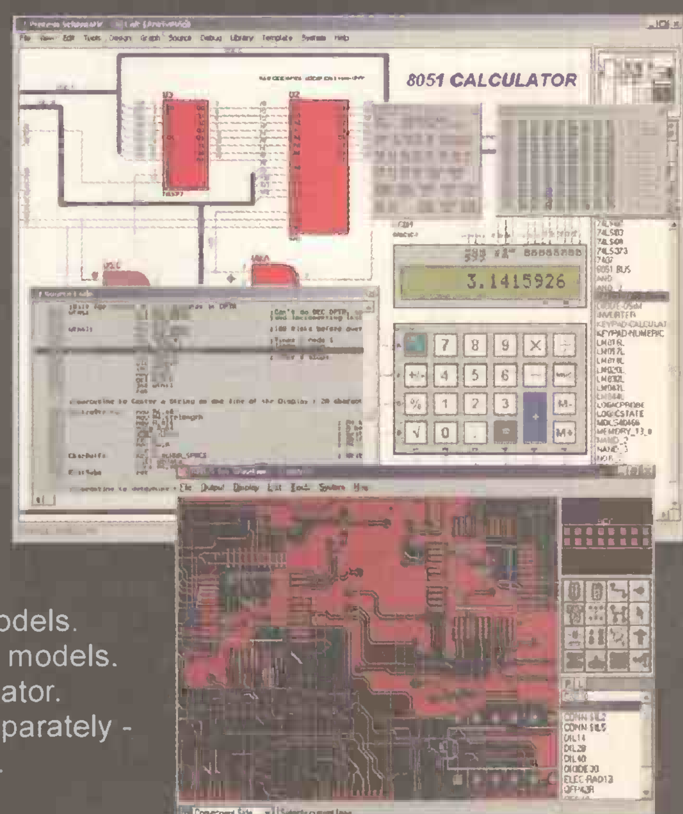

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ORDERING INFO: Kit 3123KT – £49.95; Built AS3123 – £69.95. OPTIONAL EXTRAS: ZIF Sockets add £30.00; Serial Lead, £4.95; Power Supply, £5.95.

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● **MTTX - MINIATURE TELEPHONE TRANSMITTER** Attaches anywhere to phone line. Transmits only when phone is used! Tune-in your radio and hear both parties. 300m range. Uses line as aerial & power source. 20x45mm. **3016KT £7.95 AS3016 £13.95**

● **TRI - TELEPHONE RECORDING INTERFACE** Automatically record all conversations. Connects between phone line & tape recorder (not supplied). Operates recorders with 1.5-12V battery systems. Powered from line. 50x33mm. **3033KT £7.95 AS3033 £16.95**

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● **1 WATT FM TRANSMITTER** Easy to construct. Delivers a crisp, clear signal. Two-stage circuit. Kit includes microphone and requires a simple open dipole aerial. 8-30VDC. PCB 42x45mm. **1009KT £14.95**

● **4 WATT FM TRANSMITTER** Comprises three RF stages and an audio preamplifier stage. Piezoelectric microphone supplied or you can use a separate preamplifier circuit. Antenna can be an open dipole or Ground Plane. Ideal project for those who wish to get started in the fascinating world of FM broadcasting and want a good basic circuit to experiment with. 12-18VDC. PCB 44x146mm. **1028KT. £23.95**

● **15 WATT FM TRANSMITTER (PRE-ASSEMBLED & TESTED)** Four transistor based stages with Philips BLY 88 in final stage. 15 Watts RF power on the air. 88-108MHz. Accepts open dipole, Ground Plane, 5/8, J, or YAGI configuration antennas. 12-18VDC. PCB 70x220mm. SWS meter needed for alignment. **1021KT £69.95**

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● **LED FLASHER 1** 5 ultra bright red LED's flash in 7 selectable patterns. **3037MKT £4.95**

● **LED FLASHER 2** Similar to above but flash in sequence or randomly. Ideal for model railways. **3052MKT £4.95**

● **INTRODUCTION TO PIC PROGRAMMING.** Learn programming from scratch. Programming hardware, a P16F84 chip and a two-part, practical, hands-on tutorial series are provided. **3081KT £21.95**

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● **ATMEL 89Cx051 PROGRAMMER** Simple-to-use yet powerful programmer for the Atmel 89C1051, 89C2051 & 89C4051 uC's. Programmer does NOT require special software other than a terminal emulator program (built into Windows). Can be used with ANY computer/operating system. **3121KT £34.95**

● **3V/1.5V TO 9V BATTERY CONVERTER** Replace expensive 9V batteries with economic 1.5V batteries. IC based circuit steps up 1 or 2 'AA' batteries to give 9V/18mA. **3035KT £4.95**

● **STABILISED POWER SUPPLY 3-30V/2.5A** Ideal for hobbyist & professional laboratory. Very reliable & versatile design at an extremely reasonable price. Short circuit protection. Variable DC voltages (3-30V). Rated output 2.5 Amps. Large heatsink supplied. You just supply a 24VAC/3A transformer. PCB 55x112mm. Mains operation. **1007KT £17.50. Custom Designed Box 2007 £34.95**

● **STABILISED POWER SUPPLY 2-30V/5A** As kit 1007 above but rated at 5Amp. Requires a 24VAC/5A transformer. **1096KT £29.95. Custom Designed Box 2096 £34.95**

● **MOTORBIKE ALARM** Uses a reliable vibration sensor (adjustable sensitivity) to detect movement of the bike to trigger the alarm & switch the output relay to which a siren, bikes horn, indicators or other warning device can be attached. Auto-reset. 6-12VDC. PCB 57x64mm. **1011KT £11.95 Box £5.95**

● **CAR ALARM SYSTEM** Protect your car from theft. Features vibration sensor, courtesy/boot light voltage drop sensor and bonnet/boot earth switch sensor. Entry/exit delays, auto-reset and adjustable alarm duration. 6-12V DC. PCB: 47mm x 55mm **1019KT £11.95 Box £6.50**

● **PIEZO SCREAMER** 110dB of ear piercing noise. Fits in box with 2 x 35mm piezo elements built into their own resonant cavity. Use as an alarm siren or just for fun! 6-9VDC. **3015KT £9.95**

● **COMBINATION LOCK** Versatile electronic lock comprising main circuit & separate keypad for remote opening of lock. Relay supplied. **3029KT £9.95**

● **ULTRASONIC MOVEMENT DETECTOR** Crystal locked detector frequency for stability & reliability. PCB 75x40mm houses all components. 4-7m range. Adjustable sensitivity. Output will drive external relay/circuits. 9VDC. **3049KT £12.95**

PIR DETECTOR MODULE 3-lead assembled unit just 25x35mm as used in commercial burglar alarm systems. **3076KT £8.95**

● **INFRARED SECURITY BEAM** When the invisible IR beam is broken a relay is tripped that can be used to sound a bell or alarm. 25 metre range. Mains rated relays provided. 12VDC operation. **3130KT £11.95**

● **SQUARE WAVE OSCILLATOR** Generates square waves at 6 preset frequencies in factors of 10 from 1Hz-100KHz. Visual output indicator. 5-18VDC. Box provided. **3111KT £8.95**

● **PC DRIVEN POCKET SAMPLER/DATA LOGGER** Analogue voltage sampler records voltages up to 2V or 20V over periods from milli-seconds to months. Can also be used as a simple digital scope to examine audio & other signals up to about 5KHz. Software & D-shell case provided. **3112KT £19.95**

● **20 MHz FUNCTION GENERATOR** Square, triangular and sine waveform up to 20MHz over 3 ranges using 'coarse' and 'fine' frequency adjustment controls. Adjustable output from 0-2V p-p. A TTL output is also provided for connection to a frequency meter. Uses MAX038 IC. Plastic case with printed front/rear panels & all components provided. 7-12VAC. **3101KT £54.95**

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3G AND UMTS MOBILES

The new 3G mobile networks will offer higher data rate exchanges. Barry Fox looks at the figures.

THE UK's recent 3G frequency auction was the first in the world, and earned the Treasury about £22·5bn. BT/Cellnet paid £4bn, Vodafone £6bn, Orange £4bn, One2One £4bn and TIW of Canada £4·4bn. All the licencees must now pay a similar amount to build new networks.

The Isle of Man should provide a dry run, with the first service, promised by BT and its subsidiary Manx Telecom, due to launch next year, a year ahead of the UK.

Frequency Limits

3G, third generation mobiles, will use the UMTS or Universal Mobile Telecommunications System which is now an international standard, on higher frequencies than current systems (1900-1980, 2010-2025, 2110-2170 MHz). This allows for data rates of up to 2Mbits/sec.

But the actual data speeds on offer will usually be far lower, because of error correction overheads; 144Kbps for full mobility applications over wide areas; 384Kbps for limited mobility applications with 2Mbps used only for low mobility applications in very small cells.

The issue is further complicated because the licences are for different amounts of spectrum, which will limit the bandwidth the operators can offer. New entrant TIW gets Licence A and a better chance of competing with existing operators who already have GSM 900 or DCS 1800 spectrum. TIW's Licence A is two times 15MHz paired plus 5MHz unpaired, Licence B is two times 15MHz paired and no unpaired, Licences C to E are two times 10MHz paired plus 5MHz unpaired.

Paired Spectrum

"Paired spectrum" means that a slice of frequencies is set aside for the base station to use for transmission and another slice for reception, as with existing cellphones. Paired spectrum will be used with W-CDMA, wideband code division multiple access. This is a spread spectrum system where all users use the whole band, but their signals are digitally labelled.

Unpaired spectrum must be used for time division duplex (TDD) mode of CDMA working; a single frequency is used for both receive and transmit. This is how the digital cordless phone systems CT2 and DECT work. A chunk of data is transmitted, then a chunk received, then a chunk transmitted, and so on. The mobile stitches them together.

Although existing GSM/DCS1800 cellphone services run only at painfully slow 9·6Kbps (compared to 33·6Kbps or 56Kbps from a fixed line modem) there are two ways to accelerate GSM and DCS1800 data links. The irony is that the current operators are already working on this.

System Services

Last year, Orange was promising to launch a new service for Christmas called High Speed Circuit Switched Data, which hikes the speed to 28·8Kbps.

Rivals One2One, Cellnet and Vodafone were, however, waiting a year for completely different technology, called General Packet Radio Service.

Both systems are authorised by ETSI, the European Telecommunications Standards Institute, but are not fully compatible.

HSCSD uses less error correction to increase the basic GSM data rate to 14·4Kbps, and then gangs channels together to give 28·8Kbps or higher.

GPRS works on the assumption that most users do not need constant data speed. A pool of capacity serves several users at the same time, with bits allocated as and when they are needed. Services are promised for September 2000, with speeds up to 56Kbps, rising to 112Kbps by 2001.

In March 2000 Vodafone claimed the "first public GPRS demonstration" at a trade exhibition in Birmingham, while BT announced GPRS roaming trials with AT&T in the UK, USA, Hong Kong and Taiwan.

Orange has been mysteriously quiet on HSCSD and in late April admitted that the Christmas service had still not been launched. According to Orange all the network modifications were in place by the end of 1999, but Nokia failed to deliver the PCMCIA cards that will plug into a laptop PC and connect to a phone.

In practice the difference between 144Kbps for 3G and 112Kbps for GPRS/GSM may not make much difference, because the limiting factor is more likely to be Internet congestion. MPEG-4 video will be possible at either speed. The key issue will be cost per minute on line and this will be controlled by the four existing cellphone operators and a newcomer crippled by high licence and start up costs.

3G looks most unlikely to be cheap.

NEW MICROCHIP CD-ROM

Microchip's new 2000 Technical Library CD-ROM is now available. It contains a complete compilation of documentation on the PIC microcontrollers and associated development tools, plus all other Microchip devices and peripherals. Source listing examples are also included.

The CD-ROM replicates the information on Microchip's web site and can be viewed with an HTML browser.

For further information contact Arizona Microchip Technology Ltd., Dept. *EPE*, Microchip House, 505 Eskdale Road, Winnersh Triangle, Wokingham, Berks RG41 5TU. Tel: 0118 921 5858. Fax: 0118 921 5835. Web: **www.microchip.com**.

MOBILE PHONE EARPIECE SAFETY QUESTIONED

Which? discovers hands-free earpieces might _increase_ alleged radiation hazard. Barry Fox reports.

THE recent auction of frequencies for third generation mobiles coincided with fresh questions on cellphone safety. While testing cellphone shields *Which?* also tested a couple of the hands-free earpieces (from BT Cellnet and Carphone Warehouse) that people use, either for convenience, to make driving safer or in the fond belief that they protect the head from radiation. The results were so surprising that *Which?* did the tests again.

The connecting cords acted as vertical aerials, channelling three times as much radiation into the head. Holding the phone out sideways, so that the cord is horizontal, kills the radiation.

Whose Responsibility?

The BT Cellnet headset is not made by Cellnet. But that's no excuse. If anyone else started selling products marked BT Cellnet or Carphone Warehouse they could very soon expect to hear from the companies' lawyers.

This divided responsibility is the crux of the problem. If one company made both the phone and the headset we could hope that they had used filters to stop the radio signal going up the audio lead, and screened the lead to stop it radiating. As things stand responsibility is split.

Very possibly there are other kits that don't radiate. But so far no-one has spoken out with a test-based reassurance.

Graeme Jacobs, Editor of *Which?*, is very blunt about phone shields, too. "The ones looked at don't help, so if you're thinking of buying one, don't waste your money".

Testing the Allegation

Which? reminds that there is no scientific evidence that cellphones are dangerous. If they are, it will take years to prove. It will be even more difficult to reassure that there is no risk. Negatives are well-nigh impossible to prove.

The cellphone manufacturers have yet to take the blindingly obvious and easy step of putting the aerial on the bottom of the phone so that is in free space in front of the jaw, not flat against the head. Inverse square law would then drastically reduce the strength of the signal reaching the body.

BLUETOOTH BITES

MANY moons ago we reported on how Bluetooth would provide a revolutionary standard for short-range wireless communication which is intended to replace cables connecting PCs to peripherals. Founded by global technology leaders, Bluetooth is supported by over 1000 organisations. Ericsson estimate that before the year 2002 Bluetooth will be a built-in feature in more than 100 million mobile phones and many millions of other communications devices. Bluetooth is effective over a 10 metre distance and line of sight is not required.

Brain Boxes have now launched and demonstrated the world's first working PCMCIA Type 2 Bluetooth module at the recent CeBIT 2000 fair in Hanover. The product becomes available in commercial volumes by June 2000. Amongst the other Bluetooth products to be launched will be a printer port to Bluetooth box, with support available in all Windows operating systems.

For more information contact Brain Boxes Ltd., Dept EPE, Unit 3c, Wavertree Boulevard South, Wavertree Technology Park, Liverpool L7 9PF. Tel: 0151 220 2500. Fax: 0151 252 0446. E-mail sales@brainboxes.com. Web: www.brainboxes.com.

NEC Boosts Scotland

THE NEC Corporation will this year invest a further £60 million in its subsidiary NEC Semiconductors (UK) Ltd in Scotland. The additional investment will go towards further strengthening the Scottish plant as a global production centre in NEC's electron device business.

The plant will be upgraded to use leading-edge 0·18 micron process technology, producing around 27,000 wafers a month.

For more information browse **www.nec-global.com**.

UK and the Comet

THE Surrey Space Centre, part of the University of Surrey, has won a contract to manufacture the attitude control momentum wheel for the *Rosetta Lander* mission to be launched in 2004. The *Rosetta* spacecraft will rendezvous with comet 46P/Wirtanen nine years later, mapping its surface in fine detail and land a package of instruments on its surface.

For more information browse **www.sstl.co.uk**.

B.A.E.C.

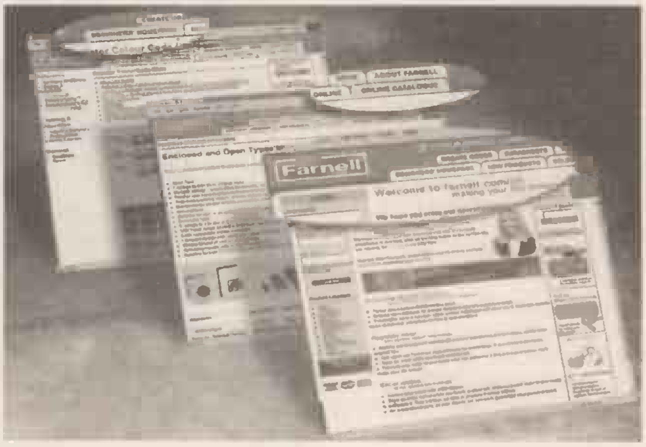
AGAIN we are given the opportunity to publicise that renowned institution, the British Amateur Electronics Club (B.A.E.C.), with the arrival of their latest newsletter (No 135, April 2000).

One of the benefits of belonging to B.A.E.C., Chairman and Editor George Burton reminds us in his Editorial, is that the Club has a library of several hundred books (mostly paperback) which are available on loan for the cost of the return postage. The newsletter itemises the books available.

The newsletter also has its usual offerings of tips and ideas for the electronics enthusiast. We've said it many times, but we have no hesitation in saying again that if you want to belong to a worthwhile Club that encourages interest in electronics, then consider joining the B.A.E.C.

For more information, contact the Hon. Secretary, Martyn Moses, 5 Park View, Cwmaman, Aberdare, Mid Glam CF44 6PP. Tel: 01685 879025. E-mail: MPMOSES@compuserve.com. Web: members.tripod/~dledgard/baec.htm.

FARNELL WEB SITE



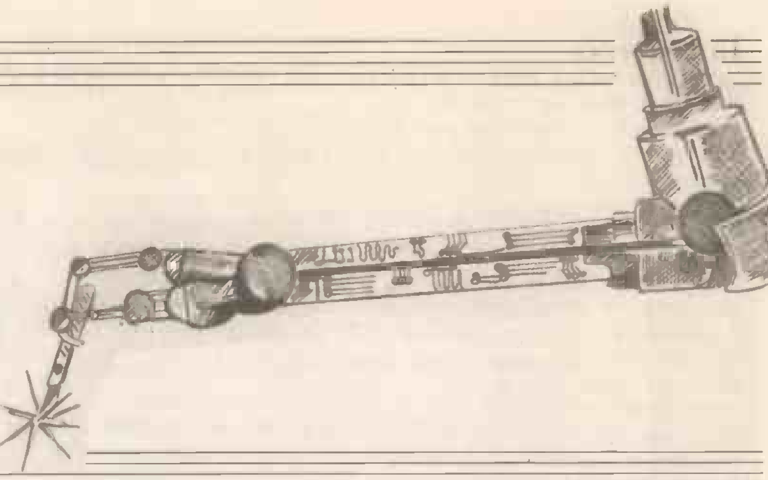
Leading distributor Farnell has recently launched an all new e-commerce web site. Available to anyone with Internet access, the site combines an intuitive user interface with sophisticated searching facilities to deliver what Farnell describe as "unrivalled access" to their 100,000-plus branded products and services.

Farnell has built extensive product search facilities into the site and combined this with a convenient "shopping basket" system for order assembly. There is seamless hyperlinking to over 750 Farnell supplier web sites making available a vast array of additional details on products.

The new web site complements Farnell's 6-book paper catalogue by providing an alternative means of obtaining products and information 24 hours day, 365 days a year. A CD-ROM version is also available.

To browse the web site access **www.farnell.com/uk**. Farnell can also be contacted via tel: 0870 1200 200.

Regular Clinic



CIRCUIT SURGERY

ALAN WINSTANLEY and IAN BELL

Our ever helpful team of circuit surgeons check out a CMOS D-type latch and offer suggestions for a low-voltage monitor circuit.

Checking the Chips

Our thanks to *Mr. D. Lee* of Birkenhead, Cheshire, who wrote asking for help in testing 4042 logic devices. Mr. Lee says that he needs a simple test circuit to "fully auto-test the logic outputs" of the 4042. He has previously built circuits to test basic gates, but testing the 4042 presents a more difficult case.

We're not sure how feasible it is to custom-build a tester dedicated to a specific chip, however our first port of call has to be the Philips Semiconductor web site to fetch a data sheet, so point your web browser at **www.semiconductors.com/products/** then do a search for "4042". Data sheets are published in Adobe Acrobat format (PDF file types) which can be read and printed using the free Adobe Acrobat Reader from **www.adobe.com**.

Data sheets often include function diagrams of the chip and Philips' data is helpful as always. The 4042 is a CMOS level-sensitive quad D-latch, with complementary outputs and a clock input with selectable polarity.

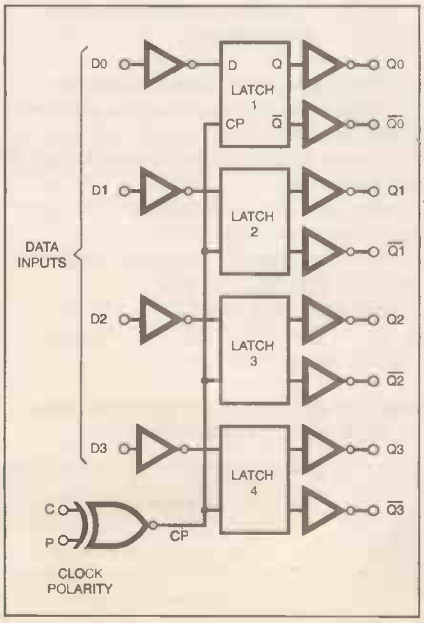


Fig.1a. Internal logic diagram for the HEF4042 (Philips Semi). Note the CP signal cannot be accessed externally.

Basically speaking, a D-Latch (or Data latch) is a circuit that "remembers" (latches) data when a suitable clock pulse comes along. The data (0 or 1) presented to the latch's D-input is written to the latch's Q output, and the latch stays in that condition until another suitable clock signal is delivered. The $\overline{Q}$ complementary output is just the inverse of Q.

The clock signals for all four latches are connected via an exclusive-NOR function (XNOR) which has two inputs. These inputs can be interpreted as the clock (C) and polarity control (P) for the clock (see Fig. 1a). Philips' 4042 data sheet describes them as Enable 0 (E0) and Enable 1 (E1). In fact the data sheet includes a function table (Table 1) which outlines the logical operation of this chip.

Looking in more detail at the circuit for an individual latch, see Fig 1b, the four latches each have a positive level sensitive clock labelled CP. When CP is high data is transferred from the D input to the Q and $\overline{Q}$ outputs of each latch, and when the clock goes low the state on the Q and $\overline{Q}$ output at that time is memorised or latched.

Test this out

To test the logic function of the latch, we would need to check that the output could follow the input to both 0 and 1 with CP high, and when CP was taken low both a 1 and a 0 could be latched without a subsequent change on D changing the stored value.

Table 1: Logic operation of the 4042

E0	*E1*	*Output Qn*
L	L	Dn
L	H	Latched
H	L	Latched
H	H	Dn

(H = high, L = low).

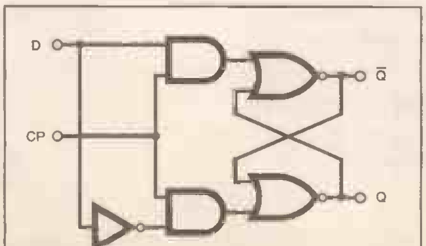


Fig.1b. Circuit for an individual latch.

In practise, the CP line is not accessible externally as it is driven from the C and P signals (pins 5 and 6) via the XNOR gate. We can hold P at one state and fully test the latches, after which all we have to do is check that the C signal still gets through to the CP with P in its opposite state (it is not necessary to fully test the latches twice).

A sequence of inputs that should achieve our purpose is shown in Fig.2, together with the expected output from Q (also $\overline{Q}$ should always be the complement or opposite state of Q) and the state of the internal clock signal CP (we cannot access this but it is drawn to help show circuit operation).

The test sequence works as follows. First the transmission of a 1 with CP high is checked (T1), then the 1 is latched (L1) and D is changed to check that the 1 has actually latched (C1). This is repeated for a 0 (T0,L0,C0). The value of P is changed and the T1,L1,C1 sequence is repeated to check that C still gets through to CP.

How do we automate the process? We need a circuit to generate the sequence on P and C and also check that the output from Q is correct, which means we need to generate the expected sequence from Q and $\overline{Q}$ too. There are a number of ways of doing this. We could program a microcontroller device such as a PIC to generate the C and P sequences and check the sequence on Q and $\overline{Q}$. This may be a good option for someone who is familiar with a particular microcontroller and has all the kit and software ready to use.

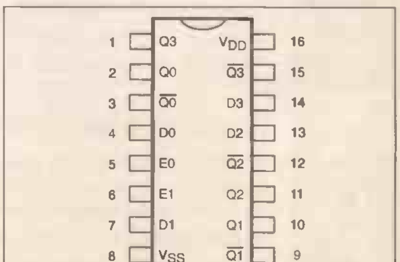


Fig.1c. pinout details for the 4042B.

In Sequence

An alternative is to build a sequence generator from basic logic. One way of doing this is to build a counter that goes through ten states: a synchronous binary up-counter which is synchronously reset to 0 from state 9 is probably the best choice.

The outputs of the counter (Q3, Q2, Q1, Q0) can then be decoded using combinational logic to give the required sequences. For example, the sequence on P is obtained using the function P = Q3 OR (Q2 AND Q1), which requires an AND gate and an OR gate. These circuits can be built with ordinary discrete logic gates designed by using K-maps (as described in our series *Teach-In '98 – An Introduction to Digital Electronics*).

To check the output we could use a logic comparator connected to the Q and $\overline{Q}$ outputs and to the Q and $\overline{Q}$ sequence logic derived from the counter's outputs. If the device under test is OK then the comparator outputs will always indicate "equals". The comparator output should be sampled by the counter clock (i.e. stored in a flip-flop using the counter clock) to prevent any variations in timing between the 4042's output and the test sequence generator from indicating false "not equals" states from the comparator.

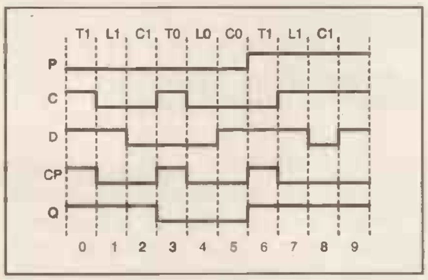


Fig.2. Possible 4042 test sequence (see text).

A third possibility for implementing the tester is to programme an EPROM with the test input and expected output sequences stored in consecutive memory locations (one EPROM data bit per device under test I/O pin). The EPROM's address bits would be connected to a counter that would step the EPROM through the addresses containing the test sequence.

As with the previous suggestion a logic comparator would be used to compare the expected and actual output sequences. This approach could also be extended to test devices other than the 4042, spare address lines could be used to select which sequence the counter ran through.

Advanced options

A more sophisticated version of this approach would be to use a RAM or E²PROM which could be loaded with a test sequence from a PC using, say a serial port, allowing a large number of test sequences to be defined and stored on the PC and downloaded to the tester when required..

The previous discussion has overlooked an important point – what is meant by "fully test"? We have only considered one latch (to keep things simple) and it would seem at first that we could supply the same sequence to all the D inputs to check the latches in parallel. This would let us detect a significant number of faults – for example if one of the Q outputs was open-circuit we would not observe the expected sequence on it.

However, if we apply the same sequence to all the D inputs then all the latches are doing the same thing and short circuits between equivalent points in any two latches would not be detected. We could get around this by running the sequence more than once with different values on adjacent D inputs, but the best way to do this may depend on knowledge of the structure of the chips (i.e. which latches, and latch I/O pins are next to one another and thus more likely to short).

The problem of short circuits gives us some hint of the difficulty of testing circuits. In general, although we can perform simple tests to prove the logic of the latches is operating, it would be difficult to prove that the device had been "fully tested" – tested for what faults? Shorts? Opens? Defects in the oxide of the MOS transistors causing increased leakage? *IMB.*

Low Voltage Detector

I am a 16 year old student designing an intercom. I'd like to attach a low battery indicator to a 9V battery for use with my project, but I can't find any schematics. Is it possible to build a low battery indicator with the ICL8211 chip? **Adam** via E-mail.

I think the 8211/8212 low voltage detectors originated from Harris, who sold their semiconductor business to Intersil. This company used to manufacturer a bipolar version, the ICL 8211/8212. Maxim also produce CMOS versions, namely the MAX8211/8212.

The overall chip design has been around a good 20 years and although Intersil flagged them as obsolete there should be plenty around. Let's narrow down our options and look at the Maxim version. Data sheets for the CMOS type can be obtained from Maxim's web site (**www.maxim-ic.com**).

Both the MAX8211 and MAX8212 contain a 1·15V reference, a comparator, an open-drain *n*-channel output transistor and an open-drain *p*-channel transistor on the hysteresis pin. The chips operate in a manner opposite to each other. The 8211 output transistor turns on when the input voltage is *less* than the threshold or reference voltage. Its output (pin 4) goes low and sinks up to 7mA.

However, the 8212 output turns on (goes low) when the input is *greater* than the threshold. Note that the 8212's output is not current limited, and can sink typically 35mA. The chips are handy for under-voltage or over-voltage detection, back-up battery switching, microprocessor monitoring etc., noting that the CMOS chips typically consume a meagre 5μA, so their impact on battery life is negligible.

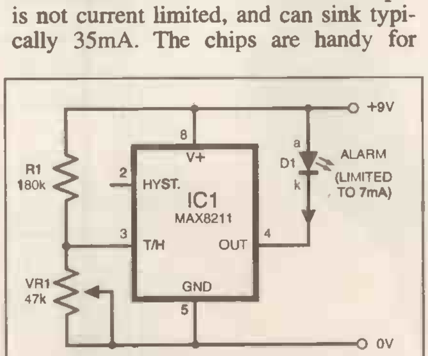


Fig.3a. Low voltage alarm using the MAX8211 to drive an l.e.d.

To answer your questions, Adam, a low voltage alarm can readily be constructed using the MAX8211 which will operate with any supply from +2V to +16·6V. Since its output is current limited it can drive an l.e.d. directly, see Fig.3a.

The chip monitors the power supply rail by comparing the voltage at the threshold pin against the internal reference. When pin 3 is less than 1·15V, pin 4 goes low, current sinks into it and illuminates the l.e.d. (consider a high-efficiency type). The potential divider R1/VR1 was set for 50μA maximum. The trimmer resistor adjusts the set-point.

The hysteresis feature was unused in this example, which means that the switching point will be very sensitive. The l.e.d. may flash or jitter when the chip is at its threshold. The addition of hysteresis introduces a difference in the switching points which allows for two switching levels (high and low). This can be accomplished using a third resistor shown in circuit diagram Fig.3b.

Note that this arrangement is only suited if detecting a drop in the supply rail, i.e. when the supply voltage is the same as that powering the 8211. To calculate the resistor values, firstly decide on the desired hysteresis voltage – the difference between the upper and the lower switching points, say 75mV. Then decide on a value for resistor R3, anything up to 10M should do. In this example, 750k (kilohms) was assumed. Choose the alarm voltage level (4·5V here).

The hysteresis resistor R2 is calculated using:

$$R2 = R3 \times \frac{(V_{low} - 1{\cdot}15V)}{1{\cdot}15V} = 2M2$$

Lastly resistor R1 is calculated using

$$R3 \times \frac{V_{hyst}}{1{\cdot}15V} = 48k9$$

This circuit is designed to monitor a +5V logic supply, with an alarm output when the rail drops below +4·5V. The 75mV hysteresis ensures that the alarm will not be for ever triggering when the 8211 is hovering around the threshold point. I'm sure the circuit can be adapted as needed. The ICL821x and MAX821x are listed by Farnell. *ARW.*

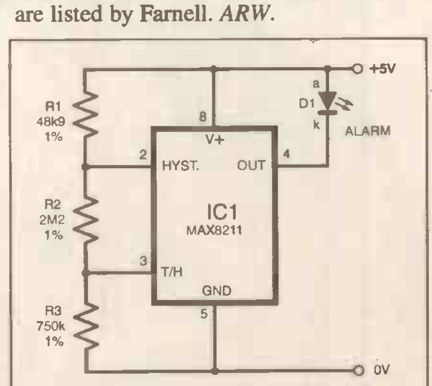


Fig.3b. A logic level alarm which monitors a 5V logic supply. Note the addition of hysterisis using resistor R2.

Constructional Project

POCKET g-METER

BILL MOONEY

Uses a space-age chip to tell you how much g-force you are experiencing.

THIS portable accelerometer will tell you the *g-force* you experience when you break hard in your car, when you ride in a lift or at the fairground. It is based on a tiny polysilicon micromachined sensor etched onto an integrated circuit. The earth's gravity is used as a reference standard.

As described, this is an experimental project designed as a simple introduction to the world of acceleration. The g-Meter output is in the form of a 10-segment bargraph type display, but for more accurate measurement or signal processing an output socket is provided.

ACCELEROMETERS

There are many ways of measuring acceleration involving various piezoelectric, resistive or inductive devices but the new micromachined silicon sensors represents a considerable advance. The ADXL105 from Analog Devices is of this type and the surface mount package contains all the driver circuitry to make a very effective accelerometer.

The sensor is a tiny, two micrometre, beam etched onto an integrated circuit along with the detector electronics. The sensor is, in fact, a beam of polysilicon held at four points by supports of the same material, see Fig.1a. The supports can flex and so act as springs.

Inertia resulting from the mass of the beam is the basis of the detection system. If the supporting integrated circuit is moved this mass tries to stay where it is. Any acceleration therefore causes the mass to move in proportion. On reaching constant velocity or if stationary, the beam returns to its rest position.

A small differential capacitor attached to the side of the beam is unbalanced by its displacement. This unbalance results in an on-board 200kHz clock signal reaching the demodulator which produces an output voltage representing acceleration.

SENSITIVITY

Originally developed specially for space research projects, micromachined accelerometers are very tough and will withstand the huge acceleration experienced by rockets. The sensing beam has a mass of 0·1 microgram and its movement can be detected down to 0·2 angstroms or about a tenth of an atomic diameter. The beam displacement-sensing capacitor is a minute 0·1pF and a change of 1aF (1 ato farad is 10^{-18}F) can be detected; real space-age stuff!

The ADXL105 accelerometers, as used in this project, can detect "*g*" down to a couple of milli-g at frequencies from d.c. to above 20kHz. A particular advantage for the g-Meter is the ease of calibration. Simply turn the chip on either end to detect +1g or −1g as it senses the earth's gravity. This is a very stable reference with a value of 9·80600 m.sec^{-2} at 45° latitude.

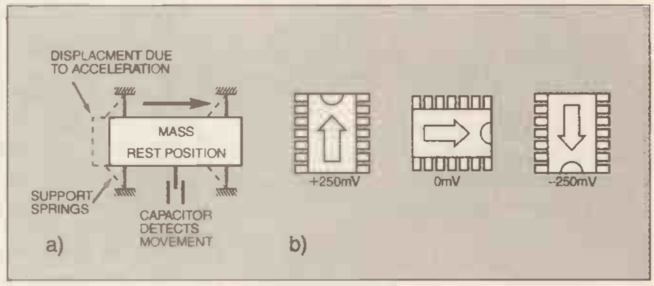


Fig.1. (a) Operating principle of the internal "beam" movement sensor and (b) influence of Earth's gravity.

Devices like the ADXL105 can be used for tilt and inclination measurement as well as shock and vibration studies. Multi-axis devices can be used to offset the effect of tilt which appears as an acceleration to the sensor.

The ADXL105 single axis device was chosen for this simple project. The effect of the Earth's gravity on the output at pin 8 is shown in Fig.1b. The internal

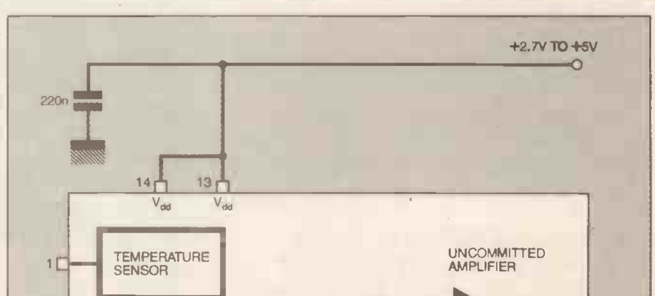


Fig.2. Internal functional circuit of the ADXL105. Gain is set by values of external resistors R1 and R2.

functional circuit for the i.c. is shown in Fig.2.

The signal from the detector has a magnitude of 250mV/g and is centered on the mid-rail voltage. An uncommitted on-board amplifier is provided for signal level adjustment and filtering. The gain is set by the selection of resistor R1 and R2 values and a variety of filtering options are possible by the addition of capacitors to the op.amp feedback circuitry.

CIRCUIT DETAILS

The g-Meter is a simple experimental circuit intended to give an insight into the scope of acceleration measurement. It consists of an ADXL105 sensor directly coupled to a simple 10-segment l.e.d. bargraph type display.

Both the LM3914 l.e.d. driver and the ADXL105 sensor will work down to 2·7V (unlike the now obsolete ADXL05 which needs 5V). The circuit can therefore be run from two AA cells.

COMPONENTS

Approx. Cost Guidance Only **£35** *excluding batts.*

See SHOP TALK page

Resistors

R1	100k
R2	220k
R3, R4	56k (2 off)
R5	2k2

All surface mount devices (SMD), case size 1206

Potentiometer

VR1	10k ceramic "knob pot", lin.

Capacitors

C1	200n ceramic chip, case size 1206
C2	82n ceramic chip, case size 1206
C3	100µ tantalum, 4V

Semiconductors

D1 to D9	3mm l.e.d., green (9 off)
D10	3mm l.e.d., red
IC1	ADXL105JQC (or AQC) micromachined sensor (SMD)
IC2	LM3914N linear bargraph l.e.d. driver

Miscellaneous

S1, S2	s.p.d.t. min slide switch, 15mm fixing centre (2 off)
SK1	phono socket, chassis mounting
B1	3V battery pack (2 x AA cells with holder)

Printed circuit board available from the *EPE PCB Service*, code 269; plastic box, size 75mm x 51mm x 28mm; multistrand connecting wire (see text); nuts, bolts and washers; solder, etc.

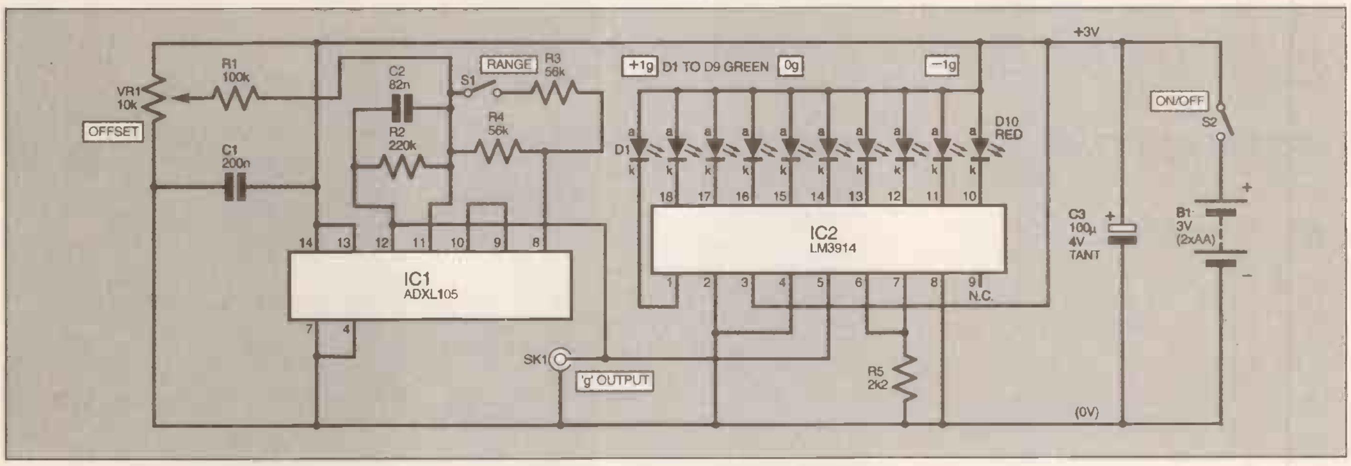


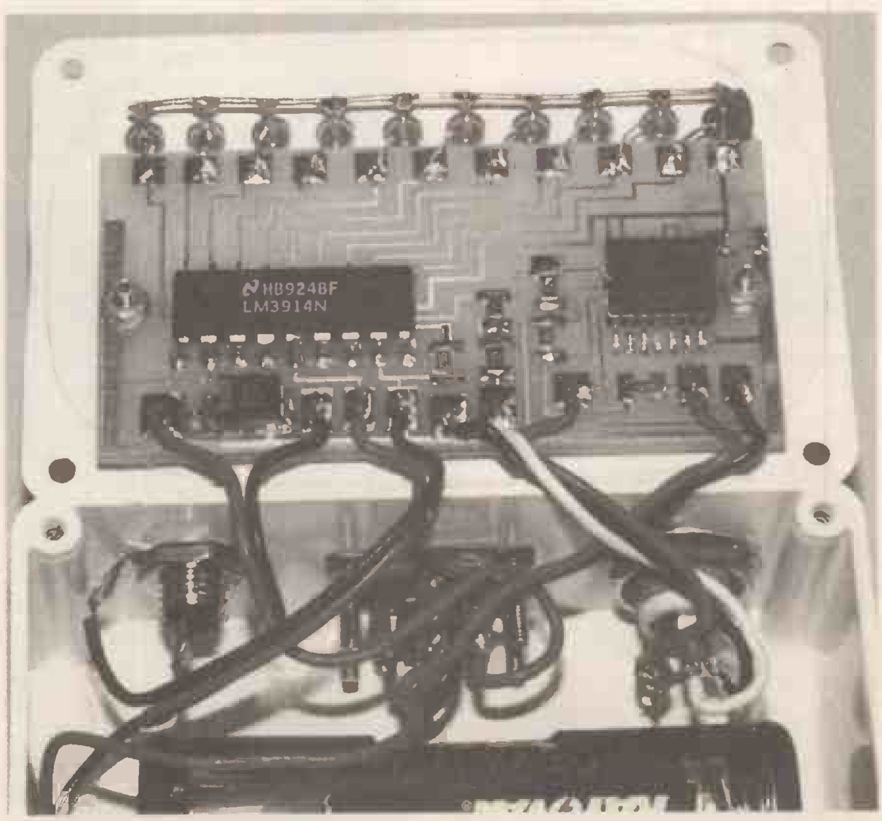
Fig.3. Complete circuit diagram for the Pocket g-Meter.

The full circuit diagram of the Pocket g-Meter is shown in Fig.3. The signal from the detector of IC1 appears at pin 8. This is coupled directly to the uncommitted amplifier which is wired for a gain of 4× or 8× corresponding to a 2g or 1g range, which is selectable by switch S1. A very rudimentary filter consisting of capacitor C2 limits the device to a frequency response of a few Hertz (Hz) to suit this application.

The LM3914 linear l.e.d. driver, IC2, is operated in dot mode for lowest current drain. It requires an input of 0V to 1·3V for full scale operation. Therefore, the mid-rail based output from the sensor must be offset as required.

Potentiometer VR1 allows the *zero-g* position to be conveniently placed at l.e.d. D1, D10 or D5 with the sensor chip in any orientation. This is a most useful feature of the design and makes the g-Meter a very versatile instrument. The amplified and filtered output is made available through phono socket SK1.

In the prototype, all l.e.d.s are green except D10, which is red. This allows D5 to be set as *zero g* with four equal steps above and below this point. This l.e.d. also behaves differently in that higher voltage inputs leave it on so it acts as a useful indicator. Resistor R5 controls the l.e.d. brightness and can be changed at the expense of battery life.



Larger-than-life view showing the tiny surface-mount components mounted on the p.c.b.

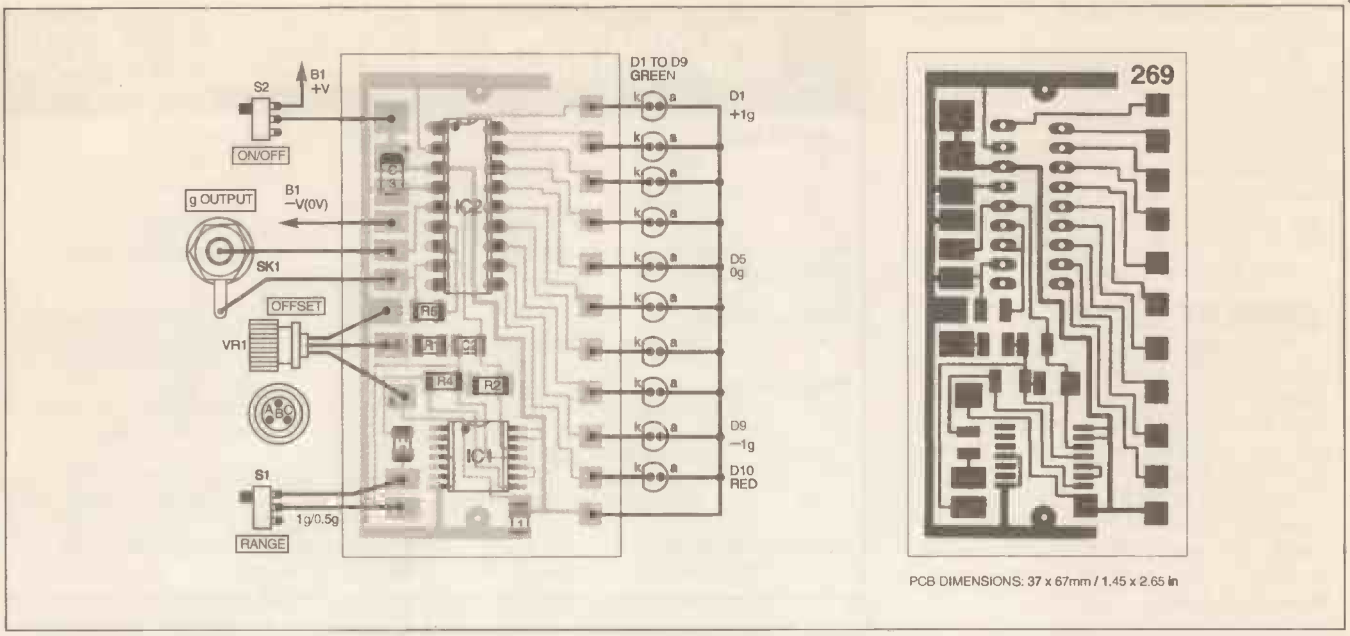


Fig.4. Printed circuit board component layout, interwiring and full-size underside copper foil master. Note that IC2 is also soldered to the topside tracks of this surface-mount hybrid board.

CONSTRUCTION

This project is a hybrid circuit in that the LM3914 l.e.d. driver, IC2, is a "standard" dual-in-line (d.i.l.) format device. This is soldered on the upper copper track side of the p.c.b. just like the surface mount devices. About half of the components fit on a single-sided printed circuit board (p.c.b.).

The component layout on the surface mount circuit board (copper pads topside), together with the interwiring and full size copper foil master, is shown in Fig.4. This p.c.b. is available from the ***EPE PCB Service***, code 269. If you are producing your own p.c.b. remember that track and components are on the same side so there is no need for the usual mask inversions.

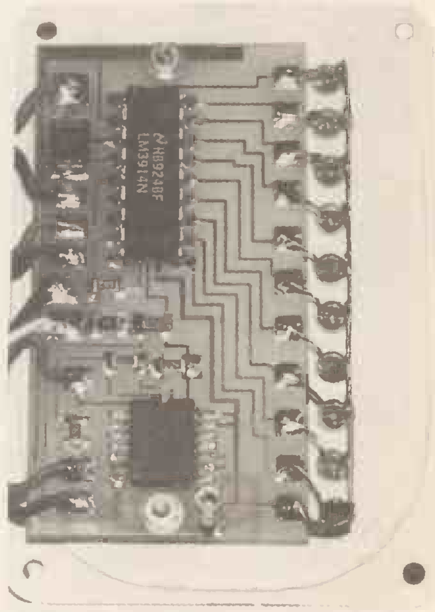
The layout of the whole instrument is designed to cater for the "sense" of movement. So that a forward movement of the g-Meter, as you look at it, results in successive l.e.d.s lighting up in the direction of movement, see photographs. Because of the inversion of the signal by the uncommitted amplifier in IC1, this means that l.e.d. D10 lights first, reaching D1 at maximum acceleration in this direction.

Similarly, the Offset potentiometer VR1 is wired so that a clockwise rotation "pushes" the lit l.e.d. towards D1. Thus the whole instrument is intuitive in operation.

The l.e.d. driver IC1 should be soldered in last because its pins protrude through the p.c.b. and the board will not rest flat on the work surface. This would get in the way of the surface mount soldering process making it even more awkward in "positioning" these components.

Placing the chip components is just a matter of soldering one end first whilst holding it in place with tweezers. The free end can then be soldered with ease.

Aim to use minimal solder. This is not just to make the project look neat but results in a more flexible connection and less stress is transferred to the chip. This is particularly important for the higher value ceramic chip capacitors like C1 and C2, which are a little more delicate.



Finished circuit board bolted to the rear of the case lid.

Completed g-Meter showing the side-mounted components.

CASE PREPARATION

Before mounting the l.e.d.s on the p.c.b. and bolting the board to the lid of the case, the two halves of the project box should be prepared. Taking the bottom half, one side panel of the case should be carefully marked and drilled to take the phono socket SK1, the two slider switches and the miniature potentiometer VR1.

The two slide switches will need careful attention and the rectangular cutouts should be made first. The best way to do this is to mark the cutout for the lower switch, on the outside of the case, with a pencil or Biro and drill holes in the four corners, fractionally inside the marks.

Next, drill a series of holes along the guide marks to join up with the corner ones. The edges of the resulting cutout should be smoothed down with a fine file.

Full-size scale and front panel legend.

Now offer up the switch to the cutout so that the slider knob protrudes into the case from the outside. Mark the two fixing hole positions, remove the switch and drill the holes.

Repeat the procedure for the other switch and mount them in the case together with the other off-board components. You can, if you wish, solder leads on these components at this stage for later wiring to the p.c.b. If you do, make the leads sufficiently long enough to allow the lid of the case to be fully opened for battery changing.

Having completed this operation, the lower half of the box can be put to one side for later. Now for the case lid and final assembly.

FINAL ASSEMBLY

In the prototype, the 3mm l.e.d.s protrude through 3mm holes in the lid of the project box. A sharp drill and a little skill should produce a push fit and no glue will be needed. Take care to drill the l.e.d. holes evenly spaced (6mm between centres) and in as straight a line as possible for best visual effect.

All the anode (a) leads are connected to the positive voltage line by a short length of stripped solid-core connecting wire. This is connected to the last copper pad in the line of l.e.d. connections, as indicated in Fig.4.

All the off-board controls and output socket SK1 are wired up using fine futaba wire as used for model control/servo work. It has a very flexible multistrand core and comes as a 3-way ribbon. You can, of course, use standard multistrand wire if you wish.

The cathode (k) lead of each l.e.d. (D1 to D10) is bent over to reach the appropriate copper pad on the p.c.b and soldered in place. This method is less critical than mounting the l.e.d.s directly on the p.c.b.

There is little room for misalignment of the surface mount ADXL105 sensor i.c. as the pads are quite small, but the axis should be lined up as accurately as possible with the long axis of the p.c.b. The circuit board is held in place with two 2mm countersunk bolts, with extra nuts to form spacers between case lid and p.c.b.

For extended frequency application and if the ADXL105 were to be pushed to its full potential the mounting method would need further consideration. But the method shown is perfectly satisfactory for this low frequency application.

Finally, the LM3914 is added and its pins are soldered on the *topside* of the board along with the SM chips. This is perfectly in order for the d.i.l. package which is frequently used on double-sided circuits. It is worthwhile removing the protruding leads from the reverse side of the board with a side cutter.

Returning now to the bottom half of the box, the off-board components should now be wired to the lid-mounted p.c.b. Give the board and wiring a final checkover and screw the two halves of the box together. All that remains is to produce a paper/card "scale" similar to the one shown in the photographs and the unit is ready for use.

CALIBRATION

The g-Meter does not require calibration and setting it up is just a matter of checking the current consumption and adjusting the Off-set control VR1 to get the active l.e.d. on scale. The drain current should be about 5mA with no l.e.d.s alight and about 10mA with an l.e.d. on.

A few initial checks using gravity as a reference will be worthwhile to show correct operation and demonstrate how the scale can be used.

FEEL THE FORCE

First set the range to ±1g. Then hold the g-Meter flat or rest it on a horizontal surface and, using the Offset control, adjust the position of the "on" l.e.d. to the mid position. If D5 is used as the 0g position this gives four steps to +1g and four steps to −1g.

Now turn the g-Meter to the vertical position with the arrow pointing upwards. The internal ADXL105 IC1 is now on end with pin 1 uppermost. The indicator l.e.d. should travel up the scale to the +1g position stopping with l.e.d. D1 active.

This is now registering the force of gravity. Standing the device on the other end, reversing the arrow direction should result in a −1g indication.

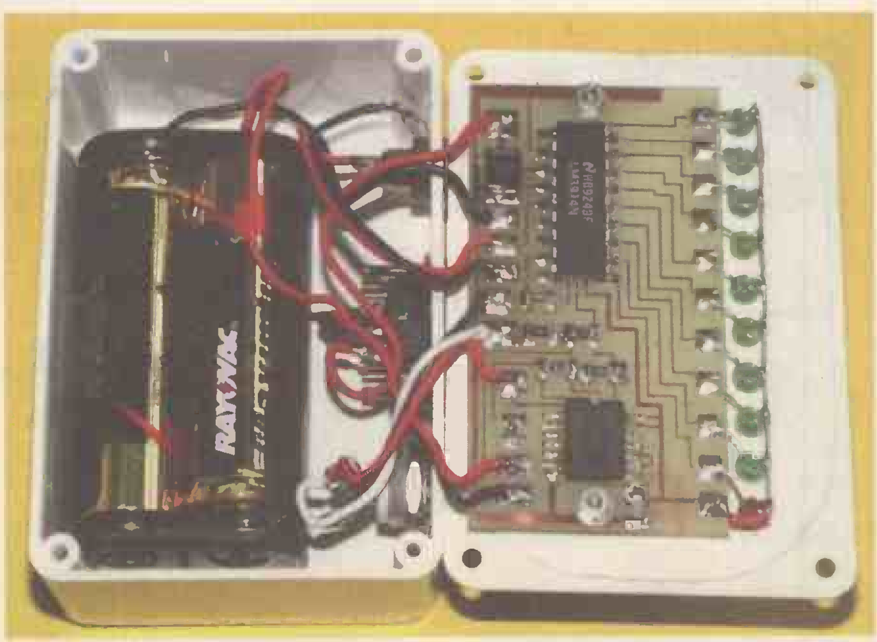
If the offset is adjusted to indicate −1g with the g-Meter horizontal it will now cover the range of 0g to +2g. As a check, stand it on end and the active l.e.d. should reach mid-scale, which now means +1g.

Setting the range switch to the ±0·5g will drive the indicator off-scale with the meter on either end. This range can be checked by setting the indicator to −1g, l.e.d. D10 in the horizontal orientation. Then by turning the meter end-on the indicator should travel full scale to D1 covering a range of 0g to 1g.

By such manipulation a variety of operating modes can be set to suit a particular type of measurement.

A few simple experiments can now be performed. Set the range to 0 to 2g and hold the box tightly in the vertical orientation whilst jumping on the spot. A small jump will generate +0·75 to 2g. A big jump may drive the meter off scale.

But an indication of the *g-force* can still be gleaned from this versatile device. Simply hold it at about 60 degrees to the



Interwiring to the off-board components. Note the "common" connection to the l.e.d. anodes and the careful positioning of the battery holder.

vertical and after resetting the off-set to the position marked –1g (LED10), you now have at a range of about 0 to 4g. Can you drive your body skyward at 4g?

Whilst sitting on a swivel chair swing around in an arc with the meter held horizontal and pointing along the radius of movement. Which way does the g-force register and why?

Monitoring the accelerations experienced during driving is revealing. A slight easing of the foot from the accelerator pedal results in surprisingly rapid deceleration due to engine breaking. Hard breaking, rapid take-off from traffic lights and excursions over hump-back bridges also produce interesting g-forces.

Too much of this in-car work can result in unwanted large deceleration so be careful or get a chauffeur. A safer way to experience smooth acceleration is by travelling in lifts but here again there can be arresting dangers. Fairgrounds also generate a wide range of acceleration experiences.

WHAT IS "g"

Before all this is understood it is necessary to explain speed and velocity. Speed is simply the average velocity over a journey and is not very useful in physics. Velocity describes the rate at which distance is covered with time and is measured in metres per second.

Velocity is always in a straight line. Any change in velocity is achieved by applying a force to the body when it will slow down or speed up, i.e. will decelerate or accelerate. So acceleration is the rate of change in velocity, and as the units of velocity are metres per second, then acceleration is metres per second per second or m. sec^{-2}

To understand "*g*" we need to invoke Newton who discovered that any two masses, like you and the earth for example, experience a force of attraction called gravity. At the earth's surface this force is the same as you would feel if you were accelerated at 9·81metres. sec^{-2} and is therefore given its special title of 1g.

Although acceleration is measured and mostly quoted in metres per sec^{-2} in many cases it is more meaningful to quote it in *g*. Acceleration (*a*), force (*F*) and mass (*m*) are all tied together in Newton's apparently simple relationship:

$$F = ma$$

With this we can calculate the acceleration which will be produced by the application of a particular force. A good example is a falling apple. It weighs about 100g (its mass, *m*) and whilst it drops from the tree it will accelerate at 1g or 9·81m. sec^{-2} (*a*) so that the force (*F*) on the apple is obtained by multiplying its mass by its acceleration.

To get the units correct the mass is measured in kilograms, in this case 0·1kg. So that the force is 0·1 × 9·81 which gives *F* as 9·81kg.m. sec^{-2} and this happens to be about 1 Newton of force.

To sum up, it is acceleration coupled with mass which is meaningful to us as this describes the force we feel. A jumping flea can generate huge acceleration without problems whereas the same acceleration would be very uncomfortable for a human.

The ADXL105 is used for earthquake detection, in particular for automatic gas cut-off. It will register vibrations very effectively and looking at the output on an oscilloscope can be very informative. Wooden floors are not as solid as they feel, but lets hope you don't get a chance to register an earthquake.

The g-Meter, used for tilt detection will quickly show just how effective even a low cost spirit level can be. It is surprising what can be done with this single axis detector and it shows how useful a multi-axis device might be. □

CONTROL & ROBOTICS

Milford Instruments

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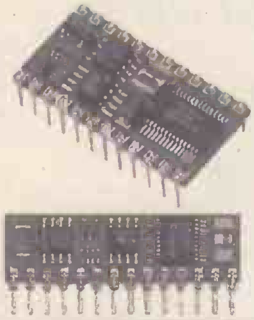
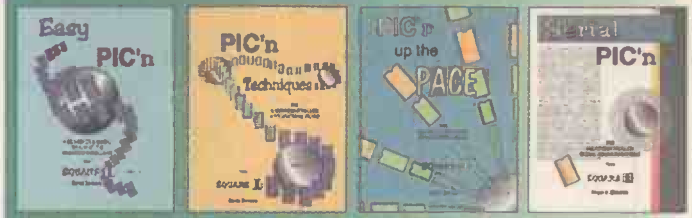
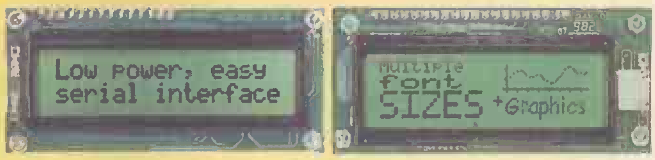


Full information on using BASIC Stamps plus lots of worked projects and practical electronics help. CD-ROM also includes 30+ past magazine articles and Stamp software. **£29.95**



New to PICs or just wanting to learn more tricks? We stock the excellent PIC primer books from David Benson- suitable for the complete beginner to the advanced user.



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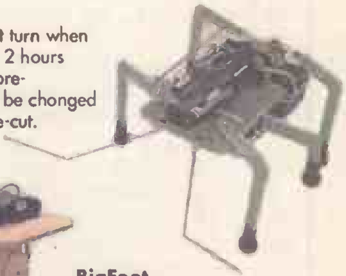
Stamp2 based 3-axis machine
Stepper drive to X, Y and Z axes with 0.1mm (4thou) resolution.
Kit conains pre-machined frame components.
Complete with Windows software for drilling pcbs.
Full kit at £249, Part kit at £189



StampBug
Stamp1 based walking insect
Forwards,backwards and left/right turn when feelers detect object in path. Up to 2 hours roving from 4xAA Nicads. Chips pre-programmed but programme may be chonged (software supplied). Body parts pre-cut.
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New range of robotic arms for educational and hobbyist use with super powerful servos. Controlled from PC (Windows freeware provided) or from optional keypad. Stands about 450mm high when fully extended.
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BASIC Stamp is the registered trademark of Parallax Inc. For further details on the above and other interesting products, please see our web site- **www.milinst.demon.co.uk**

PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

According to the old proverb "you should not judge a book by its cover", but it is a fact of life that people will judge your completed electronic projects by the standard of their external finish rather than the quality of the circuit boards and wiring.

It is probably fair to say that most constructors, even if they were primarily interested in the electronics rather than the mechanical side of construction, would prefer to produce neat looking projects. Few will be satisfied with perpetually churning out projects that look as if they have just had a nasty accident.

It takes more money and often quite a lot of additional time to put the finishing touches to the exterior of a project, but it is likely to be time well spent.

The Rub-Off

You can put a great deal of time and effort into the exterior finish of a project, but without some neat legends for the controls you will not get that professional look.

Even if you are not worried about the appearance of your projects, it is still a good idea to clearly label the controls and sockets. Having just finished the project you can probably remember the function of every control and socket, but you might find the going more difficult when returning to the project at some later date.

Also, it pays to bear in mind that others may need to use the device. With no labels to indicate the functions of the controls, operating the gadget becomes a matter of trial and error.

In the past the standard method of producing panel legends was to use rub-on transfers. These days there are a number of alternatives that are quicker, easier, and tougher. Rub-on transfers can produce some first class results, but even in the hands of experienced users they are slow to use and getting neat results is not particularly easy.

Probably their biggest drawback is their lack of durability. They rub-on easily enough, but they rub off again just as easily. Lacquers and varnishes can render them less vulnerable, but are usually something less than 100 per cent effective.

Obtaining the smaller sizes is also more difficult than it used to be, presumably due to a drop in demand as other labelling methods have become more popular. Rub-on transfers remain a perfectly valid approach to panel legends, but here we will concentrate on the other options.

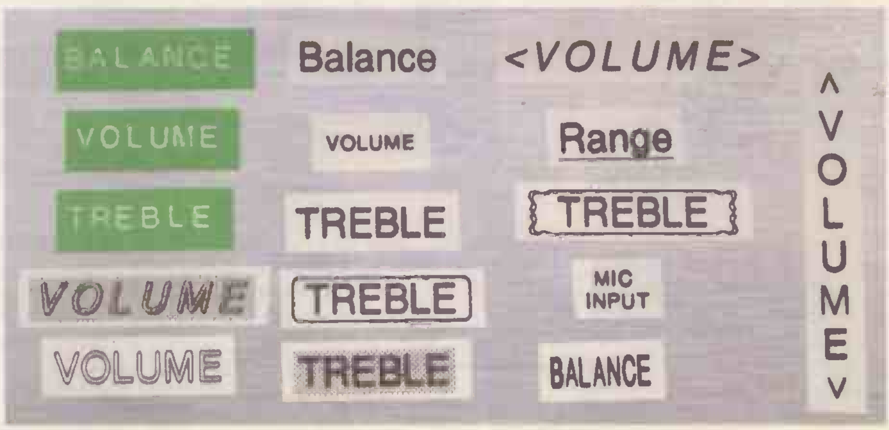


Fig.2. Some example labels produced using a Brother PT75 labeller. The three at the top lefthand corner were produced using a Dymo Mini.

Cheap and cheerful

The quickest and easiest method of adding legends is to use a labelling machine. The least expensive of these are the Dymo labellers (Fig.1), which are purely mechanical devices that produce embossed lettering on self-adhesive tapes.

These labellers cost only a few pounds each complete with one tape, and are available from the larger stationers. Tapes of various colours are available, and this is a very inexpensive means of making labels.

To produce a label you dial up the letters one by one, operating a simple lever system to put each letter onto the tape. Once the label is finished it is cut from the tape using the built-in cutter.


Fig.1. An electronic labelling machine (left) and (right) a simple mechanical type which produces embossed lettering, self-adhesive labels.

Unfortunately, the finished labels tend to have a "cheap and cheerful" look, and even if you are very careful in their preparation they do not look very professional. Another slight problem is that the tapes are quite wide at about 9mm, which makes the labels too large for some projects. However, if you simply wish to add some labels as quickly, easily, and cheaply as possible, a simple labeller of this type has no competition.

Hi-Tech Labels

Electronic labelling machines have been in existence for many years now, but they used to be prohibitively expensive for occasional amateur use. In common with most electronic goods, they have been subject to steady price reductions in recent years, and the cheaper units are now starting to "put the squeeze" on mechanical labelling machines.

The simpler electronic units from Dymo, Brother, and probably some other manufacturers, are available for less than £20 complete with one tape. They are occasionally put on special offer at about half that price.

In the Brother PT75 electronic labeller, shown in Fig.1, letters are entered on a form of QWERTY keyboard and there is a small liquid crystal display so that you can check that words have been entered correctly. Upper and lower case letters are available, together with numbers and a full range of punctuation marks and symbols. Additionally, there is a limited choice of text sizes and styles, and it is also possible to underline words or have them within a frame.

The labels are produced using some form of thermal printer technology, and the quality of results from even the cheaper labellers is certainly very impressive. The results obtained from a Brother PT75 labelling machine can be seen in Fig.2, and they are at least as good as those produced using rub-on transfers. The three labels in the top left hand corner were produced using a

Dymo Mini (mechanical) labelling machine, and are clearly not in the same league.

Operating an electronic labelling machine is extremely simple. Having set the text size, etc., it is just a matter of typing in the required word, pressing the Print button, and then pressing a lever to cut off the completed label once it has been printed.

In common with mechanical labellers, one slight drawback of the electronic units is the width of the tapes, which is either 9mm or 12mm. However, the 9mm type is well suited to most projects, and there is usually an option to print in small text if necessary. Text from the PT75 is normally a little over four millimetres high, but it can be reduced to half this if desired. With the aid of a sharp modelling knife or scalpel and a metal ruler it is possible to trim labels having small letters so that they will fit into quite small spaces.

Electronic labelling machines are somewhat more costly than the mechanical variety, but their greater versatility and higher quality results seem to more than justify the extra cost. It is worth bearing in mind that both types of labeller are also suitable for general labelling around the home or office.

Self Centred

Using labels gives less neat results than applying lettering directly on to a panel one letter at a time, but with many modern cases labels are a more practical approach. With many contemporary cases the front panel is not removable, making access to the panel very awkward. The one letter at a time approach can then be very tricky indeed.

When using labels you still need to be careful to get the words properly centred above controls and sockets, and to make sure they are not on a slant. If the lettering uses proportional spacing, and the electronic labelling machines normally do, you have to be careful when determining the centre of a word.

For example, on the face of it the centre of the word "balance" is in the middle of the second "a". However, with proportional spacing the "l" is allotted less space than the other letters in this word, pushing the centre slightly to the right of this.

The only sure way to determine the centre of the label is to measure it. You can then lightly mark lines on the panel to help keep the labels on the level, and to indicate the centre point for each label. The labels can then be carefully positioned on these marks, preferably just covering up the marks so that the problem of removing them is avoided.

Alternatively, if you are good at this type of thing you can simply position the labels "by eye". When designing front panel layouts and fitting labels it is the design that looks the best that is right, and not the one that is mathematically perfect.

The adhesive on labels from either type of labelling machine is usually quite strong, so it is not possible to slide the labels into position once they are even partially stuck to the panel. If a mistake is made it is often possible to carefully peel the offending label from the panel and reposition it, but doing this more than once will probably damage it. Fortunately, making a replacement should only take a few seconds and cost less than 0·1 pence!

Experience suggests that the best method of positioning is to place the label on the end of a metal or plastic rod about 150mm or so in length. This acts as a handle that makes positioning of the label much less fiddly. Having manoeuvred the label precisely into position it can be pressed down onto the panel.

Try going through the Vacation and Wingdings fonts. The Arial font is a good choice if you require a simple font that will produce neat looking labels. There are plenty of fonts to choose from if you prefer fancy lettering styles. Many of the standard fonts look slightly "heavy" when used for panel legends, but some of the fonts are also available in light versions.

The simple way of handling computer generated labels is to produce a page containing the required words, print it out, cut out the labels using a sharp knife and a cutting edge, and then glue them to the panel. Any general-purpose adhesive should be suitable, but do not use so much that it soaks into the labels and ruins them.

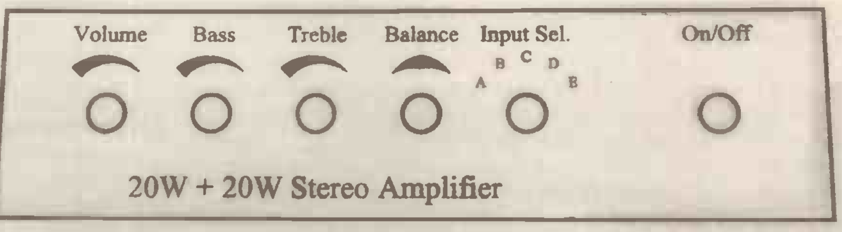


Fig.3. A front panel overlay produced using a PC and a laser printer. The printing is on the underside of a transparent sheet.

With this method the labels can be fitted into otherwise inaccessible places. They can even be added with the controls in place on the panel and the control knobs fitted.

Both types of label seem to be quite durable and do not need to be protected with lacquer or varnish. Be careful with your choice if you should decide to apply a protective coating, Some varnishes and lacquers will attack the labels, so it is advisable to make a test on a dummy label before progressing to the "real thing".

PC Labels

Many people these days own or have access to a PC and a printer. As we have pointed out in the past, this combination can print excellent labels at quite low cost. The quality of the labels clearly depends on the capabilities of the printer used, but any modern inkjet or laser printer should produce "crisp" text characters.

A laser printer seems to produce more durable labels, which are waterproof and can be printed on a wider range of media. Inkjet printers have the advantage of being able to produce multi-coloured labels if desired.

A modern word processor enables lettering to be produced in a wide range of fonts and sizes, as does any desktop publishing program and most drawing programs. If you have a PC you almost certainly have some software that can produce labels. Even the humble Wordpad word processor supplied with Windows 95 and 98 is capable of the full range of Windows fonts and text sizes.

Some of the standard Windows fonts are actually sets of symbols. Most of these are of little use in an electronic context, but it is worthwhile looking through the symbols for something useful.

Double-sided adhesive tape is also suitable, and avoids any risk of the adhesive soaking into the labels. Stick the tape in place behind the labels prior to trimming them down to size. That way the tape is trimmed down to size at the same time, and is always a perfect match.

It can be a bit difficult to get the backing paper away from the tape when doing things this way, but it can usually be prised free without damaging the label. It is also a good idea to print some extra labels to allow for casualties.

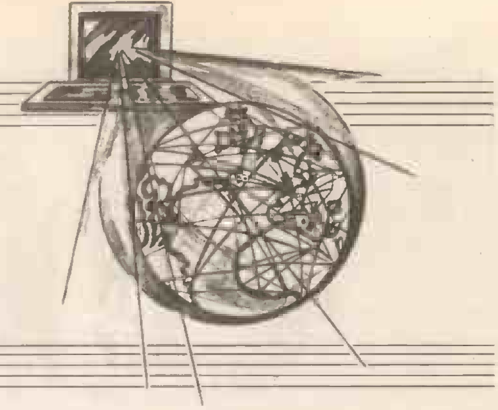
You can also print the labels in various sizes. If you then find that your original choice looks slightly too large or too small once in place, another size can be tried. It is possible to get a large number of labels onto an A4 size sheet, and the cost per label is negligible, so wastage is not a problem.

Up-Market

The more up-market approach to computer generated labels is to produce a complete overlay for the front panel. Modern wordprocessors, etc. have onscreen rulers that enable lettering to be positioned accurately on the page. With drawing programs you can add custom symbols and other graphics as well.

For the ultimate in durability the panel design should be printed as a mirror image on transparent film. When viewed from the "wrong" side the image is the right way round (Fig.3), and the lettering is protected by the transparent film.

Scotch "Spraymount" is suitable for fixing most transparent films to most types of front panel. Whatever adhesive you use it is advisable to make tests to ensure that it will not attack the film, or the panel if the case is a plastic type.



NET WORK

ALAN WINSTANLEY

FRIED SPAM

SPAM stands for Supply Pressed American Meat, a familiar tinned meat (yum) dating back over 60 years, but thanks to the Internet it also implies another form of import which is unwelcome by almost every Internet user. The past few months have seen a major resurgence in the level of unsolicited commercial E-mail (UCE) or "spam" being received at my regular E-mail address.

Recently, a number of Internet users including myself have faced a real barrage of spam, in my case 30 or more per day at times. The spam is actually a Reject message sent to my default "postmaster" address. By checking a typical Reject message, it's possible to see what's really going on. An abbreviated header and message appears below:

——— Here is your List of Failed Recipients ———
<xxxxxxx@xxx.net>

———— Here Is Your Returned Mail ————
Received: FROM mail-gw.datawld.com BY vs.mail.xxx.net ; Wed Apr 12 08:47:22 2000
Wed, 12 Apr 2000 07:58:08 -0400
Received: from ppp-xx.tnt-1.hou.smartworld.net (HELO orl2786xN?) (xx.xx.xx.xx) by xxxxx.xxxxxxx.educ.xxxxxxxx.xx with SMTP; 28 Aug 1999 02:23:13 - 0000
DATE: 12 Apr 00 7:32:06 AM
FROM: AiVs85TN4@epemag.demon.co.uk
Message-ID: <402WavWnR1A1x4s3Vz>

SUBJECT: COMPLETE ONLINE BUSINESS!!!

Build a residual income from time you spend on the Internet placing FREE advertisements like this. Successful Internet company wants you to help them market their products and services online. To Register with the program and to begin receiving instructions, simply reply to this email and type your first and last name. mailto:xxxxxxx to be removed from this list mailto:xxxxxxx@england.com?subject=remove

Many more examples of these messages started flooding in to my mailbox. This is because my domain had been forged as the original sender (see the FROM: line) by the spammer who then proceeded to mail out thousands, if not millions, of similar messages in my name. Any messages which could not be delivered would be "rejected" and sent back to its "sender" (me).

Spammers often use "open relays" – third party mail servers which inadvertently allow spammers to use them from anywhere in the world in order to mail spam to its intended victims. By examining another Reject header very closely, an open relay at the University of Victoria, Canada, was found which was promptly reconfigured to close it. All of this policework takes time and effort though, and it often needs an expert to analyse the headers fully. The ORBS (Open Relay Behaviour-modification System) at **www.orbs.org** is a voluntary organisation which provides on-line resources to help combat abuse of insecure mailservers by spammers.

HEADING FOR HOME

Looking further into the header, the interesting part is the line *Received: from ppp-xx.tnt-1.hou.smartworld.net (HELO orl2786xN?)*. Every forged Reject message contained a similar line, which starts to reveal the true identity of the spammer: it's a dial-up (PPP account) user of an American ISP called SmartWorld, who told me they were filing a lawsuit against the user.

Spam on this scale is bad for everyone: the huge volume of UCE damages the relationship between the originating ISP and its bandwidth provider, and it causes support problems for everyone concerned, including Demon Internet and SmartWorld. It blocks my E-mail, and obscures genuine E-mails which get lost amongst the volume of UCE.

Unwanted spam places the burden of cost on everyone except the sender. It causes direct costs to be incurred in terms of wasted time, lost productivity and Internet access costs. In this case it also made my domain appear to be responsible for sending the spam.

These Reject messages were unremitting for several months and the sheer volume forced me to re-configure my E-mail client. It was noticeable that almost always, the Reject messages had my genuine host name but the user name was randomised to bypass mailfilters. In the above example, it was mailed to **AiVs85TN4@epemag.demon.co.uk**.

My main Turnpike 5.0 mail software was reconfigured to only accept E-mails addressed to recognised E-mail user names (e.g. **alan@epemag.demon.co.uk**); sure enough, Turnpike immediately began to report that messages were being rejected from my mailbox, meaning that at long last, I was starting to get my revenge. There is no problem in rejecting mail in this way, as it will hopefully get routed to a "bit-bucket" where the message will be scrapped.

Interestingly, the spam stopped just a few days later, although whether this was because the spammer finally took the hint, or whether he had been closed down, is unclear. However at the time of writing, complaints are appearing in Demon newsgroups of yet another forged UCE campaign starting up.

HOW TO FRY SPAM

There are some lessons to be learned from extreme cases like this. Learn to use the mail filter rules of your software. I use Microsoft Outlook Express 5.0 on my laptop, which is configured only to allow mail addressed to my recognised E-mail addresses.

This can be done as follows: go **Tools/Message Rules/Mail**.

1. Select the Conditions for your rule: [tick Where the To line contains people].
2. Select the Actions for your rule: [tick Do Not download it from the server].
3. Rule Description: [configure Where the To line does not contain 'alan' or 'arw' or 'user' or 'postmaster']. Here, edit the rule's options then click the Options button in the 'Select People' dialog box, to further customise the rule:

Apply Rule if Message does not contain the people below, and
Apply Rule if Message matches any one of the people below.

So if the To: line does not contain 'alan' or 'arw' or 'user' or 'postmaster' it will not be downloaded from the server.

Microsoft Outlook Express 5 arrives with Microsoft Internet Explorer 5. Its filter rules look complicated but they are written in plain English and are quite easy to use, but you will need to refine the rules over time. Test the filters by sending E-mailing to yourself.

It is worth reminding readers that ***under no circumstances*** should you ever reply to any E-mail address contained in any spam message unless it's a genuine mailing which you subscribed to. *Never* E-mail to ask them to stop, and *never* reply to the Remove-me address. Replying confirms your address is valid, making it a prized commodity amongst spammers (and worth more money).

You can also help combat UCE by forwarding examples (with headers) to the originating ISP (e.g. SmartWorld). They usually have an **abuse@** E-mail address so send it there, along with your *polite* comments. Remember you are dealing with tech support people at the other end who may be inundated with problems similar to yours, so keep your complaint reasonable.

My E-mail address is **alan@epemag.demon.co.uk** and you can check my web site at **http://homepages.tcp.co.uk/~alanwin**. See you next month.

Constructional Project

PIC-GEN FREQUENCY GENERATOR/COUNTER

JOHN BECKER

Add even more versatility to your workshop facilities.

COMBINING the sophisticated features of a Maxim MAX038 waveform generator and a PIC16F877 microcontroller has resulted in a highly versatile and inexpensive workshop tool whose facilities have hitherto been unattainable without considerable design complexity.

The MAX038 is a high-frequency precision function generator whose output is selectable to produce triangle, sine and square waveforms, within a wide operating frequency span of 0·1Hz to over 10MHz, split in the PIC-Gen as eight overlapping frequency ranges. Range and waveform selection are performed by the PIC16F877 in response to pushbutton switch controls. Frequency is fully variable within the selected range by means of a front panel control potentiometer.

An alphanumeric liquid crystal module displays the frequency and range information. Four frequency outputs are provided:

- Direct output at ±1V peak-to-peak
- A.C. coupled output, fully variable between zero and 4V peak-to-peak
- Pulse output, 0V to 5V logic level
- 3·2768MHz fixed frequency, 0V to 5V logic level

The PIC is also used as a frequency counter, switch selectable to monitor the frequency generated by the MAX038, or from an external source in conjunction with a pre-conditioning waveform shaper and frequency divider. Two external signal inputs are provided: one for 0V to 5V logic level waveforms, the other for a.c. waveforms having a peak-to-peak swing of between about 2V to 5V. The prototype can monitor frequencies in excess of 40MHz.

MAX038 FUNCTION GENERATOR

In *EPE* September '96, Andy Flind first introduced readers to the merits of the then newly introduced MAX038 waveform generator, in a special feature article of the same name. He followed it up with a full constructional article, the *10MHz Function Generator*, in October '96.

Prior to the introduction of the MAX038, arguably the main contender for the most widely used function generator was the 8038, manufactured by various companies under different prefix codings, such as ICL8038 and XR8038, for instance.

The 8038 is still widely used but it has limitations in the maximum frequency that can be generated. The range is typically 0·001Hz to 100kHz.

The MAX038, however, is stated to have an upper frequency limit of at least 20MHz, and possibly around 40MHz. It has to be said, though, that attaining such high frequencies requires printed circuit board design and construction techniques normally found only in commercial manufacturing establishments.

The upper frequency limit of the device is dependent not only on very accurate control of the current flowing into its frequency setting inputs, but also on the capacitance associated with them. Maxim state in their data sheet, for instance, that the specified upper frequency limit is achieved when the timing capacitance is less than or equal to 15pF and the control current is 500μA.

Unfortunately, on a p.c.b. designed for successful assembly by the average hobbyist, the capacitance between the MAX038, other components and the tracks is likely to prevent the maximum frequency from being reached. The prototype PIC-Gen described here achieves a maximum of just over 10MHz.

PIC-GEN CONCEPT

Considering how the MAX038 might be put under semi-automatic control as part of a frequency generator and counter system, the author recognised that a PIC16F877 microcontroller might provide the key. This device has five input-output ports which, it seemed, could possibly provide automated switching of the frequency range capacitors, selection of the waveform shape, offer frequency counting and provide an output to a liquid crystal display.

Doing a basic mock-up on stripboard coupled to a PIC roughly programmed to perform the bare essentials proved the viability of the idea. The concept was then given full flesh and bones to become the design whose circuit diagram is given in Fig.1.

The MAX038 function generator is shown as IC2. It will be seen that half the pins are grounded and from some of their notations it will probably be (correctly) deduced that the device has more functions than are used here. For information about the device's full range of functions, see its

data sheet (details later) or Andy Flind's Sept/Oct '96 articles.

In the PIC-Gen design, the controls used are those that set frequency and waveform shape. The eight frequency ranges are set according to the capacitance value connected to the device's C OSC pin. Fine tuning of the frequency is performed by varying the current provided by potentiometer VR1 to the I IN pin.

Resistor R2 limits the maximum current that can flow, while R1 sets the minimum current.

Typical l.c.d. display showing that a square wave is being generated and that a frequency count of 3,706,286Hz has been read on range 7 during the normal 1-second sampling period.

FREQUENCY SELECTION

Eight capacitors are used to set the frequency ranges, C11 to C18. These are commonly connected at one end to the C OSC pin (5). Capacitors C12 to C18 have their other ends connected individually to port pins of the PIC microcontroller, IC5. For p.c.b. layout convenience these pins were chosen to be RB1 to RB5, RD6 and RD7. Capacitor C11 is permanently connected to the 0V line.

Normally, the above seven pins are set as inputs to the PIC. In this condition, they are effectively held in an open-circuit state, the PIC inputs having a very high impedance. As such, the MAX038 ignores those capacitors.

To bring one of the seven port controlled capacitors into circuit, the PIC has the appropriate pin set as an output held at logic 0 (0V). With a higher capacitance value selected, so the lower the output frequency from IC2.

For the highest frequency range, capacitor C11 is the controlling component. Note, though, that its nominal value of 10pF will be seen by the MAX038 as a value higher than this due to the (unpredictable) capacitance of the circuit in proximity to the C OSC pin. Capacitor C11 could be omitted if you want to try increasing the maximum frequency attainable.

Pushbutton switches S1 and S2 cause the PIC to step the frequency range down or up (respectively) on a continuous 8-step loop.

Nominally, the capacitor values have been chosen to provide a factor of ten difference between each step. Normal manufacturing tolerances apply to these values, especially with the electrolytic capacitors.

Potentiometer VR1 provides a frequency control range of about 1 to 50. For example, if the minimum current flow through VR1 and R2 causes a frequency of 1kHz, then maximum current flow will cause 50kHz to be generated. The range may be shortened by increasing the value of R1, although this will raise the lowest frequency that can be attained.

WAVEFORM SELECTION

PIC-Gen provides selection of three waveform shapes, Sine, Triangle and Square.

Selection is made according to the binary code placed on the MAX038's A0 and A1 inputs. The code is controlled by the PIC, via its RB6 and RB7 pins, as follows:

A1	A0	WAVEFORM
0	0	Square
0	1	Triangle
1	x	Sine

where x = don't care

Pushbutton switch S4 causes the PIC to step through the three waveform codes on a repeating cycle.

The selected waveform is output at IC2 pin OUT and has a fixed amplitude of ±1V, symmetrical about 0V. The output has a very low impedance (typically 0·1Ω) and can be used directly via socket SK5.

The same waveform is amplified by the non-inverting op.amp circuit around IC3a. The gain is set at ×2, resulting in an output swing of ±2V. Capacitor C3 provides d.c. isolation of the output and potentiometer VR2 provides full control over the amplitude output at socket SK3, from zero to maximum.

It should be noted that the TL082 used as IC3a does not permit the full frequency rage of the MAX038 to be amplified and output. In the prototype, a maximum of about 1MHz is experienced, after which the amplitude progressively falls. Other op.amps which have higher frequency capabilities are available but no recommendation is offered on this point.

Readers should be aware that whilst some op.amps may seem to offer very high frequency capabilities according their data sheets, other factors (also quoted) can affect the range and must be taken into account.

FREQUENCY COUNTER

Whilst a PIC can be programmed to act as a frequency counter simply by monitoring one input pin, the maximum frequency that can be monitored by this method is severely limited. To enable very high frequency signals to be counted by the PIC-Gen, a pre-counter is used and the output from that is monitored at regular, but slower intervals.

The pre-counter is IC6, a 74HC4040 12-stage ripple counter. Its outputs are fed into PIC pins RC0 to RC7 and RD0 to RD3. It will be seen in Fig.1 that the PIC's pin order use relative to the output pin order of the counter does not match. This is intentional to simplify the p.c.b. design, allowing software to interpret the input values as correct binary numbers.

Note that IC6's Q12 output is the final one in its counting sequence. This changes state at 1/4096 of the input frequency and even at high input rates the PIC is able to monitor this pin. Each time the pin changes state, the PIC registers the fact and increments an internal counter.

At regular intervals, selectable for one or ten seconds by switch S3 (Sample Time), the full 12-pin sequence of IC6's outputs is read and a frequency value calculated according to this value and that of the internal counter. Once the reading has been taken, the internal and IC6 counters are reset (the latter via PIC pin RD4) prior to the next batch of counting.

Frequencies in excess of 40MHz have been recorded on the author's prototype.

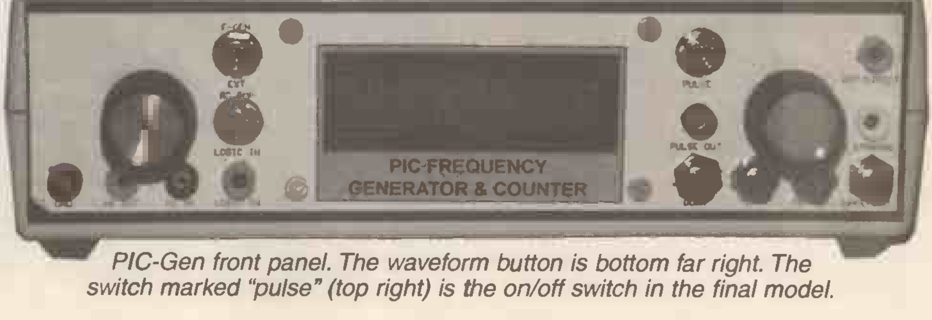
FREQUENCY INPUT

There are three sources from which the signal to be counted can be input, as described presently. All three finally arrive at counter IC6 via the Schmitt trigger NAND gate IC7a.

Immediately prior to reading the contents of IC6, the PIC sets pin RD5 low, so turning off gate IC7a and preventing further input signals from reaching the counter. This allows the ripple-nature of the counter to stabilise (ripple through) at the correct count value. Software introduces a slight delay between closing the gate and taking the reading.

Logic level signals (nominally 0V to 5V) are input to the PIC-Gen via socket SK1 (Logic Input), switch S5 selecting their routing to gate IC7a and the counter. Signals having other voltage ranges, either above or below the 0V/5V range should not be input to socket SK1. Those having lesser swings may not trigger gate IC7a, those having swings greater than about 6V could kill it.

Signals which are analogue or digital and have a swing range less than 5V, but greater than about 2V to 2·5V, are input via socket SK2 (AC Input). Switch S6 selects their routing to the pre-conditioning circuit around IC7c. This is another Schmitt trigger NAND gate, having one input (pin 13) held biassed at a mid-power line level



PIC-Gen front panel. The waveform button is bottom far right. The switch marked "pulse" (top right) is the on/off switch in the final model.

(2·5V) by the potential divider formed by resistors R8 and R9. The other input (pin 12) is held at +5V.

The input signal is a.c. coupled via C10 to the biased input of the gate. Providing the input signal's peak-to-peak range is greater than the gate's hysteresis value (which varies slightly between individual devices), so the gate will be triggered.

The output of this gate is also fed to switch S5, which routes it to the counter via IC7a when selected.

Because the main output signal from the MAX038 has a peak-to-peak swing of ±1V, it too has to be pre-conditioned via IC7c before its frequency can be counted, the routing also being selected by switches S6 and S5, respectively.

LOGIC OUTPUT

The output from IC7c is additionally fed to socket SK7 allowing, for example, the frequency generated by the MAX038 to be used as a 5V square wave (irrespective of which waveform is being generated), or for the a.c. signal to be converted to 5V pulses (whose width depends on the nature of the signal).

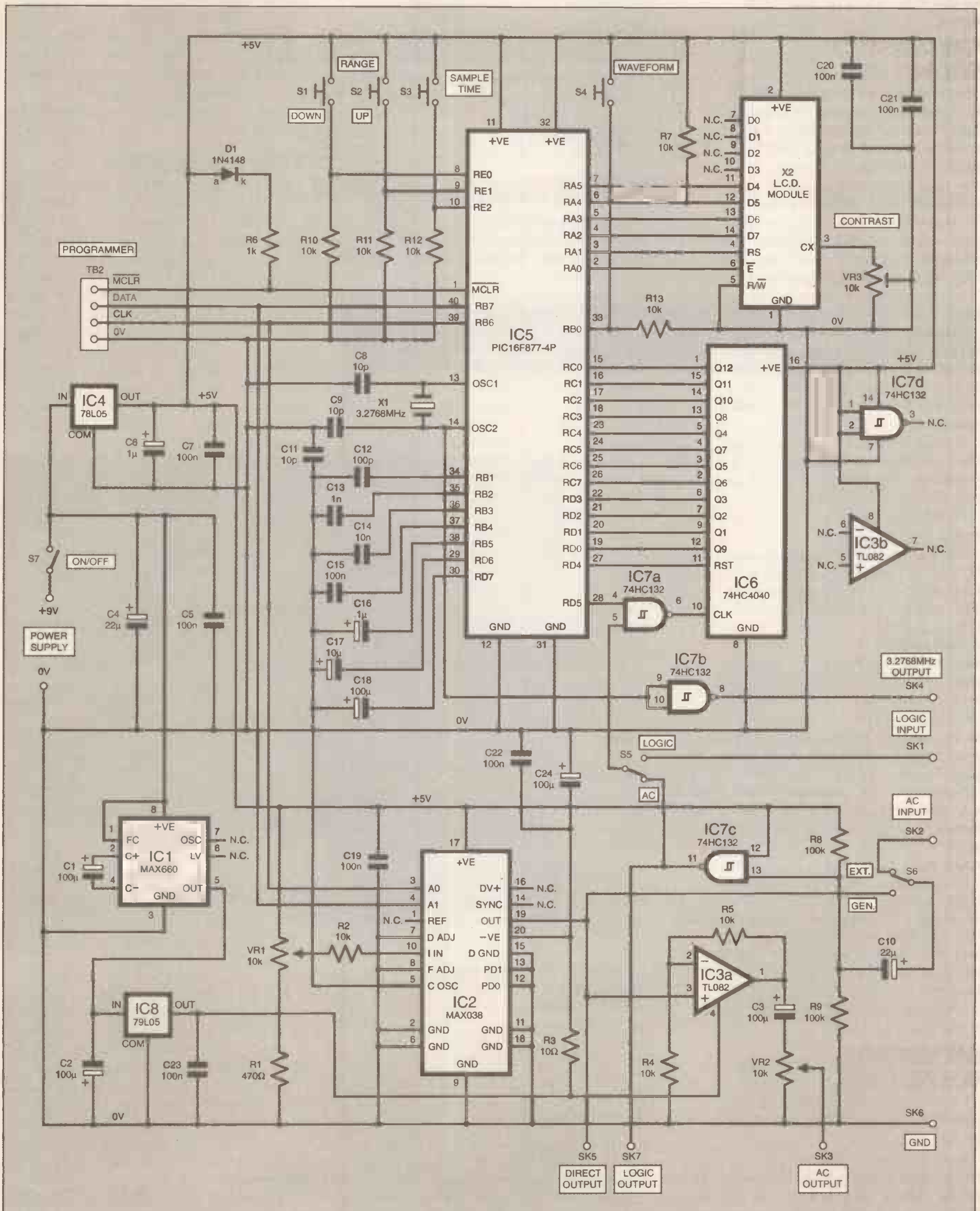


Fig.1. Full circuit diagram for the PIC-Gen Frequency Generator and Counter.

Whilst the MAX038 has its own 5V square wave available at the SYNC pin (when pin +DV is held high), it was found that instability occurred when this was generated (as cautioned in Maxim's data sheet). Consequently, the option to use this output has been dropped from the published PIC-Gen (although the connection tracks on the p.c.b. have been retained).

This display shows a sine wave is being generated and a frequency of 25,124Hz has been registered via range 4.

3·2768MHz OUTPUT

The PIC is run at a frequency of 3·2768MHz, as set by crystal X1. Although this frequency can be tapped directly from PIC pin OSC2, it was deemed better to buffer it via gate IC7b before releasing it to the outside world through socket SK4. The output is a 5V square wave.

DISPLAY MODULE

As is common with so many recent *EPE* PIC projects, an alphanumeric liquid crystal display (l.c.d.) is used. This shows the frequency count and sampling rate, plus the generated waveform selected and its frequency range (as a number between 0 and 7, where 0 is the lower frequency range). The information displayed takes a form similar to:

SINE 25124Hz
Range4 Time1 sec

where:

- Line 1 left: waveform selected (sine, triangle or square)
- Line 1 mid/right: frequency value
- Line 2 left: frequency range selected (8 choices)
- Line 2 mid/right: sampling range selected (2 choices)

The l.c.d. is shown as X2 in Fig.1. It is under standard 4-bit control, but whereas many PIC projects control it via PIC Port B, here it is controlled via Port A (RA0 to RA5). Apart from the change of PIC port register number, the software routine that drives the l.c.d. is the author's usual "library" routine.

It is worth noting, though, that because Port A RA4 is an open-collector pin, resistor R7 has to be used to bias it high in order to correctly control l.c.d. pin D5.

The l.c.d. screen contrast is adjustable by preset VR3.

POWER SUPPLY

It is intended that the PIC-Gen should be powered at 9V, either from a 9V battery or a 9V mains power supply (in fact, input supply voltages between about 7V and 12V are acceptable). Regulator IC5 drops and stabilises the input supply at 5V. This powers IC3, IC5 to IC7, and the l.c.d. These devices must not be powered within the PIC-Gen circuit at any other voltages (normal power supply tolerances apply).

The 5V supply is also used by the MAX038, but this device additionally requires a supply of –5V. A double-staged circuit is used for this purpose, based around IC1 and IC8.

COMPONENTS

Approx. Cost Guidance Only **£56** *excluding case, batts.*

See SHOP TALK page

Resistors

R1	470Ω
R2, R4, R5, R7, R10 to R13	10k (8 off)
R3	10Ω
R6	1k
R8, R9	100k (2 off)

Potentiometers

VR1	10k panel mounting rotary or multiturn, lin (see text)
VR2	10k panel mounting rotary, lin
VR3	10k min. preset, round

Capacitors

C1 to C3, C18, C24	100µ radial elect, 16V (5 off)
C4, C10	22µ radial elect, 10V (2 off)
C5, C7, C15, C19 to C23	100n ceramic disk, 5mm pitch (8 off)
C6, C16	1µ radial elect, 10V (2 off)
C8, C9, C11	10p ceramic disk, 5mm pitch (3 off)
C12	100p ceramic disk, 5mm pitch
C13	1n ceramic disk, 5mm pitch
C14	10n ceramic disk, 5mm pitch
C17	10µ radial elect, 10V

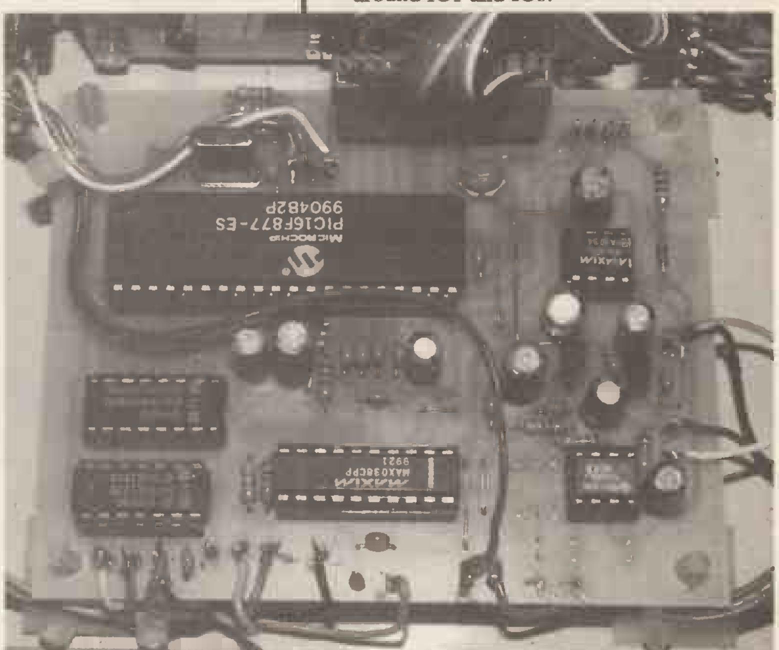
Semiconductors

D1	1N4148 signal diode
IC1	MAX660 dc-to-dc converter
IC2	MAX038 function generator
IC3	TL082 dual op.amp
IC4	78L05 +5V voltage regulator
IC5	PIC16F877-4P microcontroller (pre-programmed – see text)
IC6	74HC4040 12-stage binary ripple counter
IC7	74HC132 quad dual-input Schmitt NAND gate
IC8	79L05 –5V voltage regulator

Miscellaneous

S1 to S4	s.p. push-to-make switch (4 off)
S5 to S7	s.p.d.t. min. toggle switch (3 off)
X1	3·2768MHz crystal
X2	2-line 16-character (per line) l.c.d. module (see text)

Printed circuit board, available from the *EPE PCB Service*, code 268; knob (2 off); 8-pin d.i.l. socket (2 off); 14-pin d.i.l. socket; 16-pin d.i.l. socket; 20-pin d.i.l. socket; 40-pin d.i.l. socket; 1mm pin-header strips (see text); 1mm terminal pins; 2mm socket (7 off, various colours) (or sockets to suit other equipment); plastic case, 205mm x 108mm x 57mm; plastic feet for case (4 off); p.c.b. mounting support (4 off); PP3 battery and clip, or socket to suit external power supply (see text); connecting wire; cable ties; solder, etc.



Completed prototype p.c.b. Differs slightly from final model.

IC1 is a MAX660 voltage converter, used here to generate a negative voltage of the same (inverse) magnitude as the voltage at which it is powered. In this instance, the 9V supply is inverted to become –9V.

The MAX660 has a much greater output load capability than the more familiar ICL7660 (and similar) devices, typically about 100mA as compared with 20mA. ONLY the MAX660 should be used in the PIC-Gen.

It had been expected that the MAX660 could have been powered by the 5V regulated supply from IC4, producing –5V as a result. However, the first test model of the PIC-Gen showed significant instability in the frequency generated when this method was used. Investigation showed that the ripple frequency output by the MAX660 could not be dampened sufficiently to prevent it from modulating the MAX038 frequency output.

Consequently, it was found necessary to first generate –9V and then to regulate and stabilise it down to –5V using IC8, a negative voltage regulator. Further smoothing is given by the use of resistor R3 and capacitors C23 and C24.

A small instability remains, believed to be due to the MAX066's square wave oscillator radiating into other parts of the circuit (an oscilloscope probe on a range of 10mV just picks up the signal when held near to the device). The instability is principally noticeable at higher MAX038 frequencies.

PROGRAMMING CONNECTIONS

As is customary with the author's recent PIC projects, the PIC device used in this circuit can be programmed in-situ on the printed circuit board. The usual four connections are provided, $\overline{MCLR}$ (Vpp), DATA, CLK and 0V, accessible via connector TB2, whose connections are in the same now-familiar order. Diode D1 and resistor R6 are part of the required control configuration. The *EPE PIC Toolkit Mk2* (May/June '99) is an ideal programmer to use.

MISCELLANY

Resistors R10 to R13 are pull-down resistors to appropriately bias the respective PIC input pins when switches S1 to S4 are not pressed.

NAND gate IC7d has its inputs biassed to a power line (+5V in this case) as is required for unused CMOS gates. Op.amp IC3b had been intended for use as an external analogue input amplifier, but it was decided that the configuration around IC7c provided cleaner signal control, and at a far higher frequency.

If users need to frequency-count signals having a peak-to-peak value less than about 2V, they should pre-amplify them first.

Only the HC versions of IC6 and IC7 should be used (74HC4040 and 74HC132). These are typically capable of handling signals in excess of 40MHz. The "standard" CMOS 4040 counter is far too slow to be usable in this circuit. The use of a 74LS132 should allow lesser amplitude external signals to be input to the frequency counter, typically having a peak-to-peak swing of about 0·8V, although this has not been tried.

Numerous smoothing capacitors are used throughout the circuit at strategic points on the p.c.b.

CONSTRUCTION

Details of the component and track layouts for the PIC-Gen p.c.b. are shown in Fig.2. This board is available from the *EPE PCB Service*, code 268.

The author's preferred assembly is in order of link wires (some go under i.c. positions), i.c. sockets, resistors, diode, small capacitors, and remaining components in ascending order of size. Do not insert the d.i.l. (dual-in-line) i.c.s at this stage.

Ensure that all polarised components are orientated as shown in Fig.2.

Pin-header strips were used for terminal groups TB1 and TB2. The order of these connections is identical to that used in the author's recent PIC projects. Details of the source for the l.c.d. module complete with matching connector are given on this month's *Shoptalk* page.

The prototype PIC-Gen is housed in a plastic case measuring 205mm × 108mm × 57mm. The layout and interwiring of the off-board components on the rear of the case's front panel are shown in Fig.3. The illustration is to scale. (Note that the photographs show slightly different panel wiring to that in Fig.3.)

A choice of frequency control potentiometer is offered. The illustration in Fig.3 shows the connections for VR1 as a

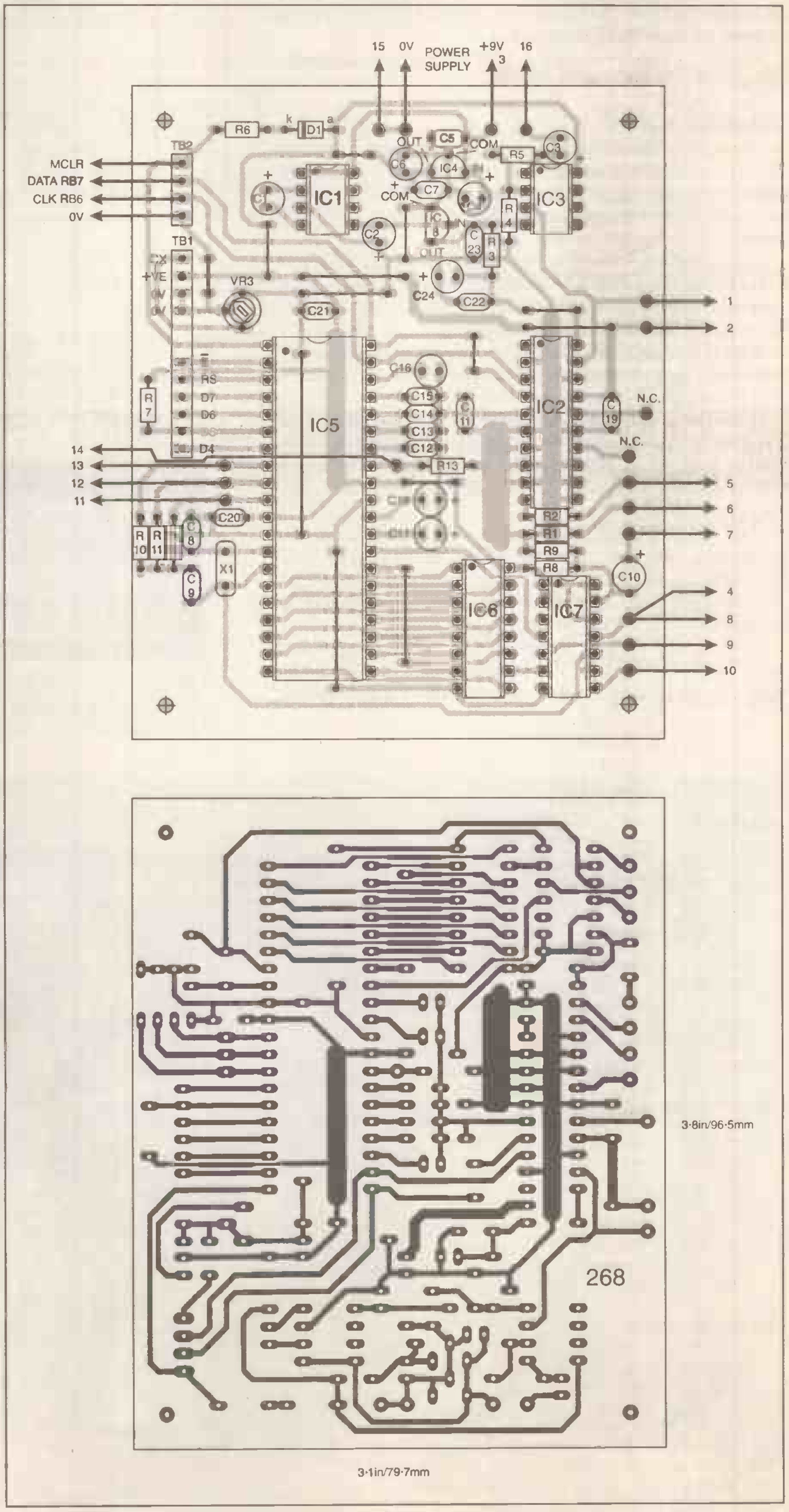


Fig.2. PIC-Gen p.c.b. component layout and full-size copper foil master pattern. The numbers at the ends of the lead-off wires should terminate at identical points on the front panel (Fig.3).

standard single-turn carbon rotary potentiometer. The inset shows the typical connections for a multiturn (10-turn in the prototype) wirewound potentiometer.

The standard pot is the least expensive choice but does not allow the same degree of frequency setting precision as the more-expensive multiturn pot.

To minimise the possibility of signals interacting with each other through the interwiring, several "harness" groups were used, keeping potentially interactive signal paths apart as seemed reasonable. The groups can be seen in the photograph, and they are itemised by connection number in the second insert of Fig.3.

Several cable ties are used to keep each group separately harnessed.

CHECK-OUT

During the checking-out of the circuit, power should always be switched off before inserting i.c.s or making other alterations. Switch off immediately if the circuit does not behave as expected, rechecking your assembly for errors.

Assuming that you have thoroughly checked that you have not made assembly or soldering errors, the first check should be with the l.c.d. and all i.c.s omitted except the two regulators IC4 and IC8.

With power applied, check that +5V is present at the output of IC4 and at strategic points around the p.c.b. (referring to both Fig.1 and Fig.2).

Insert the negative voltage converter IC1 and check that a negative voltage equivalent to the applied power supply is present at its output (i.e. –9V for a +9V supply). Check that –5V is present at the output of regulator IC8 and at the pin 20 position of the socket for IC2.

If all is satisfactory, the remaining i.c.s and the l.c.d. can be inserted. Only one l.c.d. line will be active until the PIC is running. Adjust preset VR3 until the active pixels are seen as slightly darkened rectangles, or the displayed text is clearly visible if the PIC is running.

If not already programmed, the PIC can have its program downloaded to it on the PIC-Gen board from a suitable PIC programmer, connecting the programmer via pin header TB2.

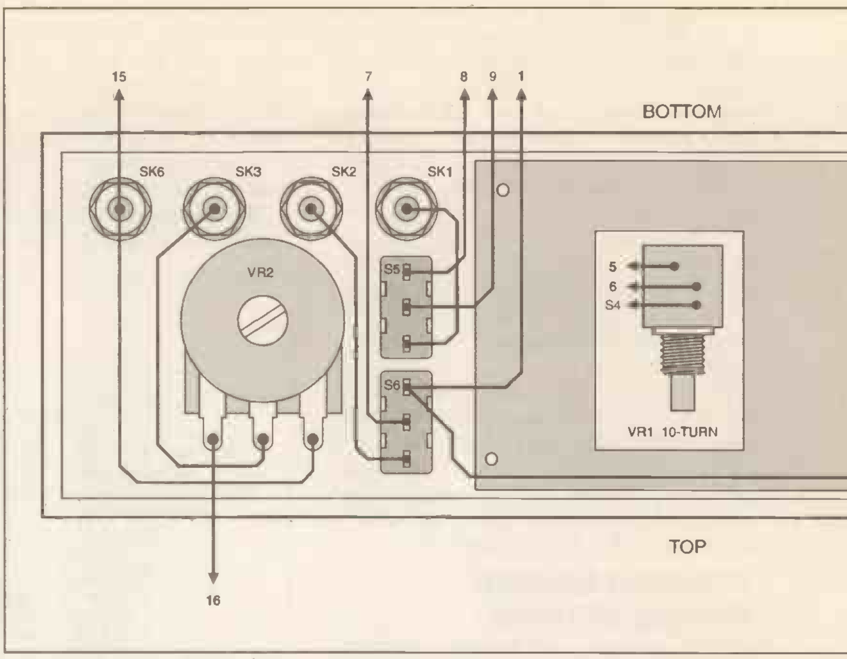
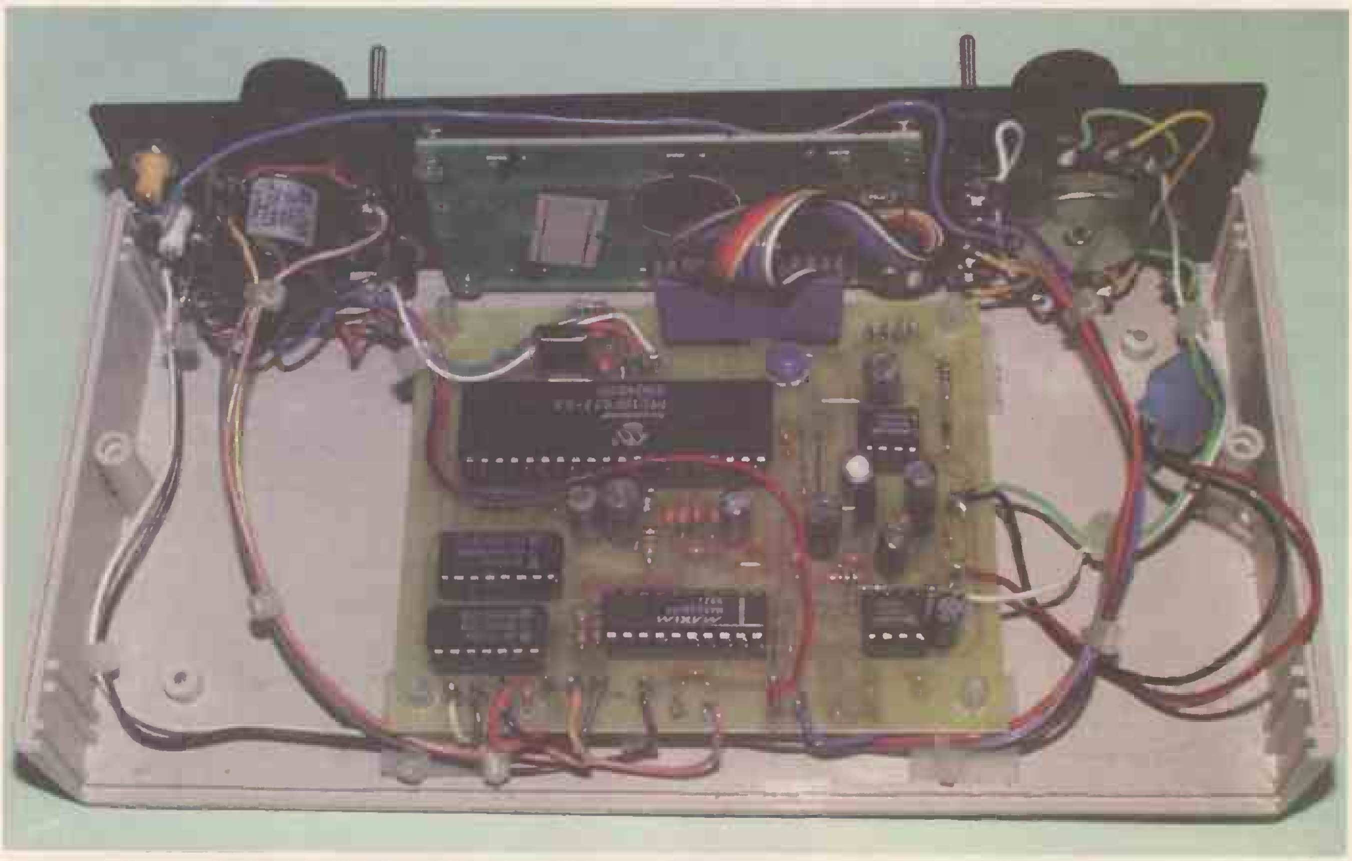
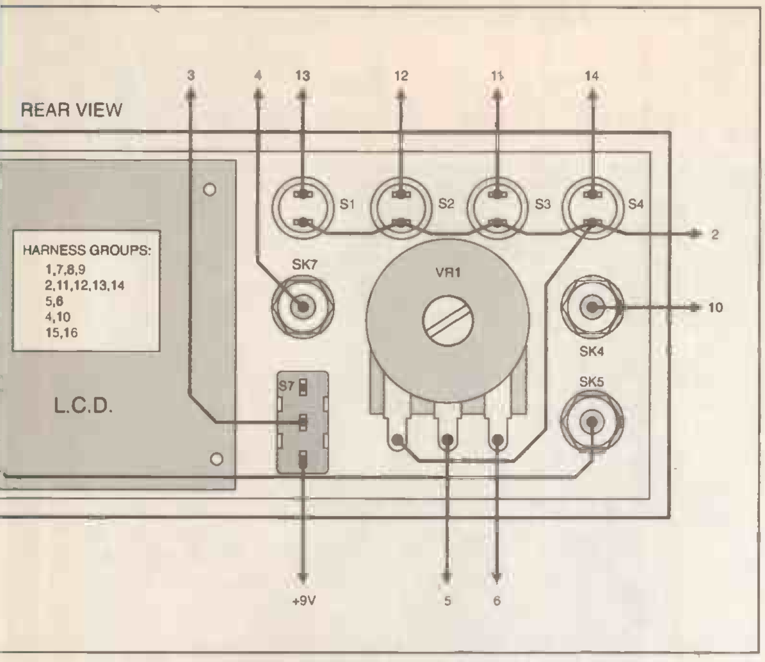


Fig.3. Layout and wiring to the front panel (full size) mounted components. The inset panels show wiring to a multiturn pot and suggested wire groupings.

When the sampling rate change switch is pressed the word "counting" is displayed until the first new count has been completed. In this instance a 10-second sampling rate has been selected.



Layout of components and wiring inside the case of the completed prototype PIC-Gen. There are very minor differences between this and the final wiring diagrams. Note the various wiring "looms".



with the frequency control potentiometer VR1 at various settings.

If you have an oscilloscope, monitor the waveforms output at all settings and from all panel outputs. Additionally check the two inputs, using an external signal generator. Outputs Out Direct and AC Out should only be fed into the AC Input (do not feed them into the Logic Input because of their negative-going content).

(You may prefer to insert a 1k resistor between socket SK1 and switch S5 to minimise the risk of IC7a becoming distressed by negative-going or over-voltage signals.)

Once fully checked, the PIC-Gen is ready to be put into general workshop use.

The PIC configuration (initialisation) required is the *PIC Toolkit Mk2* default as shown in Table 1.

Once programmed, the PIC should immediately start running and a set of data similar to that previously discussed should be seen. Set switches S5 and S6 so that the frequency being generated by IC2 is being monitored. Observe the results when different waveforms, frequency ranges and sampling rates are selected using switches S1 to S4 and

Table 1: PIC16F877 configuration bits.

CP1	CP0	DBG	NIL	WRT	CPD	LVP	BOR	CP1	CP0	POR	WDT	OS1	OS0
1	1	1	1	1	1	0	0	1	1	0	0	0	1

RESOURCES

The software for the PIC-Gen is available from the *EPE* Editorial Office on a 3.5-inch disk, for which there is a nominal handling charge (see *Shoptalk* or the *EPE PCB Service* page). The software can also be downloaded *free* from the *EPE* web site at **www.epemag.wimborne.co.uk**. The program is written in TASM.

Data sheets for the MAX038 and MAX660 can be downloaded from Maxim's web site at **www.maxim-ic.com**.

Data sheets for the PIC16F877 (and other PIC products) can be downloaded from Microchip's web site at **www.microchip.com**. □

SHOP TALK
with David Barrington

Pocket g-Meter

It's not everyday we have to find a source for such an up-to-date specialised chip as that used in the *Pocket g-Meter* project. But thanks to the guidance of Bill Mooney, the designer, we have managed to crack it and come up with a "one-off" source.

The Analog Devices' ADXL105JQC surface mount micromachined sensor chip is available from **Thame Components Ltd, Dept EPE, Thame Park Road, Thame, Oxfordshire, OX9 3UQ.** (☎ ***01844 261188*** or web ***www.impact.uk.memec.com***). It will cost you around £16.14 plus a postage and handling charge of about £4.50. Another possibility is **Avnet Macro Direct** (☎ ***01628 606000*** or ***www.avnetmacro.co.uk***), although they were not so forthcoming with information.

The miniature ceramic "knob pot" came from **Farnell Electronic Components** (☎ ***0113 263 6311*** or web ***www.farnell.com***), code 350-655. Most of our component advertisers now carry stocks of general surface mount devices. Note that the LM3914N bargraph l.e.d. driver i.c. is a standard 18-pin d.i.l. format device.

There are plenty of really small plastic boxes around and readers should have no problems in finding one to suit this project. We suggest you go for one slightly larger than that shown as the components are certainly packed tightly in the prototype model. The small "hybrid" printed circuit board (copper pads on component side) is available from the *EPE PCB Service*, code 269 (see page 557).

Probably the biggest problem constructors are going to encounter is the one of soldering the surface mount components to the small p.c.b. We suggest readers check out Bill Mooney's web site at ***www.billss-md.mcmail.com***, where a host of information on surface mount will be found, including details on soldering.

PIC-Gen Frequency Generator/Counter

Several components need highlighting when purchasing parts for the *PIC-Gen Frequency Generator/Counter* project. This applies particularly to the i.c.s.

Both the Maxim MAX660 voltage converter and the MAX038 function generator chips were ordered through **Electromail** (☎ ***01536 204555*** or web site ***http://rswww.com***), the RS mail order outlet. The MAX660 carries the order code of 265-055 and the MAX0388 code 810-396. For those interested, **Maxim's** web site is at: ***www.maxim-ic.com***.

The MAX660 converter is claimed to have a greater output load capability than similar devices and should be the *only* one used in this project. Also, the author advises that the HC versions of the 74xx4040 (IC6) and the 74xx132 (IC7) should be the only ones used in this circuit. The standard CMOS 4040 counter is too slow and although the LS132 voltage converter version should work it has not been tried in the model.

The neat plastic case, with plastic removable front and rear panels, is from a new range introduced by RS and available from the first mentioned company, code 239-7413. Multi-turn potentiometers are "off-the-shelf" items and the most popular range seems to be from around 10-turns to about 20-turns.

The alphanumeric 2-line 16-character per line liquid crystal display module used in the prototype was originally purchased from **Magenta Electronics** (☎ ***01283 565435*** or web site ***http://magenta2000.co.uk***). This come complete with a connector and is one we would recommend. Other advertisers will no doubt be able to offer something similar.

For those readers unable to program their own PICs, a ready-programmed PIC16F877-4P can be purchased from Magenta (see above) for the inclusive price of £10 (overseas readers add £1 for postage). Software for the *PIC-Gen* is available on a 3·5in. PC-compatible disk from the *EPE* Editorial Office (there is a small handling charge to cover admin costs) – see *PCB Service* page 557. It is also available *free* via the *EPE* web site: **ftp://.epemag.wimborne.co.uk/pubs/PICS/PICgen**. The software is written in TASM.

The printed circuit board is available from the *EPE PCB Service*, code 268 (see page 557).

Camera Shutter Timer

This month's Starter Project is a low-cost *Camera Shutter Timer* and we cannot picture any component buying problems.

If you decide to use a phototransistor and wish to use the 3mm SFH309 type listed, this came from **Maplin**, code CY86T. However, the circuit has been designed to work equally as well with most photodiodes or phototransistors.

Judging from photos of the prototype, the 50μA moving coil meter is one from the 2·5 class range. Another one with similar characteristics and dimensions, 51mm (2in.) by 45mm (1¾in.), is the MU38 series. Both types should be widely stocked.

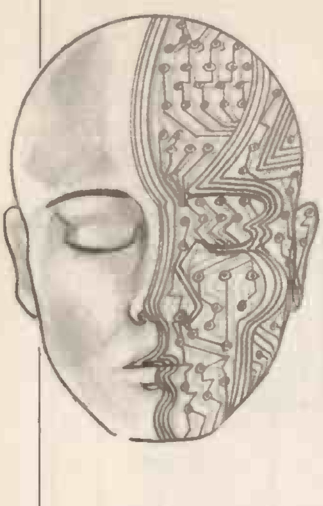
If you use a different case to the one shown, such as an all-plastic type, keep in mind that you will need plenty of space on the front panel for the controls and meter.

Atmospheric Electricity Detector–2

We have received no further feedback regarding the availability or any alternatives to the Siemens B6429 series of toroid ferrite ring cores called for in the *Atmospheric Electricity Detector*. These were purchased from **ElectroValve** (☎ ***01784 433604*** or E-mail: ***evalve@compuserve.com***), quote full code B64290K618X830 when ordering.

The choice of meters is left to the individual constructor, but most of our component advertisers should be able to help. Also note the author advises that switches S3 and S4 must be rated at least 250V a.c.

INGENUITY UNLIMITED



Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit tips, not simply mechanical or electrical ideas. Ideas *must be the reader's own work* and **not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should preferably be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and full circuit diagram showing all relevant component values. **Please draw all circuit schematics as clearly as possible.**
Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited,* Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BS21 1PF.
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WIN A PICO PC BASED OSCILLOSCOPE

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If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.
Every six months, Pico Technology will be awarding an ADC200-50 digital storage oscilloscope for the best IU submission. In addition, two single channel ADC-40s will be presented to the runners-up.

Multi-Purpose A.C. Detector/Switch – Dig Those Fields

THE circuit diagram shown in Fig. 1 has potential uses as an A.C. Field Detector, a touch alarm trigger, or as a touch-on touch-off switch. The first stage of the circuit, based upon op.amp IC1a, serves as a sensitive a.c. field detector with a range of a few metres.

If an optional coil L1 is connected as a sensor (a loudspeaker coil is fairly effective), piezo disc X1 will emit a geiger-counter-like sound in the presence of an a.c field as one moves through the home. With the correct setting of potentiometers VR1 and VR2, the device may be used to detect hidden a.c. wiring.

As an Alarm Trigger, almost any metal object may be attached to the circuit as a sensor – a door knob, a toaster, or that precious can of premium beer. Static sensitive materials may also be found to work (e.g. a synthetic tablecloth). With switch S1 closed, relay contacts RLA1 momentarily close and open again when the sensor is touched, thus serving as a trigger. When S1 is open, the circuit acts as a sensitive and reliable Touch-On Touch-Off switch.

Op.amp IC1a is wired as an oscillator, carefully tuned by VR1 and VR2 so that it is just reluctant to oscillate. The value of resistor R2 is high, so that IC1a is sensitive to stray pick-up by the sensor, which biases the oscillator into operation. IC1b is wired as a simple comparator, which detects a rise in voltage in capacitor C2 and provides a clear logic high or low output at point 'A'.

The main function of flip-flop IC2a is to prevent the circuit from re-triggering itself through stray pick-up from the relay. IC2a masks such pick-up for a fraction of a second when the relay switches. It also serves to select trigger or touch-on/touch-off modes through switch S1.

Piezoelectric disc X1 is included to monitor whether IC1a is breaking into oscillation. Light-emitting diode D2 indicates when IC1b goes high. Note that the circuit is obviously dependent on the electromagnetic field generated by the a.c. mains, and will only operate in the vicinity of a.c. wiring or appliances. It should operate successfully in most (though perhaps not all) positions in the home.

Although the circuit is sensitive, there is virtually no spurious triggering, all leads should be kept short. With a large 9V PP9 battery, the detector/trigger/switch will remain on standby for up to 2 months. A connection may be taken from point 'A' to most CMOS logic inputs.

Rev. Thos. Scarborough, Fresnaye, Cape Town, South Africa.

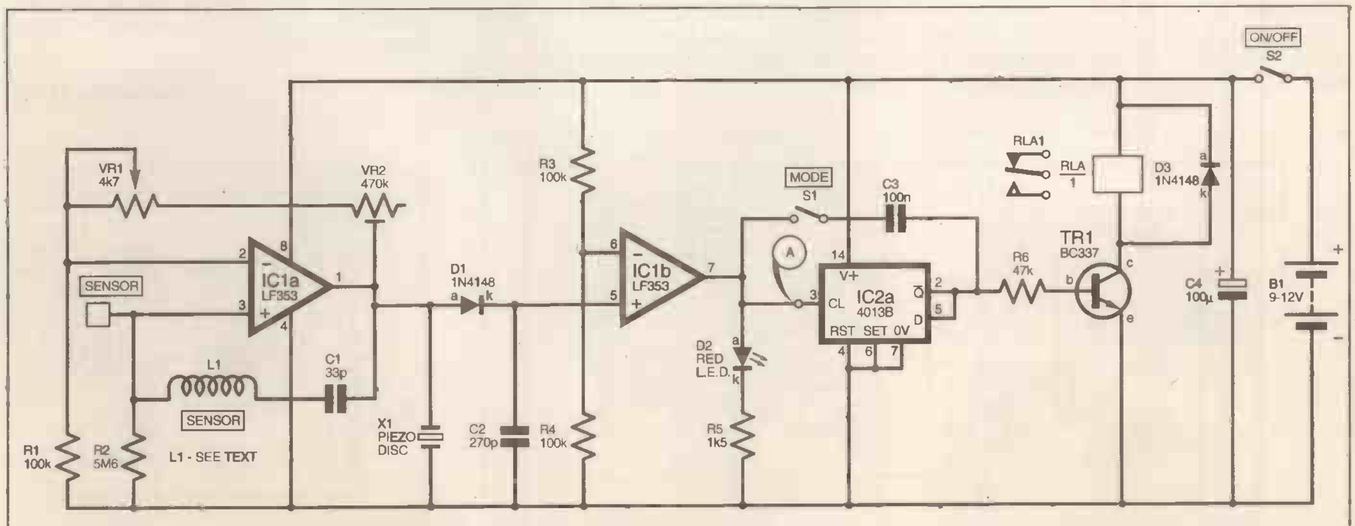


Fig.1. Circuit diagram for the Multi-Purpose A.C. Detector/Touch Switch.

Versatile Car Interior Light Delay – Light Work

MANY cars manufactured these days include an interior light ("dome light" in the USA) delay unit as a standard feature, but the circuit diagram of Fig. 2 was devised to fit an older vehicle without one. The unit uses a 555 timer in its astable mode and a useful automatic cancel feature is also included.

On opening a car door, relay RLA is energised via diode D4 which grounds the relay coil to the car chassis (0V) through the normally-closed door pillar switch. The interior light remains on for as long as the door remains open. The Reset (pin 4) on timer IC1 is grounded until the door is closed, when it goes to +12V via resistor R3, so the timing cycle starts.

The relay is now "latched on" via contacts RLA2, the supply to the 0V side of its coil now being maintained by transistor TR1 which itself is kept in the conducting state by resistor R1. After a pre-set interval (usually 1 to 3 minutes is about right),determined by the *RC* network on IC1, the output at pin 3 goes low, which turns off TR1, causing the relay to unlatch and switch off the inerior light. A fairly long ON period can be used to allow time for the pre-driving-off activities of fastening seat belts, loading audio cassettes or CDs, or applying make-up!

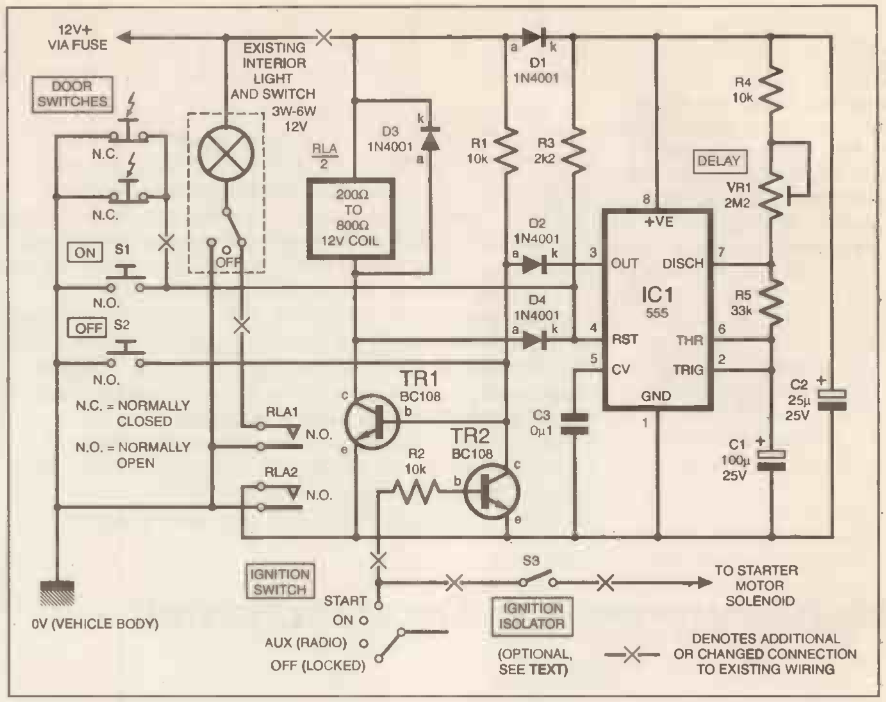


Fig.2. Circuit diagram for a Versatile Car Interior Light Delay. (Be aware that altering the vehicle wiring may invalidate any warranty – check first.)

Run-On

The problem of the light staying on after driving off is overcome by transistor TR2 which conducts as soon as the starter is operated, so switching off TR1 and the relay as before. The addition of pushbutton switches S1 and S2 as independent On and Off switches allows the light to be operated with the engine running which is useful if the driver needs to stop briefly to look at directions for example, or to switch off the light after allowing a passenger to get in or out of the vehicle.

By threading the extra wires down the same route as the existing wiring to the light (usually down a door pillar) and the use of appropriate male, female and piggy-back spade connectors, the unit can be installed without cutting existing wiring to the light. The only additional connections required are an Earth to the vehicle body and a "Scotch-lok" splice to the starter feed from the ignition switch.

Although not part of the timer circuit, a loop of suitable wire could be added while the starter switch is exposed, fitted with a concealed switch (S3) to provide added security against the vehicle being started by an unauthorised key holder.

Andrew R.G.Calder,
Leigh, Lancs.

Musical Chip Amplifier – Loud and Clear

MUSICAL greeting cards incorporate a "chip-on-board" device which plays a tune through a piezo disc when the card is opened. The card actually acts as a resonator which contributes considerably to the volume of the tune.

The circuit diagram shown in Fig. 3a is a simple amplifier which will allow a musical chip to be played over a conventional loudspeaker instead. It was found that the chip would run from 4·5V (three button cells), hence it was felt worth constructing a simple bridge amplifier to try to double the voltage swing across the loudspeaker coil. It was constructed using parts to hand and none of the transistor types are critical, neither is the loudspeaker type.

Some circuits require a pull-up or pull-down resistor on the output of the chip. If so, this provides an opportunity to add a peaking inductor to increase the voltage swing still further. A "ringing choke" (L1) load can be added (see Fig. 3b), which could perhaps be sufficient to drive a logic-compatible MOSFET transistor, which has a gate optimised for a +5V drive signal (e.g. BSS98, ZVN4206, 2SK940 etc.). The inductor L1 should have as large a value as possible, using trial and error.

I. Field,
Letchworth, Herts.

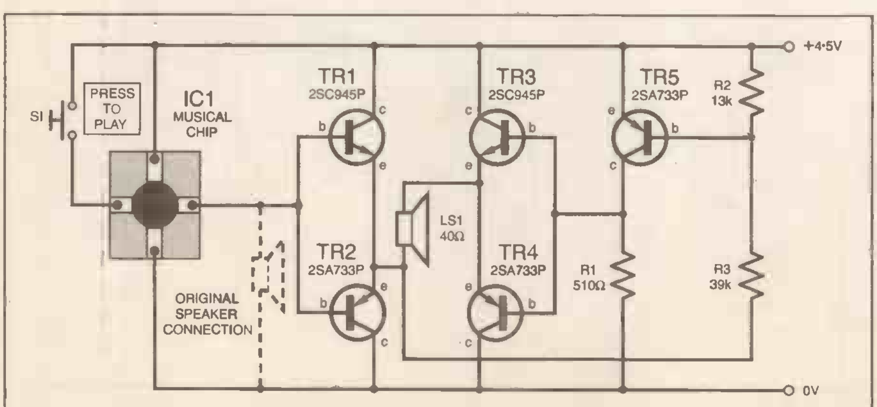


Fig.3a. Simple "greeting card" Musical Chip Amplifier circuit diagram.

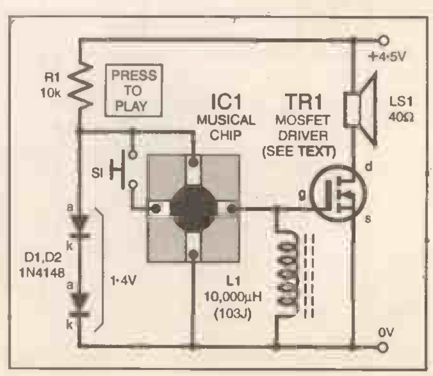


Fig.3b. Using an inductor L1 to increase the output voltage.

Narrow SCSI Active Terminator

– Cheaper Solution

IF YOU are using more than one SCSI device in your home PC, you will probably be aware that terminating the SCSI bus is essential to ensure reliable communication across the Bus. In my own experience with SCSI, I have found that "active" terminators are the better ones to use, but such devices are often expensive for what they are.

The circuit diagram of Fig. 4 shows how to construct an Active Terminator for an 8-Bit SCSI Bus (Narrow SCSI). Note the terminator is for Single-Ended SCSI only, not the differential SCSI Host Adaptors.

As can be seen, the design is very straightforward, and uses the simple Zener regulation method to hold the SCSI signals at about 3.3V (the inactive state). The 220 ohm pull-up resistors limit the current to about 25mA when the SCSI signals become active and fall to ground.

The IDC plug used in the main diagram shows the connections for an internal terminator and the Centronics plug in diagram Fig.5 shows the connections for an external terminator often used with Scanners and other peripherals.

Paul Entwistle,
Bolton, Lancs.

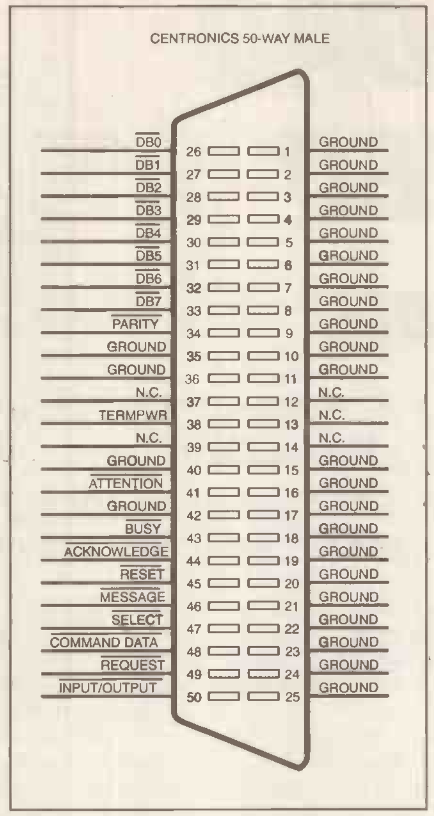


Fig.5 (right). Connection details for a Centronics 50-way male plug external terminator.

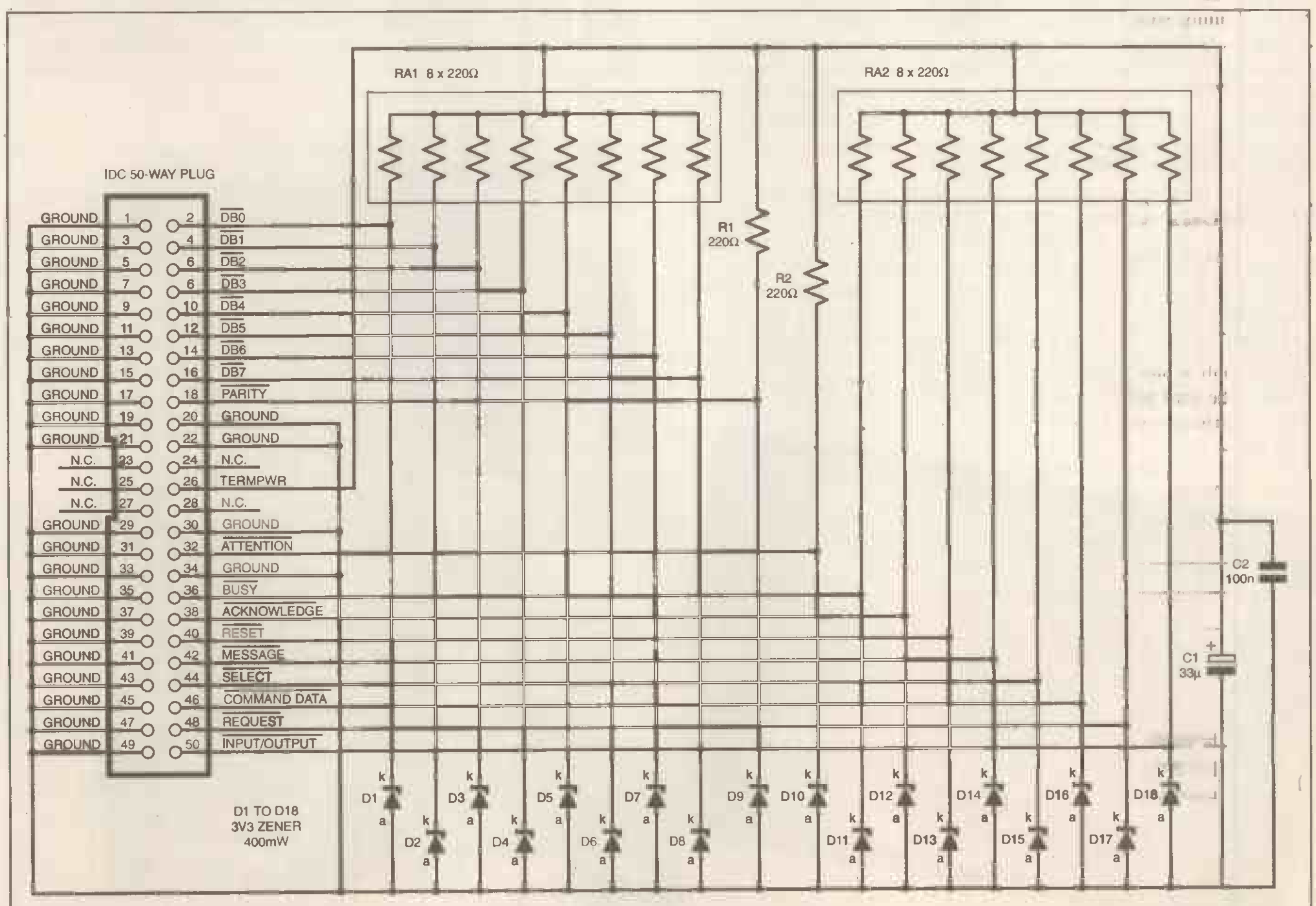


Fig.4. Circuit diagram for an 8-bit Narrow SCSI Active Terminator. The terminator is for Single-Ended SCSI only, not the differential SCSI Host adaptors.

Special Review

PICO DrDAQ REVIEWED

ROBERT PENFOLD

Robert meets DrDAQ and finds that apart from professional use he has enormous play value for the electronics hobbyist, and is eminently suited for anyone looking for an easy, inexpensive way into computer interfacing.

PICO TECHNOLOGY is a company that is best known for its PicoScope interfaces, which turn practically any PC into a storage oscilloscope. In fact the current software provides several additional functions such as frequency measurement and spectrum analysis.

The DrDAQ unit reviewed here could be regarded as a greatly simplified version of the PicoScopes. It is an analogue-to-digital converter that connects to the parallel port of a PC, but it has a relatively slow maximum sampling rate of 10kHz to 15kHz, depending on the speed of the PC used. The interface has no built-in memory, but with such a modest maximum sampling frequency the PCs memory can be used if storage facilities are required.

Although high-speed sampling is not possible, this interface is still adequate for many purposes, such as measuring temperature, light levels, pH, etc. It can also be used for sampling audio frequency signals, albeit with a somewhat limited bandwidth.

GETTING CONNECTED

DrDAQ is primarily aimed at educational establishments, but it would also seem to be a worthwhile proposition for professional electronic engineers. At a VAT exclusive price of £59 for the basic version it is within the budget of many electronics hobbyists as well. The basic version comprises the interface and a parallel port connecting cable, plus two programs and the necessary drivers.

No power supply unit or batteries are required because the interface taps off the small amount of power it requires from the parallel port. Consequently, getting the interface ready for use is just a matter of connecting one end of the supplied cable to the interface and the other to the parallel port of the PC. There is no through-port connector on the interface, so it will either require its own parallel port or a switching unit will be required to enable one port to operate with either the interface or a printer.

The interface unit is an uncased printed circuit board that seems to have most of the components on the underside, where they are hidden by a foam covering that ensures the unit will not scratch tabletops. On top of the board (Fig.2) there is the parallel port connector at one end, and three sockets plus a microphone at the other.

The built-in microphone enables sound waveforms to be displayed and sound levels to be measured. One of the input sockets is a BNC type that is intended for use with a standard pH sensor. The other two are telephone style connectors that are intended for use with temperature sensors, etc.

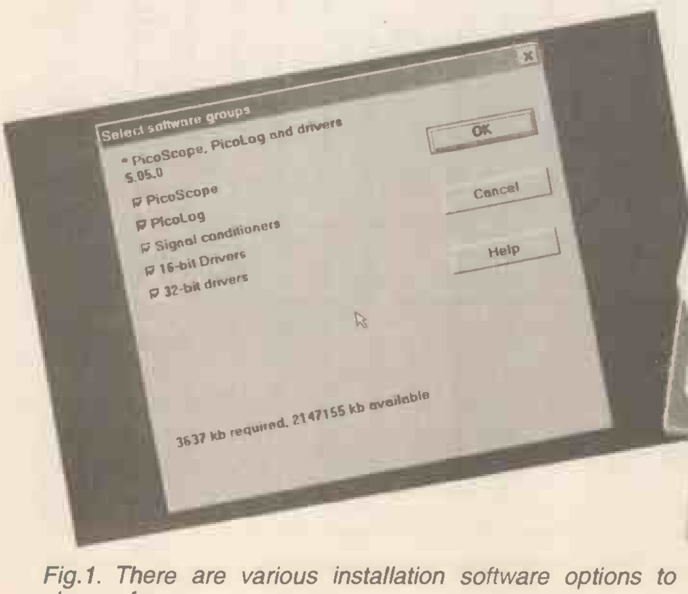


Fig.1. There are various installation software options to choose from.

Fig.2. The uncased DrDAQ circuit board showing the parallel port connector, three sockets plus microphone. The underside components are hidden by a protective foam covering.

There is also a l.e.d. indicator and a 4-way connector block that provides a ground terminal, a digital output, and voltage plus resistance inputs. The l.e.d. and the output can be set to operate at a given threshold level so that they can be used in alarm and control applications.

Last and by no means least, there is a photo-resistor light sensor and a semiconductor temperature sensor. With three integral sensors the interface is clearly useful for a variety of experiments and applications even without any external sensors added.

SOFTWARE

The review unit came complete with three floppy discs containing the software, but the production units will have the software on CD-ROM. The software is compatible with Windows 3.1, 95, 98, 2000, and NT. Under Windows 98 the software loaded without any difficulty and the installation process follows along normal Windows lines. There are various installation options to select, such as choosing the programs you wish to install (Fig.1), but simply selecting the defaults is all that will normally be required.

There are two applications programs provided, called *PicoScope* and *PicoLog*. PicoScope provides an oscilloscope style display and is used to display data gathered over a relatively short period, whereas PicoLog is primarily for gathering data over much longer time-spans.

PicoScope is therefore used for such things as viewing audio waveforms (Fig.3) or showing temperature data from experiments that produce rapid changes in temperature. PicoLog is used for an application such as logging weather data over a period of days.

Internal Sensor Specification

Channel	Range	Resolution	Accuracy
Sound Waveform	±100	0·3	–
Sound Level	55-100dBA	1dBA	5dBA
Voltage	0-5V	5mV	3% of f.s.d.
Resistance	0-1M	100Ω at 10k 400Ω at 100k	2% at 100k
pH	0-14	0·02pH	Calibration dependent
Temperature	0-70 degrees C	0·1 at 25°C	2 at 25°C
Light	0-100	0·1	–

PICOSCOPE

Starting with PicoScope, this is very similar to the software supplied with the Pico range of storage oscilloscope interfaces, but some concessions have to be made to the slower sampling rate of DrDAQ. Accordingly, the fastest sweep rate is 1ms per division, but at the other end of the range the slowest rate is a generous 50s per division. A panel having a pop-down menu enables sweep rates to be selected, and the times are in the usual 1-2-5-10 progression, as can be seen in Fig.3.

The same method is used to select a multiplication factor from 1 to 200, and this enables part of the waveform to be viewed in detail. Of course, high multiplication factors are only a practical proposition at the slower sweep rates where there are enough samples taken to permit a magnified view.

Most things can be handled by the on-screen controls, but there are the usual pop-down menus and dialogue boxes as well. For example, the Trigger dialogue box is shown in Fig.4. The basic trigger options are none (free running), auto, repeat, and single, with a fully adjustable trigger level. The dialogue box offers further options such as a preset delay, triggering on the rising of falling edge of a signal, and the channel used as the trigger source.

There are four channels available, and each one can be used to measure Sound (waveform or level), Volts, Ohms, pH, Temperature, Light, or one of the external inputs. It is possible to have all four channels operating simultaneously, with each trace drawn in a different colour. However, results are easier to follow with just two traces, see Fig.5.

The three buttons towards the top left-hand corner of the screen enable the required function to be selected. By default the program starts in oscilloscope mode, but the buttons enable oscilloscope, spectrum analyser, and voltmeter functions to be selected.

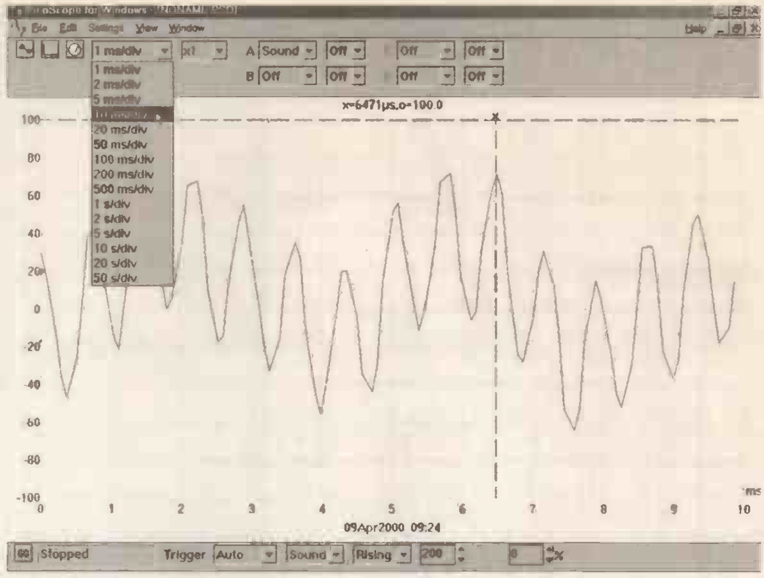


Fig.3. Selecting the PicoScope option lets you view audio waveforms or show temperature data.

Operating a button does not switch the current window to a new operating mode, but instead launches a new window. You can therefore have something like two oscilloscopes in operation simultaneously, or three windows with each one operating in a different mode (Fig.6). For this type of thing it is obviously advantageous to use a large monitor running at high resolution. The voltmeter and analyser features are useful, but the abilities of the latter are severely restricted by the relatively low sampling rate.

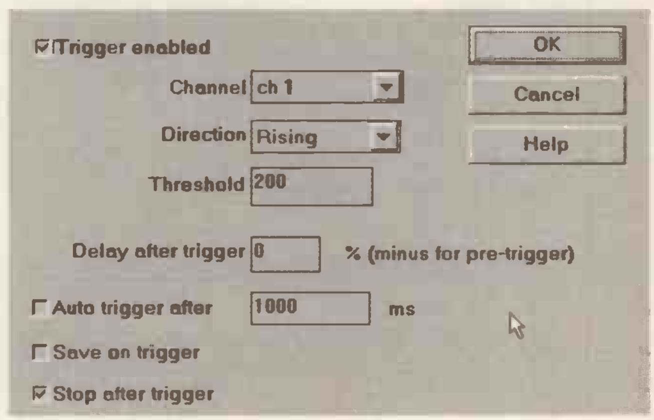


Fig.4. Trigger dialogue box. Trigger options are: none (free running); auto; repeat and single, with adjustable trigger level.

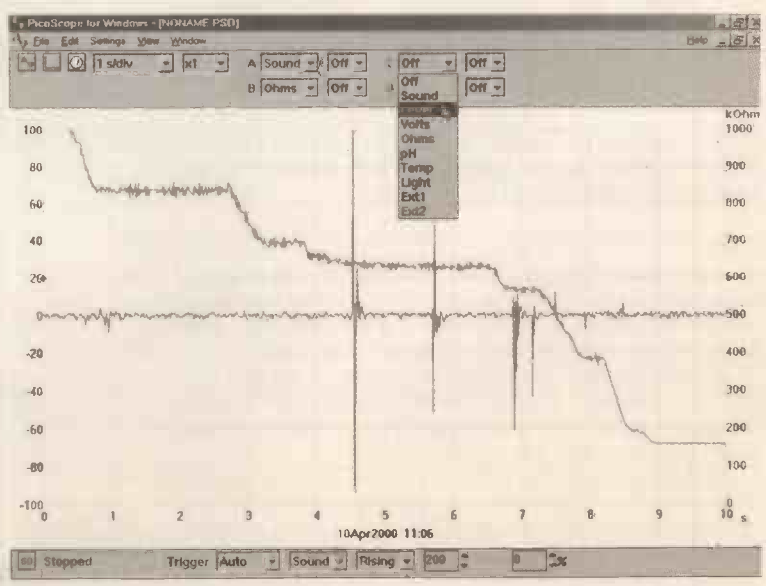


Fig.5. Using just two of the possible four traces (channels) can make it easier to follow what's happening.

The program has facilities for printing traces, etc. to any Windows compatible printer, and data can be saved to disk and exported via the clipboard. The clipboard enables data to be exported in graph form or as a text file containing a list of readings. There are various set-up options that provide control over the screen colours, maximum number of screen updates per second, and various other factors.

PICOLOG

By its nature, PicoLog is somewhat less straightforward to use. There are actually two programs, which are the recorder and the player. However, the recording program also has playback facilities, and is possible to log and analyse data without resorting to the playback program. We will only consider the recording program here. The playback facilities of the playback program seem to be much the same as those of the recording program.

A certain amount of setting up is required before the recorder is ready to do anything useful, and the software includes a "guided tour" that helps to get you started. The first task is to run the recorder (Fig.7) and then select a filename for the new data to be saved under. Then the Settings menu plus some dialogue boxes are used to set such things as the rate at which data will be read, the maximum number of samples to be taken, threshold levels for the l.e.d. and digital output (where required), and the channel to be used.

Once the preliminaries have been completed the data logging can commence, and there are tape recorder style control buttons just beneath the main menu. These provide re-record, record, pause/resume, and stop functions.

The three control buttons on the other side of the screen are used to view data. The first button just brings up a simple text editor that can be used for notes. The other two buttons bring up the data as a table of results or a graph (Fig.8). There are various control buttons in the graph window that permit part of the graph to be expanded and viewed in detail, the graph to be printed or copied to the clipboard, and so on.

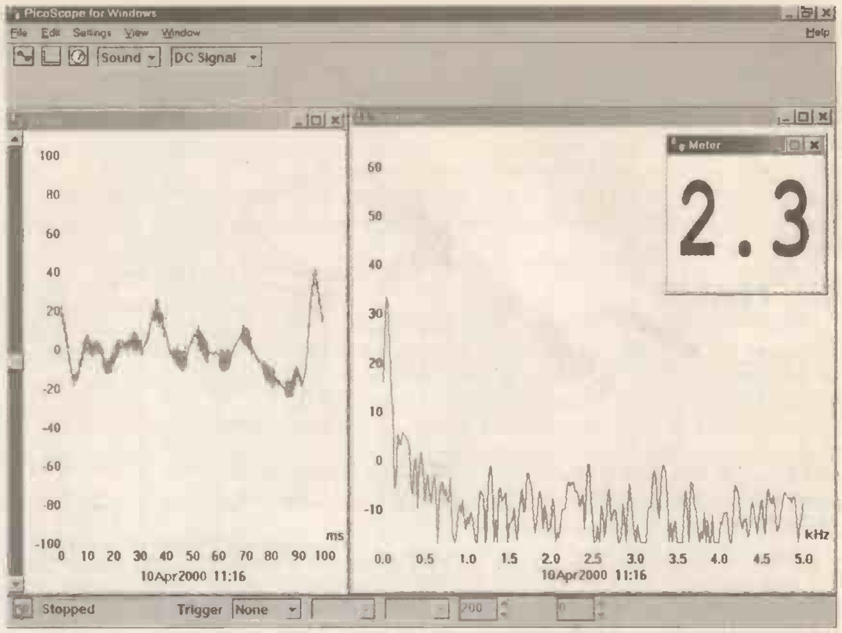


Fig.6. You can have two oscilloscopes in operation simultaneously or, as here, three windows each operating in a different mode.

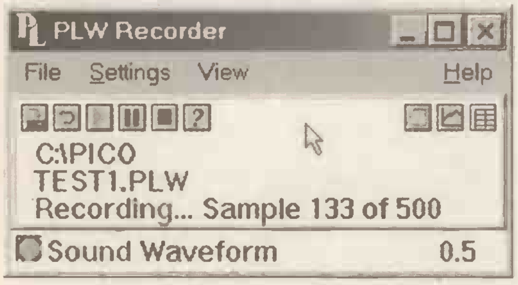


Fig.7. Setting up and selecting the record program.

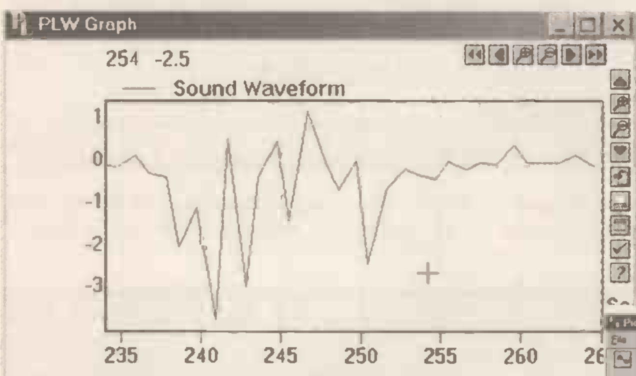


Fig.8. Test result sound waveform graph. Various control buttons in the graph window allow it to be enlarged, printed or sent to "clipboard".

OPTIONAL EXTRAS

In addition to the standard kit, Pico offer a deluxe version that also includes two temperature sensors and one pH type. One sensor of each type is shown in Fig.10. The interface is apparently compatible with any standard pH sensor. The deluxe version costs £99 plus V.A.T.

With PicoScope set to read the appropriate sensor or sensors it is possible to have a straightforward readout of temperature or pH values, and (or) a graph showing how the data changes over a period of time (Fig.9). The temperature sensors cover a range of –10°C to +105°C, and pH is measured over a range of 0 to 14.

Probably most professional users and experimenters will opt for the standard kit, but the deluxe kit seems to be a good choice for educational users.

CONCLUSION

The interface board is well built and getting it "up and running" is about as simple as it possibly could be. With built-in sensors the unit can be used for some simple experiments straight away. The price is good but not especially low for what is really a fairly simple interface, but the inclusion of the PicoScope and PicoLog software makes both the standard and deluxe kits very good value for money.

Both programs are sophisticated enough to be genuinely useful, but are still reasonably easy to use. It is only fair to point out that the programs reviewed here are beta versions that still have a few

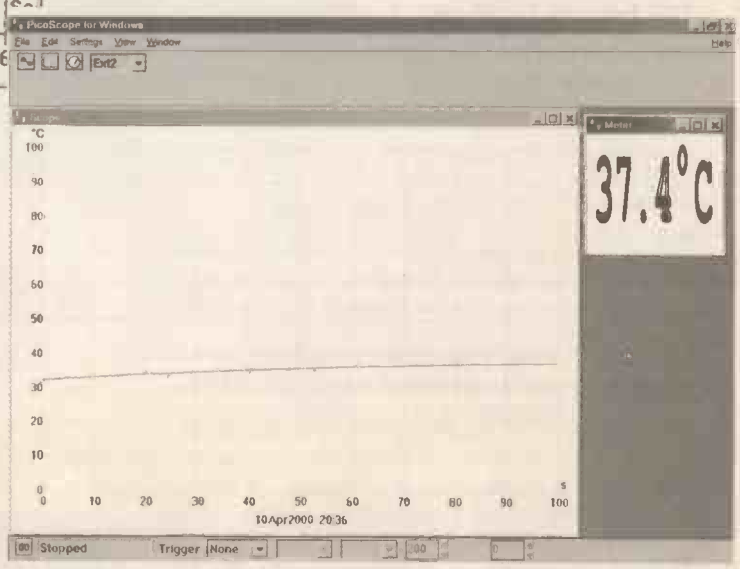


Fig.9. Graph showing how the temperature data changes over a period of time.

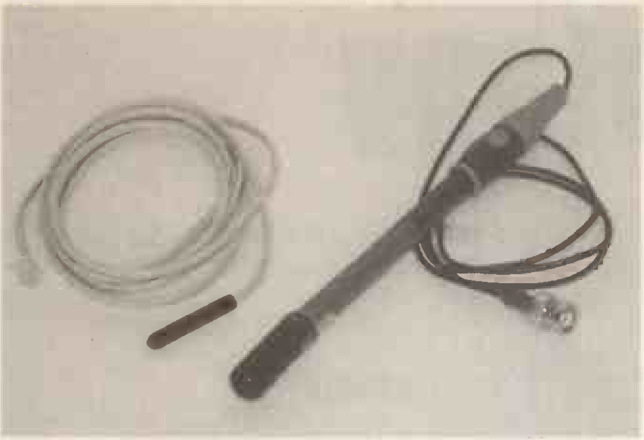


Fig.10. The two types of sensors: left, temperature sensor and right, pH sensor. Both types can be purchased separately.

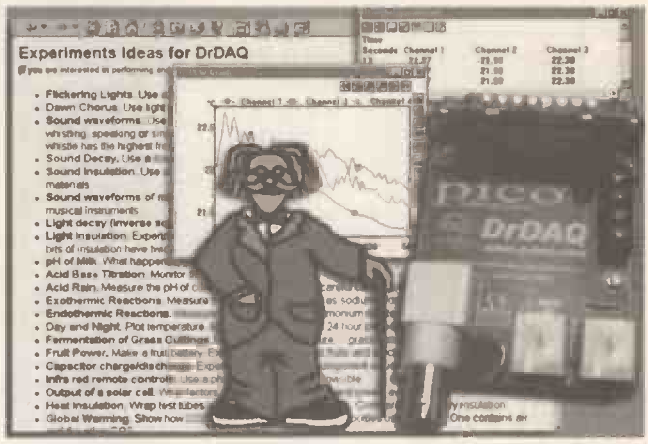
bugs and omissions, but this should all be sorted out by the time this review is published.

As pointed out previously, DrDAQ is primarily aimed at educational establishments, and it can certainly be recommended to those involved in teaching computer interfacing, or wishing to use computer based equipment when demonstrating appropriate scientific experiments. Incidentally, the Pico Technologies web site has details of numerous experiments that can be carried out using DrDAQ, and this information will be included on the CD-ROM included with the kits.

DrDAQ is also suitable for professional users requiring an inexpensive but effective analogue-to-digital converter, but only if they do not require high sampling rates. The DrDAQ kits have enormous play value for the electronics hobbyist, and are eminently suitable for anyone looking for an inexpensive and easy way into computer interfacing.

The DrDAQ standard kit costs £79.90 (£59.00 plus £9.00 for delivery within Europe, and VAT). The all inclusive prices for the kit with two temperature sensors and one pH sensor is £126.90, or £103.40 with two temperature sensors but no pH type. Both types of sensor are available separately.

For more information contact ***Pico Technology Ltd., Dept EPE, The Mill House, Cambridge Street, St. Neots, Cambridgeshire, PE19 1QB***, Tel. 01480 396395, Fax 01480 396296, Email **post@picotech.com**. More information, demonstration software, etc. is available from the Pico web sites at **www.picotech.com** and **www.drdaq.com**. □



Some of DrDAQ's possible experiments.

New Technology Update

Capacitor size and storage ability are being dramatically influenced by aerogel foam technology. Ian Poole reports.

LIKE many other areas of electronics, capacitor technology is being developed and as a result existing capacitor types are being greatly improved, and in other areas new types of capacitor are appearing. It is only necessary to look at a printed circuit board today to see the very small surface mount capacitors that are in widespread use.

Years ago all capacitors were leaded and very much larger. Now with the widespread use of surface mount technology capacitors are very much smaller. To achieve this has given capacitor developers some significant challenges. It has been necessary to squeeze very high levels of capacitance into minute packages and this has required new types of dielectric to be developed.

Whilst surface mount technology has been a major driver in pushing forward many developments in capacitor technology it is not the only one. Higher voltages, greater reliability and new applications have also played a major part.

Power storage

One such application is for a capacitor that is able to be charged up when a unit is under power and hold its charge to enable a memory to hold its data or for another device to operate if there is a power failure.

Rechargeable batteries do not always perform particularly well under these circumstances, and capacitors are an alternative. However they need to have very high levels of capacitance if they are to undertaken this function correctly.

Another application for high value capacitors is to store charge to enable high current pulses to be generated. Under these conditions the current pulses may damage the battery, if this is the source of the power, especially if the pulses are required frequently over a period of time, or the battery may not be able to supply the pulse satisfactorily.

Whilst the battery may be able to deliver the required power over a longer period of time, the high current pulse requirement means that a larger battery needs to be used, and space or weight constraints may preclude this. Unfortunately it often happens that both size and weight are of paramount importance in today's equipment.

Supercap

In applications such as these a new breed of capacitor known as supercapacitors or supercaps are being used. Although these components have been around for a while, new developments are improving their performance so that they can meet the demands being made on them.

In areas where the capacitors are used to supply current pulses, one of the most important attributes of the capacitor, apart from capacitance and working voltage is the equivalent series resistance (ESR). This is effectively the internal resistance of the capacitor, and if it is high it will tend to limit the current capability.

Cooper Electronic Technologies have developed a new type of supercap that achieves significant reductions in ESR when compared to other similar capacitors. This enables it to fulfil its role more efficiently than before.

The new capacitor is known as the PowerStor Aerogel capacitor. It is what is termed a double layer capacitor and has electrodes formed from a material called carbon aerogel foam. This foam gives a high electrical conductivity as well as providing a controlled ultra-fine pore size and it provides a high useable surface area for double layer formation.

Construction

The construction of the new capacitor bears many similarities to both Lithium Ion batteries and to electrolytic capacitors (see Fig.1). A porous separator is placed between the two electrodes. This sandwich is rolled up and then inserted into a can. Electrolyte is then added and absorbed by the separator. The can is sealed and the electrodes added to the electrodes that protrude from it.

The electrodes are formed from the carbon aerogel foam. The charge is stored in this as shown in Fig.2. Here it can be seen that the porous nature of the foam gives a significant increase in the surface area that allows much greater levels of charge storage than would normally be possible with a conventionally manufactured supercap.

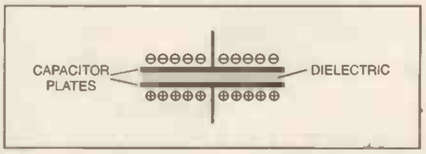


Fig.1. Representation of a "standard" capacitor.

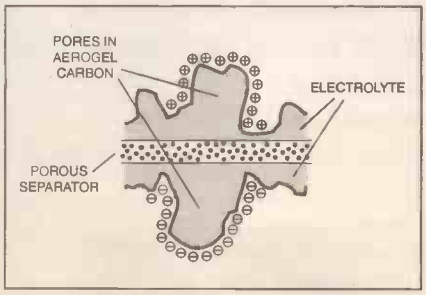


Fig.2. How charge is stored in an aerogel foam capacitor.

Results

The chief advantage of the new material is that it provides a very low level of ESR. Typically it can give a value of only 15 milliohms for a 10 farad capacitor, whereas a comparable part made by more traditional means might have a value of 200 milliohms. Although these values may appear to be insignificant for normal electronics applications they are crucial when high levels of pulse current are required.

In addition to the low level of ESR the new capacitor has a low level of leakage, and this is particularly useful in applications where the capacitor has to hold its charge over any length of time.

In addition to supplying pulse currents, supercaps can be used to provide power in other areas where the current requirement is more even. Often rechargeable cells are used in this function, but they have a number of disadvantages.

Firstly they have a limited life. The quoted life of a cell varies from one type to the next and may be a few hundred charge–discharge cycles. With each cycle their maximum capacity is slightly reduced. Capacitors are able to undergo many thousands of charge–discharge cycles with no degradation in performance. Also they do not require the very careful charging methods that are required by many types of secondary cell.

The capacitors also have advantages over other large capacitance components. When compared to electrolytics, the supercap has a far greater capacitance for a given volume, and its leakage is very much less.

All of these attributes make it an ideal choice for applications where a "hold up" current is required. Here the capacitor can supply a small current of a few microamps or milliamps for a few hours or days, to keep a circuit operational after the main power has been removed. Typically a memory circuit or a clock may be required to remain operational under such circumstances. In these circuits the very high capacitance rather than the low ESR is the main requirement. The PowerStor supercap operates well under these conditions.

Future

In view of the very high capacitance and low volume of these components, it is hardly surprising to note that the working voltages are relatively low. Components in this range are available with a working voltage up to 2·75V. However, the company expects to introduce a component with a working voltage of 5·5V.

Further information can be obtained from the Cooper Electronics Technologies website at **www.radio-electronics.com**.

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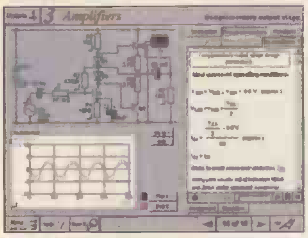
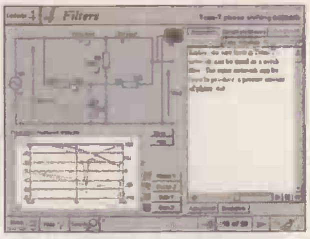


Complimentary output stage



Twin-T phase shifting network

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

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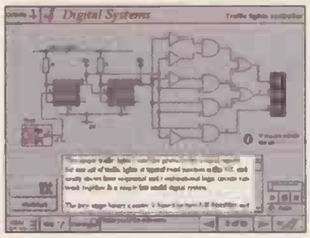
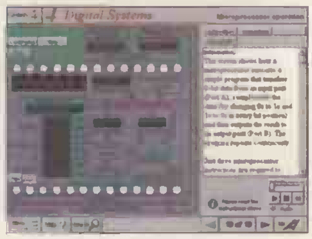


Virtual laboratory – Traffic Lights



Microprocessor

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.

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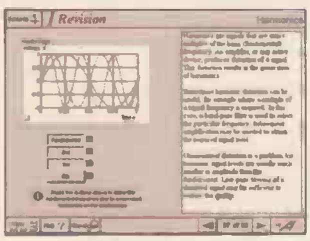
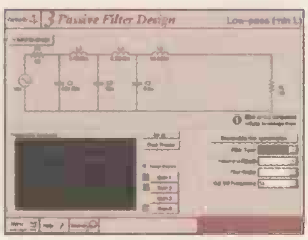
FILTERS



Filter Theory



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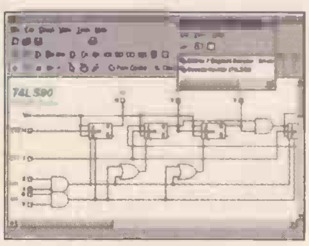
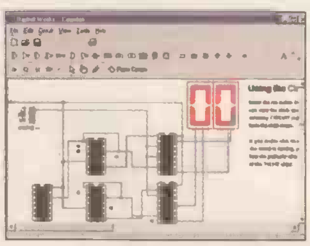
DIGITAL WORKS 3.0



Macro screen



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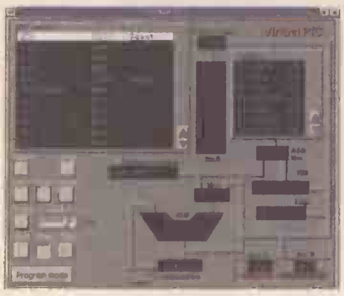

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EPE/ETI Tutorial Series

TEACH-IN 2000

Part Nine – Transistors

JOHN BECKER

With eight parts of our *Teach-In 2000* series complete, we trust that you are gaining a good grasp of what makes electronic circuits function. We have covered various passive components, examined logic gate devices and other digital integrated circuits. You have also assembled and have been using a computer interface which has allowed you to examine various waveforms generated by your experimental circuits.

In the last two parts it has been op.amps that have been covered, allowing you to amplify and otherwise manipulate analogue electrical signals. This month it is transistors we examine. These are not only the fundamental building blocks of any integrated circuit, but are still used as individual devices in many circuit designs. At the simplest level of understanding, they are not hard to use in a variety of ways.

At the heart of each active integrated circuit (i.c.) you have been using so far, whether it has been a digital inverter, logic gate, counter or op.amp, is a collection of *transistors*, cleverly interconnected during manufacture to perform the function required. The same holds true for all the i.c.s you could encounter in any of today's electronic equipment.

The 74HC14 Schmitt trigger inverter you have made great use of through much of this *Teach-In* series has 60 transistors. The Pentium microprocessor in a modern computer has in excess of seven million!

Despite the multitude of ways in which many transistors can be connected together in single packages, transistors continue to find use as individual components in a variety of more simple circuits. It is appropriate, therefore, that you now dig into your components bag and pull one out for closer examination!

One marked BC549 is what you need (or the 2N3704 if you live State-side and could not get hold of the European type numbers from your local stockist – also see Panel 9.1). It looks like the three small devices at the bottom centre of Photo 9.2.

As with op.amps, we'll first run through a few experiments using this transistor, and then we'll don our Tutorial togas and discuss what you've found.

BASIC BITS FIRST

Strip out any components currently inhabiting your breadboard between columns 16 and 36, temporarily remove oscillator capacitor C1, but otherwise leave the oscillator and computer interface circuits intact. Then assemble the breadboard layout shown in Fig.9.1, referring to Fig.9.2 for the component values and the equivalent circuit diagram. The transistor is referred to as component number TR1.

Ensure that you plug in the transistor so that its shape matches the outline in Fig.9.1, noting the different outline orientation for the 2N3704 at the bottom of the figure. Like so many electronic components, transistors are very conscious about correct power supply polarities.

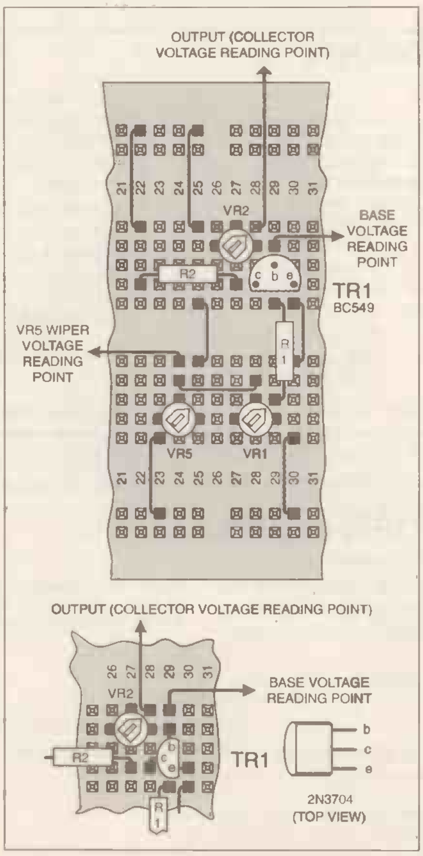


Fig.9.1. Breadboard layout for the first transistor experiment. Note the different orientation for TR1 depending on whether it is a type BC549 or 2N3704.

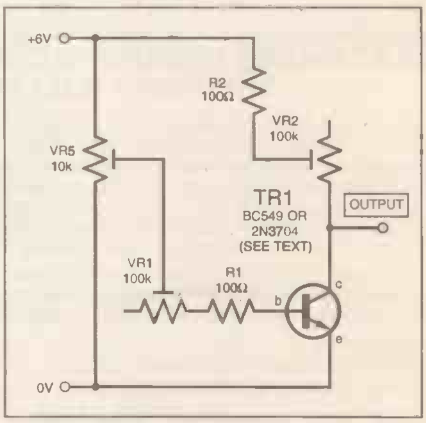


Fig.9.2. Circuit diagram for the first transistor experiment.

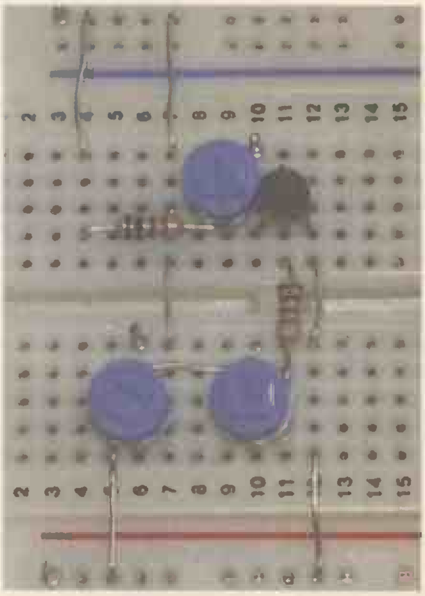


Photo 9.1. Detail of the breadboard using a BC549 transistor. Ignore column numbers.

Indeed, we'll briefly digress and point out Fig.9.3b and Fig.9.3c. The former shows the pinouts (legouts?) for the BC549 and the 2N3704, as though looking at an angled view of the top of the transistor. Fig.9.3c shows them from underneath, which is the way most data sheets show them.

Whereas i.c.s have numbers allocated to their pins, transistor legs or pins are referred to by letters. Those for the type of transistor you're using now are lettered *c*, *b* and *e*, the letters standing for *collector*, *base* and *emitter*. You will see the same letters drawn within TR1 in Fig.9.1.

The circuit diagram symbol for this transistor, in Fig.9.3a, shows the same letters next to the schematic legs, note the arrow which indicates current flow direction. We'll say more on all this by-and-by.

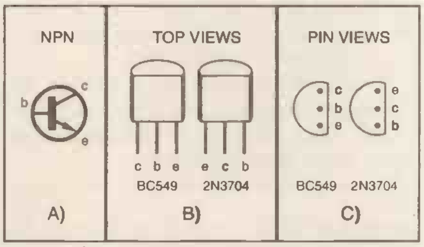


Fig.9.3. Symbol for an npn *transistor, plus pinouts for BC549 and 2N3704.*

DISCOVERY TIME

Before connecting your battery, and referring to Fig.9.1, set the preset wipers as follows: VR1 and VR2 midway, VR5 fully anticlockwise (wiper to 0V). Connect your multimeter between the point marked "Output" and the negative (0V) terminal of your battery. Set the meter for a d.c. range suited to monitoring up to 6V. Connect power to the breadboard in the same positions as in previous parts of *Teach-In*.

Note the voltage reading you get at "Output" (the connection to TR1's collector, notated as "c"), it should be virtually the same as the voltage being delivered by your battery, about 6V or so. (It would be a good idea to check your battery as well – if it's delivering nearer to 5·5V, it's time to change it!)

Very slowly rotate the wiper of VR5 clockwise, while watching the meter. As the rotation gets to about one-tenth of full rotation, the voltage reading on the meter should begin to fall. There will come a point, not long after the wiper has passed the one-tenth position, that the voltage will read as 0V. It will remain at that level however far you now rotate the wiper towards the 6V end.

Rotate VR5's wiper anticlockwise until the meter reading just ceases to be at 0V. Disconnect the meter and read the voltages at VR5's wiper and at the transistor pin marked "b" (base). Make a note of these values.

Return the meter to reading the collector voltage. Continue rotating VR5's wiper anticlockwise until the meter reads just under the maximum power supply voltage. Again make a note of the voltage at VR5's wiper and at TR1's base.

Slightly rotate VR5 back a bit until the collector voltage reads about 3V (half the battery supply). The position is *very* sensitive. Once more note the wiper and base voltages.

Now, *equally slowly*, adjust VR2's wiper, first fully anticlockwise (maximum resistance between it and resistor R2), and then fully clockwise (minimum resistance between it and R2).

In the first instance, increasing the resistance will be accompanied by a reduction in the voltage at the collector, perhaps right down to 0V. In the opposite direction the voltage will rise, back close to the power supply level, but possibly a little below it. Make a note of the voltage readings at TR1's collector and base when VR2's wiper is at the extreme ends of its travel.

Again return VR2's wiper to the position at which the meter reading is about 3V.

Preset VR1 is the next to adjust. Take a reading of TR1's base voltage before doing so. Maximum resistance between VR1's wiper (fully anticlockwise) and resistor R1 should result in an increase in the collector voltage reading; note it and the base voltage. Minimum resistance will probably decrease the collector voltage, perhaps even as far as 0V; again note it, and that at the base.

NOTED RESULTS

Cogs are probably turning in your brain right now, wondering about the meter readings you've noted down. Do they follow a pattern? If so, it's not a pattern such as you would have seen when examining the output of an op.amp in response to voltage changes on its input, as we asked you to do in Part 7.

In the op.amp experiments, within range limits discussed in that Tutorial, the results showed linear responses between the input and output voltages, even though amplification occurred.

What you should find studying your transistor voltage readings is that (within about 0·1V of the voltages we quote):

a. with VR5's wiper voltage below about 0·6V (minimum bias voltage level), the collector voltage remained close to 6V, irrespective of the settings of VR1 and VR2.

b. with VR5's wiper above about 0·7V (maximum bias voltage level), the collector voltage would not decrease below a certain level, that level being dependent on the setting of VR1 and VR2.

c. with VR5's wiper set about half-way between the minimum and maximum bias voltage readings you made (midway bias), the collector voltage could be set for varying levels, but again dependent of the settings of VR1 and VR2.

d. the voltage at TR1's base never exceeded a voltage of about 0·7V, irrespective of how high the voltage at VR5's wiper became.

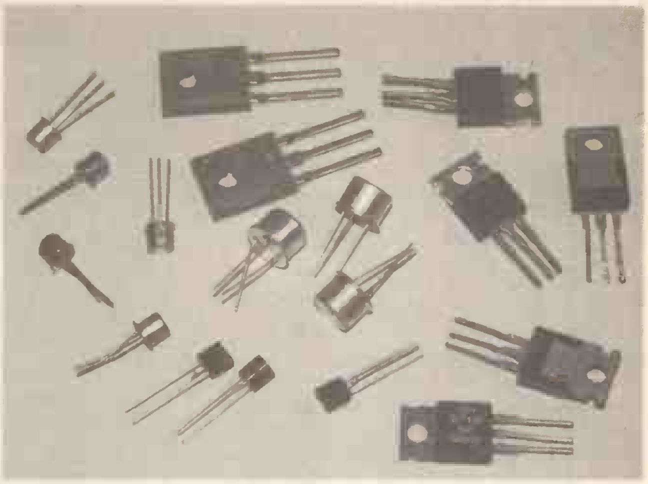


Photo 9.2. A selection of transistors and other related components. Many other case styles exist.

e. with VR5's wiper set for midway bias and VR1 set midway, increasing the resistance of VR2 (collector resistance) decreased the collector voltage, and *vice versa*.

f. with VR5's wiper set for midway bias and VR2 set midway, increasing the resistance of VR1 (base resistance) increased the collector voltage, and *vice versa*.

g. You may well have found that, whereas we state minimum and maximum bias voltage levels of 0·6V and 0·7V, your observed readings may be different, e.g. minimum of 0·5V and maximum of 0·6V.

From these facts, and the knowledge you've gained in earlier parts of this series, you should now be able to deduce that:

h. a change in current flowing through VR2 must occur in order to comply with the observed fact that its collector voltage can be changed depending on the settings of one or more resistances (VR1 and VR5).

i. a change in current flowing through VR1 must occur since the base voltage can never exceed about 0·7V, even though the voltage supplied by VR5 can be raised well above 0·7V.

j. when the base voltage is below about 0.6V, the voltage at the wiper of VR5 has the same value.

k. from (j), there is no current flowing through VR1 when the base voltage is below about 0·6V.

l. when no current is flowing through VR1, no current flows through VR2.

m. your min/max bias voltage range may be below that which we state (or even a bit above).

RAW NATURE

Two basic facts about transistors emerge from these observations:

1. a minimum base voltage (in the region of about 0·6V) must exist before current will flow through the base resistance.

2. the current flowing through the base resistance determines the current flowing through the collector resistance.

In essence, the second fact sums up the entire nature of a transistor. It is a *current amplifier*, purely and simply. The fact that you have observed *voltage* changes in respect of *current* changes is a by-product of current amplification.

Typically, for the transistor type you are using now, the current amplification (gain) might be about 100, thus 1mA flowing into the base would cause a current of 100mA to flow into the collector (assuming the resistance through which it flows will allow this amount of current flow).

GAIN TERMINOLOGY

There are two "official" terms given to a transistor's gain factor: h_{FE} and h_{fe}. The former refers to large signal (d.c.) forward current gain, and the second to small signal (a.c.) forward current gain. However, the complexities of the difference are outside the scope of what we want to demonstrate. It is h_{fe} which is quoted in most data sheets and catalogues and is the value which we shall use here (even though purists may at times regard its use as an over-simplification).

Whenever you see h_{fe} stated for a transistor type, the value given is the *expected* gain provided by a *typical* transistor of that type. However, as with other component values, the gain is subject to a tolerance factor. The BC549 has a quoted h_{fe} range of 110 to 800. The 2N3704 has a range of 100 to 300.

CURRENT FLOW

You are no doubt wondering about where the current flows, the answer is simple. Base current flows into the base and out through the transistor's third leg, the emitter (e), but it does not flow through the collector. The collector current flows through the transistor and also out through the emitter (but not through the base). The total current flowing out through the emitter is thus the total of the base and collector currents.

The fact that a minimum bias voltage is required before current amplification can occur is something of a stumbling block, however. The problem is that the region is very narrow between the bias voltage *just about* causing current to flow through the collector (causing the transistor to begin to *conduct* or *turn-on*), and it allowing maximum current to flow. The range is also somewhat unpredictable, from three points of view.

First, the actual voltages concerned vary slightly, not only between transistors of different types, but also between individuals of the same type.

Second, the current flowing between the base and emitter is not just a product of that being allowed through by the base resistance, it is subject to a more fundamental fact of nature. Here, though, we are in danger of now peering into the awesome abyss which holds the fundamental secrets of the universe, life and everything!

So we'll avoid that route and its discussion of electrons, holes and carriers and the like. Sufficient to say that at *very small* values of bias applied to transistor's base, the current flowing between the base and emitter has an essentially unpredictable value, and can change exponentially in respect of minute linear increases in bias voltage. The graph in Fig.9.4 illustrates this.

PANEL 9.1 IDENTIFYING TRANSISTORS

The American labelling system for transistor identification uses the prefix '2N' followed by four numbers. The European system for labelling standard transistors consists basically of two letters followed by three numbers. Transistors for special applications are identified by three letters and two numbers.

The first letter indicates the material from which the transistor is made:

A = germanium
B = silicon

The second letter indicates the typical area of use:

C = low power, low frequency
D = power, for low frequency
F = low power for high frequency
L = power for high frequency
P = phototransistor
S = switching transistor for low power
U = switching transistor for high power

The third letter, where included, does not generally have any particular significance, apart from manufacturer's identification. There is no coding used to indicate whether a transistor is an *npn* or *pnp* type, or whether it is bipolar or field effect, etc. (see Panel 9.3).

Bipolar transistors may also have a letter which follows the number, such as *A, B, C* or *L*. Letters A, B and C indicate the maximum amount of gain (amplification) which can be expected from a bipolar transistor, it is usually quoted in data sheets as a range within which the gain can be.

Suffix C indicates a gain greater than that for suffix B, which in turn is greater than for suffix A. Transistors without a suffix can have a gain anywhere between the extremes. Suffix L is not a gain code, it is a pinout orientation code.

Transistor specifications cannot be identified through the type number. These facts can only be identified from data sheets and catalogues.

TAMING BEHAVIOUR

Happily for us all (and the electronics industry), there comes a point once the bias has risen sufficiently high into the "turn-on" region, that further increases of current flow into the base-emitter path (*junction*) are responded to by *linear* increases in the current flow through the collector-emitter path, but amplified by the gain factor of the transistor.

Thus, in order to tame a transistor's behaviour, it is only necessary to set up a basic bias voltage on its base, somewhere between the minimum and maximum turn-on levels, and then further changes in bias current will be responded to as linear current gain through the collector-emitter path.

Of course, once we have predictable current gain, we can think about what values of resistance in the collector path can be used to produce *voltage* changes in respect of *current* changes on the base. Which is where Ohm's Law comes in handy again: $V = I \times R$.

The third problem to be considered about the circuit in Fig.9.2 is one we have mentioned several times throughout this series – temperature. The characteristics of a transistor are heavily dependent on its temperature. For example, the current flow into its base-emitter junction is likely to rise as the temperature rises, either due to the temperature of the transistor's surroundings, or due to internal heating caused by the current flowing through the collector-emitter path.

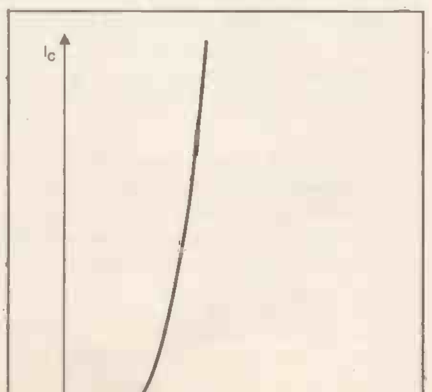


Fig.9.4. Variation of transistor base-emitter current with changes in base voltage.

In both cases, the result is that the increased current flow through the transistor will cause the voltage at the junction of the collector and its resistor to fall.

In extreme circumstances, particularly when there is no limiting resistor in the collector path, a situation known as *thermal run-away* can develop, in which the increased current flow causes increased heating, which causes yet further increases in current flow, and so on until the transistor gets so hot that it dies.

You can prove that a transistor's response is temperature dependent (without endangering it) in a very simple experiment:

Still referring to the circuit on your breadboard, first set VR5's wiper so that the collector voltage is a little below the power line maximum. Now warm your thumb and first finger against the side of a hot tea cup (or coffee cup if you prefer!). Then grip the transistor's plastic body to transfer heat to it. Observe the meter while doing so. The collector voltage will be seen to progressively fall as the transistor gets warmer.

Remove your fingers once you've seen the principle, whereupon the transistor will start to cool, allowing the collector voltage to rise again.

When you get a moment, see if you can plot graphs of the rate at which the collector voltage changes with time and temperature.

DEMO PROGRAM

Time to bring our *virtual* guns into action – from the main program menu select Transistors – Menu.

On selecting this option, you will be presented with a sub-option menu, devoted to

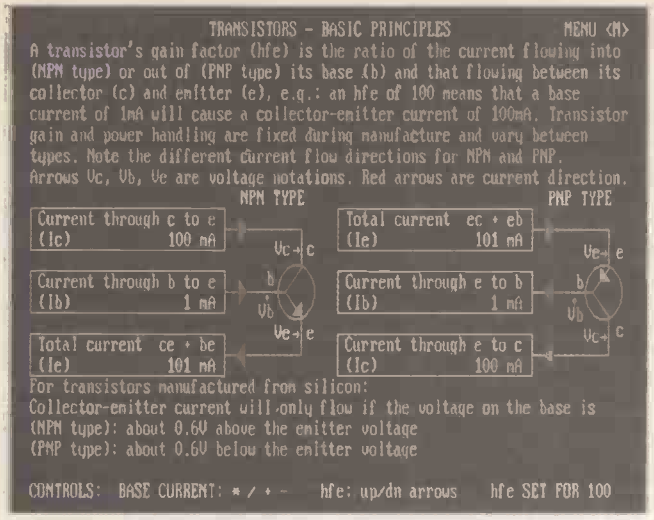


Photo 9.3. Interactive demo screen which illustrates the basic transistor principle.

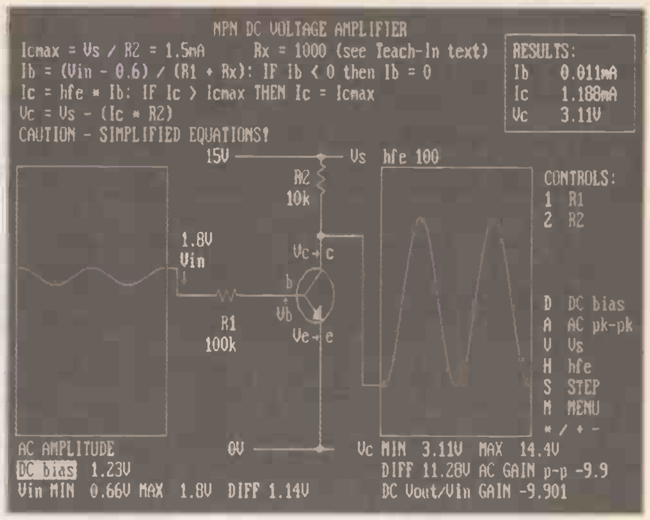


Photo 9.4. Interactive demo screen which illustrates d.c. voltage amplification.

the transistor demos. As part of this screen is a text which briefly reminds you that some transistor responses can be a bit unpredictable, and that the demos are just generalised guides to their behaviour.

Selecting the first option, Transistors – Principle, reveals another screen which shows you a theoretical transistor's response to varying levels of input current (see Photo 9.3).

You will quickly spot, though, that there are two transistor outlines, not one. The reason is that the transistor you are using now has a mirror-image "twin". Yours is known as an *npn* type and as such has its collector and emitter connected across the power lines as shown in Fig.9.2 and implied on the left of the screen display.

The second transistor is known as a *pnp* type and functions with an opposite polarity to an *npn*, the *emitter* nearest to the positive line, *collector* nearest to the lower voltage (e.g. 0V) line. This is illustrated in the right-hand screen outline. Both transistor types belong to a general family known as *bipolar*. It is a term which describes the manufacturing process.

Although most of our discussions are concerned with *npn* types, later we shall briefly describe and ask you to explore an example of a *pnp* type in operation. Basically, a *pnp* transistor is used the "other way up", and is biased accordingly.

The Principles screen display is interactive, use the control keys stated.

NPN DC AMPLIFIER DEMO

Sub-menu option two, NPN DC Voltage Amplifier, illustrates a simple form of the circuit you have been experimenting with. It has been stripped to just two resistors, base and collector, plus a variable d.c. base bias voltage (see Photo 9.4).

We mentioned a few paragraphs earlier that transistors can die if too much current flows through them. This is why in addition to presets VR1 and VR2 in Fig.9.2, we also have fixed resistors R1 and R2. The purpose of these is to limit the maximum current which you can cause to flow through the transistor, and so avoid killing it through carelessness.

With the demo screens there is no chance of you killing the *virtual* transistors. You can stick as much voltage or current through them as you wish!

On entry to this demo, the bias voltage is set just below a theoretical turn-on voltage of 0·6V (at 0·56V). There are a number of control options allowing principal factors to be changed, including the ability to use either a steady d.c. voltage or a sine wave as the input voltage. All control options are itemised on screen, as usual.

To bring in the sine wave input, first press <A> to highlight AC Amplitude. Then press the <*> key a few times to increase the waveform's amplitude. At low amplitudes you won't see it as a sine wave because of the screen resolution, but the calculations which are performed assume that it is sinusoidal.

Note how the output shape of the amplified waveform is very sensitive to both base and collector currents. It will frequently show the same "clipping" characteristics that you encountered when examining op.amps.

In a real life situation, transistors used in the manner demonstrated now are extremely difficult to bias so that the output waveform retains the shape of the original. The response is also very dependent on temperature.

Where this circuit finds considerable use, though, is as a switch. The voltage at the collector is very easy to be caused to swing between the two extremes of fully on or off in response to an input voltage swinging above and below the 0·6V turn-on threshold.

Two particular applications for this are in raising a low amplitude input waveform to a maximum power line level swing, and in switching on and off such hardware as *relays*. In the latter case the relay coil (electromagnet) is used in place of resistor R2 (sorry, but relays will not be examined in this *Teach-In* series).

CALCULATIONS

Be aware that the controlling program which simulates the transistor's response is only a simple model of what actually happens in a real transistor. For example, the base bias voltage *range* we discussed earlier is not allowed for, the "turn-on" bias being taken as exactly 0·6V. Neither has the varying current-dependent base-emitter resistance been simulated. It has been taken as a fixed value of 1000 ohms. In real life, the actually value can be vastly different.

However, we have not provided these demos as design tools, there are many excellent commercial software programs which provide such facilities. We are simply demonstrating the most elementary characteristics of transistors.

PANEL 9.2 BIPOLAR TRANSISTOR ABBREVIATIONS

When you examine the data sheets or catalogue details for bipolar transistors, you are likely to find a large number of columns and abbreviations describing each transistor's characteristics. Until you are more fully knowledgeable about other aspects of electronics, you can usually ignore most of them, with the following exceptions:

- Type – *npn* or *pnp*
- Material – silicon or germanium (silicon transistors are far more widely used than germanium, the latter having become largely obsolete). The transistors used in this *Teach-In* are made from silicon
- Pinout – the order in which the transistor's pins are arranged
- h_{fe}(typ) – Gain (amplification factor), usually specified as a typical range within which the actual gain could be, and often quoted in relation to a specified current at which that gain occurs
- $V_{CEO(max)}$ – Voltage maximum which can be applied between the collector and the emitter
- $I_{C(max)}$ – Current maximum which can safely be allowed to flow through the collector/emitter path
- P_{TOT} – Power total which the transistor can handle, the product of the voltage across the collector and emitter and the current flowing between them
- $f_{t(typ)}$ – Frequency up to which the transistor can typically operate before signal degradation occurs.

LISTING 9.1

```
10 Icmax = Vs / R2
20 Rx = 1000
30 Ib = (Vin - 0·6) / (R1 + Rx)
40 IF Ib < 0 THEN Ib = 0
50 Ic = hfe * Ib
60 IF Ic > Icmax THEN Ic = Icmax
70 Vc = Vs – (Ic * R2)
```

At the top of the screen are shown the command lines which are used within the full QuickBASIC program to perform the calculations whose results you see displayed, as repeated in Listing 9.1 (but with line numbers to aid our description of it).

The program performs the interpretation of the basic simple formula:

Vc = Vs – (Ib × gain × R2)

where:

Vc = collector voltage

Vs = positive power line voltage

Ib = base bias current

Let's quickly run through the command lines:

10. The maximum current (Icmax) which can flow through the transistor is limited by the value of resistor R2 in relation to the power supply voltage, Vs.

20. Rx represents the base-emitter resistance referred to a moment ago, and is set for a nominal value of 1000 ohms.

30. Ib represents the current flowing into the base. This is determined by the input voltage (Vin) minus the 0·6V transistor turn-on voltage, divided by the total value of the base input resistance, consisting of R1 plus the base-emitter resistance Rx. The basic formula here, as you will recognise, is I = V / R (Ohm's Law).

40. Purely for the program's benefit, current into the base is not allowed to fall below zero.

50. The basic collector current (Ic) that can flow, without the presence of R2, is the base current (Ib) multiplied by the transistor's supposed gain.

60. For the program's benefit, if the calculation result is greater than resistor R2 can allow (Icmax), the result is limited to that value.

70. The current (Ic) flowing through R2 and the collector determines the voltage that appears at the collector (Vc). This is calculated by multiplying Ic by R2 and subtracting the answer from the supply voltage, Vs.

At the top right of the screen are shown the intermediate results for Ib, Ic and Vc. They are those for the immediate value of Vin, as shown to the left of R1.

In the full program the calculations are repeatedly made for each voltage value being supplied to resistor R1, and plotted on screen as the output.

It is important to note that the *actual* overall gain (amplification) given to a voltage or current, steady or varying, is not necessarily the same as the transistor's quoted gain value. It is limited by the collector resistance and whether or not the output signal becomes clipped.

Incidentally, when the input current

PANEL 9.3 TRANSISTOR TYPES

Bipolar transistors

The simplest type of transistor is known as a *bipolar* transistor and it has three connections, referred to as the *base*, *emitter* and *collector* (usually abbreviated to *b, e, c*).

There are two fundamental types of bipolar transistor, *npn* (think of it as negative-positive-negative) and *pnp* (think of it as positive-negative-positive). These terms describe the internal construction polarity between the junctions of collector, base and emitter.

Current through a transistor's principal terminals, the collector and the emitter, should only be allowed to flow in one direction: from collector to emitter for *npn*, from emitter to collector for *pnp*.

For silicon *npn* transistors, base current must be supplied at a minimum voltage level of around 0·6V *above* the voltage at the emitter before it will "turn-on". For silicon *pnp* transistors, the turn-on voltage is about 0·6V *below* the emitter voltage.

For germanium transistors (now seldom encountered), the voltage differential is about 0·3V.

This differential can sometimes make transistors easy to check in circuit: if the voltage differential between the base and emitter is ever well above the "normal" level, the transistor is dead.

Field effect transistors

Field effect transistors (f.e.t.s) do not require current flow in order to be "turned on". Instead, this control occurs in response simply to the presence of a voltage (electrical *field*) on their control electrode (pin), the value of the voltage determining the amount of current which can flow through the transistor's main path. (There will be a small amount of control current consumed, but it will be so *extremely* small that it can essentially be discounted.)

F.E.T.s have three terminals, *gate*, *source* and *drain*, which are the equivalent of the bipolar base, emitter and collector, respectively. (In this context, the term *gate* should not be confused with a *gate* as used in logic circuits.)

They are available as two basic types, known as *n-channel* and *p-channel*. They are (usually) as conscious of their electrical orientation in respect to power line polarities as bipolar transistors.

Darlington transistors

Darlington is the name given to a configuration of two transistors connected as shown in Fig.9.5 (upper right), and combined in the same package. The first transistor has high gain characteristics, while the second is capable of passing high currents.

Because there are two base-to-emitter junctions in series, the turn-on voltage for a Darlington is twice that of a single bipolar transistor, i.e. about 1·2V to 1·4V.

Phototransistors

Phototransistors conduct current when exposed to light. They belong to the *opto-electronics* class of components. Other members of the category include any device which responds to light falling on it, or emits light, or displays information in a controllable manner. Examples of the latter two groups are light emitting diodes (l.e.d.s) and liquid crystal displays (l.c.d.s).

Thyristors, triacs and diacs

Thyristors, triacs and diacs are three of the principal components in the area of power electronics, where the switching of large currents and high voltages is involved. However, they can only block and conduct current, they cannot be used to amplify it. Strictly speaking they are not classified as transistors.

Thyristors can be used to control a.c. or d.c. power; triacs and diacs are principally intended for a.c. power control.

Thyristors and triacs are manufactured for switching currents which can range from a few hundreds of milliamps to several thousand amps and to voltages well over 1000V.

Unijunction transistors

A unijunction (u.j.t.) or *filamentary* transistor has two bases, B1 and B2, and an emitter. It is principally used in thyristor and triac firing circuits.

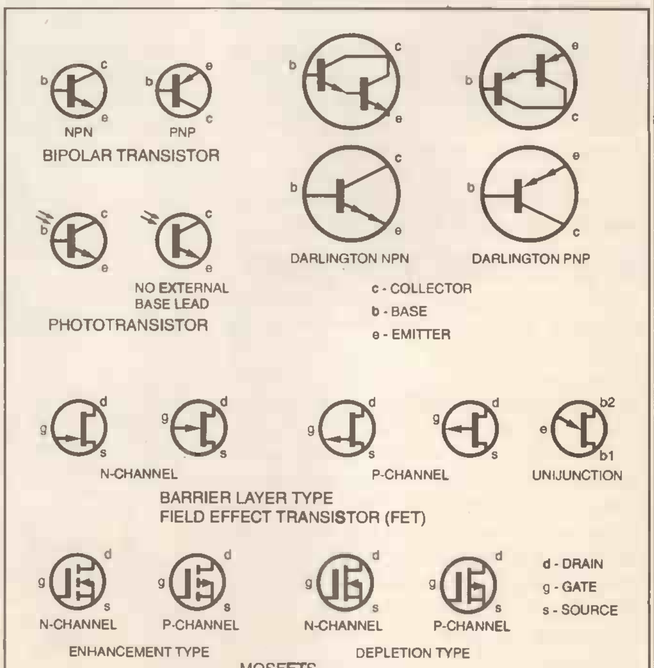


Fig.9.5. Circuit symbols for the various forms of transistor types.

causes the collector voltage to fall to the same voltage as on the emitter (in this case 0V), the transistor is said to be *saturated*.

As previously said, if you press <A> and then the <*> or <+> keys you can cause a waveform to be input to TR1 via VR1. For the most part the output will be seen to be an amplified, but inverted, version of the input but with clipping on its upper peaks. This can be adjusted by changing the d.c. bias voltage (use <D> and then the <* / + –> keys).

Experiment with this for a while, also changing the values for R1, R2, h_{fe} and the power supply voltage. You will find that, whilst the shape of the waveform can be made to follow the input more adequately, it is not easy to select the right combination of the changeable parameters.

What is much easier, though, is to set high gain values and achieve full maximum to minimum output voltage swings. This bears out our previous statement that this circuit is more suited to *switching* rather than *waveform* amplification.

IMPROVED AMPLIFIER

If you were to connect the triangle waveform from IC1a pin 1 (see previous parts of *Teach-In*) to transistor TR1 on your breadboard via preset VR1, with preset VR5 removed, you would find that the collector voltage would always be at 0V (fully saturated). The voltage from IC1a pin 1 never falls below 0·6V and so always keeps TR1 turned on.

As with the op.amp circuit, though, we can isolate the transistor from the d.c. influence of the oscillator. Basically, this is again done by inserting a capacitor (call it C1) between the oscillator and the input to the amplifier (TR1 base, in this case), see Fig.9.6.

On the breadboard layout (Fig.9.7) we have also included an op.amp buffer (not shown in Fig.9.6) between IC1a pin 1 and this capacitor, to prevent "loading the oscillator" (as discussed in Part 7). On its own, C1 might still not allow the input waveform voltage to swing adequately above and below the nominal 0·6V threshold. The signal level might cause TR1 to operate in its principally unpredictable bias region, in which the base-emitter resistance can vary greatly (as previously discussed).

What we can do, though, is to add an extra and greater *fixed* current flow into the base which is just right to ensure that TR1 is primarily biased to operate in its more linear region. In this way, the incoming signal via C1, even if it is only very small, will cause the collector voltage swing to become a more faithfully amplified version of the input waveform.

EASIER BIASING

In this circuit, the bias setting using VR5 is also far less critical. The reason is that we have introduced resistance into the emitter path, using VR3 and R3.

The addition of emitter resistance creates two new situations. First, it allows a signal to be output at the emitter. Secondly, it raises the effective resistance between the base and emitter, so reducing the load which the preceding circuit experiences through its connection to the transistor's base. The transistor circuit is now said to have a *higher input impedance*.

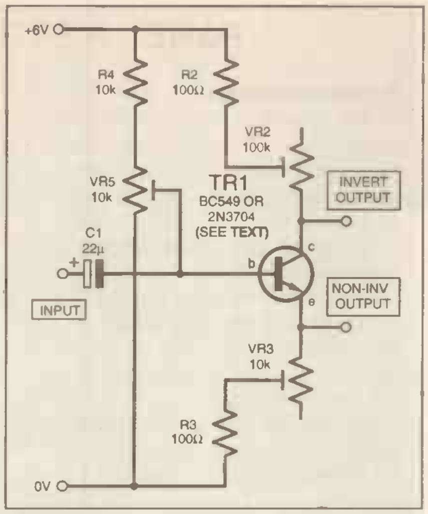


Fig.9.6. Circuit diagram for the a.c. coupled phase-split amplifier.

An important point about the signal output at the emitter is that *it does not provide an amplified signal.* The output voltage level will always have the same amplitude (minus a d.c. shift of 0·6V) as that being input, provided the latter never falls below the transistor's 0·6V turn-on voltage differential between base and emitter.

A second attribute, which follows on from this, is that the signal level is always the "same way up" as the original (as you were able to achieve with the non-inverting op.amp configuration). The output is said to have the same *phase* as the input. In some respects, the emitter output can be regarded as the transistor equivalent of an op.amp buffer.

Even though the emitter output is not amplified, the signal at the collector is still capable of being amplified according to the choice of collector resistance. It continues to be an inversion of the original, i.e. having an opposite phase.

PHASE-SPLIT AMPLIFIER

Because the circuit produces two signals of opposite phases it is sometimes known as a *phase-splitter*. This term is especially relevant when the gain is set so that the amplitude of the collector signal is the same as that at the emitter. Such a circuit is invaluable in a number of situations, one of which is in audio circuits if "push-pull" power amplification is required (offering greater power handling efficiency).

Before examining the breadboard setup of the phase-split configuration, let's again look at a computer demo. Select sub-menu option NPN Phase-Split Amplifier (see Photo 9.6).

When you experiment with the demo circuit, it will become obvious why the base bias setting is far less critical in this circuit. Whereas previously the bias had to be set precisely within the 0·6V region, we now have a situation in which a base bias voltage in excess of the nominal 0·6V will appear at the emitter, minus 0·6V. The emitter resistance "takes up the slack", so to speak.

This circuit is only for use with a.c. coupled input signals (the bias setting resistors would simply impose a greater load on a d.c. coupled circuit without actually providing the required bias).

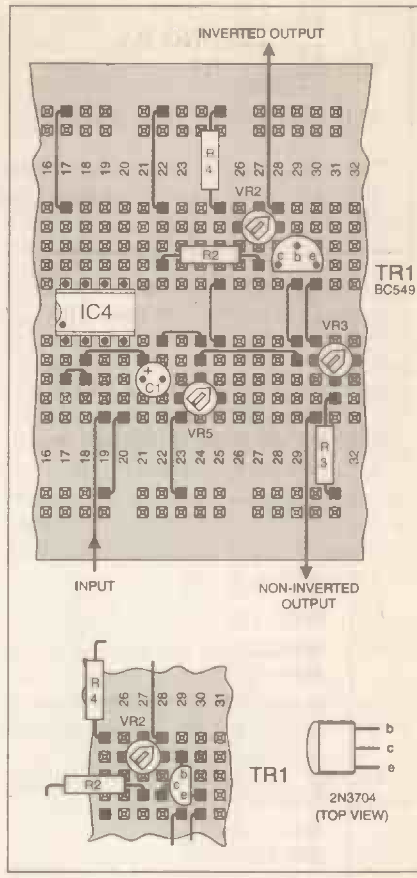


Fig.9.7. Breadboard layout for the circuit in Fig.9.6. Again note the different transistor orientation if using a 2N3704 instead of a BC549.

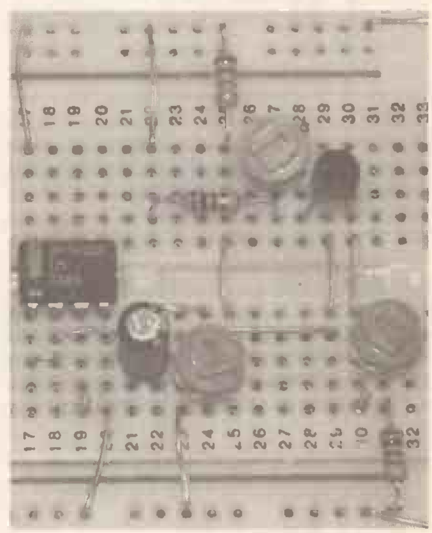


Photo 9.5. Detail of the breadboard using a BC549 transistor.

When choosing the values for the potential divider R4 and VR5, we select them so that, in the absence of an input signal, the collector voltage sits at about the midway power line level, and the emitter voltage is just above 0V.

This ensures that the collector output waveform can swing evenly, and that the emitter output waveform never "bottoms-out" (never reaches 0V).

A further and really important point about this circuit is that the signal gain at the collector is, to all intents and purposes, *independent of the transistor's own gain factor*.

With this configuration, the actual gain applied to any waveform is simply defined by the formula:

gain = R2 / R3

This is not to say that h_{fe} is unimportant, it isn't. It plays a part in the impedance that the incoming signal's source sees, and in determining the bias voltage at the base, and hence the voltage at the emitter. However, in most circuits, the input impedance imposed by the biasing resistors will be lower than the effective base-emitter resistance and the latter can have less significance.

DEMO CALCULATIONS

In the control program for this circuit, the appropriate section of which is shown at the top of the screen, a lot of commands are required to produce a reasonable model of what happens.

First, the resistance (Rx) between the transistor base and emitter has been redefined to bring h_{fe} and the value of R3 into play. Again an assumption has been made about it having a predictable value which, as we have said before, is not necessarily the case in a real transistor.

For the sake of this demo, we have defined Rx as:

$$Rx = R3 \times h_{fe} \times 100$$

With R3 in play, but having the effective value Rx, the voltage at the base is set by the potential divider in which R4 is the upper part, and the lower part (Rb) comprising R5 in parallel with Rx.

Using the resistors in parallel formula (see Part 1):

$$Rb = 1 / ((1 / R5) + (1 / Rx))$$

Therefore the base voltage (Vb), in the absence of an input signal, is defined by using the potential divider formula, as:

$$Vb = Vs \times (Rb / (R4 + Rb))$$

Because there is a (nominal) voltage drop of 0·6V between the base and emitter, the emitter voltage (Ve) is thus Vb – 0·6 (providing, of course Vb is greater than 0·6V, if it's not then Ve = 0V).

The collector voltage (Vc) is then defined as:

$$Vc = Vs - ((Vb - 0{\cdot}6) \times (R2 / R3))$$

To establish the collector and emitter voltages when a waveform is applied via capacitor C1, its instantaneous value (Vin) is simply added to the value of the base voltage (Vb) in the equation defining Vb.

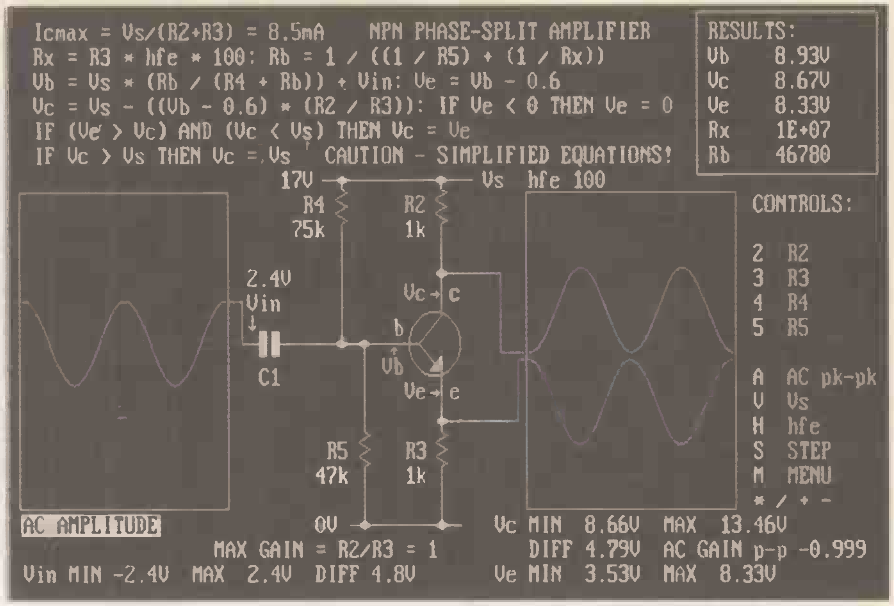


Photo 9.6. Screen dump of the interactive NPN Phase-Split Amplifier demo.

EXCESS INPUT VALUES

A curious fact is worth highlighting about the relationship between the collector and emitter voltages. It must be obvious that the collector voltage can never go below that on the emitter, since the current flows through the collector to the emitter.

By the same token, one might expect that the emitter voltage will always be less than or equal to the collector voltage. Not necessarily so, as you can illustrate via your screen demo presently (using a very high input amplitude).

Suppose that the incoming signal has a positive peak value which exceeds the calculated collector voltage by at least 0·6V. The collector voltage cannot fall to its expected value, it can only fall to the same level as on the emitter. Consequently, the collector voltage waveform will take on an unexpected shape (see Photo 9.7).

The collector voltage begins to fall in the usual way as the input voltage starts to rise. Then, as the input level continues to increase, the collector and emitter voltages become equal. Further increases in the input voltage now cause the emitter voltage to rise higher still, and the collector voltage is also forced to rise.

In extreme circumstances, where the peak input voltage level exceeds the power line voltage supplying the transistor, the emitter voltage can actually rise above the supply voltage, although the collector cannot exceed it, the internal nature of the transistor preventing it.

To prevent the latter from happening, a diode (D1 in Fig.9.8) can be connected in parallel with R4, cathode (k) on the positive power line, anode (a) on the base of TR1.

A related problem exists if the input voltage level falls greatly such that a negative voltage appears on the transistor base. Whilst the transistor can withstand a certain amount of *reverse bias* (base less positive than the emitter) there are limits as stated in transistor data sheets. If these are exceeded, the transistor could die.

Another diode (D2 in Fig.9.8) can prevent this, using it in parallel with R5, anode on 0V, cathode on the base of TR1.

In both cases, excess voltage flows through the diode to or from the relevant power line. The voltage drop across each diode is about 0·7V (as discussed in Part 4) and the voltage on the base is limited to within ±0·7V of the power lines.

You are more likely to encounter circuits which use the negative-limiting diode (that across R5), rather a diode across R4. (CMOS integrated circuits have voltage limiting diodes between their inputs and the internal power connections to "short out" such excess voltages).

Note that the diode must be capable of

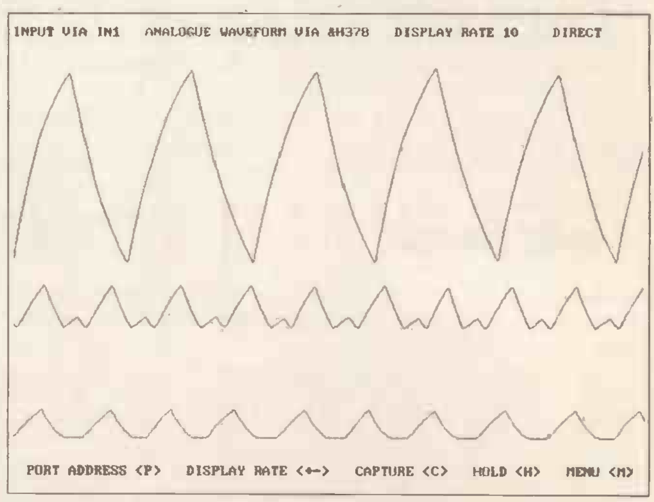


Photo 9.7. Composite screen dump of three transistor-amplified waveforms as monitored at the collector. Top, evenly amplified using correct base biasing. Middle, lower part of waveform distorted by emitter voltage rising too high. Bottom, base bias too low causing waveform to saturate ("bottom-out").

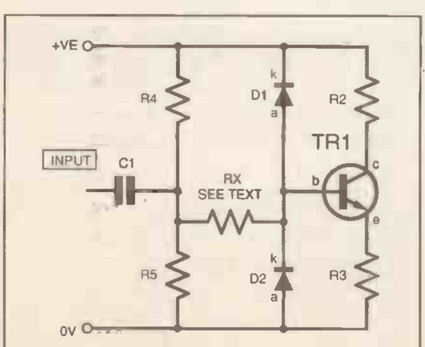


Fig.9.8. Using diodes to protect a transistor from excess input voltages.

handling the currents which are likely to flow in excess input voltage situations. In most cases, though, a diode such as the 1N4148 type you have been using in the oscillator circuit will provide adequate protection.

Also be aware that the diodes will place a load on the signal source if they are caused to conduct. In some cases it may be desirable to have a current-limiting resistor between them and the source (e.g. Rx as in Fig.9.8).

When you have assembled the split-phase circuit layout of Fig.9.7, experiment with the presets and observe the results on your computer (Analogue Input Waveform Display) and meter.

NPN AC AMPLIFIER DEMO

A shortened version of the phase splitter which is well suited to a.c. coupled signal switching is demonstrated in the sub-menu selection NPN AC Voltage Amplifier. In it, the emitter is taken direct to the 0V line. We shall not discuss this demo, but let you explore it at your leisure.

TRANSISTOR BUFFER

We have commented on the emitter voltage retaining the same phase and amplitude as the signal on the base. What may not be immediately apparent is that the current available at the emitter is related not only to the resistance in the collector emitter path (R2 + R3 as in Photo 9.6), but to the current gain provided by the transistor.

If we remove resistor R2, the total current flowing into R3 is the current flowing into the base times the gain (h_{fe}) of the transistor. The maximum current that can be allowed to flow into R3 is only limited by what the transistor can safely handle. In the case of the BC549, this is a maximum of 100mA; the 2N3704 can handle 800mA.

However, the "safely" term must also take in account the heat which will be generated within the transistor when that current flows, in other words, the *wattage* limits of the transistor must also be considered. The limits for the BC549 and 2N3704 are 625mW and 360mW respectively.

Note that more heat will be generated when the transistor is only *partly* turned on, rather than when it is fully turned off or fully turned on. This is due to the transistor offering resistance to the current flow when it is only partly turned on.

Recalling the derivative of Ohm's Law from Part 3, which states that P = I × V, where P is the power in watts, you measure the voltage drop between the transistor's collector and emitter, and the current flowing into the collector. From this you can calculate whether the transistor is safely operating within its current and wattage limits.

Another test that can sometimes be useful (if not very scientific), is to feel the transistor between your fingers. If it feels hot, then it is probably *too* hot, and the current flow should be reduced. With power transistors (those designed to handle high currents), metal *heatsinks* can be clipped or bolted to them to dissipate excess heat. That is another story, though, beyond the scope of this series.

The benefit of a transistor configured in this mode, known as *emitter-follower* mode, is that it can be used as a buffer to increase the impedance (resistance) seen by a preceding circuit, allowing the current-amplified signal to drive (feed into) a much lower resistance.

The mode can be used for a.c. and d.c. coupled signals.

CURRENT AMP DEMO

The demo program NPN DC Current Amplifier shows a simple circuit for a d.c. coupled emitter follower (with the collector resistor R2 omitted).

In the demo, emitter resistor R3 represents the resistance of the load (e.g. next circuit) into which the amplified current can be fed. The use of base resistor R1 is not always necessary.

The maximum current that *can* flow through R3 is expressed according to Ohm's Law, I = V / R

With R1 omitted, the current (Ie) which *will* flow through R3 is:

I = (Vb – 0·6) / R3 or
I = Ve / R3

For the demo calculations and with R1 included, Vb is calculated using the potential divider formula:

Vb = Vin × (Rx / (R1 + Rx))

where Rx = R3 × h_{fe} × 100 (using the same assumption as discussed earlier)

The program's calculation commands and intermediate results are again shown at the top of the screen.

Experiment with the program's options, and then return to your breadboard layout in Fig.9.6 for of the Split-Phase circuit and experiment there, concentrating on the emitter voltage when the collector resistance VR2 is at its minimum. If you wish, replace R2 and VR2 by a wire link between the collector and the positive line, but retain R3 and VR3 in the emitter path as a safety measure.

NEXT MONTH

In Part 10 we examine the theory of power supplies, including those operated from the a.c. mains. We shall not ask you to actually plug anything into the mains (other than your computer as usual!).

PANEL 9.4 CALCULATING RESISTORS

When deciding which range of resistor values to choose from in an amplifying circuit, the first matter you should consider is what load is going to be placed on the collector output by the circuit into which it feeds.

The resistance of the load forms a potential divider with the collector resistor R2 as its upper part. The voltage output at the collector can only ever have a maximum of the potential divider voltage. As discussed in other parts (e.g. Part 1), the load should have a resistance at least 10 times greater than the resistance of the significant divider arm, i.e. R2 should be at least 10 times less than the minimum load resistance.

Once R2's value is known, the other resistor values can be chosen to achieve the optimum biasing as discussed. Should doubt exist about any current requirements, assume a worst case condition and calculate accordingly. It is always better to have more current capability available than is likely to be consumed.

Always ensure that the components you use are capable of handling the currents and wattages required. Err on the side of caution in all cases and don't allow components to exceed their limits. Manufacturers' data sheets quote component limits and other parameters.

TEACH-IN 2000 – Experimental 9

AS THIS month's first experimental suggestion, insert l.e.d.s (light emitting diodes) into the emitter and collector paths in your breadboard assembly of Fig.9.7 from the Tutorial. Each should be placed between the relevant power line and existing 100Ω resistor. An extra link wire will be needed for each of them.

Discover how the l.e.d.s can give an indication of the transistor's response to different choices of circuit gain and signal bias.

Remember that an l.e.d. requires a voltage drop across it of about 2V. If the l.e.d. is placed between the emitter and 0V, how does this affect the base bias voltage required to turn it on?

Can you have an l.e.d. in both the collector and emitter paths at the same time?

BUZZER CONTROL

Experiment with placing the active buzzer (one of the components you were advised to obtain in Part 1) into the collector and emitter paths, in place of the l.e.d.s. Allow the oscillator frequency setting to vary the rate at which the buzzer is turned on and off. Which position of the buzzer produces the best response, in the collector or emitter path?

Reinstate diodes D2 and D3 in the oscillator circuit (see Part 4, Fig.4.1) and experiment with different ramp waveform settings, discovering how the buzzer's on-to-off periods can be changed. Try different values for the oscillator's capacitor C1.

AUDIO OUTPUT

If you insert your headphones into the collector or emitter paths (l.e.d.s and buzzer removed), you can hear the frequency generated by the oscillator around IC1a. How does the base bias voltage setting affect not only the volume of the sound but also its quality?

Also try inserting a volume control preset between the transistor's input capacitor C1 and its base, referring to the circuit diagram shown in Part 8, Fig.8.13.

Next remove oscillator diodes D2 and D3 again, and replace D3 with a 100Ω resistor.

Running the Computer as Frequency Counter program, connect the output of IC1a pin 2 to one of the computer interface inputs. Discover the range of frequencies which you can hear through the headphones. Use different values of oscillator capacitor C1 and settings for its preset VR1.

MIC AND SENSORS

With the op.amps discussion last month, we explained how an electret microphone, a light sensor (l.d.r.) and a heat sensor (thermistor) could be used with an op.amp circuit.

We believe that now having worked your way through eight Tutorials, your confidence will be such that you can experiment with finding out how all three devices can be used with a transistor amplifier. With your headphones still in use, start off by putting the microphone into circuit.

Then, with headphones removed, experiment with the two sensors, monitor the response on your meter and the computer's waveform display program.

PNP CONVERSION

Now for another challenge (or more)!

Our discussions and demos in this month's Tutorial were all associated with transistors of the type which we referred to

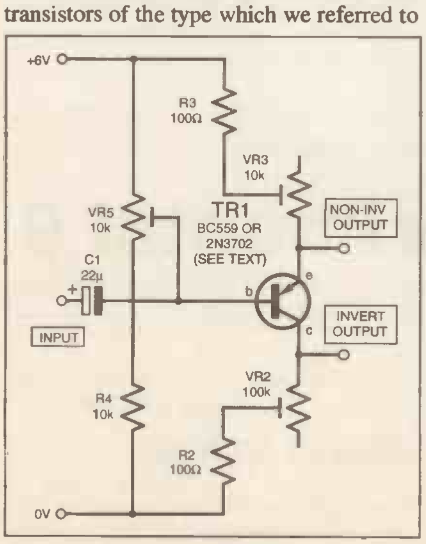


Fig.9.9. Circuit diagram for a pnp Phase-split amplifier.

PANEL 9.5. PRINTER PORT PROBLEM

A few readers have experienced problems regarding the voltages obtained when their demo p.c.b. is coupled to the computer via the Centronics printer port cable, in some cases experiencing negative voltages.

It appears as though there are at least three different wiring arrangements for Centronics cables, even though the fittings at each end are the same:

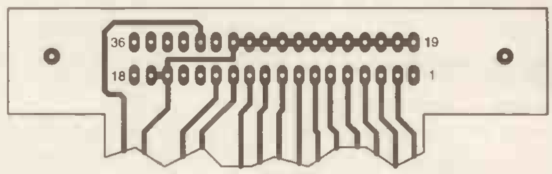
- Type 1 – no pins connected to ground, but case connected to ground.
- Type 2 – one pin only connected to ground.
- Type 3 – at least five pins connected to ground.

We were totally unaware that PC to Centronics printer port cables might differ. We have numerous such cables and all work interchangeably and we have never had to specify a particular type when purchasing new ones. It had been assumed that IBM PC-compatible computers would all be identically compatible in respect of parallel printer port connections.

The IBM data we have states that Centronics parallel printer connectors have 0V (ground) at the following pins: 16, 17, 19 to 30 and 33. The *Teach-In* interface board was designed to minimise the number of soldered connections that inexperienced constructors would have to make.

Consequently, only one 0V connection was incorporated, that being the one at the "front" of the connector.

Readers who are having problems which might be attributable to the printer port connection should try connecting all the 0V pins to the 0V pin already in use on the *Teach-In* board, as shown below. Solder connecting wire between all the 0V pins, ensuring that it is insulated against connecting to other pins.



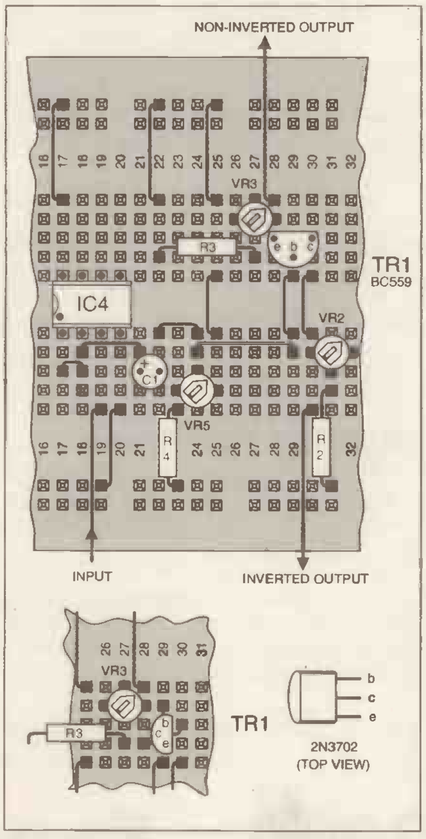


Fig.9.10. Breadboard layout for the circuit in Fig.9.9, again with choice of transistor.

as *npn*. We mentioned that an "upside-down" version of this transistor type exists, that known as *pnp*.

With a *pnp* transistor, current flows from the emitter into collector, and from the emitter into the base. When the difference in the base bias and emitter voltages is less than 0·6V, the transistor is turned-off. A bias voltage difference greater than this turns the transistor on.

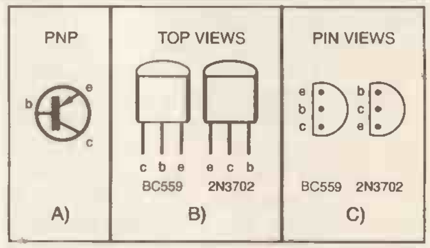


Fig.9.11 Symbol for a pnp transistor plus pinouts for BC559 and 2N3702.

When turned on, the current flowing through the emitter-base path causes a current to flow through the emitter-collector path, amplified by the gain (h_{fe}) of the transistor. Apart from the different current flow directions, *pnp* and *npn* transistors behave identically.

In Fig.9.9 is shown the *pnp* equivalent of the *npn* phase-splitting circuit of Tutorial Fig.9.6. Compare the two circuits and observe how all component positions have been swapped between top and bottom to match the reverse emitter and collector positions. Their values, though, are identical for each circuit.

The *pnp* transistor you require from your bag is marked either BC559 or 2N3702.

The breadboard layout for the circuit of Fig.9.9 is given in Fig.9.10. Reassemble the board to match this layout and perform the same experiments as you did for its *npn* counterpart. Use your meter and computer display to observe the results.

You might also care to experiment with the l.e.d.s, buzzer and headphones insertion as you did for the *npn* circuit.

When you've spent a while at this, turn your attention back to Fig.9.1 and Fig.9.2. Reconstruct the breadboard in Fig.9.1 for use with the *pnp* transistor. It will help if you first redraw Fig.9.2 as a *pnp* circuit diagram.

Again check out your results on the meter and computer display.

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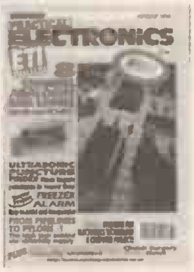

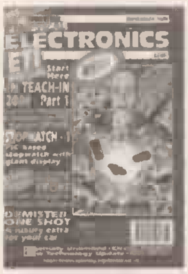

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M7/00

Constructional Project

ATMOSPHERIC ELECTRICITY DETECTOR

KEITH GARWELL Part Two

Investigate Nature's power-house with this intriguing experimental design.

LAST month we dealt with the Meter Interface Buffer and Dual-Voltage Power Supply circuits together with suggested stripboard constructional details. We conclude this month with meter switching, module interconnections and probe details.

SYSTEM METERING

Moving coil meters are the favourite for this application as they show more clearly the activity which is taking place. Digital voltmeters (DVMs) are fine in some respects but when the voltage is changing rapidly (as it often is in this caper) the digits just whirl about and it can be very difficult to make head or tail of them.

A pair of moving coil meters are required with a full scale of 0·1 milliamps. These are usually around 1000 ohms or less in resistance, which is small enough to be ignored for this exercise. The scale will normally be marked with 0 to 10 with 0·2 intervals.

Meter ME1 in Fig.8 is used with a 10 volt scale to show the output of the high resistance meter and is provided with a centre zero facility, and a reversing facility. Included along with the meter and its switches is a 2-cell AA size battery pack which is switched into effect by S2 to give half scale deflection i.e. centre zero. Preset VR2 is used to adjust the reading to 5, the half-way mark.

This means that the meter unit's output of +5V or –5V can be read and is very helpful when trying to back off the plate voltage with the high voltage supply. When voltages of greater than 5V are present at the meter output, S2 can be turned off so that the full range (10V) of the meter is available. Switch S1 is used to reverse the meter connections if necessary.

Meter ME2 is also a 0·1 milliamp meter which is used to measure the high voltage supply output. It is very helpful if this meter is marked 0 to 3, and there are some meters about which have two scales 0 to 10 and 0 to 3. The alternative is to do the arithmetic, i.e. multiply the reading by 30 if it is calibrated 0 to 10.

It is entirely up to the user how the "metering" is arranged. In the prototype, the meters are separate, but it could be more convenient to build them into a dedicated unit. It depends whether you have other uses for them, and they do require the largest capital outlay of the whole project.

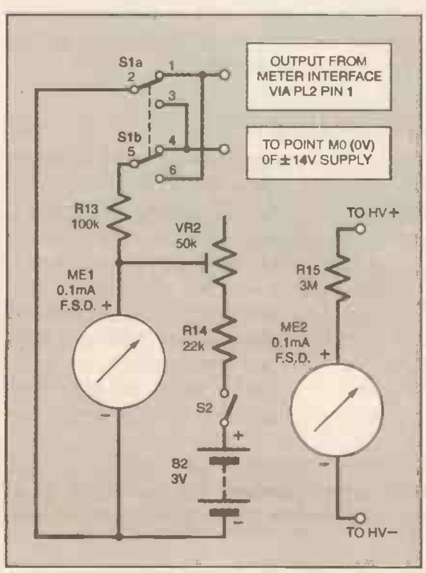


Fig.8. Circuit diagram for the twin meters.

INTERCONNECTIONS

So far we have discussed the various units in isolation, and they must be brought together to implement Fig.1 (last month).

The interconnections between the various system components are shown in Fig.9. There are three controls, an on/off switch (S4) and a reversing switch (S3) to change the potentials of the high voltage supply, plus a rotary control (VR3) to adjust the voltage supplied to the monitoring system. There are also the two moving coil meters, ME1 and ME2, connected as shown earlier in Fig.8.

Switches S3 and S4 must be rated at least at 250V a.c. The current involved is only a few microamps.

A 6-way cable (low voltage) with a 7-pin DIN plug at either end connects this unit with the meter interface unit and needs to be long enough to enable the user to be well away from the plate when it is being used for atmospheric measurements, 15 metres for example.

It must be pointed out that the sensitivity of the meter unit allows it to detect the static on the author's clothes at 10 metres, and don't try using the unit if there's any washing hanging on the line – the pinging noise made by the meter becomes quite audible! Arrange to share the good days with wife and family!

The author has not tried screening the system between himself and the probe (he doesn't think he's really cut out to be the monkey in the cage!), but he has noticed that walls seem to provide protection, whether glazed or brick.

The 0V line of the 12V power supply source and the case **MUST BE CONNECTED TO GROUND**. If the 12V supply is derived from a mains power supply

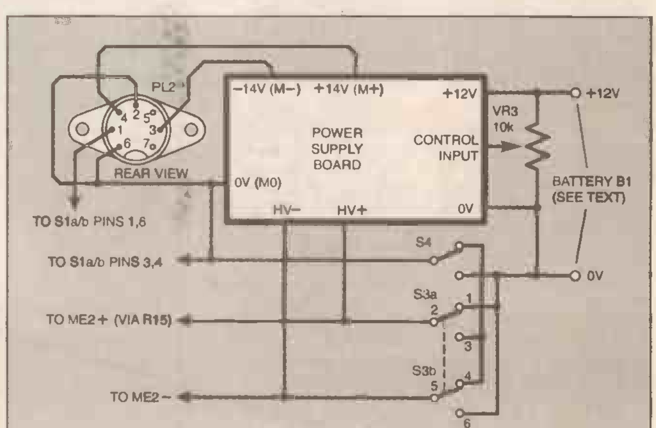


Fig.9. Schematic illustrating the connections distributed from the power supply.

rather than a battery, then the mains earth will be sufficient, but check that there is no significant voltage between this and true ground. If a battery is being used for the 12V supply then an earth connection must be made to the 0V line. If no other is available an earth spike must be used, driven into the ground beside the unit. DO NOT earth the 0V line of the ±14V supply.

CONSTRUCTION

An aluminium box about 120mm × 120mm × 50mm deep was used for the prototype power supply, its controls and connectors.

The panel layout is open to the constructor's preference and no layout is offered. In the prototype the connectors are at the top of the panel and the controls below.

For a portable unit perhaps a 12V lead acid battery, meters and the dual supply should all be in the same box, with just the controls and the 7-pin DIN connector to connect to the meter circuit showing, plus some means of easily removing the battery (or connecting to it) for charging.

Sealed versions of lead acid batteries are available which can be mounted in any position. A whole range is available from about 0·5Ah upwards (YUASA range). If such a battery is used it must be provided with a suitably rated fuse (100mA) as they are capable of very high currents under fault conditions.

The author has two separate power supplies available, a mains only unit, and a battery powered unit which can also be connected to the mains (the latter is effectively a no-break 12V supply), with the option for supplying 12V at 100mA or 500mA.

There are various aluminium boxes available and one convenient form is a two-part unit where the top (lid) is formed into a U-section and fits over the base, which has sides formed and an edging with fixing holes to fasten the top. One of these was used for the meter unit, and another for the high voltage power supply and controls.

However you decide to house it, once the building work is finished it is time for testing. Thoroughly check all connections, particularly the 0V line. At this stage don't connect the meter unit or its cable.

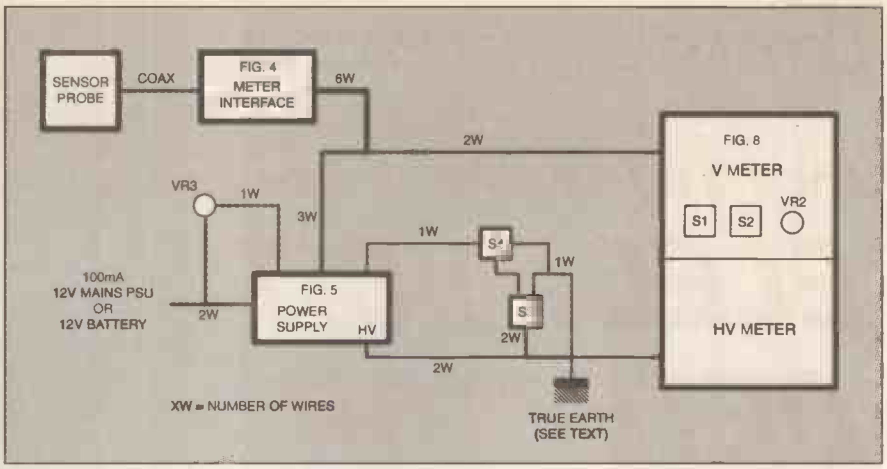


Fig.10. Block diagram illustrating the cabled interconnections between the various units.

It is recommended that a regulated and current-protected (at about 100mA) 12V power supply should be used while testing the units.

With power switched on, the output of the high voltage meter should be adjustable (using VR3) between about 0V and 300V. Note that 0V might not be reached and that the minimum might be nearer to 5V.

If this is OK so far, check the low voltage (nominally ±14V) outputs at pins 2, 3 and 4 of the 7-pin connector SK2.

Fit the two AA cells to the low voltage meter ME1 and switch on S2. Adjust VR2 to give exactly half scale (5V).

Connect the meter interface unit and open the case just enough to get at its offset balance adjustment preset VR1 and adjust it to give zero output, i.e. the meter needle on the 5V mark. Refit the cover.

Now fit the short coaxial connector with about 6cm of coax cable attached to it, and a crocodile clip at the far end of the cable. The screening is removed for about 30mm to allow the clip to be fitted.

The meter needle should wander back and forth as you move around the unit. The next step is to check the calibration, which requires another meter, preferably a DVM, and two or three test voltages of between 0V and 5V. The latter can be achieved by using three single cells or a battery with a potentiometer across it.

By this means apply voltages between the meter unit input and the 0V line of the 12V supply. Check on both polarities and on the agreement between meter ME1 and the DVM. Don't be surprised by slight irregularities, moving coil meters are not perfect.

To make checks above 5V up to 10V, the meter's centre zero will have to be switched off and the full scale used.

If this is OK, you can now prepare the probes.

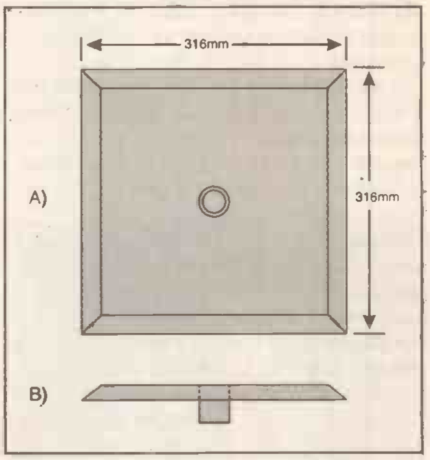
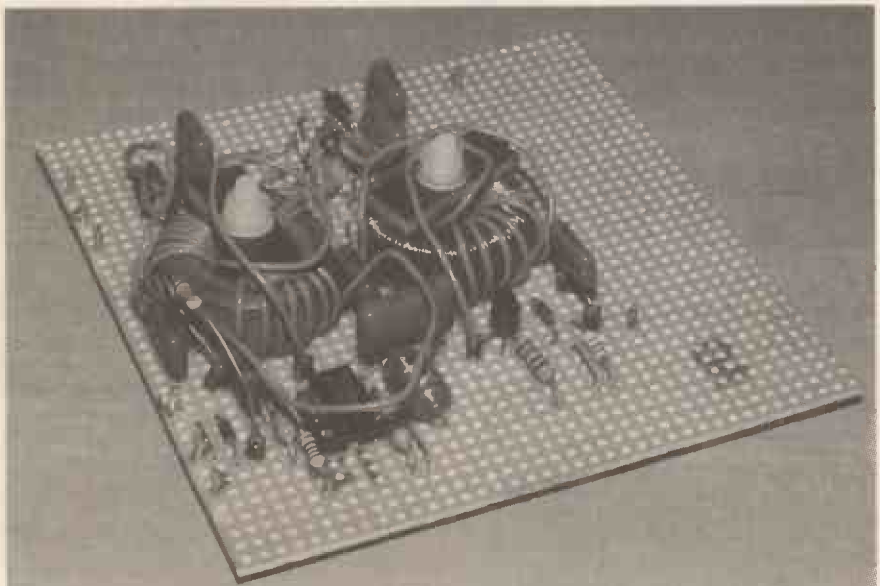


Fig.11. Details of the suggested sensor probe plate.



Close up details of the constructed power supply board.

PROBES

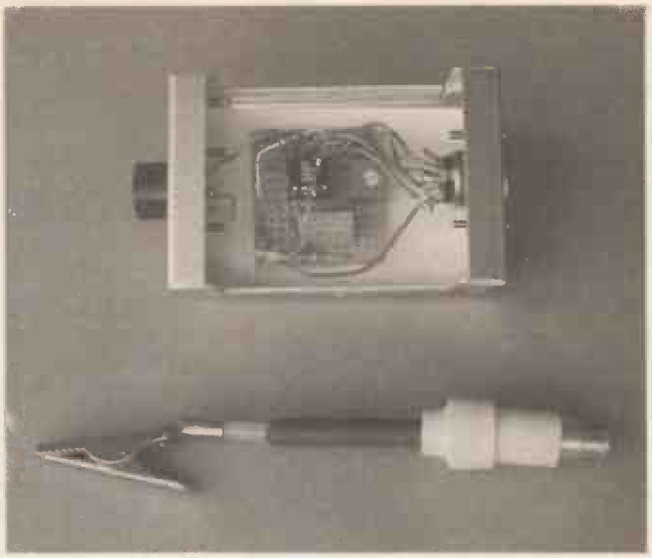
The probe suggested in Fig.1 last month is the author's principal tool. As the illustration suggests, it is nothing more than a piece of aluminium 316mm square, which gives one tenth of a square metre in area.

The corners are just nicked with tin snips or a fine saw from the corner towards the centre for about a centimetre and then the four edges are just dressed down a little way. This both stiffens the plate and prevents it fluttering in the wind, see Fig.11.

It is supported on 41mm, outside diameter, standard plastic waste pipe and connector, both obtainable at any DIY store.

The connector was first cut in half, the sealing rings removed, and then glued to the centre of the metal plate using hot-melt

Meter interface unit connected to the sensor probe plate.



Details of the meter interface unit and the interconnecting probe clip.

glue. The pipe was then pushed into the connector.

In a very similar way, the base for the pipe was made from a piece of chipboard, 380mm × 280mm × 20mm. This was just a scrap found in the workshop and its thickness makes it heavy enough to be a firm support. Screwed to the centre of this is a "socket" made from another scrap of wood about 100mm × 100mm × 45mm.

A 41mm diameter hole was drilled into this block, which was then screwed to the chipboard. It provides a firm fit when the pipe is pushed in and there is no tendency to wobble.

The pipe can be cut to length as required – the "standard" length is one metre, the length used for reference readings, but experiments may require alternative lengths of perhaps 0·5 and 1·5 metres.

The author's prototype single-plate atmospheric detection platform.

Connection between the plate and the meter unit is made by means of the short length of coaxial cable with its plug at one end and a crocodile clip at the other, the latter clips on to a small screw on the underside of the plate.

This arrangement works well and the pieces (plate, pipe and base) need only to be connected together as and when required. Several lengths of pipe allow measurements to be taken at different heights.

ALTERNATIVE SUPPORT

The simple arrangement described has two shortcomings. A change in height requires a change in the supporting pipe and, as the values being measured can change quite quickly, it would be nice to be able to change the height quickly.

Secondly, it is necessary to be aware of the possibility of condensation on the surfaces of the pipe. On one occasion when the readings didn't make sense it was realised that condensation was taking place. A quick wave of a hair drier warmed the pipe enough to stop the condensation, but the readings were still nonsense. It eventually became apparent that condensation was taking place on the inside of the pipe as well!

In a sense, these are trivial problems, one of which only occurs when it's cold and damp, but it was still thought desirable to avoid the support problem altogether. As a consequence, the arrangement shown in Fig.12 was invented.

No support is used as the plate is suspended and can be raised or lowered by shortening or lengthening the guy line when the whole affair tips backwards or forwards on its foot. It all works like a charm – until there is a breeze when the plate waves around like a mad thing! So do the meter needles!

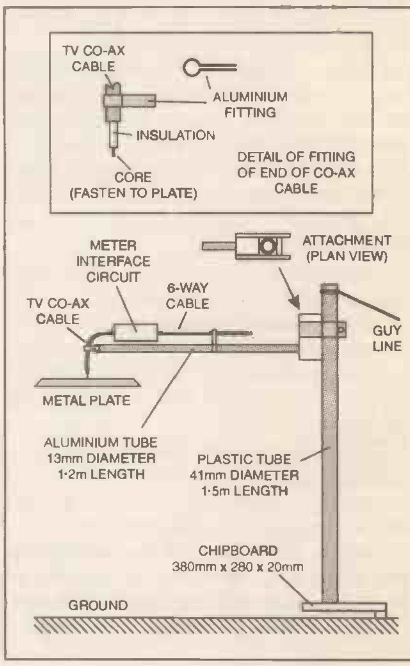


Fig.12. Alternative sensor plate support construction.

Ah well, there are times when you can't win them all, but it otherwise does the job it's meant to. Do any readers have any bright ideas to steady the plate? □

We will be happy to published any feedback from readers through Readout. *Ed.*

AUTHOR'S WEB SITE

This equipment is referred to on the author's web site under Atmospheric Electricity, and which is kept updated with developments:

http://members.tripod.co.uk/GarwellK

The author would also be pleased hear from you via his E-mail address at:

kgarwell@hotmail.com

There are many other sites dealing with Atmospheric Electricity which are well worth a browse – in particular the meteorological site at Reading University: **www.met.reading.a.c.uk**.

The UK Meteorological Office site is at **www.meto.gov.uk**.

The equivalent US site (National Oceanic and Atmospheric administration) is at **www.noaa.gov**.

READOUT

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

WIN A DIGITAL MULTIMETER

A $3^1/_2$ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a Digital Multimeter to the author of the best *Readout* letter.

★ LETTER OF THE MONTH ★

SELLING IDEAS AND INVENTIONS

Dear EPE,

I was saddened but maybe not surprised to read Jim Delaney's letter (*Readout* May '00) regarding the reception he had from various companies and individuals when trying to sell his inventions. From two years of earning a living from doing just this I can understand how tough it appears. On the bright side there are ways of approaching this that might be more likely to bring success, or at least won't leave you feeling as downcast when another rejection letter hits the mat, or worse still, nothing hits the mat. They are summarised in ten golden rules, plus an eleventh platinum that is probably the most important:

Ten (+1) Golden Rules for selling ideas:

1. Develop any ideas you have informally, to see how "logical" they are: only ever spend significant money and time on ideas where you know it satisfies a current need which is not being filled, or filled badly at the present time.

2. Only concentrate on things people are likely to spend money on; a remote control integrated into a coffee table is probably useful to somebody but nobody is ever likely to buy one. If it is to business then it's likely that products that save money will succeed. If its aimed at consumers, then things like fashion, labour saving features, etc. are often important.

3. Research your target companies (customers) VERY, VERY carefully. Understand their current product line, work out a logical fit for your invention in their current product range. If you can't see where your product fits, they're probably the wrong company.

4. Work out who their competitors are (this is becoming progressively easier with the Internet). If the first company turns you down, approach their competitors armed with a more complete case using the experience of your prior conversations

5. Never send open letters addressed as "Dear Sir" etc. Find the exact names and job titles of both management and the plebs who do the work and decide who might be best to contact. People in sales are the easiest to find (for obvious reasons) but often the hardest to make any progress with. Try to get them to give you a name of a technical contact.

Always try and speak to people on the phone and begin the conversation by saying that you "need advice" on a new product idea rather than trying to sell it to them in the first 10 seconds. If nothing else these conversations will often give you high quality market research data. Try to strike up a rapport with the person on the other end of the phone, after all they're human too, and will often respond positively if you're friendly and amiable. Practice on your bank manager.

6. Be prepared and plan realistically for failure; if you go into a meeting deciding the colour of the Porsche you'll buy with the proceeds from selling your idea, you're doomed to disappointment. This can de-motivate you just at the time you need to be at your most productive.

7. If you do manage to sell your idea, understand that it might be many months or even years before you see any cash from the sale of a product based on your technology. How will you feed and clothe yourself in the meantime?

8. Have plenty of ideas on the go at any one time; truly inventive people have hundreds of ideas, some good, most not so good. Be objective at every stage of the development as to how useful an idea is. Concentrate on the wheat and not the chaff, but never discard anything as you can never tell how circumstances might change in favour of a particular idea. If ideas are left to their own devices, they often seem to develop and improve of their own accord.

9. Ideas often run out of steam; sometimes you've done as much as you can think of developing and selling an idea, and you literally can't think of anything else to do. Often a good strategy is to stop and "park it" and get on with something more promising. Doing this isn't giving in to failure, it's pragmatism taking over. As above, a parked idea can spring back into life for any number of reasons; you might be surprised how different things look after a few months' break.

10. Don't be tempted to file patents on every idea you have at the time you have it (you'll soon run out of money!). Develop ideas privately until you can convince yourself of their worth, and then file (be careful of disclosure to anybody during this period). Good patent agents will never give an opinion as to the worth or otherwise of an idea, they assume you have done that and that's why you are patenting it.

11. (***MOST IMPORTANT***). Don't give up your day job; at least try not to until you can see money generated by your invention being paid into your bank account.

Julian White, via the Net

Thank you Julian, we believe quite a few readers will benefit from this advice.

The UK Government also offers the following web sites for further guidance:

The Patent Office: www.patent.gov.uk
NESTA: www.nesta.org.uk
Business Link: www.businesslink.co.uk
DTI Innovation Unit: www.innovation.gov.uk
Institute of Patentees and Inventors: www.invent.org.uk

HISTORY

Dear EPE,

Just a little note to say thank you for the many years that the mag has been going. The value for money has never been greater than it is today. I have a copy of *Practical Electronics* from Nov 1971, one of the few older ones that I have left. From 20p in those days, to £2.65, the magazine is worth every penny.

Andrew Allen, via the Net

Thanks Andrew, we appreciate your kind note, and long term support.

SCOPE CHOICE (1)

Dear EPE,

Regarding the Scope Choice question by R.J. Spratt in *Readout* April 2000 issue, I read this letter and the corresponding answer and thought that perhaps I could add a little information on virtual scopes on PCs, and whether an old '386 could cope.

From 1995 to '97 my job involved designing software for data acquisition and control using PCs (I don't think the field will have changed much in the last three or four years). To say it shortly, it is possible to have data acquisition, and thus a virtual scope, on a '386 computer (or even less), at least using plain old DOS. The problem is whether you can get it at an affordable price, and that almost nobody programs for DOS nowadays.

There are three main ways to do data acquisition with a PC that I know of:

1. Directly with an unbuffered internal card. The card does one A/D conversion, then the computer reads the data (1 or 2 bytes). The speed limit here is the bus or interface used. In the case of the ISA bus (the old 8-bit for PCs, and perhaps the 16-bit expanded version for ATs) the limit was 100K samples per second using DMA transfer. I couldn't find a faster card of this type; but even a 30Ks/s card had a price of around 400 euros (clones were cheaper). Much better cards, PCI bus version from a well known manufacturer could cost 3000 euros. And, yes, we used them on the now old '386, running plain DOS, at perhaps 20Ks/s. For Windows you need much better computers, as it is slower in general.

2. Buffered type internal card. These have a local memory, used to store a number of conversions (running unattended by the main CPU) till the computer reads all the samples in one operation. I saw a prototype, two 8-bit channels running perhaps at 1Ms/s on a 10MHz 8086 PC, around 1990. The snag is that acquisition is not continuous if the sampling speed is faster than what the computer bus can handle; but for a scope displaying continuous periodic signals, it is usually OK.

3. An external box, connected to the serial or parallel port (or another dedicated port, e.g. GPIB), buffered or unbuffered (even a real scope connected to the PC could be grouped here). The limits are similar to the above said cases. There are little ones advertised in your magazine (Pico ADC200 and 216, but I have not used them personally) which claim to sample at 100Ms/s, storing the 8-bit samples on a 32Kb internal memory (that means 0·16ms total time for two channels). I find 8-bit insufficient for serious work, other than seeing the shape: I prefer 12-bit minimum, but then the sampling rate goes down to 3Ms/s, and I do not find them very cheap then. They supply DOS based software, so perhaps it will work OK on the '386 computer.

The card I used most was a PClab 812PG from Advantech, old technology even on Win95, and expensive at 400 euros (local Spanish price). There were clones at nearly half that cost, and much better cards from National Semiconductor for 3000 euros and more.

Carlos Robinson, Spain, via the Net

Thank you for your useful contribution.

SCOPE CHOICE (2)

Dear EPE,

As a Solatron CD1400 user myself (*Readout* April '00), I am aware of the transformer problem, the second one that blew-up is still in my possession just in case I ever find the time to repair it!

What I had originally considered was replacing the circuitry used to generate the EHT and focus potentials and it occurred to me that the line timebase section from a B&W portable TV might do the job. Typically, the EHT in one of these units is around 12kV. The fact that this is three times the value required may not be a problem.

A well known fact in my trade, not so widely appreciated elsewhere, is that in the CRT horizontal drive timebase the scanning coils are the primary inductive component in the resonant system. With these disconnected, the EHT voltage will fall dramatically. From this point it is possible to "tune" the primary inductance of the flyback transformer by experimenting with different values of flyback tuning capacitor. This component is directly across the collector/emitter pins of the line output transistors and usually has a value of several nanofarads and a voltage rating of at least 400V. *Don't try this with a colour chassis.*

There are several reasons why I did not proceed with this plan. The first being the limited space inside the CD1400 casing, also the need to accurately determine the final EHT voltage. This was not so much for safety reasons – the low power flyback generator is "harmless" compared to the Cockroft and Walton voltage multiplier fed by a mains transformer winding which, typical with many oscilloscope designs, will be between 750V and 1000V and capable of supplying several hundred milliamps from the winding, and at least a lethal number of milliamps from the multiplier!

The concern over voltage regulation stems from the fact that increasing the EHT increases the electron beam current – this results in greater deflection energy requirement to deflect the spot. The EHT is just as much a calibrated specification as the attenuator trimmers and timebase oscillator presets!

The most compelling reason for abandoning these plans was the fact that a visit to the local council tip produced an Advance OS2000R that was much easier to repair!

Such Civil Amenity Sites are usually contracted out to private operators by the Environmental Health division of local authorities. In my experience, it is possible to "haggle" for discarded items. Oscilloscopes, computers and an unexpected diversity of electronic equipment form a "not infrequent" part of the treasure trove!

I. Field, Letchworth, Herts

We wonder just how many readers these days are familiar with working on high voltage electronic equipment. Personally I learned much of my early electronics only through figuring out how to repair defunct TVs purchased for about five shillings (25p in today's currency) from local markets. It also taught me to respect the charge held on capacitors even when the mains power is switched off!

Perhaps we now "molly-coddle" readers too much by stressing the dangers of a.c. mains voltages and the like. But then most of electronics these days is only powered at low d.c. voltages. Gone are the days when most of what the hobbyist electronics magazines published was thermionic valve based and as such often required voltages well into the several hundreds.

None-the-less, Mr Field's observations may provide excellent food for thought for the adventurous amongst you should your local "tip" not prove to be a viable materials source (and it has to be said that many are prohibited from allowing the public to acquire materials from their sites, especially electrical goods).

QBASIC ETC

Dear EPE,

There is from time to time discussion in *EPE* about what can be used to replace GW and QBasic at a reasonable cost. I have come across a product called Envelope Engine on the web. It was intended as a rival to Visual Basic. Although the project was abandoned the product has been made available as Freeware and can be downloaded as a self-extracting file from:

www.winsite.com/info/pc/win95/programr/envlpl4.exe

It will only run on Win 95 or later but it is complete, is based on Basic and its free. Thought this might be of use to readers.

Bob Allan, via the Net

Thanks Bob. We have to comment, though, that whilst individual readers may find this program to be beneficial, as a magazine we can really only "take on board" programming languages and dialects which the majority of the readers use or have access to. In terms of Basic this really brings us to only supporting QBasic, QuickBASIC, Visual Basic and Delphi (the latter Robert Penfold has been discussing in several of his recent Interface *columns).*

I have previously commented that QBasic and QuickBASIC are no longer available commercially, but that it is supposedly possible to download them from some private Internet sites (details not known). However, we have recently been informed by Alan S. Raistrick via E-mail that (unknown to us):

"It is included on every CD-ROM with Windows 95 and 98. Do a search on the CD-ROM using Windows Explorer Tools/Find/Files or Folders and there it is."

We invite all of you who use Win 95 and 98 to check your CD-ROMS on this point and to inundate us with replies (my Win 95 CD-ROM does *include QBasic). It is immensely important that we get to the bottom of the apparent Basic problem. I for one have tried getting into Visual Basic but have not yet got on too well with it – it does not seem as instinctive as the other many languages and dialects I use. Delphi I have not yet tried, though Robert has been encouraging me to think about it.*

MORE BASIC

Dear EPE,

Several years ago I developed a "machine" in my spare time and used the ZX Spectrum (16K) computer to do all the calculations and control the "machine".

I wrote a program (approx 5000 instructions) in Basic using a lot of the ZX functions. I also used designs similar to those shown in Mike Tooley's *Electronic Circuit Book* to input and output analogue information via the ZX printer port.

I am about to purchase a "proper" computer, with Windows 98 software so my granddaughter can use the Internet. I would also like to write programs on it in Basic and, being a simple soul, imagined that I could get a CD-ROM to program the computer in Basic with at least all the functions of the ZX.

I have made several enquiries with computer manufacturers and Microsoft, but I have not found anyone, so far, who can supply anything to meet these requirements. Can you advise me of a suitable supplier.

May I say how much I enjoy reading *EPE* each month and have been a regular subscriber for many, many years.

Peter Gardner, Pucklechurch, Bristol

I refer the honourable gentleman to the reply I a gave a few moments ago (to mimic Maggie – remember her?)

PIC NOP TRICK

Dear EPE,

I am new to the PIC game so my trick may well be old news. It concerns the OTP (One Time Programmable) chips. In my case it was the PIC16C773SP. The trick is about multiple programming of those chips. Providing that your program size is less that half the program memory size and you are not using interrupts and, with some exceptions, the configuration bits have been set correctly the first time, you can reprogram the chip by overwriting the programmed memory area with the NOP instruction and shifting the entry point to a new location.

I guess there is no need to explain that programming an EPROM memory is about writing 0s in specific bit positions and the NOP instruction is all 0s. So all you have to do is insert enough NOP instructions at the beginning of your new program to overwrite the old one. The cost obviously is a number of clock cycles when the chip is doing nothing (NOP) but only when the program starts to run and the extra program memory used which would have been lost in any case.

There is no need to type several hundred NOP instructions either. Just work out how much space your faulty program takes up and use the FILL directive. Using the MPLAB dialect it could look like this, assuming the original faulty program size was 0x200 (512 words):

;New **ORG 0X00 FILL 0,0x200** ;puts 0s (NOP) in the first 512 program memory locations
GOTO Start

;Old **ORG 0X00**
GOTO Start

Peter Malczyk, Cape Town, South Africa

The OTP PIC chips are not components that I have had occasion to use. The reprogrammable EEPROM PIC16x84 and PIC16F87x devices are far too useful when developing a design for publication and which some readers may wish to ultimately amend to suit their own particular needs. With the very rare exception, it seems preferable for us to avoid OTP devices, even though their unit cost can be lower.

However, we recognise that some of you will be taking the OTP route and are using PICs that are only available with that structure. As a designer who used EPROM memories until a few years ago (until PICs enabled me to move away from 6502 microprocessor-based designs), I can recommend Peter's technique.

With the EPROMs, although they can be erased using UV light, it was not necessarily convenient to take time out to erase them (as I recall it took 10 to 15 minutes a time). For each successive change to EPROM code, I would start the new code at an address just a few bytes beyond where the previous code version had ended, writing zeros into the foregoing addresses, and making a note of the end address of the new code, so that the process could be repeated.

In this way it was possible to make maximum use of the EPROM chip before having to erase it. With some codes it was possible to have many version updates before the space ran out.

MISSING LINK

Dear EPE,

I experience "Unforeseen DOS Error 75" when I run tk.bat of *PIC Toolkit Mk2*. It worked fine on previous attempts. Any ideas?

Hennie R van Rensburg,
South Africa, via the Net

To which I replied via E-mail:

Error 75 is path/file Access Error. Check that you are not trying to access a non-existent file or folder. And Hennie came back with:

Thanks for the help!

Next time I will read the installation instructions more carefully! It's working like a charm!

Best regards and thanks for the Great Magazine, Hennie.

There's a public lesson here for a few other readers – I like to think that the instructions I write are going to be followed! T'aint always so – some of you don't from time to time!

Everyday Practical Electronics Books

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 DISK** 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.

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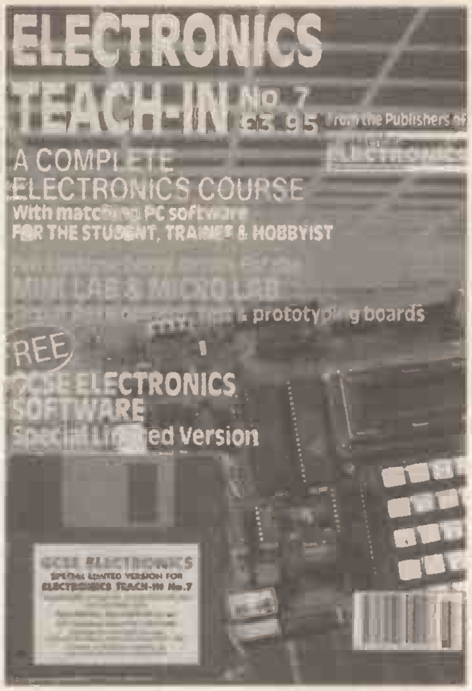
152 pages | **Order code TI7** | **£3.95**



DIRECT BOOK SERVICE

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order to your door. Full ordering details are given on the last book page.

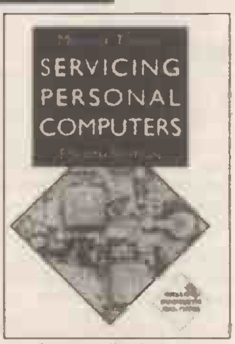
For a further selection of books see the next two issues of *EPE*.

Testing and Test Gear

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold
This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators.

104 pages | **Order code BP267** | **£3.50**

SERVICING PERSONAL COMPUTERS – 4th EDITION
Mike Tooley BA
The revised and enlarged forth edition has been completely re-written to cover the latest technology. such as 32-bit microprocessors and serial communications servicing. It includes a diagnostic disk offer. Essential for anyone concerned with the maintenance of personal computer equipment or peripherals, whether professional service technician, student or enthusiast.



397 pages Hardback | **Temporarily out of print**

Radio

BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole
Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages | **Order code NE30** | **£14.99**

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold
This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.

92 pages | **Order code BP304** | **£3.95**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole
Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages | **Order code BP257** | **£4.99**

SIMPLE SHORT WAVE RECEIVER CONSTRUCTION
R. A. Penfold
Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to costruct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.

The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.Contains everything you need to know in order to get started in this absorbing hobby.

88 pages | **Order code BP275** | **£3.95**

Computers and Computing

MULTIMEDIA ON THE PC
Ian R. Sinclair
In this book, you'll find out what a CD ROM is, how it works, and why it is such a perfect add-on for a PC, allowing you to buy programmes, text, graphics and sound on a CD. It also describes the installation of a CD ROM drive and a sound card, pointing out the common problems that arise, and then shows how to use them to create a complete multimedia presentation that contains text, photos, a soundtrack with your own voice recorded as a commentary, even animation and edited video footage.

184 pages | **Order code PC112** | **£11.95**

HOW TO BUILD YOUR OWN PC
Morris Rosenthal
More and more people are building the own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a state-of-the-art computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. For non-specialists, there's even a graphical glossary that clearly illustrates technical terms. The author goes "under the hood" and shows step-by-step how to create a socket 7 (Pentium and non-intel chipsets) and a Slot 1 (Pentium II) computer, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows 98. The few existing books on this subject, although badly outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

224 pages – large format | **Order code MGH2** | **£19.99**

UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold (Revised Edition)
If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.

This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!

128 pages | **Order code BP282** | **£4.95**

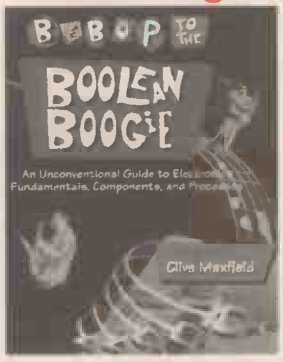
Theory and Reference

Bebop To The Boolean Boogie

By Clive (call me Max) Maxfield

Specially imported by *EPE* – *Excellent value*

An Unconventional Guide to Electronics Fundamentals, Components and Processes



This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!). Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day. . . .

470 pages – large format Order code BEB1 £24.95

DIGITAL ELECTRONICS – A PRACTICAL APPROACH

With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality) FREE SOFTWARE

Richard Monk

Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer aided design including the FREE software.

There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

250 pages Order code NE28 £16.99

Bebop Bytes Back FREE CD-ROM

By Clive "Max" Maxfield and Alvin Brown

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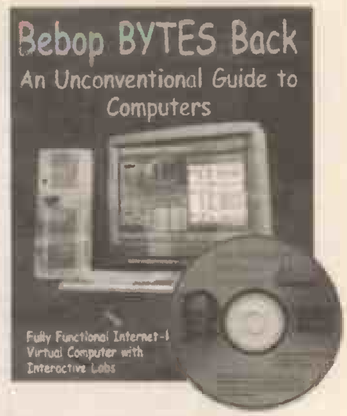
An Unconventional Guide To Computers



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This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design. . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the accompanying CD-ROM (for Windows 95 machines only) contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the book contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers.

If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this one!

Over 500 pages – large format Order code BEB2 £29.95

DIGITAL GATES AND FLIP-FLOPS

Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages Order code PC106 £8.95

Music, Audio and Video

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN

V. Capel

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him – or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

148 pages Order code BP256 £3.99

ELECTRONIC MUSIC AND MIDI PROJECTS

R. A. Penfold

Whether you wish to save money, boldly go where no musician has gone before, rekindle the pioneering spirit, or simply have fun building some electronic music gadgets, the designs featured in this book should suit your needs. The projects are all easy to build, and some are so simple that even complete beginners at electronic project construction can tackle them with ease. Stripboard layouts are provided for every project, together with a wiring diagram. The mechanical side of construction has largely been left to individual constructors to sort out, simply because the vast majority of project builders prefer to do their own thing in this respect.

None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.

138 pages Order code PC116 £9.95

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR

R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages Order code PC115 £9.95

COMPUTERS AND MUSIC – AN INTRODUCTION

R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.

174 pages **Temporarily out of print**

THE INVENTOR OF STEREO – THE LIFE AND WORKS OF ALAN DOWER BLUMLEIN

Robert Charles Alexander

This book is the definitive study of the life and works of one of Britain's most important inventors who, due to a cruel set of circumstances, has all but been overlooked by history.

Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first electronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

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HIGH POWER AUDIO AMPLIFIER CONSTRUCTION

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Circuits, Data and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop

This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

88 pages **Order code BP299** £4.99

ELECTRONIC HOBBYISTS DATA BOOK
R. A. Penfold

This book should tell you everything you are ever likely to want to know about hobby electronics, but did not know where to ask or refer. Comprehensive contents pages makes it easy to quickly locate the data you require.

The subjects covered include: Common circuits, and related data (including helpful graphs and tables of values); Colour codes for resistors, capacitors and inductors; Pinout details for a wide range of CMOS and TTL devices, plus basic data on the various logic families; Pinout details and basic data for a wide range of operational amplifiers; Data and leadout information for a wide range of transistors, FETs, power FETs, triacs, thyristors, diodes, etc; General data including MIDI message coding, radio data, ASCII/Baudot coding, decibel ratios, etc.

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R. N. Soar

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CIRCUIT SOURCE BOOK 1
A. Penfold

Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.

The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.

Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.

182 pages **Order code BP321** £4.99

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold

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E. A. Parr

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CIRCUIT SOURCE BOOK 2
R. A. Penfold

This book will help you to create and experiment with your own electronic designs by combining and using the various standard "building blocks" circuits provided. Where applicable, advice on how to alter the circuit parameters is provided.

The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.

The topics covered in this book include: 555 oscillators; sinewave oscillators; function generators; CMOS oscillators; voltage controlled oscillators; radio frequency oscillators; 555 monostables; CMOS monostables; TTL monostables; precision long timers; power supply and regulator circuits; negative supply generators and voltage boosters; digital dividers; decoders, etc; counters and display drivers; D/A and A/D converters; opto-isolators, flip/flops, noise generators, tone decoders, etc.

Over 170 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.

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Build your own working robot or android using both off-the-shelf and workshop constructed materials and devices. Computer control gives these robots and androids two types of artificial intelligence (an expert system and a neural network). A lifelike android hand can be built and programmed to function doing repetitive tasks. A fully animated robot or android can also be built and programmed to perform a wide variety of functions.

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224 pages **Order code MGH1** £20.99

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

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PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** £4.95

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Order code BP392** £4.95

A BEGINNER'S GUIDE TO MODERN ELECTRONIC COMPONENTS
R. A. Penfold

The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.

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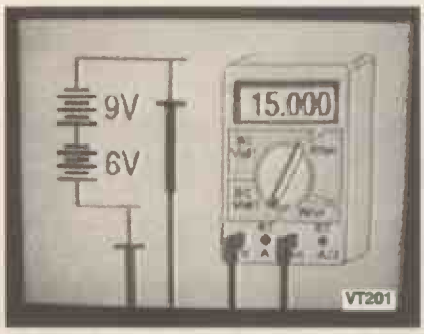

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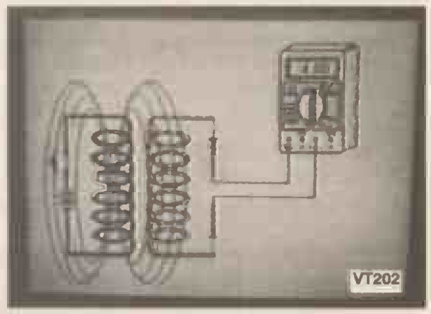

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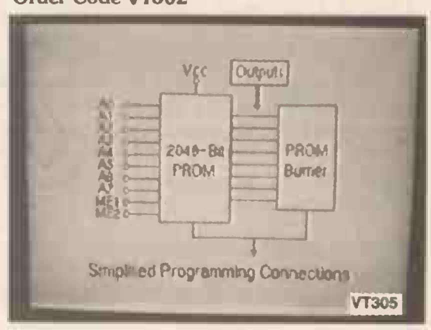

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PCB SERVICE

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 overseas orders or queries by Fax); E-mail: orders@epemag.wimborne.co.uk.** Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**
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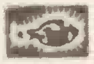

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SP130	100 x Mixed 0·5W C.F. resistors		

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POWER AMPLIFIER MODULES-LOUDSPEAKERS-MIXERS 19 INCH STEREO AMPLIFIERS-ACTIVE CROSS/OVERS.

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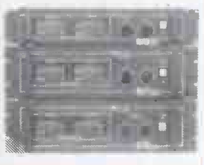

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PRICES:- MXF200 £175.00 MXF400 £233.85 MXF600 £329.00 MXF900 £449.15

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OMP XO3-S STEREO 3-WAY ACTIVE CROSS-OVER | SWITCHABLE 2 WAY

BASS / MID / TOP — CONFIGURED 3 WAY
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BASS / MID/TOP — 2 WAY MID/TOP COMBINED

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- HEADPHONE MONITOR WITH PFL
- ASSIGNABLE CROSSFADE
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PLEASE NOTE:- POWER RATINGS QUOTED ARE IN WATTS R.M.S. FOR EACH INDIVIDUAL CABINET. ALL ENCLOSURES ARE 8 OHM.
15=15 inch speaker
12=12 inch speaker

ibl FC15-300 WATTS Freq Range 35Hz-20KHz, Sens 101dB, Size H695 W502 D415mm PRICE:- £299.00 per pair

ibl FC12-300 WATTS Freq Range 45Hz-20KHz, Sens 96dB, Size H600 W405 D300mm PRICE:- £249.00 per pair

ibl FC12-200 WATTS Freq Range 40Hz-20KHz, Sens 97dB, Size H600 W405 D300mm PRICE:- £199.00 per pair

ibl FC12-100 WATTS Freq Range 45Hz-20KHz, Sens 100dB, Size H546 W380 D300mm PRICE:- £179.00 per pair

ibl WM12-200 WATTS Freq Range 40Hz-20KHz, Sens 97dB, Size H418 W600 D385mm PRICE:- £125.00 EACH

SPECIALIST CARRIER DEL:- £12.50 per pair, Wedge Monitor £7.00 each

Optional Metal Stands PRICE:- £49.00 per pair Delivery:- £6.00

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* Frequency Range 30 Hz-1.0KHz PRICE £159.00

COLOSSUS 18XB:-* 18 INCH * 600WATTS R.M.S.
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OMP MOS-FET POWER AMPLIFIER MODULES
SUPPLIED READY BUILT AND TESTED

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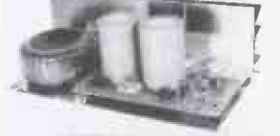
THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz - 3dB, Damping Factor >300, Slew Rate 45V/uS, T.H.D typical 0.002%, Input Sensitivity 500mV, S.N.R. - 110dB. Size 300 x 123 x 60mm.
PRICE:- £42.85 + £4.00 P&P



OMP/MF 200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB. Size 300 x 155 x 100mm.
PRICE:- £66.35 + £4.00 P&P

OMP/MF 300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB. Size 330 x 175 x 100mm.
PRICE:- £83.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output power 450 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 385 x 210 x 105mm.
PRICE:- £135.85 +£6.00 P&P

OMP/MF 1000 Mos-Fet Output power 1000 watts R.M.S. into 2 ohms, 725 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. -110dB, Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti-Thump Delay. Size 422 x 300 x 125mm.
PRICE:- £261.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. OR PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC

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