EVERYDAY PRACTICAL ELECTRONICS

SEPTEMBER 1998

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

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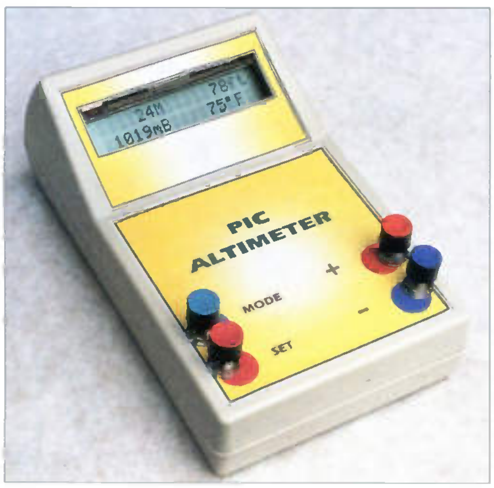
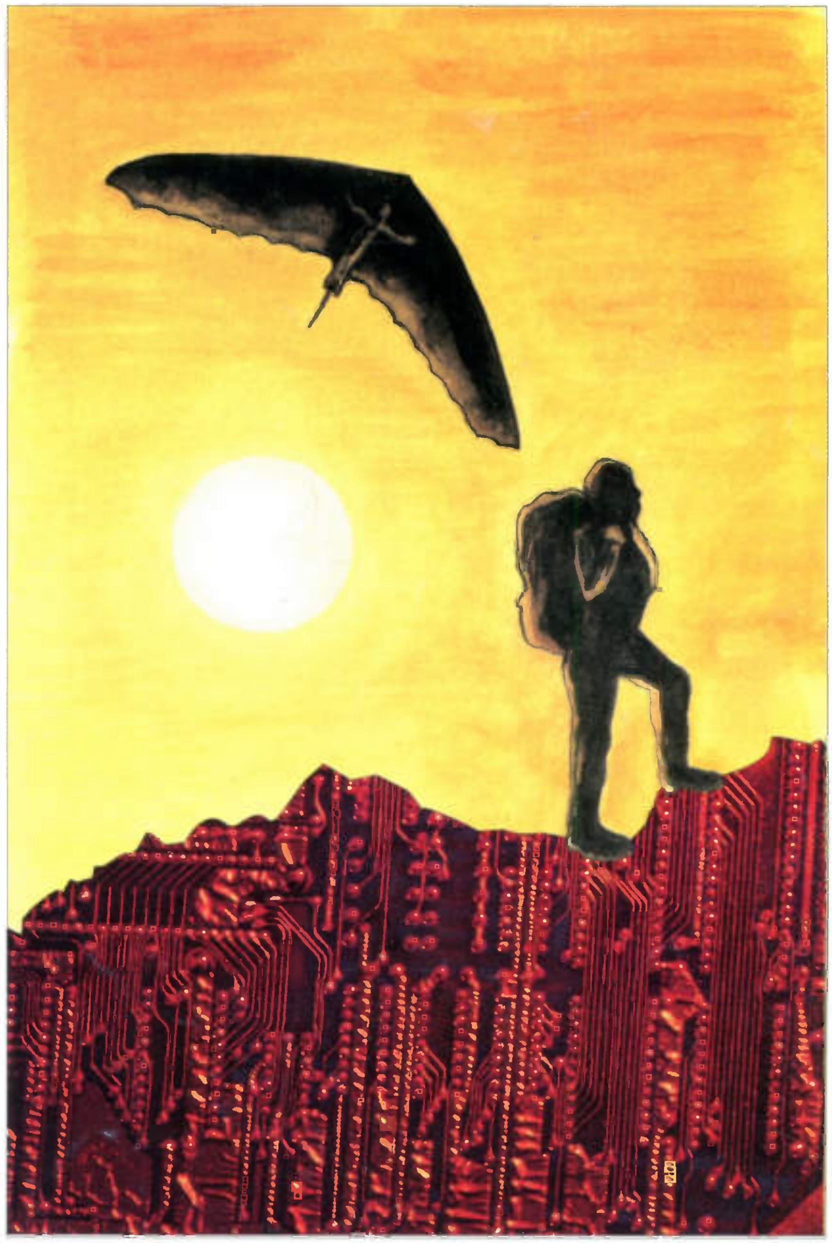
PIC ALTIMETER

Measures altitude, barometric pressure and temperature





PERSONAL STEREO AMPLIFIER

Drive stereo speakers from your personal stereo

MAINS SOCKET TESTER

Simple test for mains wiring

INGENUITY UNLIMITED

A selection of readers' circuit ideas

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

09

9 770262 361089

PLUS Circuit Surgery - New Technology Update
Interface - Innovations - Network

WIND GENERATORS 380 WATT

1.14 metre dia blades, carbon matrix blades, 3 year warranty, 12vdc output, 24v version available, control electronics included, brushless neodymium cubic curve alternator, only two moving parts, maintenance free, simple roof top installation, start up speed 7mph, max output (30mph) 380w. £499 ref AIR1

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.

PORTABLE X RAY MACHINE PLANS Easy to construct plans on a simple and cheap way to build a home X-ray machine! Effective device, X-ray sealed assemblies, can be used for expenmental purposes. Not a toy or for minors! £6/set. Ref F/XP1.

TELEKINETIC ENHANCER PLANS Mystify and amaze your friends by creating motion with no known apparent means or cause. Uses no electrical or mechanical connections, no special gimmicks yet produces positive motion and effect. Excellent for science projects, magic shows, party demonstrations or serious research & development of this strange and amazing phychic phenomenon. £4/set Ref F/TKE1.

ELECTRONIC HYPNOSIS PLANS & DATA This data shows several ways to put subjects under your control. Included is a full volume reference text and several construction plans that when assembled can produce highly effective stimuli. This material must be used cautiously. It is for use as entertainment at parties etc only, by those experienced in its use. £15/set. Ref F/EH2.

GRAVITY GENERATOR PLANS This unique plan demonstrates a simple electrical phenomena that produces an anti-gravity effect. You can actually build a small mock spaceship out of simple materials and without any visible means- cause it to levitate. £10/set Ref F/GRA1.

WORLDS SMALLEST TESLA COIL/LIGHTENING DISPLAY GLOBE PLANS Produces up to 750,000 volts of discharge, experiment with extraordinary HV effects, 'Plasma in a jar', St Elmo's fire, Corona, excellent science project or conversation piece. £5/set Ref F/BTC1/LG5.

COPPER VAPOUR LASER PLANS Produces 100mw of visible green light. High coherency and spectral quality similar to Argon laser but easier and less costly to build yet far more efficient. This particular design was developed at the Atomic Energy Commision of NEGEV in Israel. £10/set Ref F/CVL1.

VOICE SCRAMBLER PLANS Minature solid state system turns speech sound into indecipherable noise that cannot be understood without a second matching unit. Use on telephone to prevent third party listening and bugging. £6/set Ref F/VS9.

PULSED TV JOKER PLANS Little hand held device utilises pulse techniques that will completely disrupt TV picture and sound! works on FM too! DISCRETION ADVISED. £8/set Ref F/TJ5.

BODYHEAT TELESCOPE PLANS Highly directional long range device uses recent technology to detect the presence of living bodies, warm and hot spots, heat leaks etc. Intended for security, law enforcement, research and development, etc. Excellent security device or very interesting science project. £8/set Ref F/BHT1.

BURNING, CUTTING CO2 LASER PLANS Projects an invisible beam of heat capable of burning and melting materials over a considerable distance. This laser is one of the most efficient, converting 10% input power into useful output. Not only is this device a workhorse in welding, cutting and heat processing materials but it is also a likely candidate as an effective directed energy beam weapon against missiles, aircraft, ground-to-ground, etc. Particle beams may very well utilize a laser of this type to blast a channel in the atmosphere for a high energy stream of neutrons or other particles. The device is easily applicable to burning and etching wood, cutting, plastics, textiles etc £12/set Ref F/LC7.

DYNAMO FLASHLIGHT Interesting concept, no batteries needed just squeeze the trigger for instant light apparently even works under water in an emergency although we haven't tried it yet! £6.99 ref SC152

ULTRASONIC BLASTER PLANS Laboratory source of sonic shock waves. Blow holes in metal, produce 'cold' steam, atomize liquides. Many cleaning uses for PC boards, jewllery, coins, small parts etc. £6/set Ref F/ULB1.

ANTI DOG FORCE FIELD PLANS Highly effective circuit produces time variable pulses of accoustical energy that dogs cannot tolerate £6/set Ref F/DOG2

LASER BOUNCE LISTENER SYSTEM PLANS Allows you to hear sounds from a premises without gaining access. £12/set Ref F/LLIST1

PHASOR BLAST WAVE PISTOL SERIES PLANS Handheld, has large transducer and battery capacity with external controls. £6/set Ref F/PSP4

INFINITY TRANSMITTER PLANS Telephone line grabber/room monitor. The ultimate in home/office security and safety! simple to use! Call your home or office phone, push a secret tone on your telephone to access either: A) On premises sound and voices or B) Existing conversation with break-in capability for emergency messages. £7 Ref F/TELEGRAB

BUG DETECTOR PLANS Is that someone getting the goods on you? Easy to construct device locates any hidden source of radio energy! Sniffs out and finds bugs and other sources of bothersome interference. Detects low, high and UHF frequencies. £5/set Ref F/BD1

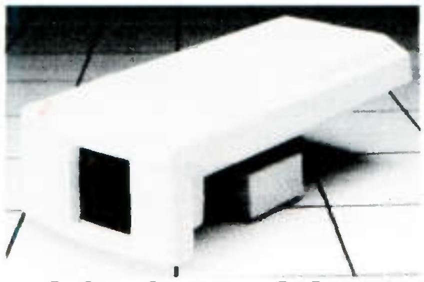
ELECTROMAGNETIC GUN PLANS Projects a metal object a considerable distance-requires adult supervision £5 ref F/EML2

ELECTRIC MAN PLANS, SHOCK PEOPLE WITH THE TOUCH OF YOUR HAND! £5/set Ref F/EMA1

SOLAR POWERED WIND UP RADIOS BACK IN! These FM/AM radio's have a solar panel and a hand operated charger! £17.95 ref SOLRAD

PARABOLIC DISH MICROPHONE PLANS Listen to distant sounds and voices, open windows, sound sources in 'hard to get' or hostile premises. Uses satellite technology to gather distant sounds and focus them to our ultra sensitive electronics. Plans also show an optional wireless link system. £8/set ref F/PM5

2 FOR 1 MULTIFUNCTIONAL HIGH FREQUENCY AND HIGH DC VOLTAGE, SOLID STATE TESLA COIL AND VARIABLE 100,000 VDC OUTPUT GENERATOR PLANS Operates on 9-12vdc, many possible experiments. £10 Ref F/HVM7/ TCL4.



COLOUR CCTV VIDEO CAMERAS,

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Works with most modern video's, TV's, Composite monitors, video grabber cards.

Pal, 1v P-P, composite, 75ohm, 1/3" CCD, 4mm F2.8, 500x582, 12vdc, mounting bracket, auto shutter, 100x50x180mm, 3 months warranty,1 off price £119 ref XEF150, 10 or more £99 ea 100+ £89

CIRCUIT PACKS Packs of 35 circuit diagrams covering lasers, SW radios, geigers,bugs,char etc. Pack1, Pack2, Pack3 £4.99 each.

SMOKE ALARMS Mains powered, made by the famous Gent company, easy fit next to light fittings ,power point. £4.99 ref SMKX

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

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

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

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

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

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

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

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

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

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

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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

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

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 simulated 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

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

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

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

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

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

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

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

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

UK SCANNING DIRECTORY As supplied to Police, MOD,M15 and GCHQ! coverers everything from secret government frequencies, eye in the sky, prisons, military aviation etc £18.50 ref SCANB

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 &earwaveguides, 1.1"x2.7"x4.6" fits on sun visor or dash £149 ref

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

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

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

DIGITAL PROPORTIONAL B GRADE RADIO CONTROLLED CARS From World famous manufacturer these are returns so they will need attention (usually physical damage) cheap way of buying TX and RX plus servos etc for new projects etc. £20 each. sold as seen ref LOT2DP

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

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

HIGH POWER DC MOTORS, PERMANENT MAGNET

12 - 24v operation, probably about 1/4 horse power, body measures 100m x 75mm with a 60mm x 5mm output shaft with a machined flat on it. Fixing is simple using the two threaded bolts protruding from the front

£22ea REF mot4

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

VOL. 27 No. 9 SEPTEMBER 1998

EVERYDAY PRACTICAL ELECTRONICS

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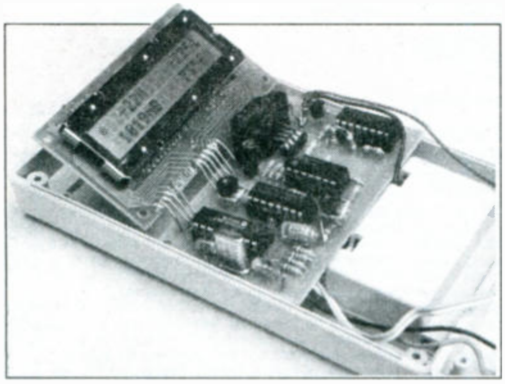
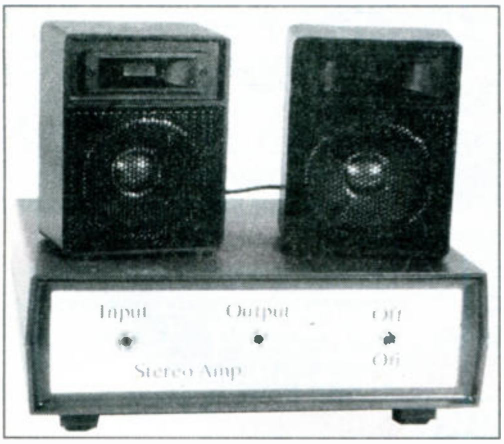
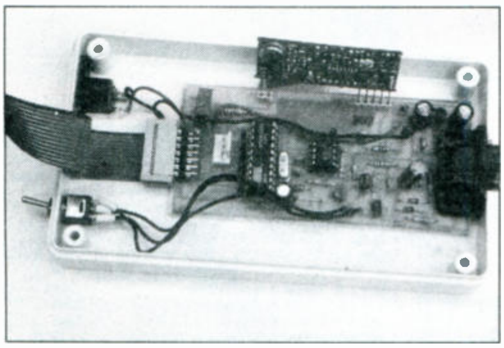
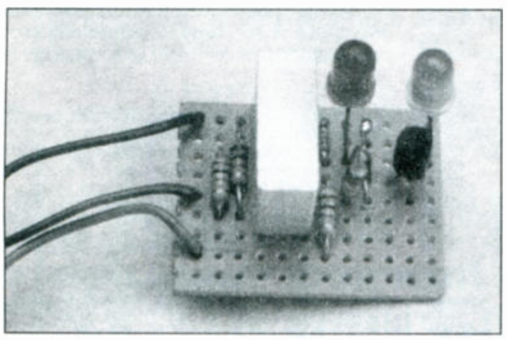
The No. 1 Magazine for Electronics Technology and Computer Projects









Our October '98 issue will be published on Friday, 4 September 1998. See page 627 for details.

Projects and Circuits

Series and Features

Regulars and Services

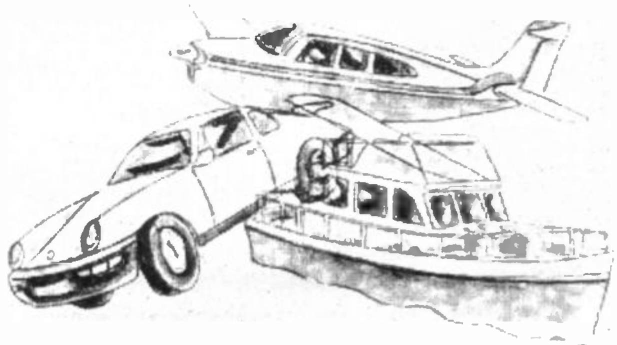
NEXT MONTH

VOICE PROCESSOR

SING ALONG WITH YOUR OWN VOICE!

This sound processor is designed to be used with an inexpensive microphone and domestic audio system or amplifier. It will provide a variety of changes to the speaking or singing voice. The most important of these is frequency-shifting, but there is also a vibrato and robot effect.

The circuit may be used for parties, Karaoke evenings, for special purposes such as amateur stage productions and for DJ work. A useful feature of the design is that the processed voice may be used alone or combined with the normal (unprocessed) one. The effect will then sound like two separate people or a comic voice singing along with the normal one.



RELIABLE IR CONTROL SYSTEM

Previously published IR remote control systems generally fail to measure up to the ease of construction, testing and using of commercial equipment. Hence the determination to design a system which is free from interference, has few components, does not rely on specialised components available from only one source, is inexpensive, has a 10m range, and above all, is likely to work first time!

The system to be described fulfils these requirements, and can be constructed in the following forms:

- *Momentary remote control*
- *Low power single beam alarm system*
- *1 to 4-way remote control (with optional latching)*
- *15-way remote control (with optional latching)*

DIGISERV

A RADIO CONTROL FUNCTION EXPANDER

Have you ever wished that your radio controlled model boat, plane or car could have a few more controllable functions such as lights, sound effects or a water pump that you could surprise interested onlookers with? Unfortunately, the cost of radio control transmitters and receivers escalates as more channels are required. That tired old two-channel equipment that you picked up cheaply or have had for years just isn't good enough these days. Or is it? – why not expand the use of one of the channels.

Digiserv can be a useful addition to any radio control system, and is particularly suitable for expanding the functionality of small two or three-channel systems often used for controlling model boats or cars. Your existing transmitter can be used to control up to ten functions with no modification required to the transmitter.

PC CAPACITANCE METER

An easy-to-build unit that, when used with a PC, will allow measurement of capacitance. The design covers capacitance values from 0 to 10µF in four ranges and can be used with both polarised (electrolytic) and non-polarised capacitors.

NO ONE DOES IT BETTER

PLUS ALL THE REGULAR FEATURES

EVERYDAY PRACTICAL ELECTRONICS

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TXM-418-A or F Transmitter

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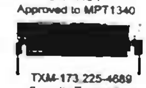
BIM-418-F
Approved to MPT1340



TXM-173.225-4689
Security Transmitter

RXM-173.225-4666-60
VHF Security Receiver

Part	Catalogue RRP**	Our Price
TXM-418-A (9V) TXM-418-F (3V)	£ 14.50	£ 10.99
SILRX-418-A or SILRX-418-F	£ 29.95	£ 22.48
BIM-418-F BIM-433-F	£ 58.00	£ 49.92
TXM-173.225 (1mW) or TXM-173.225- (10mW)	£ 42.00	£ 20.48
RXM-173-4666	£ 64.75	£ 24.65

**Typical Catalogue Company RRP effective Jan 1998 ex VAT

Prices Exclude VAT and Carriage. P & P add £1.50 for orders < £ 100.00 otherwise £6.00 of next day delivery.

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NEW SPECIAL OFFERS

Amiga genlock pcb (uncased) for titling videos it has a 23pin D lead to plug into the computer and pcb pins for composite video in and out. When no video input is connected the normal computer display is shown on the composite video out when the video input is added the white areas on the screen are replaced by the video image. The pcb is powered from the computer....................£19.98

WATCH SLIDES ON TV "Liesgang diatv" automatic slide viewer with built in high quality colour tv camera, composite video output with a BNC plug. In very good condition with few signs of use.... £108.00

Board cameras all with 512x582 pixels 4.4x3.3mm sensor with composite video out. All need to be housed in your own enclosure and have fragile exposed surface mount parts and require 10 to 12vdc power supply.

47MIR size 60x36x27mm with 6 infra red leds (gives the same illumination as a small torch would) ....£50.00+vat=£58.7540

MP size 39x38x23mm spy camera with a fixed focus pin hole lens for hiding behind a very small hole....................£57+vat=£66.98

40MC size 39x38x28mm camera for 'C' mount lens this gives a much clearer picture than with the small lenses....................£68.79

Standard 'C' mount lens F1.6 16mm for 40MC ....£26.43+vat=£31.06

Waterproof camera with stylish tilt & swivel case £92.76+vat=£109.00 or 10+£89.32+vat=£104.95

DTA30 Hand held transistor analyser it tells you which lead is the base, the collector and emitter and if it is NPN or PNP or faulty. HMA20 hand held MOSFET analyser identifies gate drain and source and if P or N channel DTA30 & HMA20 ....£38.34 each

DCA50 component analyser with lcd readout identifies transistors mosfets diodes & LEDs lead connections....................£69.95

Speaker cabinets 2 way speaker systems with motorola tweeters

speaker dia	15"	12"	8"
power rating	250WRMS	175WRMS	100WRMS
impedance	8ohm	8ohm	8ohm
freq. range	40hz-20khz	45hz-20khz	60hz-20khz
sensitivity(1W/1M)	97dB	94dB	92dB
size in mm	500x720x340	450x640x345	315x460x230
weight	21.1kg	16.8kg	7.4kg
price each for black vinyl coating	£139.95	£99.99	£54.94
grey felt coating	£159.97**	£119.97**	£64.99

(** = not normaly in stock allow 1 week for delivery)

Power amplifiers 19" rack mount with gain controls
STA150 2x160Wrms (4ohm load) 14kg £202.11
STA300 2x190Wrms (4ohm load) 11kg £339.00
STA900 2x490Wrms (4ohm load) 15kg £585.00

LEDs 3mm or 5mm red or green .. 7p each yellow 11p each cable ties 1p each £5.95 per 1000 £49.50 per 10,000

Rechargable Batteries

AA(HP7) 500mAH	£0.99	AA 500mAH with solder tags	£1.55
AA 950mAH	£1.75	C(HP11) 1.2AH	£2.20
C 2AH with solder tags	£3.60	D(HP2) 1.2AH	£2.60
D 4AH with solder tags	£4.95	PP3 8.4V 110mAH	£4.95
1/2AA with solder tags	£1.55	Sub C with solder tags	£2.50
AAA (HP16) 180mAH	£1.75	1/3 AA with tags (philipsCTV)	£1.95

Nickel Metal Hydryde AA cells high capacity with no memory. If charged at 100ma and discharged at 250ma or less 1300mAH capacity (lower capacity for high discharge rates)....................£2.95

Special offers please check for availability stick of 4 42x16mm nicad batteries 171mmx16mm dia with red & black leads 4.8v....................£5.95

5 button cell 6V 280mAh battery with wires (Varta 5x250DK)....................£2.45

Orbitel 866 battery pack 12v 1.60AH contains 10 sub C cells with solder tags (the size most commonly used in cordless screwdrivers and drills 22 diax42mm tall) it is easy to crack open and was manufactured in 1994 ....£8.77 each or 110.50 per box of 14

BCI box 190x106x50mm with slots to house a pcb the lid contains an edge connector (12 way 8mm pitch) and screw terminals to connect in wires and 5 slide in cable blanks....................£2.95

7segment common anode led display 12mm....................£0.45

GaAs FET low leakage current S8873 £12.95 each £9.95 10+ 7.95 100+ BC547A transistor 20 for £1.00

SL952 UHF Limiting amplifier LC 16 surface mounting package with data sheet....................£1.95

DC-DC convertor Reliability model V12P5 12v in 5v 200ma out 300v input to output Isolation with data....£4.95 each or pack of 10 £39.50

Airpax A82903-C large stepping motor 14v 7.5' step 27ohm 68mm dia body 6.3mm shaft ....£8.95 or £200.00 for a box of 30

Polyester capacitors box type 22.5mm lead pitch 0.9uf 250vdc 18p each 14p 100+ 9p 1000+ 1uf 250Vdc 20p each,15p 100+,10p 1000+

Polypropylene 1uf 400vdc (Wima MKP10) 27.5mm pitch 32x29x17mm case 75p each 60p 100+

Philips 123 series solid aluminium axial leads 33uf 10v & 2.2uf 40v 40p each, 25p 100+

Solid carbon resistors very low inductance ideal for RF circuits 27ohm 2W, 68ohm 2W 25p each 15p each 100+, we have a range of 0.25w 0.5w 1w and 2w solid carbon resistors, please send SAE for list.

MX180 Digital multimeter 17 ranges 1000vdc 750vac 2Mohm 200mA transistor Hfe 9v and 1.5v battery test....................£9.95

Hand held ultrasonic remote control....................£3.95

CV2486 gas relay 30x10mm dia with 3 wire terminals will also work as a neon light ....20p each or £8.50 per 100

Varbatim R300NH Streamer tape commonly used on nc machines and printing presses etc. it looks like a normal cassette with a slot cut out of the top ...£4.95 each (£3.75 100+)

Heatsink compound tube....................£0.95

HV3-2405-E5 5-24v 50mA regulator ic 18-264vac input 8 pin DIL package....................£3.49 each (100+ 2.25)

All products advertised are new and unused unless otherwise stated. Wide range of CMOS TTL 74HC 74F Linear Transistors kits, rechargable batteries, capacitors, tools etc always in stock.

Please add £1.95 towards P&P (orders from the Scottish Highlands, Northern Ireland Isle of Man, Isle of Wight and overseas may be subject to higher P&P for heavy items).VAT included in all prices.

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Callers welcome 9.30am to 5.30pm
Monday to Saturday

B. BAMBER ELECTRONICS

Bridge rectifier, type WO8, 800V at 1·5A. £1 for 10
Diodes type 1N4007, 1kV at 1A. £1 for 50
Klockner Moeller FAZG DIN rail mounting circuit breakers, single pol. 4A, 6A, 16A, 20A. £2 each
Seiko Epson supper twist graphics blue mode l.c.d.s, 230 × 240 pixel size. 132 × 103 overall. £5 each. 3 for £10. No details
Densitron liquid crystal displays, 5 digit,. type LSH5060RP. £1 each
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Capacitors, 4·7mfd. 400V, radial electrolytic (Jamicom) 15mm × 10mm. £2 per 200
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Zemco central locking interace kits., type SA535, allows the Zemco SA530 vehicle alarm to automatically lock and unlock the vehicle doors by use of the remote transmitter. £5 each
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Zemco add-on quartz ultrasonic sensor kits,, type SA404. £5 each
Rolling ball fuel flow sensors, suitable for petrol and diesel. £5 each
Pin Switches for car door/boot/bonnet etc. £1 per pack of 4
Image Powersense mains analyser, £400
Marconi AF power meter, type TF893A, £250
HeiHemann lighting arresters, type SAL, 220/250 vac, £10
SCART plus, £2 for 5
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Konek capacitors (dipped), 10nF, 250 vac, 15mm pitch, £1 for 25
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Big Tower PC cases, 190 × 460 × 620, £20
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Sanyo Laptop Nicad batteries, type 4KR-5000DE, size 240 × 32 round, 4·8V, 5AH, £5 each
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Frame HDD Part No. 55F9915, 1GB, £20 each
Mains transformers, 240vac input, 12V at 2 amp output, £2 each
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Pye Pocketfones type P5001, low band AM, 86MHz, sets complete but untested and sold as is, £25 each
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Pye battery chargers, type BC28, for P5000, 10-way, £45 each
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Pye controllers, type MR290, £25 each
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Hewlett Packard signal generator, type 8616A, 1·8-4·5GHz, £250
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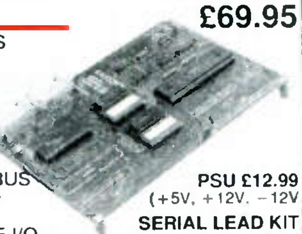

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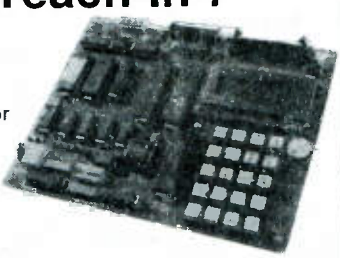

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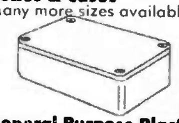

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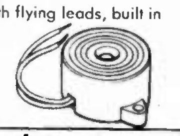

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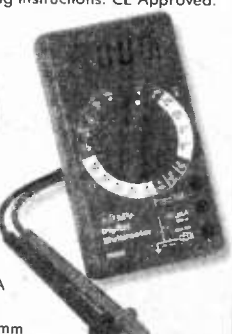

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EVERYDAY PRACTICAL ELECTRONICS

VOL. 27 No. 9 SEPTEMBER '98

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BRITISH

It's good to be able to report a true British invention which is being marketed by a British company, even if it is being made in Taiwan. Last month I said that our *Lightbulb Saver* project might eventually inspire a commercial product; I said that we had first published a design back in 1987 so it has taken some time.

Well, a regular reader, Mr. Tasker from Grantham, faxed me with details of a commercial Bulbsaver (see *Innovations*). This product is the invention of two British chemists and the prototype dates back to 1979. The design was originally conceived to help an elderly caretaker who was changing a lightbulb, using a loft ladder, about every three months – around 1,000 hours use. Nineteen years later the caretaker has retired but the original bulb and prototype circuit are still going strong.

What a pity that the inventors could not find a British company to make the miniaturised product without signing over part of the Rights to it. No such problem with manufacturing companies in Taiwan, who did not even want to know what the finished item was for, they just got on with the task of miniaturising it and then manufacturing it.

TOLD YOU!

I hate to say "I told you so", but I did last month and it is very embarrassing. What did I say? "We very rarely need to publish a *Please Take Note* because of an error (I bet we have to now I've said that)". Well, we have had to (see *Shoptalk*), and we had some other problems with last month's issue where the *Readout* heading got lost and some of the wording on some pages and on the cover was wrong.

I guess I should have kept my big mouth shut – my apologies to you – hopefully it will at least give you all a bit of a laugh at my expense. We will go on trying hard to get everything right and I won't tell you how good we are again as it obviously annoys the gremlins who get to work with a vengeance. Will I never learn?

SEE YOU

If you are learning about electronics, and particularly if you have been following *Teach-In '98*, then our Teach-In Team would be delighted to see you at our Teach-In Meet. For details about this see page 663. It's a good chance to get answers to your queries and sort out any problems you may have had with Teach-In Labs.

Mike Kenward

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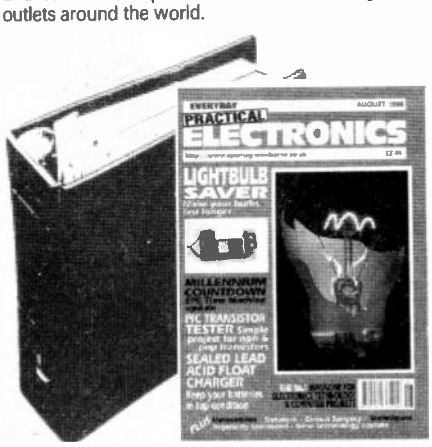

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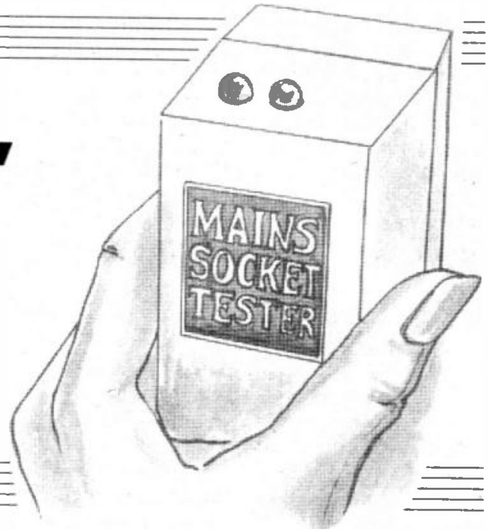
Constructional Project

MAINS SOCKET TESTER



BART TREPAK

How to check the integrity of your mains power sockets.

ALL new domestic appliances in the UK now come fitted with a 3-pin mains plug so that, unless the plug has to be changed for some reason, there is no possibility of it being wired incorrectly.

With d.i.y. activity continually increasing, however, there is the ever present danger of a wrongly wired mains socket. Unfortunately, a mistake in wiring a socket, which a previous occupant might have made, is likely to be just as dangerous as an incorrectly wired plug. One cannot necessarily be sure that the correct connections exist.

This is especially true when an older installation is to be extended or modified. The old red wire could be connected to the Neutral, for example, somewhere down the line and the installation would still work.

SHOCKING CONTINUITY

The need for a mains tester arose recently when the author touched the metal case of an appliance connected to the mains and an adjacent wall which, having been freshly plastered, was still damp, whereupon a slight tingle was felt. It could have been far worse!

Obviously the appliance was not earthed, but on checking it the Earth conductor was found to be connected correctly. Further investigation revealed that the Earth cable was not connected at one of the fittings earlier in the chain back towards the consumer unit. The whole installation from this point on was not earthed.

Clearly, what was required was a simple method of ascertaining that the electrical wiring was correct and that the Earth connection was continuous.

It is also always wise to test a new mains socket following its installation to ensure that the connections have been made correctly as, for example, it is often quite easy to trap the insulation rather than the conductor under the terminal screw.

This simple Mains Socket Tester can be built into a small plug and will provide an indication of not only the integrity of the wiring but also any dangerous mistakes in the connections.

MAINS SUPPLY

The block diagram of a typical standard domestic mains supply circuit is shown in Fig.1. From this it can be seen that the supply enters the premises and goes via the supply company fuse and meter to the consumer unit.

All the wiring up to this unit is the responsibility of the supply company and is not accessible to the consumer. The wiring after this, including the consumer unit, is the responsibility of the householder and it is here that mistakes can occur.

The consumer unit is basically a box which contains an isolating switch, enabling the supply to be turned off if required, together with a number of fuses or circuit breakers on the Live supply line. Current to any load connected to the circuit flows through the Live and Neutral conductors.

The Earth conductor is provided for safety and no current normally flows through this except in fault conditions. Any conducting surface which someone might touch, such as a water pipe, tap, radiator or the case of any metal appliance, is connected to this line.

It should be noted that some appliances (normally referred to as "Double Insulated") do not require to be earthed as the internal electrical parts are separated from the case by two independent layers of insulation, one of which may be the case itself when it is made of an insulating material such as plastic.

Power tools are an example of this and, although they are normally fitted with a 3-pin plug, the Earth pin is not connected and only a 2-wire flexible cable is used to connect the appliance.

The other end of the Earth conductor is connected to a terminal block in the consumer unit, which is connected to Earth. In the past, this was done via a metal stake driven into the ground, but nowadays the connection is provided by the supply company and is bonded to the Neutral wire so that the Neutral is also at Earth potential.

A voltmeter, therefore, will give a reading of 230 volts a.c. between Live and Neutral, and between Live and Earth, but a reading of zero volts between Neutral and Earth, as shown in Fig.2.

It is of particular interest to note that, unlike the flexible cables connected to

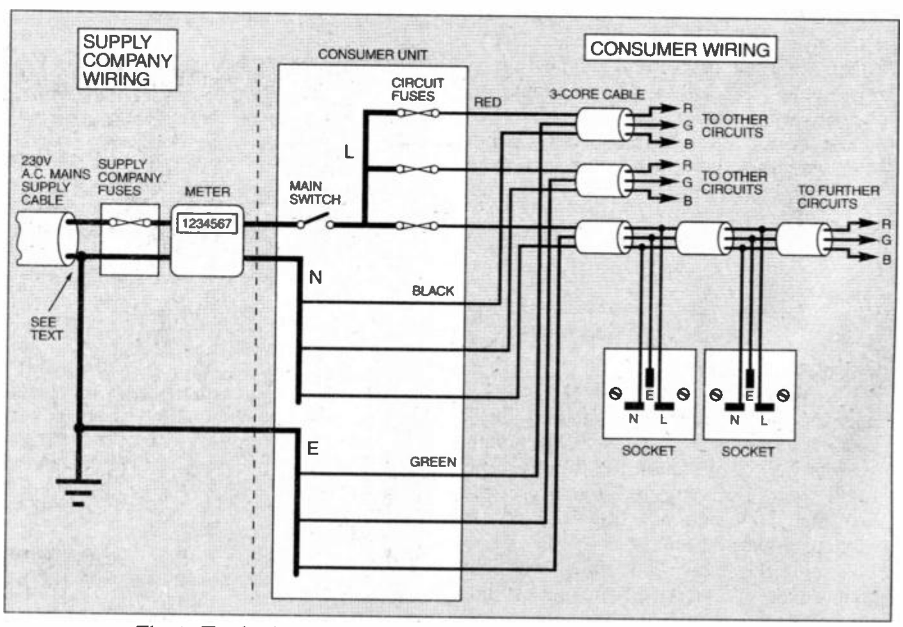


Fig.1. Typical domestic mains electricity supply installation.

appliances, which now use brown, blue and green/yellow to signify the Live, Neutral and Earth conductors, the cable used for domestic wiring (i.e. within the walls) still uses red and black for the Live and Neutral conductors. The Earth conductor is not insulated and green/yellow sleeving is usually fitted on this conductor when it leaves the cable sheath.

TESTER CIRCUIT

The Mains Socket Tester described here basically ensures that the voltages shown in Fig.2 are present at the three connections. However, instead of giving a voltage reading, the tester simply indicates their presence by means of light emitting diodes (l.e.d.s).

A basic configuration for a circuit tester is shown in Fig.3. Capacitor C1 and Zener diode D1 provide a low voltage supply when the mains is present between the Live and Neutral terminals of the plug. The voltage across D1 is approximately a square wave (phase shifted by 90 degrees with respect to the mains by the action of C1) with an amplitude determined by the Zener voltage of the diode.

Assuming that there is 230V a.c. present between the Live and Earth terminals, transistor TR1 will turn on during the negative half cycles (when the collector (c) is positive with respect to the Live rail) causing l.e.d. D2 to light, indicating that the connections are OK.

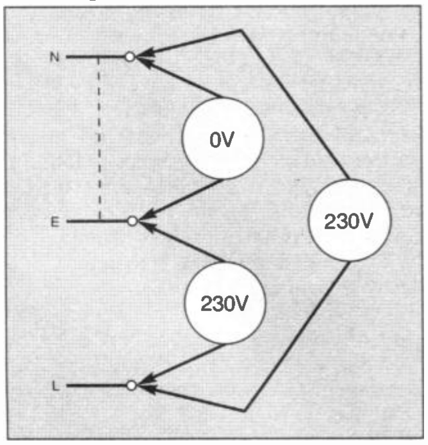


Fig.2. Voltages measured between terminals.

This of course, will not be the case if either the Live or Neutral connection is missing, as there will then be no supply for the transistor collector.

Similarly, if the Earth connection is not made there will be no base current for the transistor, which will not turn on and the l.e.d. will remain off. Faults in the wiring, such as interchanged Live and Neutral connections in the socket, will result in zero voltage between the base (b) and emitter (e) of TR1 because the Earth and Neutral are at the same potential, again leaving the l.e.d. turned off.

The only wiring fault which will not be indicated is if the Neutral and Earth conductors are interchanged on the mains socket. This is because the Neutral and Earth wires are connected together at the consumer unit and are therefore at the same potential.

Fortunately, these two wires and their connections at the socket are almost impossible to confuse because the Earth conductor is a bare wire whilst the Neutral wire always has insulation around it. The Earth connection on the socket is also difficult to confuse with the others as it is normally sited away from the other two and is connected to a metal bracket, which also connects to the two fixing holes.

As shown in Fig.4, the basic tester can be improved by fitting two l.e.d. indicators; one to show that a supply is present (D3 – red) and another to indicate the integrity of the Earth connection (D2 – green). This enables problems to be diagnosed more readily.

For example, if the red l.e.d. does not light, then the fault must be due to a blown fuse or a faulty connection in either the Live or Neutral; if it does light but the green one does not, the problem must lie with the Earth conductor.

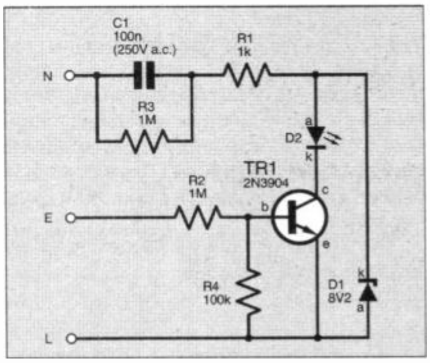
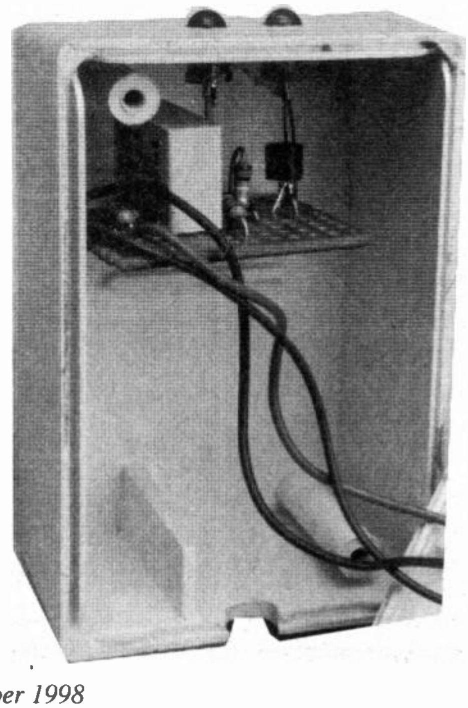


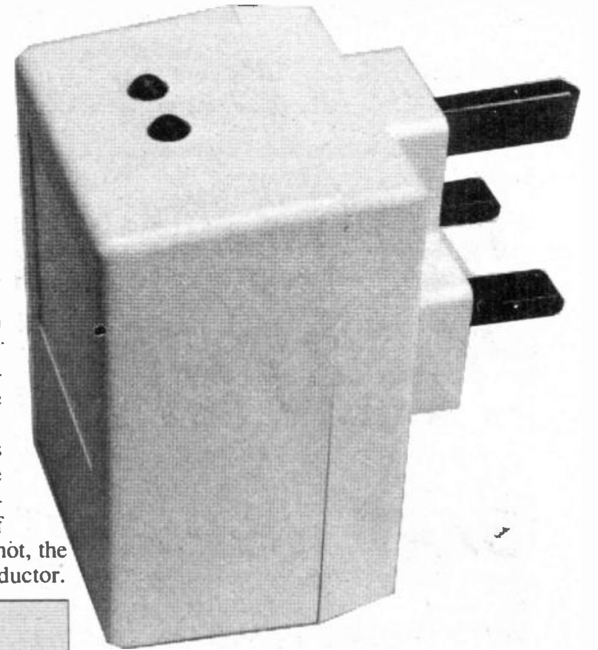
Fig.3. Circuit diagram for the basic tester.

In Fig.4, the red l.e.d. (D3) is turned on during the positive half-cycle when Zener diode D1 is conducting in the forward direction. Diode D4 (an ordinary silicon type) is connected across the l.e.d. to prevent it from breaking down in the reverse polarity direction.

The current through both l.e.d.s is limited by capacitor C1, which acts as a mains dropper enabling the red l.e.d. to light on positive half-cycles and the green on the negative (assuming that transistor TR1 is conducting).

Using the l.e.d.s to secure the circuit board in the case.





Resistor R1 is included to limit any initial surge when the supply is first switched on and R3 serves to discharge the capacitor quickly when the plug is disconnected from the mains, thus preventing the user getting a shock if the pins are touched while the capacitor is still charged.

Resistors R2 and R4 limit the base current to the transistor, whilst diode D1 limits the voltage across the transistor to prevent it from breaking down when it is off.

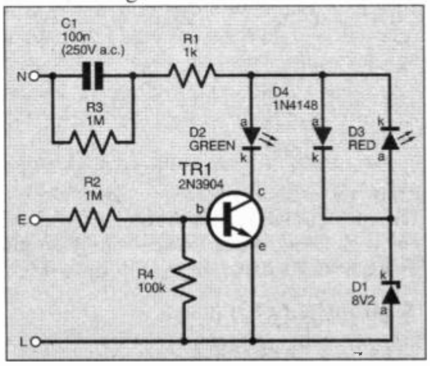


Fig.4. Full circuit diagram for the Mains Socket Tester.

COMPONENTS

Resistors

R1	1k	
R2, R3	1M (2 off)	
R4	100k	

All 0.25W 5% carbon film.

See SHOP TALK Page

Capacitor

C1	100n 250V a.c. polyester (class X)

Semiconductors

D1	8V2 Zener diode
D2	5mm green l.e.d.
D3	5mm red l.e.d.
D4	1N4148 silicon diode
TR1	2N3904 *npn* transistor

Miscellaneous

Stripboard, 9 strips × 12 holes; 3-pin mains plug; plastic case to suit; connecting wire; solder etc.

Approx Cost Guidance Only £3 *excluding case and plug*

CONSTRUCTION

Warning. This circuit must only be built by those who are competent at working with electronics and mains electrics.

The prototype Mains Socket Tester was built on a tiny piece of stripboard (9 strips × 12 holes) as shown in Fig.5.

Since the circuit carries mains voltages, great care must be taken to ensure that the correct connections are made and suitable clearances are maintained between tracks. Remember also, that it is not only important to make the connections which are required, but also to break those which are not, as shown in Fig.5.

The choice of the current limiting capacitor (C1) for the l.e.d.s is also very important and only capacitors rated at 250 volts a.c. (X-rated) must be used. *Components marked 250V d.c. or even 400V d.c. will not be suitable as their a.c. ratings are normally only 200V or so.*

None of the other components are critical and almost any transistor or Zener diode could be used in this circuit, the only stipulation being that the transistor is an *npn* type and the breakdown voltage of the Zener is lower than the maximum permissible collector voltage of the transistor.

Note that the layout is shown for the 2N3904 transistor specified and this has different pinouts from the more usual types such as the BC548, BC182 etc. (see Fig.5).

The values of the resistors are also not critical and any value around that specified will do. Resistors R2 and R3 could be anywhere between 470k ohms and 2M2 ohms, whilst R1 may be as low as 100 ohms without any problems being encountered.

The circuit is best mounted in a small plastic box and connected to a 3-pin plug by a short 3-core cable. Make especially sure that the correct connections are made to the plug pins as a fault here will defeat the whole object of the device!

Alternatively, a "plug box" of the type normally used for building small power supplies could be used. The type with a ***metal*** Earth pin must be purchased.

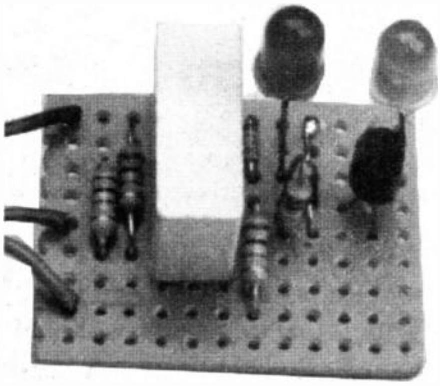
TESTER TESTING

In use, the device is simply plugged into the mains socket to be tested and the l.e.d.s observed. Table 1 shows the displays obtained when various faults are present in the wiring. For a standard 3-pin mains socket, if both l.e.d.s light then there is no fault, although care should be taken to ensure that the Neutral and Earth connections are correct.

The best way to test the tester is to wire it to the plug in various ways that will simulate a fault in the socket and connect this to a known good socket. The use of a connector block or a "quick test" type of connector will speed up this process. **Ensure that the device is disconnected from the mains when changing any of the connections.**

This tester will provide reassurance that a socket is wired correctly and, more importantly, that the Earth connection is sound. It will also do so much more quickly than similar tests with a voltmeter. Anyone who is rewiring a house or just fitting a new socket should find it very useful.

There is no method which can be safely recommended for using it to test light fittings. □



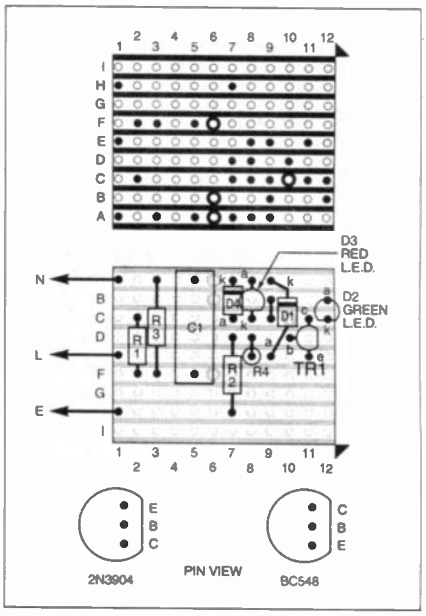
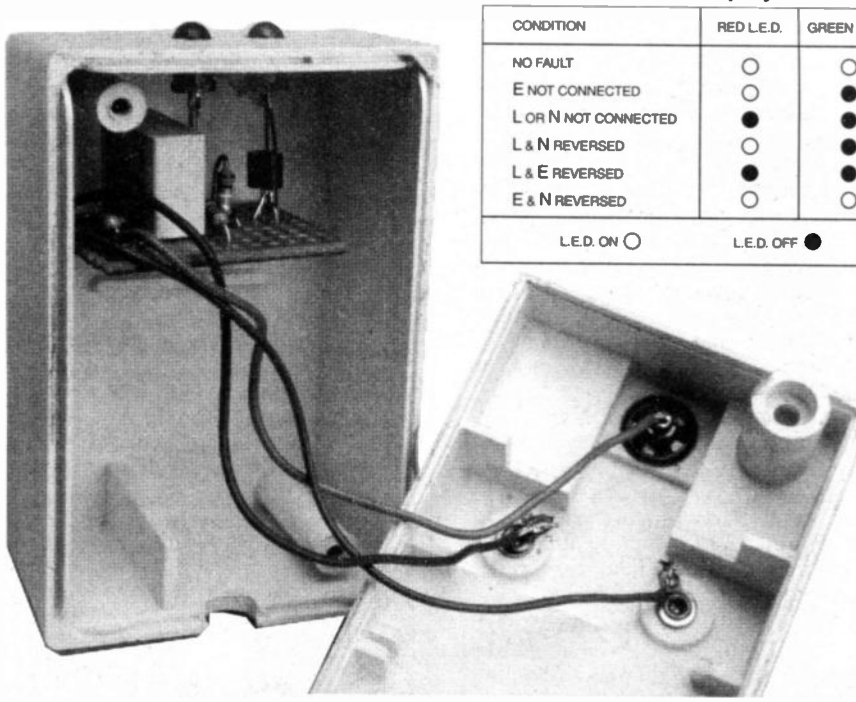


Fig.5. Stripboard component layout, underside showing breaks in copper tracks and pinout details for the suggested transistor types 2N3904 (model) and BC548. Note the small link wire beneath the Zener diode D1. The completed circuit board is shown above left.

Table 1: Fault Display Check

CONDITION	RED L.E.D.	GREEN L.E.D.
NO FAULT	○	○
E NOT CONNECTED	○	●
L OR N NOT CONNECTED	●	●
L & N REVERSED	○	●
L & E REVERSED	●	●
E & N REVERSED	○	○

L.E.D. ON ○ L.E.D. OFF ●



Wiring from the circuit board to the case "plug" pins.

Innovations

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

CINEMA FILM NOT YET DEAD

Video as a replacement for celluloid is not yet viewed as a success. Barry Fox has more details.

RECENTLY, BT gave the first demonstration of its new electronic cinema system (see *EPE* May 1998). The event turned into a major embarrassment. A key partner in the project publicly denounced the pictures screened at a cinema in London's West End as "appalling".

BT's Broadcast Services division has for two years been working secretly with Virgin Cinemas, JVC, British electronics company Snell and Willcox, and Channel 4 TV on big screen video. BT installed one of JVC's video projectors in Virgin's Haymarket cinema and piped digital signals down an optic fibre link from a computer system at the BT Tower. Snell and Willcox provided the digital circuitry, called Supervisor, which artificially enhances clarity by doubling the number of TV picture lines.

Rupert Gavin, MD of BT's Consumer Division, called for industry support to make electronic cinema a replacement for 35mm film. An audience of film and TV experts watched horse racing shot by C4 and excerpts from movies including the *Madness of King George*, *Four Weddings and a Funeral* and *Tomorrow Never Dies*. There was no direct comparison of modern film with video.

The only 35mm material shown for comparison was historical, a 1929 black and white movie, *Birds of Prey*, the first British talkie shown at the Haymarket.

Richard Patterson, Head of the Information and Education Division at the BFI, agreed with members of the audience who said the pictures had looked "soft" and "out of focus" with poor contrast and colours compared to film. Patterson added that they were "unacceptable for West End premieres".

This prompted David Youlton, S&W's Chief Executive and Chairman of UK industry body the Digital Television Group, to berate BT. "I am ashamed to be associated with this event. We can do ten times better. You people don't understand digital processing. I am appalled at what I've seen."

Closing the meeting Rupert Gavin said "This was intended to initiate dialogue – and it's certainly done that".

"But we were marginalised at the Haymarket" said S&W's Kevin Melia afterwards. "We were relegated to the role of supplier. We were given no voice on the panel. David Youlton was incandescent throughout the whole event."

"I spoke out to save electronic cinema, not kill it", said David Youlton later.

"We still believe that Electronic Cinema is good for the industry in the long term", says John Swingewood, BT's Director of Internet and Multimedia Services. "We are still playing a full and functional role and making technical improvements".

BT had delivered D5 tapes to the Ealing cinema, but piped signals into the Haymarket by optic fibre link. Picture quality is directly affected by the rate at which the digital data is delivered by a link. The full rate, as used by studios and production facilities, is 270 million bits a second. But this high rate would heavily increase the cost of using the system. John Swingewood confirmed that the data rate used to pipe the signals in from the BT Tower was the much more economical 45 million bits a second. But later, following criticism of the system performance, BT said Swingewood had been mistaken and the data rate had been a full 270Mb/s.

At the Ealing trial Snell and Willcox had been given a free hand and had installed three Supervisor circuits, one each for the red, green and blue signal channels used in the video projector. At the Haymarket, BT had used just one.

YEDA AWARDS 1998

THE *1998 Young Electronic Designer Awards* were recently presented to the winners by HRH The Duke of York at Granada Studios, Manchester during a celebration dinner attended by 200 guests including parents, teachers, local dignitaries and members of the business community.

Sponsored this year by Cable and Wireless Communications and the Institution of Electrical Engineers, the Awards, now in their thirteenth year, recognise the creativity and initiative of young people using modern technology. To succeed, contestants must conceive and design a solution to an everyday problem which they have identified, and to produce a working prototype.

This year's winning projects included a fridge alarm the size and shape of an egg, which costs under £5 and warns if the fridge door is left open; a portable basketball scoreboard; a black box flight recorder for model aircraft; a device to warn lorry drivers if their vehicle is in danger of being toppled over by a side wind; and an electronic location device which can be fitted to life jackets.

Edith Butterfield (15) is delighted with the success of her egg-shaped fridge alarm.

Andrew MacLachlan (18) proudly shows off his basketball scoreboard.

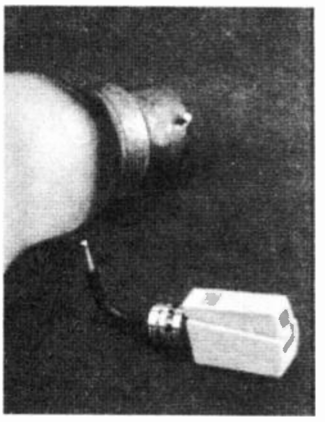
The fridge alarm and basketball scoreboard jointly won the Cable and Wireless Prize for the most commercially viable project. Respectively they were designed by Edith Butterfield of St Margaret's Senior School, Midhurst, and Andrew MacLachlan of King Edward's School, Birmingham.

The two of them also featured strongly in the IEE Award for the Best New Entrant to YEDA: Edith won second prize in the Intermediate Category (15-17 years), and Andrew came first in the Senior Category (18-25 years).

For more information about the YEDA Award scheme, contact the YEDA Trust, 60 Lower Street, Pulborough, West Sussex, RH20 2BW. Tel: 01798 874767. Fax: 01798 873550. E-mail: postmaster@yeda.compulink.co.uk.

BULBSAVER

IN *EPE* August '98 we published a *Lightbulb Saver* and in our Editorial expressed our opinion that "this is an idea that we will eventually see on sale in the local d.i.y. store". We also published a similar idea in '87.



Unbeknown to us, a commercial product has already been on the market for five years. We have been sent information about it by its originators, Microcel.

The device, Bulbsaver, is a British invention that vastly increases the life of ordinary filament bulbs, including halogen hob lamps, tungsten halogen bulbs, spotlights, etc. It is fitted either behind the light switch or in-line in the case of traffic lights and signal applications.

Sales of Bulbsavers have been made to railways, local government, hotels, restaurants, oil rigs, harbour authorities and even a stately home for their chandeliers.

Microcel say that Bulbsaver reduces the surge at switch on and limits the power surges that occur due to fluctuations in supply. They point out that bulbs used with the device will be dimmer than with unprotected circuits, but say that using a higher wattage bulb to compensate will not cause an increase in power consumption. This is because Bulbsaver is designed to save energy and not dissipate significant amounts of heat. The device also causes the light to shimmer – this effect is reduced in areas with multiple lamps.

Bulbsaver is rated for 1000 watts maximum at 240V 50Hz a.c. supply. Bulb life in one case proved to be in excess of 85,000 hours (85 times normal rated bulb life). Bulbsaver's life is expected to be in excess of 10 years.

For further information contact Microcel (UK) Ltd., PO Box 2, Dept EPE, Market Deeping, Peterborough, PE6 8SP. Tel: 0778 347214. Fax: 0778 347928.

SMART KITS

TO some of you it may come as a surprise to learn that Greece has a good number of electronics hobbyists and an infrastructure to support them. You will frequently see, though, electronics magazines at their news kiosks, in English and in Greek, and including *EPE*.

We have now learned that one Greek company, Smart Electronics Ltd, is intent on achieving worldwide export of its hobbyist electronic kits. Already they are on the Internet with information about their Smart Kits in English, German, Dutch, Danish, Swedish, Italian, Spanish, Portuguese, French and Greek.

They have also sent us their kit catalogue. There are over 60 kits on offer, including devices such as A.F. amplifiers, F.M. transmitters, alarms, power supplies, instruments, bugging devices etc. Most of them are said to have CE approval according to EC regulations. They also have a range of ready-made products.

The catalogue says that a Smart Kit pack contains everything that you need to build the circuit. All the components, printed circuit boards and instructions – usually in the your language, they say – are included in the package. It is expected that it will be as easy for UK readers to buy from Greece as it is for Greek readers to buy from the UK.

For more information contact Smart Electronics Ltd., Dept. EPE, 39 Ag. Kostantinou Street, Athens 104 37, Greece. Tel: 00 301 5230 000. Fax: 00 301 524 5474. E-mail: smarty@hol.gr. Web: www.smartkit.gr.

Quickroute Expo

THE latest issue of Quickroute Systems' magazine *Expo* has arrived at the office. In it is introduced Quickroute 4, the latest version of the award winning electronic design software. There is also information about SymbolWizard, a new plug-in module which "makes creating new symbols for Quickroute a breeze", and accelerates the development of custom p.c.b.s and circuits.

The IdeaFactory is also introduced. This is said to be an amazing new product which brings visual simulation and modelling to maths, science, design and technology. Using this tool enables you to turn your ideas into models and then simulate them, and is fun to use.

There is also MExpress 2.0 highlighted, which is the latest incarnation of MExpress, the BASIC development tool for scientists and engineers that has received "rave reviews". The latest version includes a compiler so you can create executables directly from your script files.

For more information contact Quickroute Systems Ltd., Dept. EPE, Regent House, Heaton Lane, Stockport SK4 1BS. Tel: 0161 476 0202. Fax: 0161 476 0505. Web: www.quickroute.co.uk.

Amazing Microchip

INFORMATION received from Microchip Technology tells us that in 1997 shipments of their popular PIC microcontrollers jumped to 176 million units. This has placed the company in the number two position for worldwide shipments of 8-bit microcontrollers. The company was founded in 1989, shipping just 20 million devices in 1990.

We know that *EPE* readers have helped to boost the sales of PICs – and will continue to do so!

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

SQUIRES MOVE

SQUIRES Model & Craft Tools have moved! They have now brought all their operations under one roof (still in Bognor) and have planning permission to open part of the premises as a retail showroom which is expected to open in early December for a full six days a week. They will still attend shows throughout the country.

The extra space will allow Squires to sell many more new products, including a very large range of electronic components. This will be highlighted in their forthcoming 1999 catalogue, due for publication August/September '98.

For more information contact Squires Model & Craft Tools, Dept. EPE, 100 London Road, Bognor Regis, West Sussex PO21 1DD. New tel: 01243 842424. New fax: 01243 842525.

ET's RESOLUTION

By Barry Fox

JVC in Japan has now announced a new version of VHS, called ET or Expansion Technology – or Extension Technology, JVC uses both phrases. ET uses analogue technology to deliver near digital quality.

Like Super-VHS, ET will offer twice the picture resolution of Standard VHS (over 400 lines instead of 240 for NTSC). But whereas S-VHS recorders needed S-VHS tapes to deliver S-VHS quality, ET machines will use improved recording heads and signal amplifiers to capture ET quality on good quality standard VHS tapes.

First reports said that tapes made on ET machines would play back on standard decks, albeit in standard resolution. This backwards compatibility would have allowed single inventory pre-recorded tapes. It was lack of this compatibility that failed S-VHS as a table-top format. Over 650 million standard VHS decks have been sold over the last twenty years, and the mass market will not upgrade.

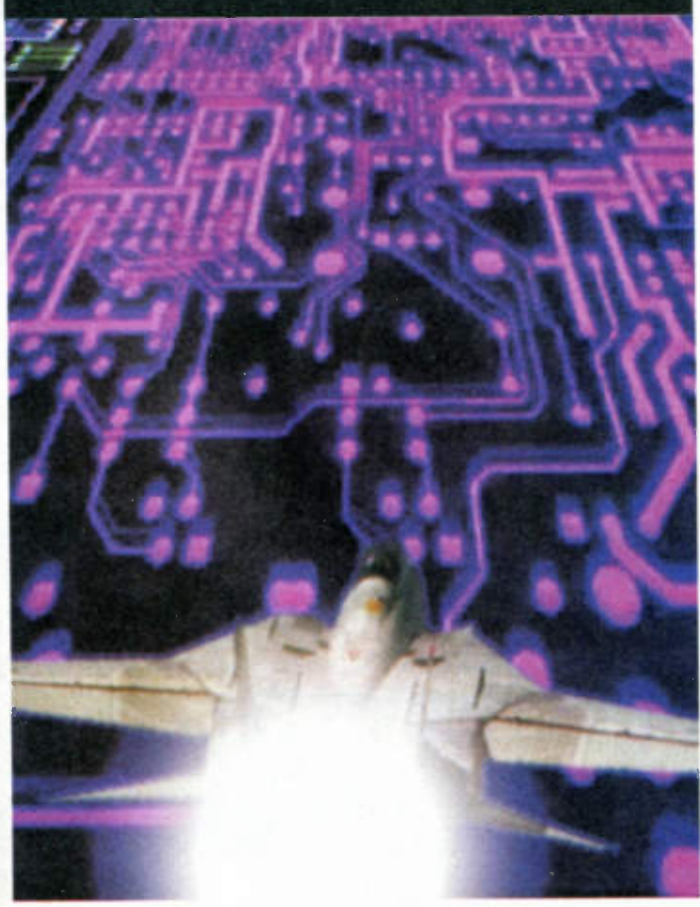
Samsung invented a system called Augmented VHS which would have allowed backwards compatibility, with new Augmented recordings playing back on old machines. But the VHS family never adopted the Korean idea.

Now we know that ET recordings will play back only on S-VHS decks, or standard VHS decks with "quasi S-VHS playback" or SQPB. But there are very few of these.

ET will launch in Japan this summer, and reach the USA in the autumn, with no firm plans for Europe.

QUICKROUTE

THE QUICKROUTE



Simulation Circuit Capture PCB Autorouting CADCAM

Imagine an electronics design system that lets you draw schematics onto the screen and then simulate them at the touch of a button. Now imagine pressing another button and seeing the schematic replaced with a PCB rats-nest. Pressing another button starts the autorouter, and finally you can click on File then Save As to create a complete set of CADCAM files.

Too easy? We hope so. Quickroute has always been designed first and foremost to be easy to use. That's why simulation, circuit capture, PCB autorouting and CADCAM support are all integrated into **one** package, So that you only have to learn **one** package.

But it doesn't end there. We have included a wide range of features in Quickroute to help you work effectively. For example our Gerber import facility lets you check your CADCAM files before sending them to your manufacturer.

We have also introduced a major new PLUGIN module called the SymbolWizard that actually creates custom symbol designs for you. Simply select a template, specify pad and spacing properties and SymbolWizard creates the schematic and PCB symbols for you!

If you would like to find out more about Quickroute, why not call us on FREEphone 0800 731 28 24, or visit our web site on www.quickroute.co.uk. Prices start at under £100 including UK P&P and VAT for a complete system.

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TEP ENHANCEMENT

New Technology Update

Ian Poole reports on the strides being made to overcome some of the many hurdles confronting today's semiconductor industry.

MANY people wonder where the semiconductor industry will be in a year or more. There are tremendous advances being made in various sectors, and all the time it appears that insurmountable hurdles are about to be met.

Nevertheless, progress still keeps being made and the hurdles are overcome. As a result semiconductor devices become larger and contain much greater levels of functionality.

They are also becoming much faster and despite their increased levels of functionality they are becoming less power hungry. The question is will it ever stop because there is a truly insurmountable barrier, or will it just keep on going in one way or another?

High Finance

There are many factors that govern the rate at which developments are made. Obviously there must be a need, and there must be sufficient people working in that area. But one of the other main factors is the availability of finance.

The semiconductor industry ploughs billions of dollars into the development of new processes and products. To keep the pace going there must be sufficient funds available to keep the wheel turning. At the moment the Asian financial crisis may have the effect of slowing down some of the development.

However, much of the rest of the World's economy is still in a very good state and this will help to limit the impact. Accordingly there is still a vast amount of development that will be ongoing with little or no slow down. Faster clock speeds, shrinking dimensions and greater functionality are all taking place as you read this.

Smaller sizes

Many of the chips currently being produced have design rules that allow feature sizes of as small as 0·25 microns. Several of the large manufacturers, including Intel, Digital, and Motorola, have installed plant to enable them to produce chips with this technology. By using these minute sizes not only can the required amount of electronics be placed onto a single chip, but also the requisite speeds can be achieved.

However, chips with these dimensions generally have to be run at lower voltages and this is one of the reasons for the migration to 3·3V as the standard for logic operation rather than the more familiar 5V lines. The other reason for this migration is the requirement for much lower levels of power consumption in today's equipment.

With many more portable items like mobile phones, laptop computers and so forth being manufactured, battery life becomes a significant issue. Whilst battery technology is improving there is still a need to reduce the power consumption of the circuitry.

With these requirements in mind, researchers into chip technologies are continually looking to be able to reduce the feature sizes on the chips. Even when a smaller size has been proved possible it takes some time before it can be reliably used in mass production.

Some of the large manufacturers have made the enormous investments required to make the transition to a smaller technology. However, against this there is always the pressure to keep up with or ahead of the other chip manufacturers.

Amorphous Polyolefin

In order to be able to achieve these remarkably fine feature sizes a combination of new technologies and developments have been brought together. With a combination of these new technologies and new design rules, feature sizes of 0·08 microns have been proved.

Researchers at the University of Texas devised a new photoresist known as amorphous polyolefin. This took nearly three years to perfect, and it works by interacting with a laser light source to produce the required pattern on the wafer.

One of the properties of the new photoresist is that it is optimised to match the much shorter wavelength light, that is being used these days, to achieve the greater resolution. In fact these resists show excellent mechanical stability, etch resistance and a broad process latitude with the high definition required for processes of well below 0·2 microns.

In a further development Du Pont PhotoMasks Inc has introduced an etched quartz shift photomask that provides the precision images of the features to be patterned on the wafer.

Laser Light

One of the other major areas where development has produced marked improvements is in the field of the laser generation of light.

In order to be able to attain the definition required the light must emit a narrow band of light. A wide bandwidth will cause a degradation of resolution, limiting the effectiveness, especially of systems requiring feature sizes below 0·30 microns. The light must also have a short wavelength.

Currently many manufacturers are installing deep ultraviolet (DUV) systems. At the moment DUV tools account for around 20 per cent of this market, and this is expected to rise rapidly so that by the year 2000 they occupy nearly half the market.

To meet the requirements placed upon the light source, the excimer laser is the most widely used for these systems. It is a high power gas discharge laser that emits pulses of narrow bandwidth light on a short wavelength. The high power also enables shorter exposure times to be used and this has the added benefit of reducing the exposure times and increasing the throughput.

One such laser developed by Cymer Corp of San Diego uses an argon fluoride laser that is a development of its krypton fluoride laser. This laser offers excellent resolution, depth of focus and dimensional control to enable image patterns to be controlled down to sizes of 0·10 microns and below, leaving some margin for associated technologies to catch up.

Optics

The lenses used in these systems are also of extreme importance. Those used in new DUV systems have higher numerical apertures than those used in the previous generation systems.

In conjunction with the shorter wavelength light, this enables them to resolve the much finer features of 0·25 microns and below. To give the required projection quality, manufacturers of the lenses have had to significantly increase the homogeneity of the materials used in the lenses.

Future

It was not so many years ago when people wondered whether sub-micron feature sizes could be attained. Now various final limits are being proposed beyond which current technologies will not be able to proceed, but each time a way around some of these boundaries seems to be found, and feature sizes fall still further.

The reduction in feature sizes also brings with it a corresponding increase in speed, and fall in power consumption. With the ever present demand for faster speeds, a greater number of features and increased flexibility, the demand for bigger and better chips will always be present.

It is hoped that these new technologies will play a vital part in enabling today's needs to be met, and later they will be seen as a vital stepping stone in enabling the next advances to be made.

Constructional Project

PERSONAL STEREO AMPLIFIER

ROBERT PENFOLD

Share the pleasure of your personal listening with this low-cost, low power, add-on amplifier.

THE AUDIO quality available from even the cheaper personal stereo units is higher than one might expect, and the popularity of these gadgets is not surprising. By using headphones it is possible for the user to listen at high volume levels while causing minimal disturbance to those nearby. The audio quality of modern lightweight headphones is very good, and it is probably this factor that is largely responsible for the success of personal stereo units.

It is possible to further increase the usefulness of these devices by feeding the output to miniature loudspeakers rather than using headphones. Special loudspeakers for this purpose are available at quite low prices, and by using these it is possible for a personal stereo unit to be utilized by more than one person at a time.

Some loss of audio quality has to be accepted, as does a rather limited maximum volume. In fact, the main drawback of these add-on loudspeakers is the very low volume levels they produce.

Although they are relatively efficient, the power available to drive them will normally be no more than a very few milliwatts. It is not feasible to produce decent volume levels from such meagre output powers.

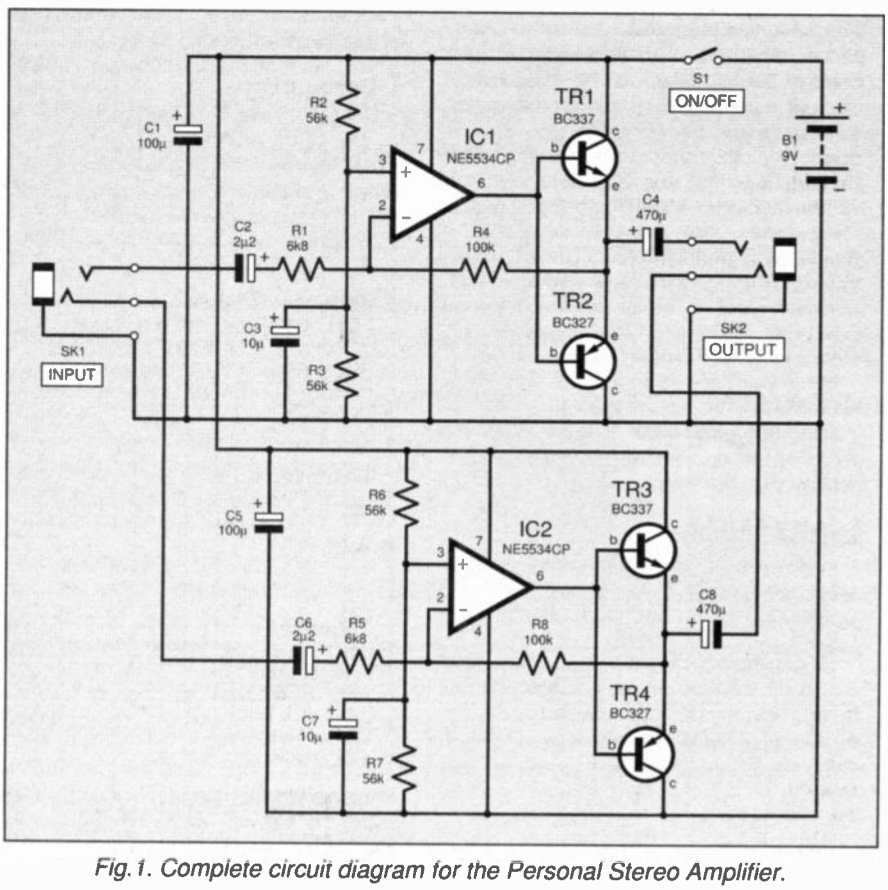


Fig. 1. Complete circuit diagram for the Personal Stereo Amplifier.

POWER BOOST

The obvious answer is to use a small battery powered amplifier to boost the output of the personal stereo unit to a level that will provide more satisfactory volume levels. The complete set-up remains quite small and portable, and the personal stereo unit can still be used on its own when maximum portability is required.

Output powers of up to a few hundred milliwatts r.m.s. per channel can be provided by the amplifier featured here. This will not give sound levels that rival a hi-fi system, or even one of the larger "ghetto blasters", but coupled with the high efficiency of the special miniature speakers it gives more than enough volume for many purposes.

CIRCUIT OPERATION

The full circuit diagram for the Personal Stereo Amplifier is shown in Fig.1. The circuit consists of two identical amplifier modules that share common input and output sockets, battery, and on/off switch, but are otherwise separate. Here we will consider the operation of the amplifier for the left hand channel which is based on IC1, but the right hand channel circuit operates in exactly the same fashion.

A low noise and low distortion operational amplifier, specifically designed for use in audio circuits, is used for IC1. It operates in a form of inverting mode circuit, with biasing for the non-inverting input (pin 3) provided by resistors R2 and R3.

Resistors R1 and R4 are the negative feedback network, and these set the closed loop voltage gain of the circuit at about 15, and the input impedance at 6·8 kilohms. Capacitor C2 provides d.c. blocking at the input of the circuit, and C4 provides the same function at the output.

The maximum output current available from an operational amplifier is only a few milliamps, and without some discrete assistance IC1 will provide little more output power than the personal stereo unit itself. Transistors TR1 and TR2 form a complementary class-B emitter follower output stage that greatly boosts the output current available from the circuit. Transistor TR1 acts as a current source for the loudspeaker on positive output half cycles, and on negative half cycles TR2 acts as a current sink.

The emitter follower mode provides only about unity voltage gain, but it gives a high level of current gain. This is, of course, exactly what we require in this case.

The point of using a complementary class-B output stage is that it provides a level of current consumption that varies with changes in the volume level. At high volumes the current consumption will be as much as 100mA, but at low volume levels it will only be a few milliamps.

A class-A amplifier has an average current consumption that is constant, and always high. This is undesirable for a battery powered amplifier, since it results in the battery running down rapidly even if the amplifier is only used at very low volumes.

loop gain. Only a minute input voltage is therefore sufficient to send the output of IC1 about 0·7V positive.

The voltage at the output of the circuit then starts to rise, and the normal level of feedback is restored. A similar action occurs at the beginning of negative half cycles, with the output of IC1 almost instantly reducing by about 0·7V, and the normal voltage gain of the circuit then being resumed.

With a sinewave input signal this gives a distorted output signal from IC1 of the type shown in Fig.2c. The crossover distortion removes the initial 0·7V from each half cycle, but on the output from IC1 about 0·7V has been added at the beginning of each half cycle. In other words, IC1 is distorting the signal in a way that counteracts the crossover distortion through the output stage.

The overall result is that the output signal is largely free from crossover distortion. It will probably be detectable if the volume is set very low and you listen with one ear very close to the loudspeakers, but at normal volume levels the crossover distortion should not be significant.

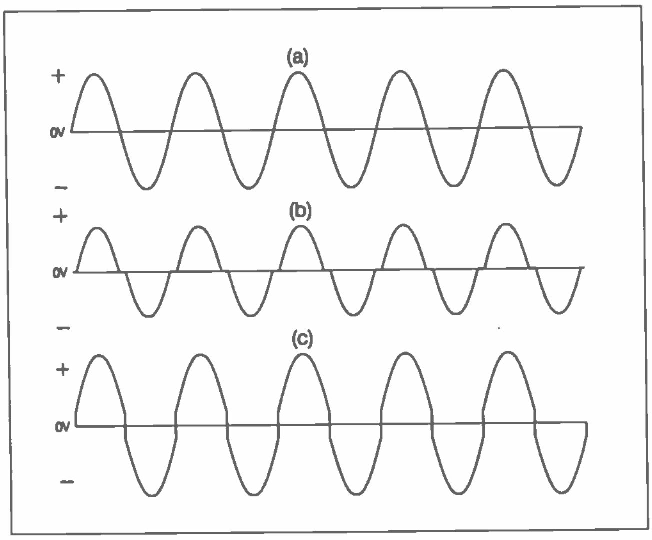
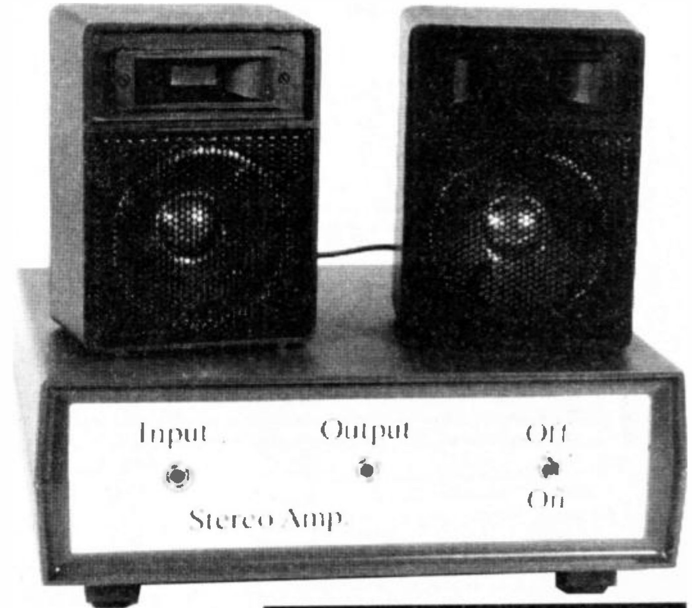


Fig.2a. Sinewave signal, (b) sinewave signal after crossover distortion and (c) output from IC1.



CROSSOVER DISTORTION

In this circuit the output stage is a minimalist type which does not include any quiescent bias to the output transistors. This is helpful in that it wastes no significant output current through transistors TR1 and TR2 when there is no output signal.

However, it does have the drawback of introducing a severe form of distortion known as "crossover" distortion. This is due to a voltage drop of about 0·7V from the base of a transistor to its emitter. This means that the voltage at the output of IC1 has to change by about ±0·7V or so before there is any change at all in the output voltage from TR1 and TR2!

Even with large output signals, the initial and final part of each half cycle is missing. Fig.2a shows a sinewave signal, and Fig.2b shows the affect of severe crossover distortion on this signal.

Rather than combating the distortion with the usual method of using a forward bias to the output transistors, this design relies on large amounts of negative feedback. Feedback resistor R4 connects to the emitters of TR1 and TR2 rather than to the output of IC1, so that the negative feedback is applied to the amplifier as a whole and not just to IC1.

When the output is positive going, the voltage drop through TR1 results in a lack of feedback, and IC1 exhibits its full open

CONSTRUCTION

This project is built using *two* of the *EPE* multi-project printed circuit boards; one board for each stereo channel. This board is availablefrom the *EPE PCB Service*, code 932. The component layouts for the two boards (which are identical), together with all the hard wiring and full size copper foil master pattern are provided in Fig.3.

The two boards are very simple, but the usual warning about the multi-project board has to be repeated here. Unlike a normal custom printed circuit board, many of the holes in this board are left unused. In fact the vast majority of them are unused in this case.

This makes it much easier to get a component fitted in the wrong place, and a little extra care has to be exercised when fitting the components onto the board. Apart from this, construction of the boards is very simple, but make sure that the electrolytic capacitors and semiconductors are fitted with the correct polarity.

The NE5534AN op.amp used for IC1 and IC2 is not a static-sensitive component, but it is always advisable to use holders for d.i.l. integrated circuits. The circuit will work using the slightly inferior NE5534P, or even bi-f.e.t. op.amps such as the TL071CP. However, due to their lower bandwidths and switching speeds,

COMPONENTS

Resistors

R1,R5	6k8 (2 off)
R2, R3, R6, R7	56k (4 off)
R4, R8	100k (2 off)

All 0·25W 5% carbon film

See SHOP TALK Page

Capacitors

C1,C5	100µ radial elect. 10V (2 off)
C2, C6	2µ2 radial elect. 50V (2 off)
C3, C7	10µ radial elect. 25V (2 off)
C4, C8	470µ radial elect. 10V (2 off)

Semiconductors

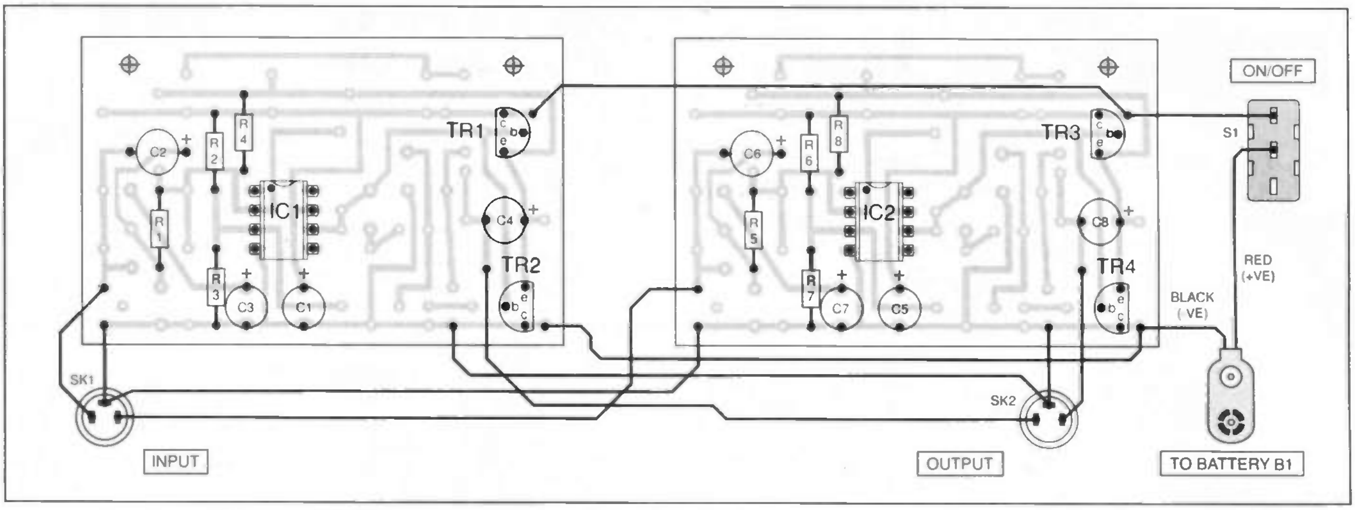
TR1, TR3	BC337 *npn* transistor (2 off)
TR2, TR4	BC327 *pnp* transistor (2 off)
IC1,IC2	NE5534AN low noise op.amp (2 off)

Miscellaneous

SK1, SK2	3·5mm stereo jack socket (2 off)
B1	9V battery pack (6 x HP7/AA size cells in holder)
S1	s.p.s.t. min. toggle switch

Medium size plastic box or instrument case, size to choice; multi-project printed circuit board available from the *EPE PCB Service*, code 932 (2 off); 8-pin d.i.l. holder (2 off); battery connector; multistrand connecting wire; solder pins; solder, etc.

Approx Cost Guidance Only £9
excl. batts., case & speakers



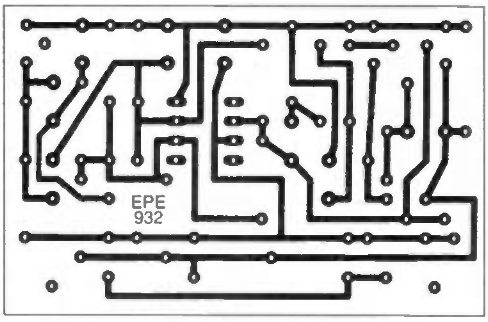
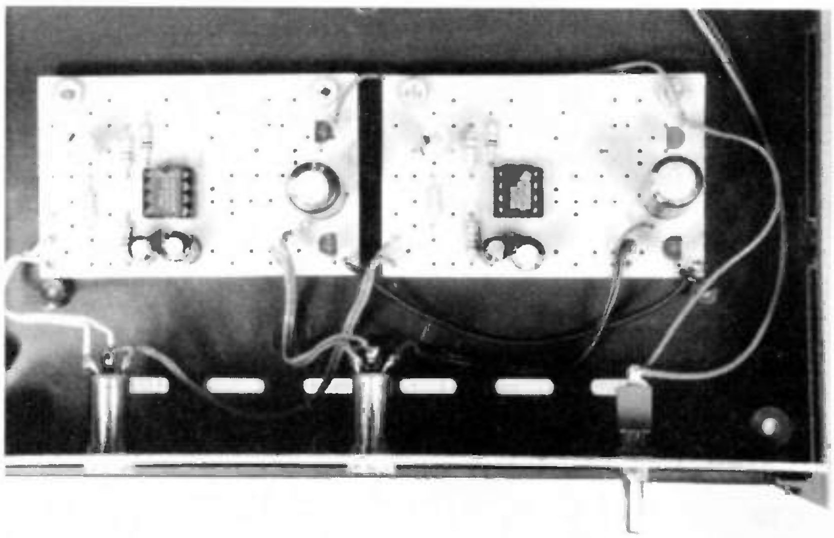


Fig.3. Printed circuit board component layout, copper foil master and interwiring for the Personal Stereo Amplifier. Double-check positions of components before soldering in place. Suggested layout of components inside the case is shown below.



there may be a noticeable loss of quality if less expensive operational amplifiers are used.

FINAL ASSEMBLY

Any medium size plastic or metal box should accommodate everything, but the size of the battery pack precludes the use of a very small case. The circuit can be powered from a smaller battery such as a "high power" PP3 type, but this is likely to be a relatively expensive way of doing things.

The low voltage gain and input impedance of the amplifier means that the layout is not critical, and you are free to locate things wherever you want them. The circuit boards are mounted on the case using either metric M3 bolts, nuts, and spacers, or plastic stand-offs.

If the unit is being made as small as possible it might be helpful to stack the boards one above the other. This will require the use of long mounting bolts, together with spacers about 12mm long between the two circuit boards.

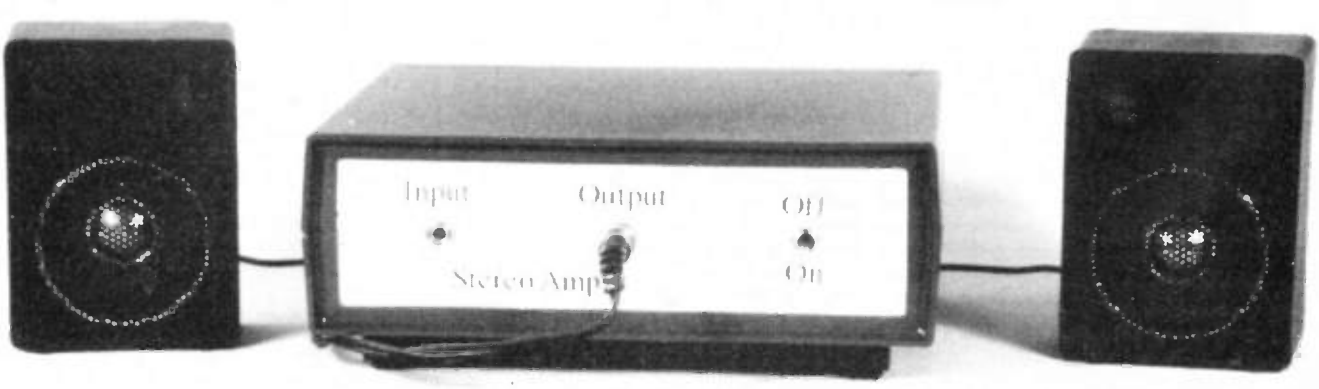
Once everything has been fitted inside the case the unit is completed by adding the hard wiring, see Fig.3 and photograph. Due to the low gain of the circuit it is not necessary to use screened leads at the input, or to worry about keeping the input and output wiring well separated.

Sockets SK1 and SK2 are 3·5mm stereo jack sockets, which match the connectors used on portable stereo units and the miniature loudspeakers. A lead fitted with two 3·5mm stereo jack plugs is needed to connect the personal stereo unit to the amplifier. These are available ready-made if you do not wish to make up your own. It is the type of lead used with computer soundcards.

Of course, if preferred the amplifier can be built in the form of a unit containing the amplifiers, battery and one loudspeaker, and a second unit containing the other loudspeaker. This is likely to be slightly more difficult, but it is a neater solution as it reduces the system from four boxes to three.

TESTING

After a thorough check of the finished amplifier, connect everything up, switch on, and check that the amplifier is functioning correctly. There should be no difficulty in getting plenty of volume from the system, but if necessary the gain of the amplifier can be boosted by raising the value of R4/R8 to 220 kilohms. □



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

The DMT-1010 is a 3½ 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 DMT-1010 Digital Multimeter to the author of the best *Readout* letter.

✭ LETTER OF THE MONTH ✭

ELECTRONICS HERITAGE

Dear EPE,

Bill Jackson's *Letter of the Month*, May '98, raised some important points about the way in which we electronics hobbyists approach our hobby, but your reply also highlighted one major misunderstanding prevalent among many readers; namely, that we amateurs should be trying in some way to emulate the activities of the industry.

The truth is, the nature of the hobby has changed significantly over the past two or three decades – gone are the days when we could build a hi-fi system (or even a "wireless" or TV set) cheaper or better than commercial units.

However, we have the industry to thank in that the flow of cheap or "obsolete" parts, from tuppenny transistors and a constant push to "new" technology leads to significant over-production of discrete components. Our hobby, to some extent, rides on the backs of these huge companies, where we amateurs can make good use of their cast-off components, be it for fun, or to solve problems or fill niches for which there are no commercial products, or even to undertake a little occasional amateur scientific research.

Bill Jackson's comments about simple test procedures are crucial to those of us on limited budgets, but even if I could afford the equipment, I would personally get a lot more out of measuring inductances with simple apparatus than I would do following the industry approach, which would no doubt involve a piece of apparatus costing in the region of £5000!.

If readers know of such techniques, I would much rather read about their implementation than another rehashed constructional project (no offence, *EPE*) using the latest i.c. (which no doubt will disappear in two years' time!).

But please, please, tell us the source of the information! Mr Jackson, in *which* book did you read about this technique? (You may have gathered by now that I need to be able to measure inductances too!) There are some very effective dodges and short-cuts out there, but the knowledge doesn't reside in the industry, where speed is king and cost comes second; rather, it dwells in the heads and notebooks of the enthusiasts, especially those who pursued electronics during an earlier era, together with articles residing in the rapidly dwindling library stocks of old magazines dating from the sixties and seventies.

Either way, these tricks are in danger of being lost, and we should pay more attention to preserving *them* than to collecting old wireless sets in museums.

Electronics as a hobby has never been more accessible or affordable than it is today, but we must regard yesterday's devices and techniques as resources rather than anachronisms. I'm very keen on discrete transistor circuits (they're *cheap*), but have had some difficulty tracking down enough circuit ideas to keep me fully occupied.

In the end I took advantage of my proximity to London and spent a couple of days in the British Library reading rooms at Holborn reliving my childhood with a notebook and the entire 1970's output of *Practical Wireless* and *Practical Electronics* (the British Library doesn't seem to have a stock of old *Everyday Electronics* – any suggestions where I could find them?)

I thoroughly recommend this approach to anyone living near a city library that might have a stock of such journals; who knows, it may even persuade the library service that those journals are worth keeping for future generations!

Come on, fellow enthusiasts, let's go into the new millennium not only with new technology, but also with a re-discovery and re-appraisal of our heritage, and encourage the next generation into realising that electronics is a truly rewarding pastime, a worthwhile education, and affordable at all levels.

Furthermore, I would opine there is currently no better forum for these principles than in *EPE*.

Philip Miller Tate,
Walton-on-Thames, Sussex

You are absolutely right, our heritage in all its aspects is so important to preserve – the list of things and techniques we try to preserve is imponderably long. Apart from the Science Museum in London, and an equivalent museum in Munich, I have come across few that preserve electronics technology (although I do remember a rural museum near Arundel – Chalk Pits Museum? – that had a display of early electronics components and magazines).

Preserving techniques, though, is a really problematic matter. Whilst, say, ancient techniques of sheep shearing and of weaving can be actively preserved, electronics techniques are less easy since the tools and components of past decades seldom escape destruction, and without them how can the skills in their use be maintained? But, yes, I agree that there are some fundamental skills which are in danger of becoming lost since the advent of computerised design and test facilities.

This reminds me of an SF story I read years ago in which the skill of writing by hand, in some distant future, had been lost due to total computerisation of manual skills – the punch line to the story was the "invention" of the pencil, what an incredibly versatile tool the author's hero had created!

Returning to your searches, we are surprised that you could not find ancient EE *in the British Library. We believe that all publications are required to be sent to and retained by the British Library – we are under an obligation to provide copies of* EPE *to the Library through an intermediary. You should discuss the lack of* EE *with a senior librarian – it is a matter that has greater significance than you might think: if one publication is not being preserved, what others are not as well? – a situation which is not in the interests of future historians.*

Readers, we recognise in Philip's letter the seeds of subjects which you might care to develop through this column, it's up to you; and you can even keep the skills of the pencil alive if you wish!

PIPPED BY THE POST

Dear EPE,

I am retired and tinker with electronics as my hobby, and look forward to the new mag every month. There are many projects I would really enjoy building but with my limited funds am unable to afford them.

Recently I built the *Draught Detector* (Sept '96), obtaining the thermistors from Electromail as suggested in *Shop Talk*. I was a little shocked at the cost of £3.87 for the pair, but required mouth to mouth resuscitation over the postage at £5.40, making a total of £9.27.

If one cannot obtain all the components from one supplier, postage costs make projects unviable. Living in Cornwall, telephoning around looking for parts and costs is very expensive and seldom taken into account when costing projects. Some advertisers in the mag charge as little as £1.25 for postage. Would it be possible to negotiate with one or more of these companies to stock all the components for each of your projects and save us all a lot of money, and they would also get a plug in *Shop Talk* instead of the greedy larger companies. Better still – *EPE* could stock kits for parts!

Harold Chamberlain,
Padstow, Cornwall

Yours is a perennial problem to which we have replied on many previous occasions in various ways. In a nutshell, we do encourage companies to kit our projects and you will find that ESR do this on a regular basis, whilst Magenta supply kits for some of them.

In many cases all the components can be purchased from the larger companies, but unfortunately some projects do require shopping around. This is inevitable since some of the components are quite specialised and are not necessarily stocked by all suppliers. We are sure that you would not want us to restrict the nature of projects in order to only use those parts common to all stockists. We try to stay close to the leading edge of technology and feel it is part of our remit to make use of more recent devices where the situation merits it.

There are, of course, some components which all constructors ought to keep in their own stock, such as regularly called for resistors and capacitors, enabling them to be bought in greater quantities, thus qualifying for quantity discounts.

It should also be remembered that large companies have larger overheads than smaller companies. Higher post and handling charges are an inevitable by-product of higher overheads. Where you can use a smaller supplier, it is often preferable to do so, as much as it is desirable to support local corner shops in preference to giant supermarket chains. The community at large suffers when smaller traders go out of business through lack of local support.

Regarding your last point, EPE *is committed to its principal role as a publisher and, apart from supplying p.c.b.s, does not wish to become a component supplier. In fact, it would be detrimental for us to do so as it would severely alienate those advertisers who specialise in components. We need advertisers as much as we need readers!*

TURN-AROUND

Dear EPE,

I agree with Mark McGuiness (*Readout* April '98) and identify myself as one of the people who moved from practical electronics to computers. On reflection, I feel that the magazines in the '80s contributed to their own decline in popularity by publishing so many of those specialist circuits for micro computers such as the BBC, Amiga, Atari etc. Many had complex p.c.b.s. with masses of large scale integration i.c.s for interface type projects which few of us wanted to build.

For me you have now turned it all around with the excellent *EPE PIC Tutorial*. At last someone has written an article that I can understand and work with. I cannot wait for more information, either through projects or programming items.

For my part, I would like to see some PIC software ideas as, perhaps, an extension to the Tutorials, illustrating how the PIC can be made to communicate using a single I/O with other PICs connected by just a twisted pair. Perhaps in a nurse-call or alarm type system. I live in hope.

Also, I particularly agree with your reader that what the majority of hobbyists prefer to see is a regular supply of innovative, simple to construct projects which are unusual or not generally available. I am sure many readers will agree that the *Ingenuity Unlimited* column is the first place to peruse for such ideas. Perhaps we could all take a leaf out of Mark McGuiness's book and become contributors to this column.

Indeed, I have just taken my own advice and posted off an item to *IU*.

Come on you hobbyists, dig out your circuits and let's show we are still out here!

Don Clark,
Seaford, E.Sussex

It is gratifying to know that so many of you are appreciating the PIC Tutorials *and that you are making good use of the information.*

Whilst I agree that computers were partly responsible for a decline in the popularity of constructional electronics, I cannot agree that we were mistaken to publish projects associated with them. Then, as now, we responded to reader demand and published projects which reflected the moods and desires of the period. Remember also that today's computer compatibility did not exist in the era you refer to – there were several systems vying with each other and we had to cater to needs of readers who used them.

We welcome your suggestions for IU *and PIC support (your offering is in the hands of Alan W. and will appear in due course). We'll do our best to fulfil all your hopes!*

BYTING CHIPS AND CONVENTIONS

Dear EPE,

I am in total agreement with your statement in *PIC Tutorial Part 1* about byte sizes and can offer two more references:

* A group of bits taken together and treated as a unit in a digital computer. *The New Penguin Dictionary of Electronics* – Penguin Books and Allen Lane 1979
* A byte is a unit of storage in a computer. *BBC English Dictionary* – BBC English and HarperCollins Publishers 1993

However, the following books, of which the first three are US school and college text books, all define a byte as eight bits:

* *Basic Electronics* – Bernard Grob
* *Understanding Electricity and Electronics Technology* – Buban Schmitt and Carter
* *Digital Electronics* – William Kleitz
* *Computer Engineer's Pocket Book* – Mike Tooley (abridged edition)

Unfortunately, popular usage has ensured that many people will insist on the 8-bit definition and indeed without that definition what would 64Mb of RAM or a 6·4Gb hard disk mean? I think those of us who think otherwise are fighting a losing battle!

Another word that has changed its meaning is "chip". This is defined in the *Penguin Dictionary of Electronics* as "A small piece of a silicon crystal of semiconductor material containing either a single component or device or an integrated circuit ... chips are not normally ready for use until suitably packaged".

The *BBC English Dictionary* definition is "... a very small piece of silicon with electric circuits on it which is part of a computer". This is, perhaps, a subtle change of meaning but it has occurred in quite short space of time, mainly as a result of misuse by the media who cannot resist headlines such as "Chips with everything"!

Moving on to *Crazy Conventions* (*Readout* June '98), I re-read Jose Antonio's letter and can find no evidence that he was confused by the use of conventional current flow. I think it more likely that Martin Baxter's students will be confused when they have to relate what they have been taught to the real world of circuit diagrams where the symbols for diodes and transistors have arrows pointing in the direction of conventional current flow.

One thing in the *Teach-In* authors' reply puzzles me: how do they justify the statement that "physics is a branch of electronics, and not the reverse"? Not when I was at school! I cannot find any dictionary that supports their view, in fact the *Little Oxford Dictionary* (OUP 1968) states that electronics is a "branch of physics and technology . . .".

Barry Taylor,
Rickmansworth, Herts

Thanks for adding to the discussion Barry, and for your other interesting comments (your Singapore/Oz trip obviously revealed amazing opportunities for computer buffs).

I shall presume to answer your last statement without referring to the TI Team. My understanding of their statement is that to us on EPE, it is electronics that we are teaching, a subject which at its baser level needs little reference to the much broader field of disciplines as encompassed by physics as a whole. We therefore only "branch" into broader aspects of physics when relevant to our own specific discipline. Consequently electronics is our main stream, and "physics" is treated as a set of tributaries to that stream. It's simply a matter of our relativistic view point!

WHY A PC?

Dear EPE,

In your reply to Hugh Smith (*Readout* June '98) you recommend buying a PC. This isn't a great idea for someone who wants to write assembler. Very few companies have access to the huge volume of source code that is required to get the attention of Windows, open a window and start your code. It is even overwhelming in C. So, on a PC most programs seem to be written in Basic where a huge library file is required for even the smallest of programs – it's expensive too.

The next problem is portability – the Windows 95 programs don't run on Windows 3.1 systems etc. There is also the problem of obsolescence – this year's bus won't accept your old "cards" so you've got to buy new cards if you upgrade. The CPU (80486 or whatever) is also about to be superseded by a RISC chip so all your software may well shortly need replacement if you go this route.

I would recommend that Hugh buys an Amiga 1200 with a monitor or Scart TV and a memory expansion or accelerator card and tries all the various Public Domain C or Pascal compilers and assemblers. There are many available on the Amiga for Z80, PIC, 8052 and many other processors too.

John Gray,
London N10 2NU

I have no knowledge of the Amiga, other than being aware that a decade or more ago Amigas were a respected make with their own architecture system. What you have said does not reassure me that such computers are now compatible with what most of the world seems to be using these days for the majority of its serious software use.

In my reply I did not say that a PC should be bought – as I understand it, the term PC is, strictly speaking, a copyrighted term owned by IBM and referring to a specific base architecture within any IBM computer to which the term applies. What I recommended is a PC-compatible computer, i.e. one which, while possibly having its own architecture, also has the ability to emulate a true IBM-PC, using the same (apparent) addresses for all the relevant registers etc., allowing it to run the same software.

Providing it has this ability, I see no reason why any make of computer should not be used. But PC-compatibility is essential unless you want to get sidelined. I am told that even the well-renowned Apple-Mac system has had to bow to this – they basically use a different, though excellent, architecture of their own, but have included additional protocols which emulate the PC-compatible environment.

All the stated things you do on your machine, I can do on mine. Why do you think Windows gets in the way? It needn't – ignore Windows and work through the DOS environment. All my assembler-programming I do on inexpensive (including shareware) software that can run without Windows intervention.

It is not clear why you consider the '486 to be the latest in processors; we are well beyond that benchmark having progressed through several versions of the original Pentium (which some might call a '586 – Greek pente *– five) and into the realms of the Pentium II. I suspect that if you really researched the latest PC-compatibles you too would be converted to embracing their abilities and be able to enhance your own.*

At the very least, you are currently missing out on the software which we release on disk for many of our projects. You additionally miss out through not having access to the Internet. Some may decry the Net's possibilities, but I have found it to be the most incredible reference library ever invented, and for anyone involved in electronics or computing, is an astonishingly useful provider of data sheets and software.

Anyone who still thinks the Net has nothing for them, simply has not understood its capabilities or tried it in a meaningful manner. It is far more than just a chat-line variant – as some seem to regard it.

Readers, we invite your views on these (perhaps controversial) subjects!

CAR CONNECTIONS

Dear EPE,

In answer to Dave Clarke's letter (*Readout* March '98) on connecting to vehicle wiring, I would like to tell you how I do mine.

I go to the local Lucas dealership and purchase the male/female contacts and the appropriate male/female housings. These connectors were used on the Austin range of cars. They are available with 1, 2, 3, 4, 5 and 7 terminations.

Cut the wire you wish to use, strip the insulation off, twist both together again and crimp on the female connector pin. Solder and push into the housing (it is normally the one that has no shoulder). Strip the wire of the project, then crimp and solder the male pin onto the project wire and push this into the other half of the housing. Simply connect together and repeat with the other wires.

The beauty of this method is that, when you wish to sell the car, the project can be unplugged and taken out.

Robert Knights,
Royston, Herts

Very useful info, and a good example of forward thinking at the end!

PROTEUS

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Schematic Capture

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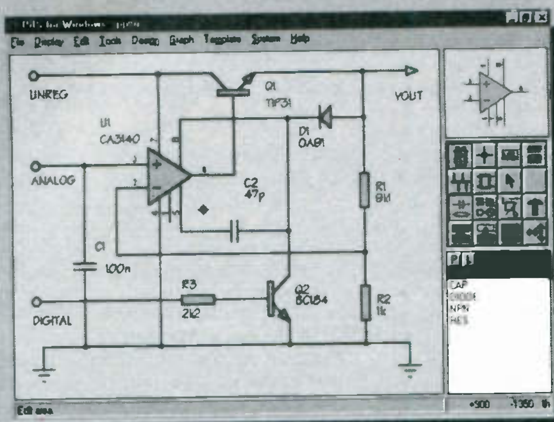

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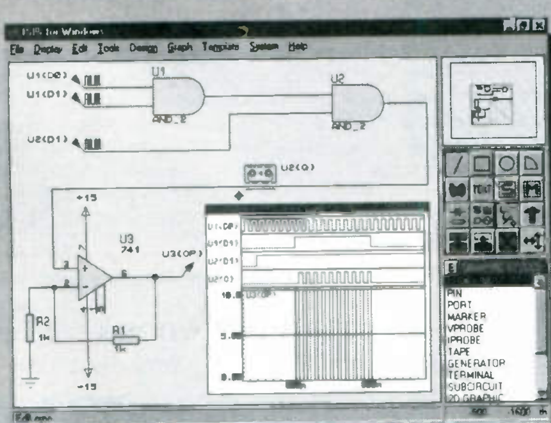

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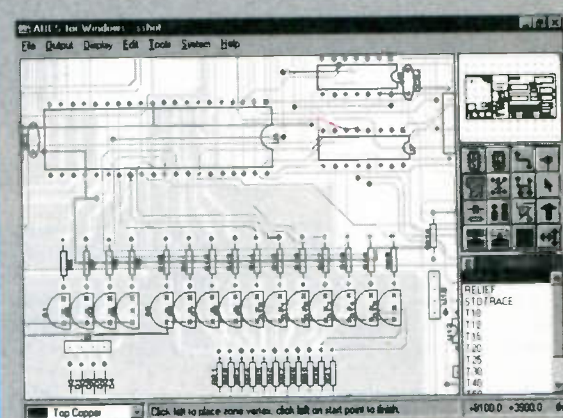

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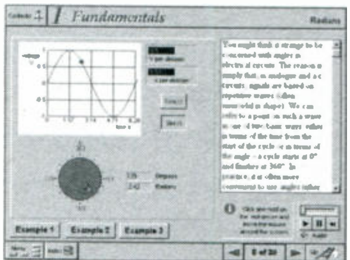
ELECTRONIC CIRCUITS & COMPONENTS + THE PARTS GALLERY
by Mike Tooley

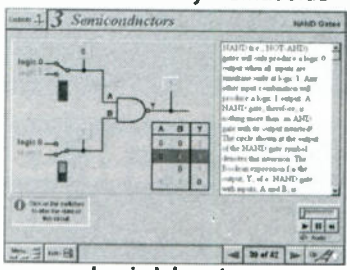
ELECTRONIC CIRCUITS & COMPONENTS

Electronic Circuits & Components provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding as they proceed through the sections on the CD-ROM. Sections on the disk include:

Fundamentals: units & multiples, electricity, electric circuits, alternating circuits.
Passive Components: resistors, capacitors, inductors, transformers.
Semiconductors: diodes, transistors, op.amps, logic gates.
Passive Circuits
Active Circuits



Virtual laboratory – sinusoids

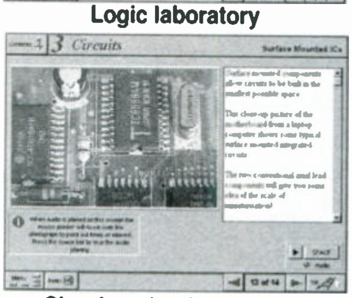


Logic laboratory

THE PARTS GALLERY

Many students have a good understanding of electronic theory but still have difficulty in recognising the vast number of different types of electronic components and symbols. *The Parts Gallery* helps overcome this problem; it will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Selections on the disk include:

Components
Components Quiz
Symbols
Symbols Quiz
Circuit Technology



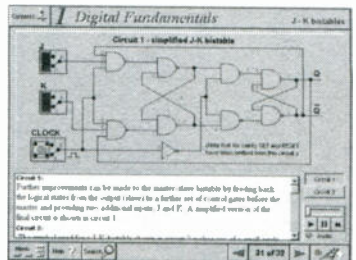
Circuit technology screen

Hobbyist/Student .... £34 inc VAT
Institutional (Schools/HE/FE/Industry) .... £89 *plus* VAT
Institutional 10 user (Network Licence) .... £169 *plus* VAT

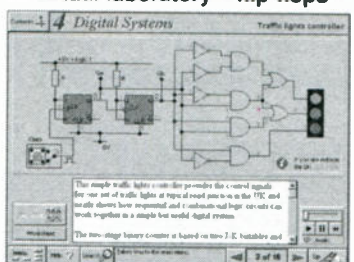
DIGITAL ELECTRONICS
by Mike Tooley

NEW

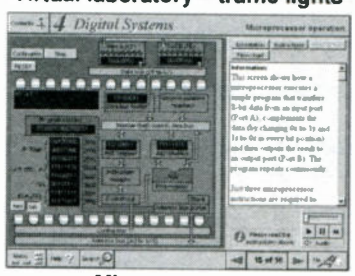
Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components*, and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.



Virtual laboratory – flip-flops



Virtual laboratory – traffic lights



Microprocessor

FUNDAMENTALS

Fundamentals introduces the basics of digital electronics including binary and hexadecimal numbering systems, ASCII, basic logic gates and their operation, monostable action and circuits, and bistables – including JK and D-type flip-flops

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A/D and D/A converters and their parameters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic unit.

GALLERY

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EE50

Constructional Project

PIC ALTIMETER

JOHN BECKER

Reaching for the heights? Keep track of your progress!

THE atmosphere – 5000 billion tons of air surrounding our planet, its effective pressure increasing the deeper we are below its tenuous surface.

Using a PIC microcontroller and a temperature-compensated pressure sensor, we describe how this pressure can be measured and interpreted as a relative height above sea-level.

The circuit is remarkably simple to build, with the microcontroller performing the sophisticated calculations. An intelligent liquid crystal display shows the pressure in millibars, and the height in both metres and feet. Ambient temperature is also displayed, with a choice of Centigrade or Fahrenheit scale.

Setting-up requires little more than an Ordnance Survey map and a glance at the BBC TV weather chart, plus an ordinary thermometer. You would also find it useful to have a hill near you!

WE'RE ALL UNDER PRESSURE

Three quarters of the Earth's atmospheric pressure is held within the first seven miles above the surface, although its presence can still be detected at around 500 miles high, as depicted in Fig.1.

The amount of pressure exerted at any point within the atmosphere is relative to the depth below its surface and to its density at any given moment. The Earth has a surface area of about 197 million square miles and at sea level the average pressure is about one kilogram per square centimetre (14·72 pounds per square inch).

As a round figure, at sea level the average pressure is expressed as having a value of one *bar*, although we are probably more accustomed to it being expressed as 1000 millibars (mb). More precisely, meteorologists take the average atmospheric pressure at sea level as 1013·25mb measured at an air temperature of 0°C and at a latitude of 45°.

The term *bar* comes from the Ancient Greek word *baros* meaning *weight*. From the same source also comes *metron* (*measure*), which has provided our word *meter*. Hence *barometer*, a device to measure weight; of air in this case.

Water, by contrast to air, has a much greater density. At a depth of 10 metres, sea water exerts the same pressure as the entire mass of air above it, one bar. The deeper under the sea we descend, the pressure increases linearly at a rate of one bar per ten metres of depth.

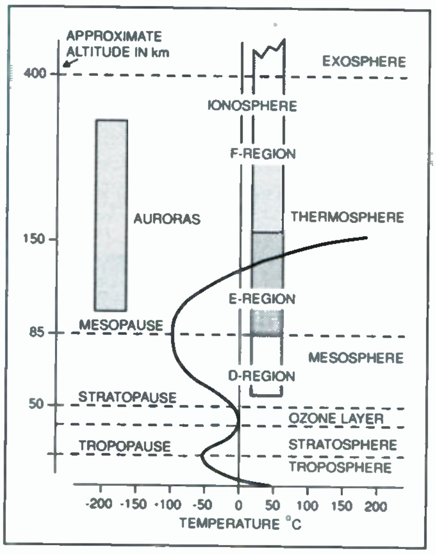


Fig.1. Atmospheric layers.

Similarly, the higher we rise in the atmosphere, so the pressure of the air above us decreases. There is a significant difference, though, between changes of pressure with water depth and atmospheric depth.

Whereas water cannot be compressed into a smaller volume (and so its depth-to-pressure has a linear relationship), air density within a given volume changes in relation to the pressure on it. Consequently, the relationship of air pressure to height within the atmosphere is not linear. The pressure relationship between water depth and atmospheric depth is shown simplistically in Fig.2.

Conveniently, however, within the first 5000 metres or so above sea level, the air pressure to height relationship can be regarded as linear, allowing it to be used as the basis for a barometric altimeter. (Note that the term *height* will be used to mean *altitude* throughout this article.) To all intents and purposes, within this range a change in pressure of 1mb is equal to an equivalent change in height of 10 metres.

IN TURMOIL

There is a major problem, though, when using a Barometer to determine height. As we all know, the atmosphere is in constant motion, incessantly swirling and changing under the influence of the sun and the moon, and the great stirring action of the land masses below it. Its density, too, is affected by the amount of moisture held within it.

As a result, the atmospheric pressure at any given point is never static. It rises and falls in the same way that the waves on the sea surge up and down, varying the pressure on the sea bed.

If you examine an ordinary Barometer, you are likely to find that its scale extends from about 940mb to 1060mb. Whilst you may never encounter pressures at these two extremes at sea level, you could experience the lower value by climbing up a mountain, and the higher value by descending deep into a mine.

You will no doubt recall the infamous storm of 1987. On 15 October, the centre of the storm in the English Channel had a pressure of 960mb, descending further to 954mb by the time the storm reached the Shetlands.

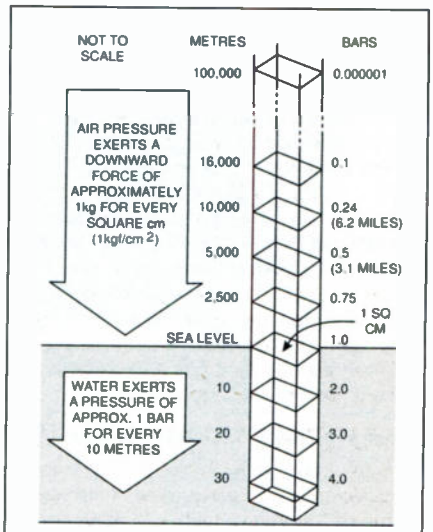


Fig.2. Atmospheric and hydrostatic pressure.

Historically, the lowest pressure recorded was on 24 September 1958, during hurricane *Ida* in the Pacific. Disappointingly, no record of the highest pressure experienced has been found.

RELATIVITY

Any random fluctuation of atmospheric pressure obviously has a bearing on the accuracy with which height can be determined barometrically.

Suppose, for example, that the atmospheric pressure shown on a Barometer at sea level is 1000mb. Assuming a height-to-pressure change ratio of 10:1, at the same instant the pressure at a height of 1000 metres will be 900mb.

However, if there is a time lapse between taking a reading at sea level and another at 1000 metres, although the former reading might show 1000mb, that taken at 1000 metres may not necessarily show 900mb. The overall atmospheric pressure may have changed in the time between the two readings, resulting in a height reading that may be above or below the actual height.

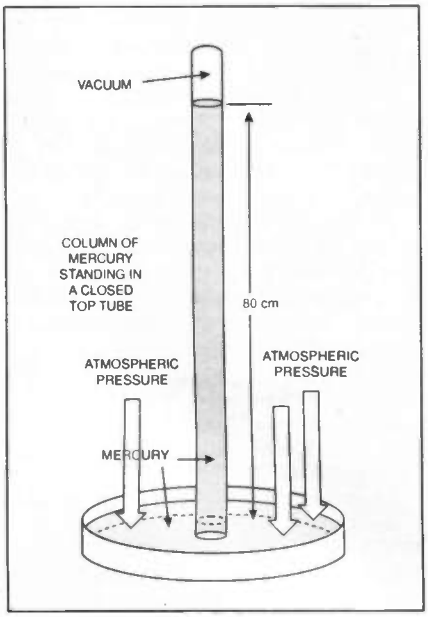


Fig.3. Mercury column supported by atmospheric pressure.

An Altimeter based on barometric sensing, therefore, can only give an approximate indication of height relative to a known starting point.

Nonetheless, unless precision accuracy is required (as with many aircraft), the technique is perfectly usable over a limited period of time, and is the method used in the PIC Altimeter described here.

Whilst this altimeter is not intended for aircraft use, it is well suited to walkers and cyclists, and perhaps balloonists and hang-glider hangers! In other words, to anyone out and about who wants to know roughly how high they've climbed or descended.

It can also be used just as a barometer in a fixed position in your home.

BAROMETRIC INCHES

You may well have heard weather forecasters give barometric readings in terms of "so-many inches" rather than in millibars.

Traditional barometers, whose origins long predate modern mechanical and electronic devices, consist of a narrow-bore glass tube which is sealed at one end and filled with mercury (invented by Torricelli in 1643). The open end is immersed in a reservoir of mercury and the tube stands upright, as in Fig.3.

The weight of the mercury creates a vacuum gap at the top of tube, the volume of which varies according to the weight and the opposing atmospheric pressure on the reservoir. Changes in air pressure cause the column of mercury in the tube to rise or fall accordingly. The height of the top of the mercury relative to the top of the reservoir thus represents a measure of the pressure.

Using this technique, another definition for one atmosphere of pressure is the pressure that will support a column of mercury 29.92 inches (760mm) high. Again this is related to 0°C, sea level and latitude 45°. The origin of quoting pressure in inches now becomes obvious.

The more recent aneroid barometers are mechanical devices. They consist of an evacuated metal cylinder, flattened and ribbed at each end, with an internal spring to prevent complete collapse. Changes in external pressure on the cylinder react against the spring, causing the distance between its ends to vary. An attached pointer moves in sympathy and so indicates the relative pressure. Calibration is usually made against a mercury barometer.

ELECTRONIC SENSOR

For several years, electronic equivalents of aneroid barometers have been available. The type used in this altimeter, Sensym's SCC15A, has an enclosed and evacuated chamber, in common with the above mechanical one. As part of the chamber, it uses a strain sensor made from a piezo-electric material which generates a voltage dependent on the pressure to which it is exposed.

Unlike some sensors, the SCC15A is temperature compensated and has been manufactured to automatically compensate for the temperature changes to which it is normally subjected.

Uncompensated sensors require additional circuitry that has to be "tuned" to correct for temperature drift – as in

COMPONENTS

Resistors

R1, R9 to R12, R16 to R20	10k (10 off)
R2	3k3
R3	750Ω 1% metal film
R4	56Ω 1% metal film
R5, R7	4k7 (2 off)
R6	68Ω
R8	2k2
R13 to R15	100k (3 off)

All resistors 0.25% 0.5W carbon film or better, unless marked.

Potentiometers

VR1	5k sub-min round cermet
VR2	10k sub-min round cermet

Capacitors

C1	2n2 polystyrene
C2, C3	10p polystyrene (2 off)
C4	22µ radial elect, 16V
C5	100n polyester

See SHOP TALK Page

Semiconductors

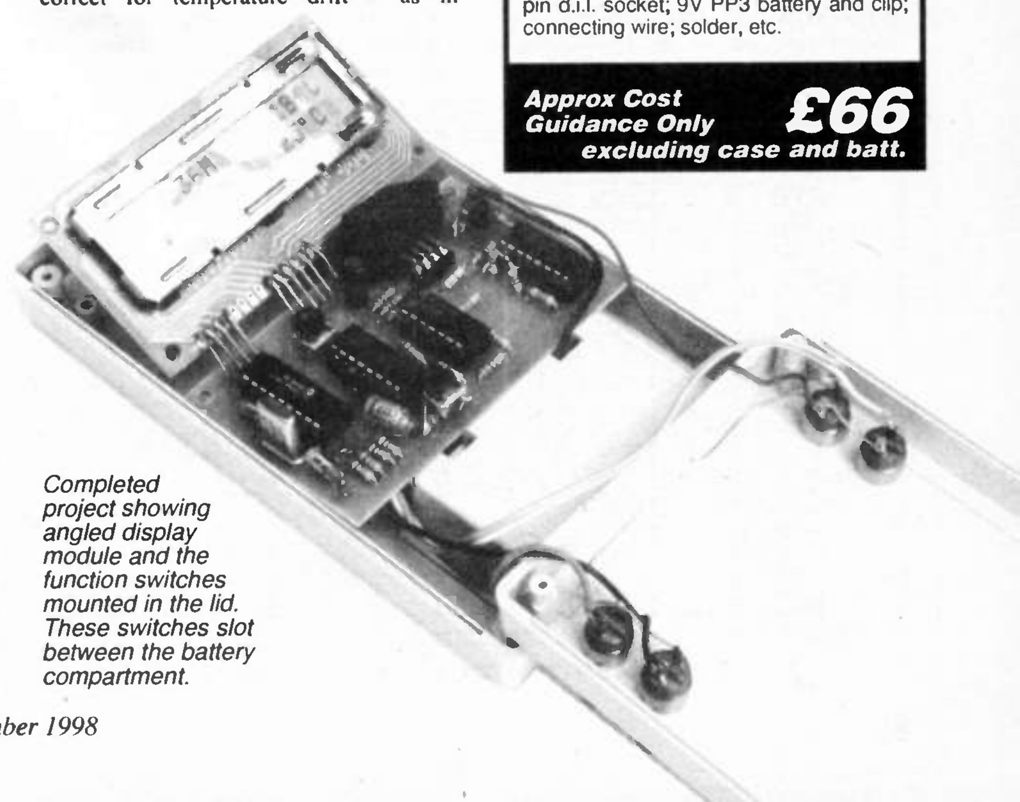
IC1	LM324 quad op.amp
IC2	4052 dual 4-way analogue multiplexer
IC3	4046 phase locked loop
IC4	PIC16C84 or PIC16F84, pre-programmed microcontroller (see text)
IC5	78L05 +5V 100mA voltage regulator

Miscellaneous

S1 to S4	min. single-pole pushswitch push-to-make (4 off)
S5	min. s.p.s.t. toggle switch
X1	SCC15AN temperature compensated pressure sensor
X2	3·2768MHz crystal
X3	2-line 16-character intelligent l.c.d. module (0V/+5V version)

Printed circuit board, available from the *EPE PCB Service*, code 201; plastic case to suit (see text); 4-pin s.i.l. socket; 14-pin d.i.l. socket; 16-pin d.i.l. socket (2 off); 18-pin d.i.l. socket; 9V PP3 battery and clip; connecting wire; solder, etc.

Approx Cost Guidance Only £66 excluding case and batt.



Completed project showing angled display module and the function switches mounted in the lid. These switches slot between the battery compartment.

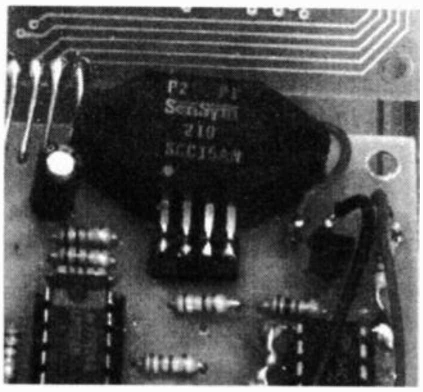
Table 1. Basic characteristics for the SCC15A pressure sensor

Operating Pressure Range	0 to 15psi
Maximum Over-Pressure	30psi
Accuracy	0·50%
Temperature effect on span (0 to 50°C)	1·50%
Temperature effect on offset (0 to 50°C)	2·00%
Full-scale span (in mV)	30 to 95

Table 2. Extreme characteristics for the SCC15A pressure sensor

Characteristics	*Minimum*	*Typical*	*Maximum*	*Unit*
Zero Pressure Offset	−20·00	0·00	+20·00	mV
Combined linearity, hysteresis, repeatability	–	0·10	0·50	%FSO
Temperature effect on span	–	0·25	1·50	%FSO
Temperature effect on offset	–	0·50	2·00	%FSO
Long term stability of offset and span	–	0·10	–	%FSO
Response Time (10% to 90%)	–	0·10	–	ms
Input Impedance	–	5·00	–	kΩ
Output Impedance	4·00	5·00	6·00	kΩ
where: FSO = full scale output	Supply current = 1·5mA		Ambient temperature = 25°C	

Note that this device is powered by a constant current and not by a specific voltage, consequently operational voltages are not quoted, these being dependent on the current generating source used to power it.



Close-up view of the pressure sensor showing its pins bent at right-angles, pugged into the s.i.l. socket and soldered in position. Note the "spot" indicating pin 1.

the *EPE Altimet* of Nov '92, for example, which used the low cost MPX100A device.

The SCC15A pressure sensor is a bit more expensive than the MPX100A, but is worth the extra. Table 1 and Table 2 show its characteristics.

SENSING CIRCUIT

Details of the complete barometric pressure sensing circuit are shown in Fig.4. Apart from the insertion of IC2, the circuit is a minor variant of the one recommended in the sensor's data sheet.

The SCC15A sensor (X1) is used as a negative feedback component in the inverting op.amp configuration around IC1a. The reference voltage for the circuit is provided by the potential divider formed by resistors R1 and R2.

Current flow through the sensor is equal to the reference voltage divided by the total value of resistors R3 and R4, namely 806 ohms, a value recommended by the manufacturer (but not readily available as a single component).

There are two outputs from the sensor X1, at pins 2 and 4. They have a differential relationship – when the voltage on one rises, the other falls.

With multiplexing gate IC2 in its "normal" mode, the outputs from the sensor pass through paths X0 to X and Y0 to Y, to the non-inverting inputs of op.amps IC1b and IC1c. These are configured for conventional differential amplification in association with IC1d, the output from which (at pin 7) is now suitable for analogue-to-digital conversion.

An additional potential divider is included prior to IC2. It is formed by resistors R5 to R7 which are connected between the positive supply line and the 0V line. This configuration forms the basis for a temperature monitoring facility controlled by the software.

Although the sensor itself is temperature compensated, the rest of the circuit is not. As you know, the characteristics of any electronic device are subject to change in relation to the device's temperature. The purpose of the twin-node potential divider is to provide a reference value against which the software can make corrections.

The voltage across resistor R6 is referenced to the nominally-stable +5V supply line. When IC2 is in its secondary mode, this voltage is fed through paths X1 to X, and Y1 to Y, to be amplified identically to the sensor voltage. It is at the amplifier and the subsequent analogue-to-digital stage that temperature-related changes are likely to occur.

In the initial setting-up, the software stores the reference value existing at that time. From then on, any deviation from that value is used to correct the value of the sensor's output, and to provide the basis for calculating ambient temperature, as discussed later.

Software alternately switches IC2 between the reference and sensor modes via IC2's control pin 10.

DIGITAL CONVERSION

The altimeter's control circuit is shown in Fig.5. In it, IC4 is the PIC microcontroller, X3 the liquid crystal display module, and IC3 the device used in the analogue-to-digital conversion.

A phase-locked loop chip, IC3, is used as a voltage-to-frequency converter (v.f.c.). The output frequency is relative to the voltage received from the amplifier. The software assesses the frequency as a count value which is used as the base for subsequent calculations.

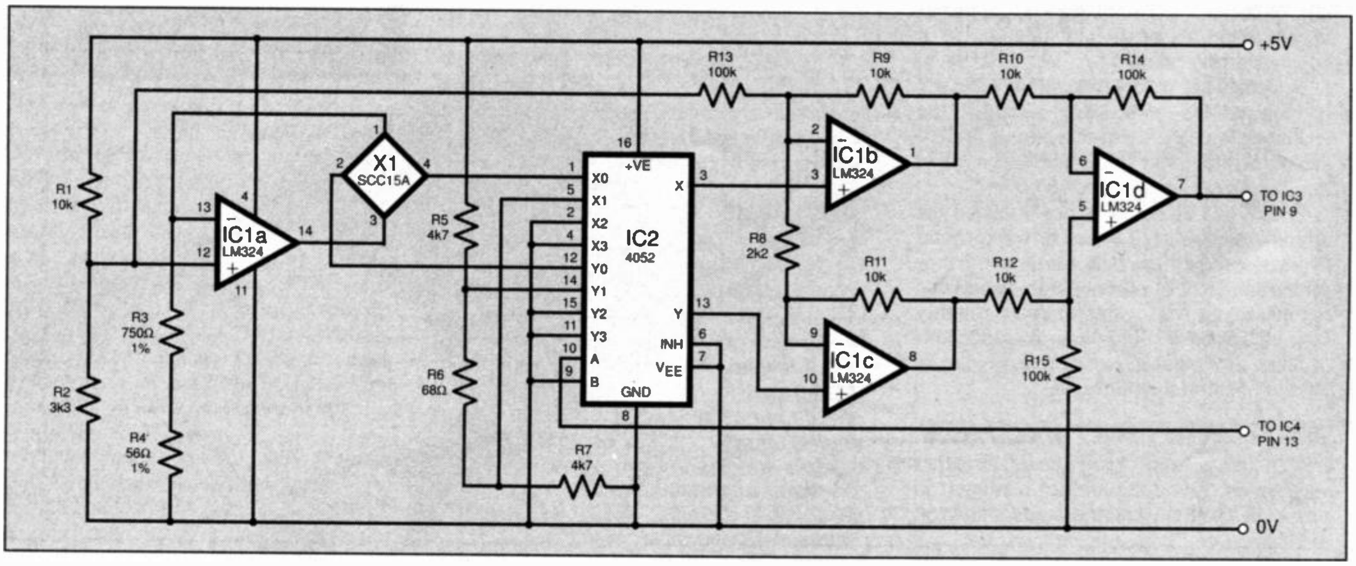


Fig.4. Complete circuit diagram for the barometric pressure sensing section of the PIC Altimeter.

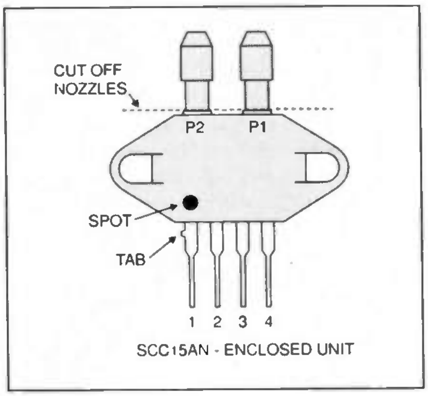


Fig.6. Pinout details for the enclosed version of the SC15A pressure sensor.

This technique allows for a far wider conversion range than would a standard 8-bit analogue-to-digital converter.

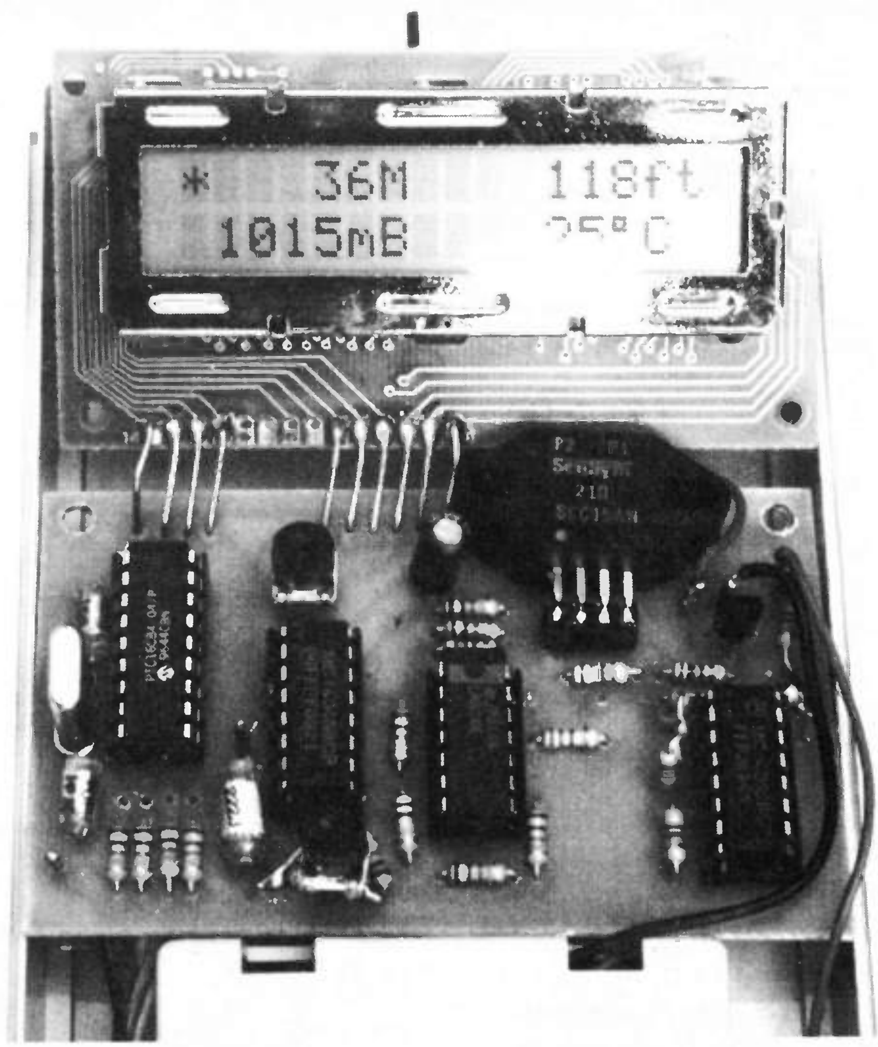
During setting-up, the frequency is displayed on the l.c.d. screen and all you need to do is to adjust preset VR2 until the frequency is within a particular range (it's straightforward).

Power is supplied to the circuit by a 9V battery and regulated down to 5V by IC5 for use by the rest of the circuit. The PIC is configured to run at 3·2768MHz, as set by crystal X2.

L.C.D. MODULE

The l.c.d. module displays different calculation results depending on which routine the software is performing, as set by switches S1 to S4. The display has two lines of 16 characters each and is operated in 4-bit mode. Preset VR1 adjusts the screen contrast.

Only the single supply (0V/+5V) type of l.c.d. can be used in this circuit. The type which additionally requires a negative voltage is not suitable.



Layout of components on the completed prototype printed circuit board. In this photograph, capacitor C5 has been soldered to the track side. However, in the final version, space has been found for it between IC3 and the bank of resistors just above IC1, see Fig.7. The l.c.d. module has been linked to the p.c.b. using resistor lead off-cuts. This enables the display to be angled to match the case display slope.

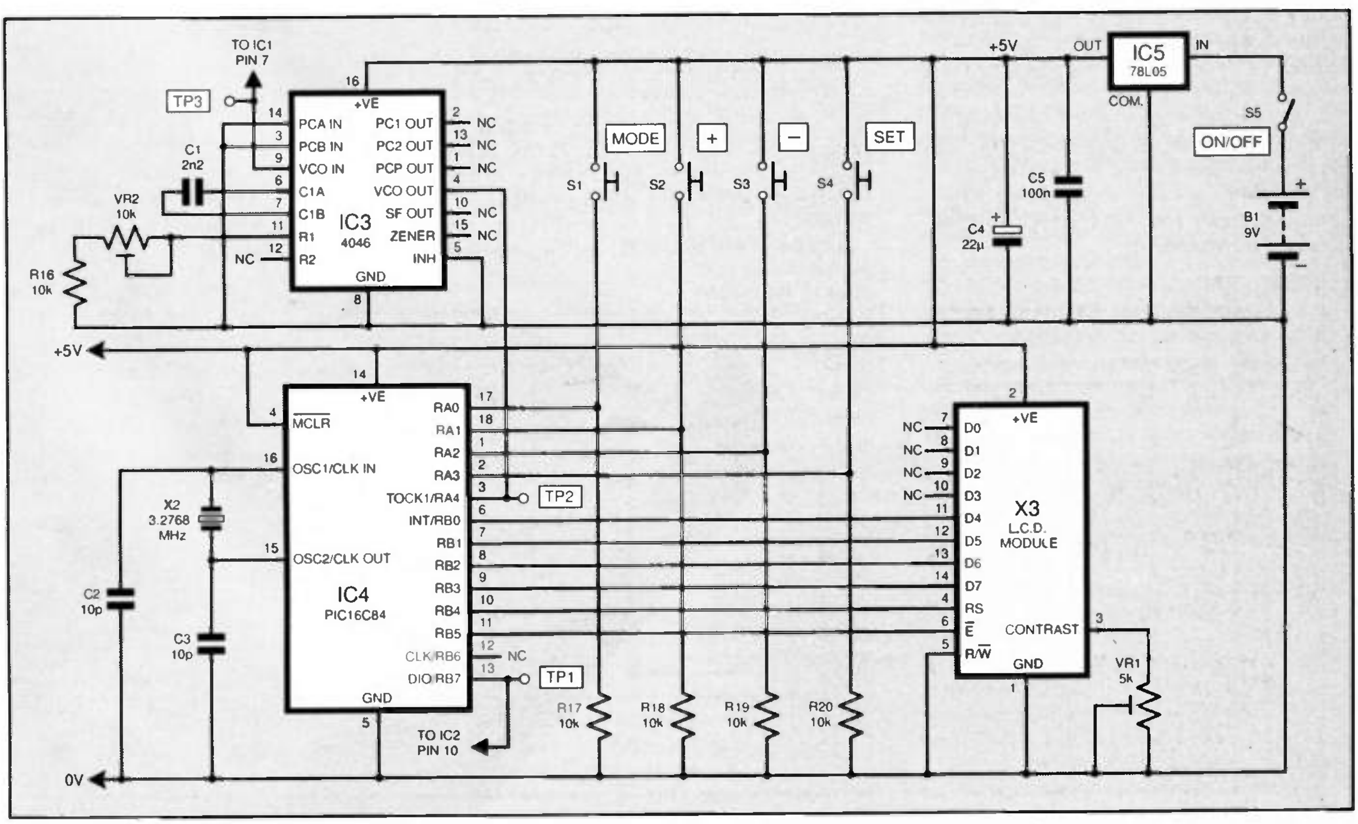


Fig.5. Circuit diagram for the control/display and supply regulator section of the PIC Altimeter.

CONSTRUCTION

Details of the topside component and underside track layouts for the printed circuit board (p.c.b.), together with those for off-board interwiring, are shown in Fig.7. This board is available from the *EPE PCB Service*, code 201.

First insert the on-board link wires and then assemble in order of component size. Use d.i.l. sockets for IC1 to IC4, and a 4-pin s.i.l. socket for the sensor. Note that two link wires are sited beneath IC2 and IC3.

The sensor X1 may come in one of two package types, as a "naked" device or with a plastic encapsulation having two nozzles (Fig.6). Carefully cut off the nozzles (the author used a Stanley knife), ensuring that the two holes below remain open. **DO NOT poke anything into the holes.**

Using thin-nosed pliers to grip the sensor's legs close to the body, and with the sensor's imprinted identity uppermost, bend the tips of the legs down to a right angle. The length of the angled tips should be long enough so that they push into the 4-pin s.i.l. socket and allow the sensor body to sit on the p.c.b. (about 3mm).

Ensure that the sensor's pin 1 (indicated by a dot on the identity side) is to the left when looking at the p.c.b. as in Fig.7.

Once you are satisfied that the entire assembly is functioning correctly, it is suggested that you solder the sensor's pins to the socket to provide stability.

CASE AND L.C.D.

The way in which the l.c.d. is connected depends on the case used. There-in lies a problem!

A search was made through various catalogues for a case which had a slot to suit this size of l.c.d. None could be found.

After further searching, one of RS Components' cases was thought to be nearly suitable. Although it had a slot somewhat larger than needed, it was felt this could be masked off in some way. The quoted measurements for the case itself appeared to be just large enough for the l.c.d. width, and it also had a PP3 battery compartment. It was ordered, and is the one seen in the photographs.

However, on receipt, the box was found to have tapering sides whose minimum measurements were less than expected. By carefully filing down the edges of the l.c.d., it was made to *almost* fit, but not quite flush with the lid. Nonetheless, it was decided to use the case.

It is suggested, though, that if you can find a case more suited, then use it (and tell the author about it). It seems that there ought to be ready-made cases suited to this size of l.c.d. somewhere on the market. There are plenty for the smaller 2-line by 8-character l.c.d. modules, why not for the 2 × 16?

Alternatively, you could use an ordinary plastic case and cut your own slot for the l.c.d.

With the author's unit, the l.c.d. was connected to the p.c.b. using short resistor off-cut wires (see photograph). The two end wires were inserted and soldered first, enabling the distance between the l.c.d. and p.c.b. to be set evenly and clear of the sensor. The remaining wires were then shaped and inserted.

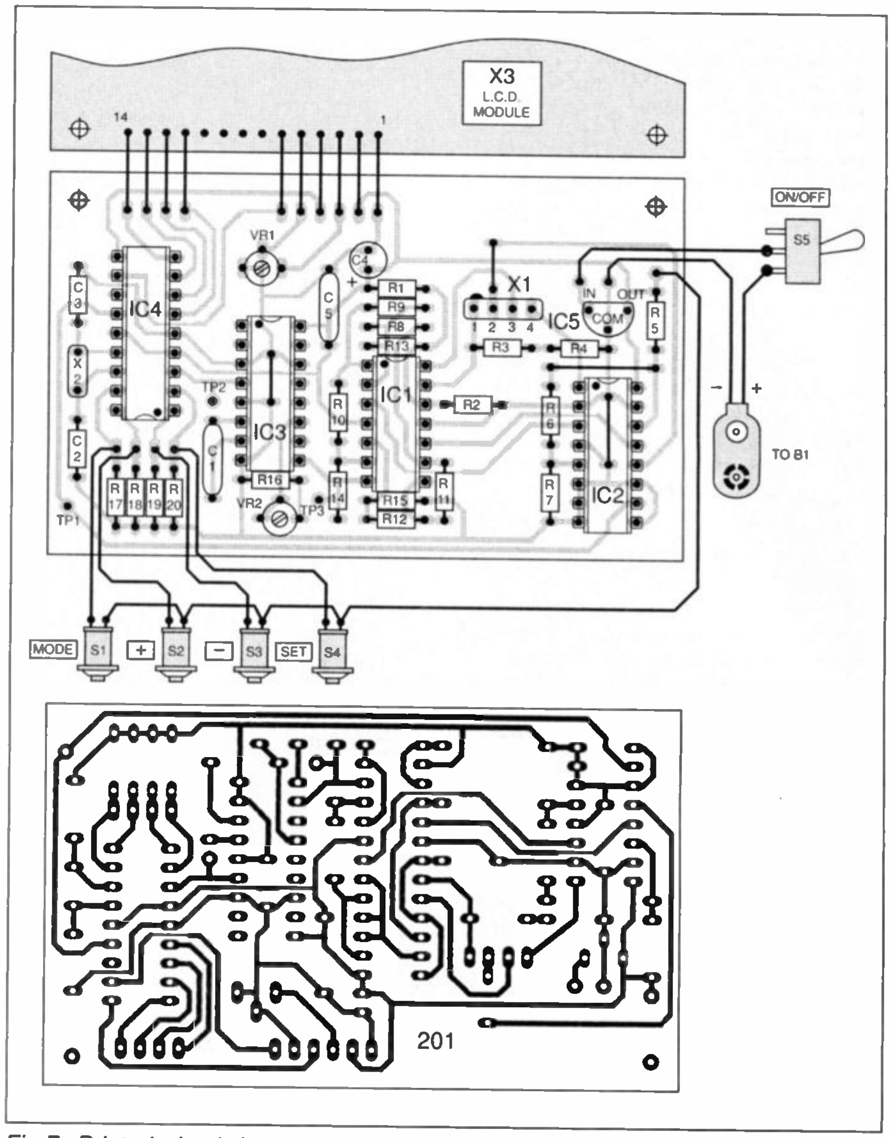


Fig.7. Printed circuit board component layout, off-board interwiring and full size copper foil master for the PIC Altimeter.

The elevated slope of the l.c.d. to the p.c.b. was then adjusted so that with the p.c.b. mounted in the case, the angled l.c.d. would be in line with the slot. The height of the p.c.b. was adjusted using spacers to obtain the best (though not perfect) fit.

The pushswitches were positioned so as to be clear of the battery compartment. The power on/off switch was mounted at the rear.

PIC Altimeter display window and front panel function switches.

TESTING

With IC1 to IC4 omitted, switch on the 9V power supply and check that 5V is present on the output pin of IC5. A voltage greater than this (e.g. 7V) will indicate that IC5 is the wrong way round.

Switch off the power and insert IC1 to IC4. Note that microcontroller IC3 must have been pre-programmed with its software. It may be either a PIC16C84 or a PIC16F84 – they are interchangeable in this circuit.

At switch-on, the program goes straight into an l.c.d. initialisation routine and then into Screen 1 Mode 1. It may be necessary to adjust the contrast control, VR1, before the screen display is seen.

At this stage, the data shown will be calculated against random factors held in the EEPROM memory, but modified by the actual signal conditions on the p.c.b. The values shown will probably be non-sensical.

Having established that the screen is showing data, default factors must be set into the EEPROM. Switch off and allow a few seconds to elapse to allow capacitors to discharge.

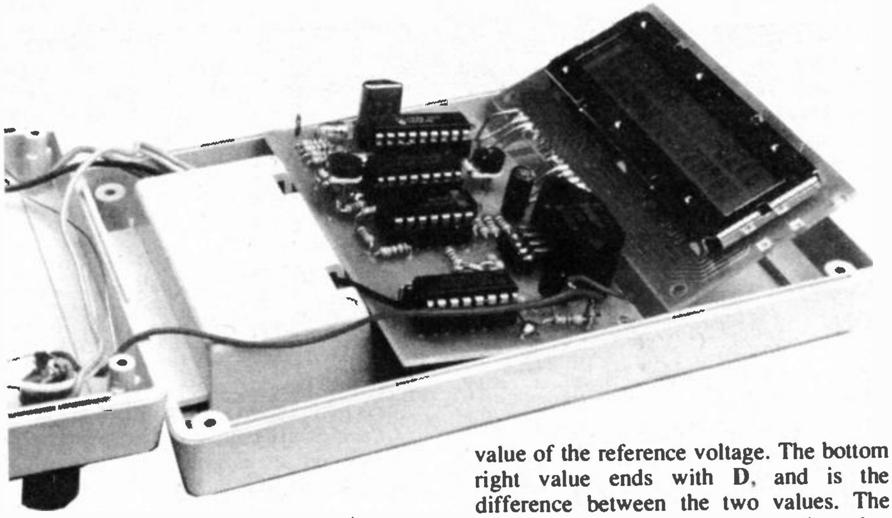
With switch S1 (Mode) pressed, switch on again and wait a moment, during which time the screen will remain blank. Release S1. The default factors are now programmed in from the software and the display should now show values that are more sensible. They represent:

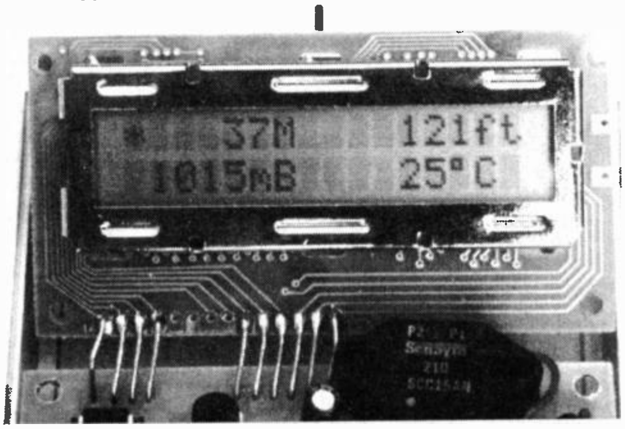
- Height in metres
- Height in feet
- Barometric pressure in millibars (mB)
- Ambient temperature in °C or °F

In normal use, only this screen is displayed. The photograph shows a typical display following setting-up.

This screen has five switch-selected submodes which are used when adjusting height, barometric and temperature values.

There are two test points on the board: TP1, for monitoring the line which switches IC2 between its two modes at 0·5Hz; TP2, for monitoring the frequency output by the VCO (IC3). They were used by the author only during software development and can be ignored.





Screen 1: Typical screen display at switch-on, after completion of all setting-up procedures.

OPERATIONAL CHECKS

Check out the program operation using the function pushswitches as follows:

Press and release Mode switch S1. The slowly flashing asterisk at the top left of the screen should jump to the right of the height in metres reading, flashing somewhat faster. This indicates that the metres reading can now be adjusted if desired.

Adjustment is made upwards by S2 (+) and downwards by S3 (−). Try both switches at random. The value should continue changing for as long as either S2 or S3 is pressed. The height in feet reading will change in relation to the metres setting and does not have a separate adjustment.

The adjustment factor entered at this time is recorded by the PIC in its EEPROM memory, and will remain there even after switch-off. It may be re-adjusted at any time.

When satisfied, press Mode switch S1 again. The asterisk will now appear alongside the millibars (mB) reading. This may be adjusted at any time using S2 and S3, with the new setting stored in the EEPROM memory.

The next press of S1 moves the asterisk to the final cell to the right of the temperature reading. This too may be adjusted by S2 or S3 and its setting stored.

On pressing S1 again the asterisk will be replaced by a question mark (?). Now pressing S2 or S3 will alternate the display in the cell to its left between C and F, this factor also being stored. Set this to the scale in which you want to see future temperature readings.

Note that the temperature calculation routine is unaffected by this setting. The corrective factor for Centigrade or Fahrenheit display is set in a separate mode.

Press S1 again. The display now changes slightly – the height and temperature values remain as previously, but the barometer reading is replaced by a temperature-correcting display with a form similar to:

<T÷ 23*>, in which the asterisk is flashing.

The number in this statement is the factor by which the difference between the preset and current reference values is divided in order to obtain a reading in either °C or °F. Switches S2 and S3 amend and store the value. Its setting will be covered later.

SCREENS 2 AND 3

Press S1 again to change the display to Screen 2. The top left number ends with the character **R**. This is the value of the initial reference voltage reading automatically obtained during setting-up. The top right number ends with **H** and is the current value of the reference voltage. The bottom right value ends with **D**, and is the difference between the two values. The values are not actual voltage readings, but the frequency count in Hertz obtained while reading the reference voltage.

In the bottom left of the screen is a display similar to the following:

<Dx 14*>, in which the asterisk is flashing.

This display is used when setting a temperature correction factor for the barometric readings.

Screen 3 appears when S1 is pressed again, showing the default height and reference values. Different values will be seen following height set-up. They are for interest only.

RETURN TO SCREEN 1

The final press of S1 returns the screen to the main display, showing height, barometric pressure and temperature, with the asterisk once more flashing slowly at the top left.

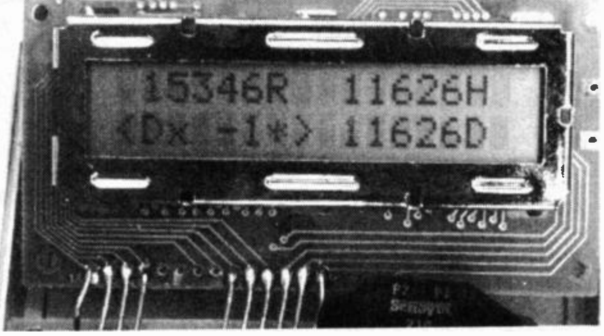
In active use following the setting-up, you will probably only ever want to amend the height value, the other settings normally remaining fixed once satisfactorily set.

You may, though, want to correct any of them in order to compensate for slight inaccuracies in the original settings. In this case just press S1 as many times as are necessary to place the asterisk where you want to see it or to step through to the other screens.

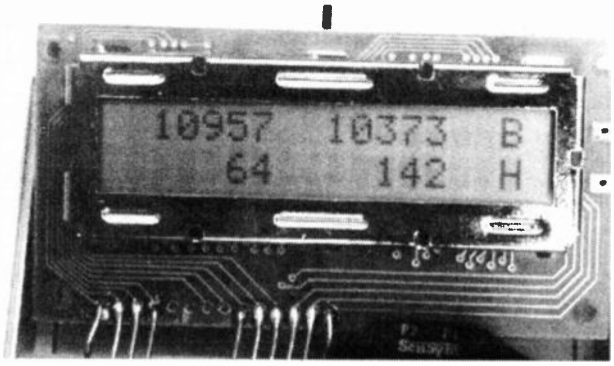
To return to Screen Mode 1 from any display position, just press switch S4 (Set).

FIRST ALIGNMENT

Because of the manufacturing tolerances of all the components, it is necessary to set the span ranges for



Screen 2: Display of typical register values shown during primary setting-up mode.



Screen 3: Display of typical stored register values acquired during altitude span setting.

height and temperature. Both are easy, but need a bit of patience.

First, you must adjust preset VR2 to set the v.f.c. range. With the asterisk at the top left of Screen 1 (Mode 1 – press S4 to put it there if necessary), adjust VR2 until the barometric reading shows about 1013mB. Height and temperature values will also change – ignore them.

Now check that in Screen 2 the top left value is between about 15000R and 15500R. Press S1 six times to get to this screen. If the value is outside this range, press S4 to return to Screen 1 Mode 1 and readjust VR2 a bit, then check Screen 2 again. (Note that changes to VR2 are only registered by the software when in Screen 1 Mode 1 – asterisk at top left.)

In the software's calculation routines, this reference value is multiplied by four and it is essential that the answer does not exceed 65535 – the maximum value before the 2-byte register used rolls over to zero.

Preset VR2 should never need readjusting again unless an i.c. or the sensor fail after long-term use.

TEMPERATURE SETTING

A default temperature span for °F has been programmed in but this will probably need changing to suit your own model. When changing it you need an ordinary thermometer alongside the PIC Altimeter. True temperature and reference value readings are taken at two different ambient temperatures.

Keep the altimeter in a room at the first temperature long enough for it to acquire the same temperature. Press S1 until Screen 2 is shown. Note the temperature on the thermometer (in C or F as you prefer) and call it T1. Note the value of the reference at the screen top left (the 15000-odd value ending in R) and call it R1. Note the value of the height count at the top right (ending in H) and call it H1. Press S4 to return to Screen 1 Mode 1.

Move the altimeter and thermometer to another place at a significantly different temperature. Don't use the fridge as condensation may form on the circuit board, causing severe disorder. You may take it outside, but don't do it on a windy day as the changing wind pressure will upset the readings.

Try to have the altimeter at roughly the same height above ground level as it was for the first position.

Wait a while for the unit to stabilise at the new temperature. Again press S1 until Screen 2 is shown. Again note the temperature, reference and height values, calling them T2, R2 and H2 respectively.

Subtract R2 from R1 and call the answer RT. Subtract T2 from T1 and call it TT. Subtract H2 from H1 and call it HT. Ignore any minus signs.

Divide RT by TT to obtain the units of reference per degree of change, call it CT. Press S4 to return to Screen 1 Mode 1.

Press Mode switch S1 five times so that the second screen line shows the flashing asterisk alongside the statement:

<T ÷ 23 *>.

Using S2 or S3, replace the default value of 23 with the whole number value of CT (rounded up or down as appropriate).

Press Mode switch S1 once so that the second line in Screen 2 shows the flashing asterisk alongside the statement:

<Dx 14 *>.

Divide HT by CT to get HD.

Using S2 or S3, replace the default value of 14 with the whole number value of HD (rounded up or down as appropriate).

Return to Screen 1 Mode 1, and then use S1 to put the asterisk at the bottom right of the screen. Using S2 or S3, correct the screen's temperature value to that currently shown on the thermometer.

The temperature span is now set and should track changes in ambient temperature within the limits of the whole number value for CT. Be aware, though, that the rate at which the altimeter changes temperature will be slower than the actual ambient change.

During this operation, a correction factor per degree of temperature change has also been set for height readings. The altimeter is now ready to have the height span factor set.

HEIGHT ALIGNMENT

To set the height span you need an Ordnance Survey map for your area showing the height in metres at two places. Preferably use the *Pathfinder* series of maps, which have a 1:25,000 scale. The greater the difference between the two heights, the better the resolution of the settings obtained (the author chose 64m and 142m).

It does not matter whether the highest or lowest height is chosen first, the software compensates appropriately. Go to the first known height.

Switch on the unit and leave it on for a few minutes to let its working temperature stabilise. Advance the asterisk to be alongside the metres reading (one press of S1). Press S2 or S3 to set the screen metres reading to the same as that shown on the map, and then release it.

Press Set switch S4 on its own and hold it down, then press Mode switch S1 and hold it down. The screen will now display on its second line:

H1 SET

Release both switches. The height value for this location is now set and the asterisk will again be flashing slowly in the top left corner.

Go to the second site on your map. **DO NOT SWITCH OFF THE UNIT.**

Follow the same procedure as for the first site: press S1 to place the asterisk alongside the metres display, press S2 or S3 to set the height for this location, and release them. Press S4 followed by S1 and hold them down. This statement will now appear:

H2 SET

Release S1 and S4. The height value for the second location is now set.

That concludes the height span setting. It will not normally need to be repeated. Should you need to, though, you must always set the height at two locations without switching off the unit in between.

From hereon, all you need to do is to correct the displayed height figure to correspond to that known for the location you are at. For example, if the true height of your home is known to be at 60 metres, simply set that value when you leave the house at the start of the journey during which you want to keep track of height.

Only under extreme weather conditions (pressure contours closely packed) is it likely that the overall barometric pressure will change enough to significantly affect height readings during an average outing.

BAROMETER SETTING

Setting the height span automatically sets the span for barometric readings, as a change in height is linearly related to barometric pressure (10 metres to 1mB).

What is needed, though, is for a precise value to be given to the pressure reading at a known height. This is where BBC TV comes in with its weather charts. Periodically, these show pressure contours and their respective millibar readings across the British Isles. The values are with reference to sea level.

Alternatively, if you have Internet access, call up:

http://www.meto.gov.uk

to get into the UK Met Office site. Once in, click on the MetWEB icon, which will reveal the latest surface pressure chart and millibar values.

Establish a value suited to your area, correct for your known height above sea level (as indicated by the Ordnance Survey map), and set that value into the altimeter (two presses of S1, and then using S2 or S3; when done, return to Mode 1 with a single press of S4).

For example, your house is at 60 metres above sea-level and the weather chart shows 1020mB for your region. A height of 60 metres above sea-level represents a reduction in pressure of 60/10 = 6mB. The value to which you set the altimeter's barometric display is thus 1020 − 6 = 1014mB.

Once set, the millibars value should not normally need correction.

That concludes the setting-up.

SOFTWARE vs HARDWARE

You might, perhaps, be thinking that the setting-up is complicated. In reality, it is quite straightforward once you actually get down to it. It is, though, worth doing a "trial run" to get the hang of it before making the final adjustments.

None of the settings are irreversible, even though settings are retained when the power is switched off. You can at any time go through any of the procedures to change the values.

You might also care to think about how similar procedures would have had to be done with a system that was purely hardware based, without the benefits of software. With the *EPE Altimet* of November '92, for instance, there were eight presets to be fine tuned, plus an external potentiometer. All the pre-setting had to be done using a small screwdriver plus trial and error.

Although the PIC software took *many* hours to write (over 1000 commands), the physical construction and setting up is far simpler than with a pure hardware design.

As far as you need be concerned, the PIC is simply just another component to be plugged into the p.c.b. in the same way that any other i.c. is plugged in. Unless you wish to, you need give no further thought to what goes on inside the PIC than you would, say, to what happens inside the op.amp, IC1. (For details of obtaining a ready-programmed PIC see *Shoptalk* page).

SOFTWARE HIGHLIGHTS

For those of you who *do* want to know what happens inside the PIC, there follows a brief description of its program.

The full program, both as a notated source code and as a binary file for loading into the PIC, is available from the Editorial office and from our web site. The program was written in TASM, but may be translated to MPASM using the *EPE PIC Toolkit* software of July '98.

Of initial interest, perhaps, is the heavy use made of the PIC's EEPROM data memory, and that each of its used location has been named (equated) at the head of the program. Whilst naming of program variables will be commonplace to many of you, naming of EEPROM locations may not.

Moderately heavy use is made of tables – eight of them, their use relating to factors such as l.c.d. initialisation, storage of default values, message display, path routing, display mapping, and decimalisation of binary numbers.

To cut down on program space, extensive use is made of sub-routines. A lot of them are only short, but when space is limited even a saving of a few bytes is significant.

Calculation of the frequency output by the v.f.c. is referenced to precision timing set by the PIC's internal clock. The basic timing is against a 1:64 TMRO rate, which is further subdivided to 1/25th of second, and then to exactly one second. The reference values referred to earlier, and shown in Screens 2 and 3, are thus values in Hertz.

The main counting loop starts in the source code at INTCLR, which clears the timer's interrupt flag. In the next 19 lines, the status of the interrupt register, the v.f.c. line and the switches is repeatedly read.

Each time the level of the v.f.c. line changes state, a 16-bit counter is incremented. When each one-second time-out occurs, jumps are made to various calculation sub-routines, using the 16-bit count as their starting value.

On alternate seconds, the v.f.c. is switched between barometric and reference sources. The difference between the immediate and initial reference values is the value from which temperature is calculated. It is also used to correct the barometric readings.

Height is calculated in a two-step process. First, the corrected barometric value is converted to the ratio it represents between the preset count values obtained when setting up at the two known heights. During that setting-up, not only were the counts stored, but also the heights as set via the switches.

The second step, therefore, is to apply the ratio from the first step to the span between the reference heights, to obtain the height that the ratio represents. To this result is added any corrective factor as set in via the switches at the start of the outdoor excursion. The answer gives the current height in metres, a value which is multiplied by 3·28 to also obtain the height in feet.

It may interest you to know that all calculations are done in binary, including the multiplication by 3·28. To assist this, the 0·28 is set into the program as a fixed 8-bit binary literal of 72 (obtained by multiplying 256 by 0·28 and rounding to an integer). This is held in one byte as the LSB and the value of 3 in another as the MSB.

Immediately prior to adding the corrective height value, the intermediate result is stored. Once height has been fully established and displayed on the l.c.d. screen, the equivalent barometric pressure value is calculated.

Since changes in barometric pressure and height have a 1:10 relationship, the value is easily obtained by dividing the intermediate value by ten and adding it to 1013 (average barometric pressure as an integer). To this answer is added any corrective factor as set via the switches when the instrument was first set up. This is the millibar value sent for display on the l.c.d.

Yes, it's complex – be grateful that the author programmed it all into the PIC software on your behalf!

TEMPERATURE CALCULATION

The difference between the reference values, as referred to a moment ago, is now used to establish the current ambient temperature.

During the original setting up, the count values obtained at the two extremes of temperature are stored, as are the temperatures they represent as set via the switches. The procedure for calculating current temperature, therefore, is very similar to that for calculating height.

First, the reference value difference is converted to the ratio it represents between the preset count values obtained when setting the two known temperatures.

Now the second step is to apply this ratio to the span between the reference temperatures, to obtain the temperature that the ratio represents. During the process, a conversion factor is applied to modify the answer according to the Centigrade or Fahrenheit base.

To this result is added any corrective factor as set in via the switches during the initial setting-up. The answer represents the current temperature, which is output to the l.c.d.

IN USE

Using the PIC Altimeter is simple. If all you want to know is how high you have climbed (or descended) relative to your starting point, there is no need to set the starting height to an absolute value as shown on a map. Just note the height shown when you start, and again when you get to the top, then subtract one from the other – as easy as that!

You could also set an ascent (or descent) starting value to zero and directly read off the immediate height difference whenever you want.

If you really want to know how high you are relative to sea-level, then you will have to set the starting value with reference to a map. (Just to be jestingly pedantic – remember that map heights do not reflect the state of the tide, so for a true height above sea-level you also need tide tables. But what about wave heights? No suggestions!)

Whilst the tracking of the pressure sensor and the overall linearity of the circuit are pretty stable once the software parameters have been correctly set, it is inevitable that slight drifts will occur. As with an ordinary barometer, minor adjustments to the barometric reading may occasionally need to be made so that it matches that shown on BBC TV. Even they, though, will not show the precise value for your locality at any given time.

Basically, what the PIC Altimeter does is to provide closely accurate information on *relative* values for changes in height and pressure. In doing so, it is an instrument that fulfils the author's intention – to add additional interest to his upward mobility! May it move you too!

IN CONCLUSION

It has to be said that the programming complications created by the need for such a variety of calculations were quite extensive. The situation was aggravated by the PIC16C84 only having 1K of memory (all but six bytes were used) and not having multiply and divide commands.

It is a pity that the PIC16x84 is the only PIC having EEPROM data memory (essential to the Altimeter) and that it does not have a relative with greater program space. Even 2K of the latter would be highly beneficial.

In retrospect, the Altimeter program is one which, perhaps, might have been better suited to one of Atmel's more recent microcontrollers, such as one from the AVR series, for example. This series has EEPROM data memory and some of the individuals have greater program memory than PICs. They also have multiply and divide commands, plus over 100 other commands.

EPE will be taking a closer look at AVR devices in the near future. They seem very promising for more complex situations where a PIC might be stretched beyond its limits. They are also as easy to program as a PIC. □

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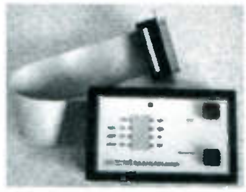

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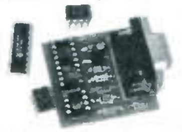

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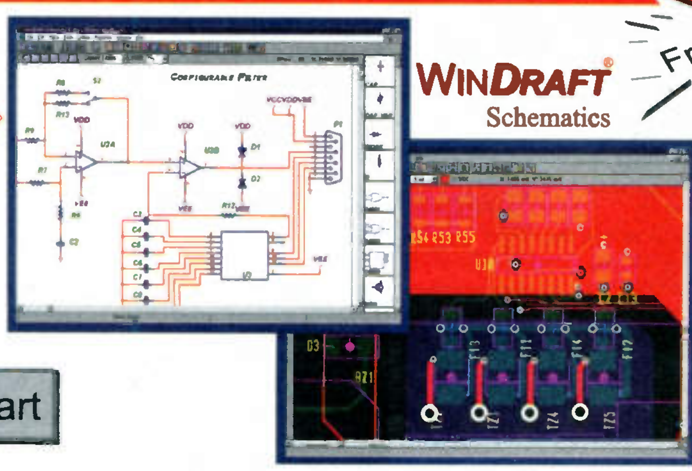

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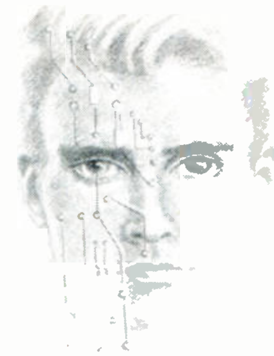

An Introduction to DIGITAL ELECTRONICS

Ian Bell, Rob Miles, Dr. Tony Wilkinson, Alan Winstanley

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Part Eleven: MEMORIES AND THE COMPUTER

Happy Memories

IN THIS series so far we have only discussed single bit memories (flip-flops) and small registers, but most of you will be aware that many digital systems also contain large banks of memory capable of storing many millions of bits. The most obvious place you will come across memory is in the memory chips in your PC, but such chips are also used in other digital systems and memories may also be "embedded" in other devices, from complex dedicated systems to the read only memory chips which make musical Christmas cards play "Silent Night".

A key difference between memories and individual registers and flip-flops is that we do not have separate input/output connections for each bit in the memory. Instead, we supply an ***address*** which determines which bit(s) we want to store data in, or output data from. (We will look at how this is accomplished later.)

The storing and outputting of data from memories is conventionally referred to as ***writing*** and ***reading*** respectively. Some memories address individual bits, but in many cases a number of bits (i.e. a word or byte) is accessed by each address and data is written to, or read from, them in parallel. The data is usually written and read through the same connections using a tristate, bi-direction data bus.

A timing diagram for a typical memory is given in Fig.11.1.

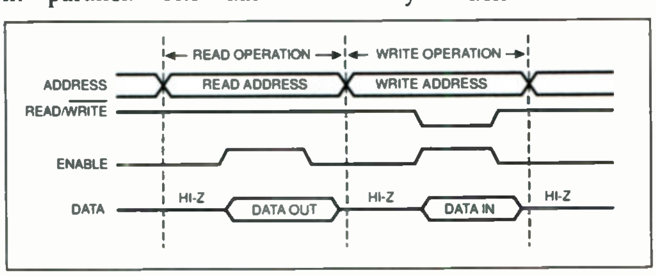


Fig.11.1. Typical memory signal timing diagram. Note: Always check data sheet of real chip for actual signal and timing requirements.

Random Access Memory

The fact that any of the locations in the memory can be accessed in any order without any impact on the speed of writing or reading leads to the name ***Random Access Memory*** (RAM), to distinguish it from storage devices such as disks and tapes where the media or read/write head has to be moved to access the required location and the "seek time" will depend on how close the previous location was to the current one.

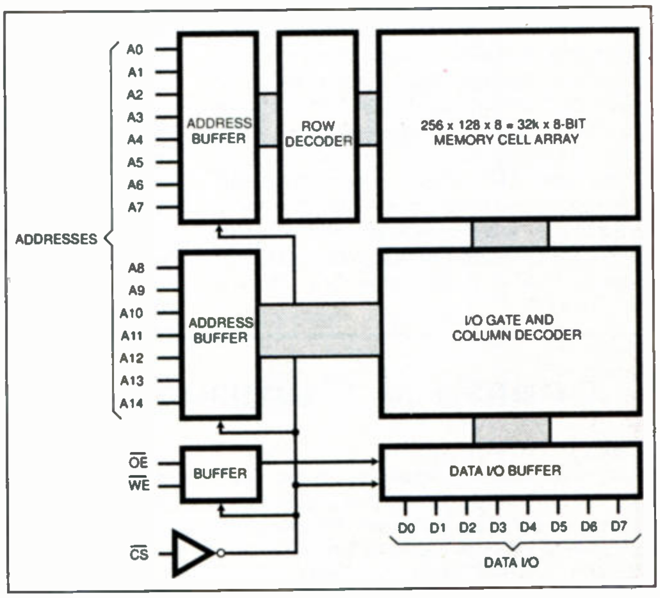


Fig.11.2. Block diagram of internal operation of a 32K × 8-bit Random Access Memory (RAM) chip.

To describe a memory we must define the *word size* in bits and the *capacity* of the memory in bits or words. The size of memories is often expressed in terms of K (Kilo), or M (Mega) bits or words.

These multipliers are based on the powers-of-two values which usually determine the number of addressable locations based on the number of address bits. An address of N bits can select one of 2^N memory locations.

The value of these Ks and Ms is therefore larger than the ks and Ms used for resistance and capacitance values. For memories K = 1024 and M = 1048576. 10 bits can address 1K memory locations and 20 bits 1M locations.

Birth of a Memory

The problems of providing high capacity, high speed memory (usually for use in computer systems) has been addressed in many different ways over the years.

Early attempts stored individual bits by sending a pulse of sound round a metal wire. The sound took a certain time to travel down the wire, and in that time a sequence of bits could be held.

Such a device could store a few hundred bits. Later versions of the same idea used columns of mercury and could hold around 1,000 bits.

The first stored program digital computer in the world, the "Baby" at the University of Manchester which in 1998 celebrates its Fiftieth anniversary, stored bits by means of patterns of light on an oscilloscope tube.

Nowadays memory is built from semiconductor based circuits. The circuitry of individual bits of memories is called a *cell* and may resemble the flip-flop circuits we have discussed in that a loop of two inverters can be used.

However, the design of memory cells is a specialist field and a variety of circuits have been developed – we certainly haven't got the space to go into all the details here! The cells are usually arranged in a two-dimensional array so that an individual cell is addressed by a particular row and column in the array.

In addition to the memory cells themselves, a memory also contains the *address decoding logic* to direct the data to and from the correct location, converting the supplied binary address to the internal row/column address. The memory will also contain some control logic to ensure the correct flow of signals both internally, and in and out of the memory, during read and write operations.

As the cells may not output full logic-levels there may also be *sense amplifiers* which restore the output logic levels from the cell array. A block diagram of a static memory is shown in Fig.11.2.

Memory Capacity

A key selling point of memory is, of course, the capacity which can be obtained in a single package. The size of cell circuitry is obviously important here as the cell is repeated millions of times on each memory chip.

To get the maximum density of data stored per unit area a single MOS transistor/capacitor may be used as the storage element. In this type of memory data is stored as *charge* (or lack of it) on a MOS capacitor.

You have met MOS capacitance before – recall that we discussed MOS gate capacitance in relation to circuit delays in Part 3. Also, you may have found that a CMOS inverter with a "floating" input remembered its previous definite logic input in Lab Work Part 4.

The problem with a capacitance-based memory is that it forgets after a short time due to the "leakage currents" inherent in semiconductor devices. So memories like this have to be continuously *refreshed* – that is, have their data written back into them, and for this reason they are referred to as ***dynamic*** RAMs (DRAM). The inverter-loop memory does not forget, so this and similar circuits are called ***static*** RAMs (SRAM).

The schematic representation of an SRAM cell, based on an inverter loop, is shown in Fig.11.3 and a single transistor DRAM cell is shown in Fig.11.4. We discussed the use of the inverter loop, as used in the SRAM cell, in the context of flip-flops in Part 6.

In the SRAM cell the wordline enables the cell, while the complementary bitlines are used for reading and writing data. In the DRAM cell the transistor acts as a switch to control the flow of charge on and off the capacitor *CM*, which is also a MOS (polysilicon-oxide-silicon) structure.

DRAM design is not straightforward – the charge on capacitor *CM* must be refreshed periodically and reading the data-in cell is difficult as only a minute amount of charge distinguishes a 1 (CM charged) from a 0 (CM not charged).

When a 1 is read the charge moves onto the data/column wire which actually has a larger capacitance than CM. Thus, only a very small voltage change occurs if 1 was stored.

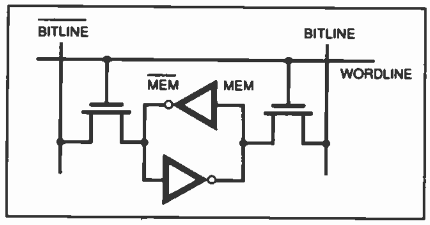


Fig.11.3. Static RAM cell based on inverter loop.

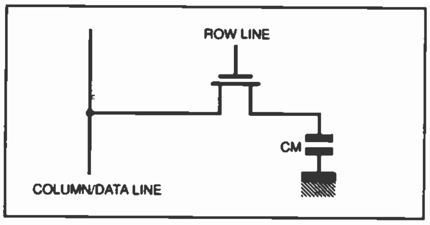


Fig.11.4. Dynamic RAM cell using a single transistor.

Analogue Computers and Digital Signal Processing

When we considered analogue circuits in the early parts of the course we found that there are mathematical equations which can be used to predict the performance of circuits containing particular components. We looked at these in the context of selecting the appropriate component for the job. For example, you can pick resistance and capacitance values to obtain a particular delay. However, since the behaviour of the components is governed by this mathematics, you can construct circuits which will perform mathematical functions for you.

The precise way in which this is done is beyond the scope of this course, but it is the case that you can perform complex calculations on incoming signals by a carefully designed set of amplifiers, resistors and capacitors. The value you wish to process is represented in the form of a voltage level, and the result of the calculation is the voltage level which is output by the circuit.

Analogue computers can process their inputs extremely quickly, and have been used in control systems, where a voltage is produced by a sensor of some kind, and it is necessary to produce a control voltage to drive the system. The main advantage of an analogue computer is the great speed at which it can work, since the signals are processed "instantly".

However, they are hard to design, and it is very difficult to change the functions which an analogue computer performs because this requires the circuit to be re-wired using a "patch panel". They are also prone to changes in the physical characteristics of the components used in the computer, which can change the way that they work.

Op.amps were developed for use in analogue computers (hence the name operational amplifier – an amplifier to perform a mathematical operation). Early analogue computers used op.amps built from vacuum tubes. A 1950's analogue computer typically consumed more than 25KW and occupied a volume of around 20 cubic metres. You should remember that most early computers were analogue, and were often hard wired to perform such calculations as range tables for guns.

Digitally Controlled Analogue

The advent of high performance microprocessors has led to the development of digital systems which can be used in a similar way to analogue computers. A ***Digital Signal Processor*** (**DSP**) is a custom microprocessor which is designed to perform rapid calculations on incoming data. The input is a digital value which has been obtained from an analogue source. The output signals are usually converted from digital back into analogue form.

A system based around a DSP component is much more flexible than an analogue computer because the program is more easily changed, and the number of calculations which can be performed is much greater.

The principles by which a DSP works are exactly the same as other microprocessors, it is just that they have been optimised for this specific task. DSP systems are appearing in many consumer items, including Hi-Fi systems which can make your living room sound like the Albert Hall.

However, there are still applications where direct analogue processing is the best solution, and some chips now work by means of "digital controlled analogue". Here the analogue circuits, which actually process the signal, are controlled by digital circuitry in order to achieve the required function. An example of this technology can be found in some musical keyboards, where the sound is actually produced by a number of amplifiers, mixers and oscillators working under the control of a microprocessor.

In order to read the data the output wire is first precharged to a known voltage, then the row line is activated to switch on the transistor and a sense amplifier is used to detect the small voltage change which occurs. The control circuitry in a DRAM must deal with refreshing and precharging in addition to address decoding and read/write control.

ROMs and PROMs

In addition to RAM there are a number of other types of memory, in particular a variety of types which, unlike RAM, do not lose their data when power is removed. ***Read Only Memory*** **(ROM)** contains fixed data which is determined when the device is manufactured, or which can be written once and *only* once by the user (these are called **PROMs** – *programmable* ROMs). **EPROMs** (*erasable*, programmable ROMs) are ROMs which can be erased using ultraviolet light.

Both ROMs and EPROMS are usually programmed outside the system in which they operate using special programming equipment. These memories allow systems to be periodically reconfigured or updated. Equipment (as opposed to PCs) which contains microprocessors performing fixed tasks often has software in ROMs or EPROMs.

A PC runs a program in a ROM to get it started in order to load the operating system (Windows etc.) off the hard disk. This ROM chip also contains the programs which perform the Power On Self Test (POST) sequence and provides low level control of the hardware. It is often referred to as the **BIOS** (Basic Input Output System) of the PC motherboard.

Also available are electrically erasable ROMs, E^2PROMs (also called *NVRAM* – non-volatile RAM), which can be rewritten or erased electrically without removal from the circuit. Such memory is present in the popular PIC16F84 processor, allowing programs to be repeatedly loaded and tested.

An alternative to E^2PROM, which is used to hold the system configuration in many PCs, is to use a CMOS static RAM powered by a battery. The CMOS RAM takes such little power when inactive that the battery life should easily cover the periods when the computer is not in use.

From Household Control System to Digital Computer

Whilst a comprehensive overview of a computer is beyond the scope of this course, we have now reached the point where we can start to consider just how a computer works. At the lowest level a computer is a collection of sequential and combinational circuits which can understand and execute the instructions which we give it.

With enough time (and enough paper!) it would be possible to draw a complete circuit diagram of a computer, from the microprocessor through the memory chips to the keyboard and screen. It is important to remember that the principles we have described underpin the operation of every device in there!

In Part 8 we described the "Faversham-Wills Household Command System" which allowed His Lordship to communicate with his staff. The underlying principle of the communication was based upon signals which identified the room in the house with which we want to talk (*address bus*), signals which comprise the data we are transferring (*data bus*) and a final set of signals which synchronise the transfer of the data (*control bus*).

If we replace the control panel with a computer processor, and each of the rooms in the Faversham-Wills home with a memory address, we can see how a computer system fits together. A simplified overview of a computer system would look like that shown in Fig.11.5.

All the time the processor is active it is placing addresses on the address bus, selecting read or write with the control signals and then transferring data to or from the memory. The information which is transferred is made up of the *program code* (which controls what the processor actually does) and the *data* (which is what we want processed).

The sequence of operation is essentially:

1. *Fetch the instruction which is to be performed.*
2. *Decode it and act on it.*
3. *Go and fetch the next instruction.*

Note that the instruction itself may well involve fetching data from other places in memory, or saving results of instructions, and that some instructions will change the place from which the next instruction is to be fetched.

These are often called ***jump*** instructions. Sometimes the instruction will tell the processor to jump to a particular location if a given condition is true, this allows the programmer to place decisions into programs.

Within the processor itself there are collections of components which provide the data processing capability. These include *registers* which hold patterns of bits which represent the data and circuits such as ALUs (see Part 5) which perform calculations. Other circuits within the processor decode the instructions and cause the required operations to take place on the register contents.

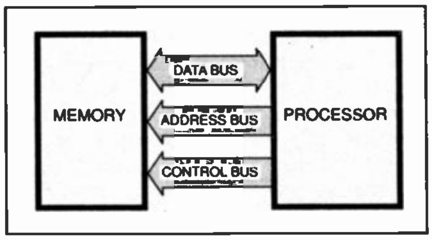


Fig.11.5. A very simplified overview of a Computer System.

Clever Tricks

It is worth remembering that the fundamental principles of the stored program computer have been unchanged for many years, and that the major thrust of computer development has been to make computer systems smaller, faster and cheaper.

Modern processors such as the Pentium use very clever tricks to boost their speed, such as fetching instructions from memory before they are required – so that they can be prepared in advance for execution. Of course this technique can fail if the program performs a jump instruction to a different part of the code, so *predictive branch* techniques are used in order that the chip can decide in advance the likely destination of the jump and start fetching instructions from there!

However, even with all its high performance tricks and seven and a half million transistors on board, the Pentium is still operating using the principles which we have covered over the last 11 parts. This doesn't necessarily mean that you can design and build your own Pentium chip, but it does mean that you can point at a computer and say that at least at one level *"I know how that works"!*

Now go to **Lab Work** for some practical suggestions to demonstrate a simple RAM chip and digital-to-analogue converter.

TEACH-IN '98

LAB WORK 11

Objectives: Demonstration of a RAM chip; writing to and reading from storage; DAC theory; Digital Echo Unit.

OUR final *Lab Work* undertaking offers a range of practical and suggested circuits to round off our introduction to digital electronics.

Lab 11.1 – RAM Memory Chip Demonstration

In Lab 10.3, we demonstrated a National Semiconductor ADC0804 A/D converter, showing how it is possible to convert an analogue "wavy line" signal into an eight-bit digital sample. This analogue signal could be generated by a transducer such as a light-dependent resistor or a microphone, or a measurement transducer such as a strain gauge.

The purpose of the next demo is to illustrate the principle of digital storage using a typical memory chip, by "storing" the output of the ADC. The same demonstration circuit of Fig. 10.17 is used – an ADC driving eight l.e.d.s – with a 32K Random Access Memory (RAM) chip type MB84256A added, see Fig.11.6.

The data (D0 to D7) output of the ADC is directly wired to the *data input/output* (I/O) pins of the RAM chip. Note that the 84256 is a 28-pin d.i.l. device whose pinouts and Truth Table are shown separately in Fig.11.7 and Table 11.1.

The location within the memory, i.e. the address where the data will be stored, is set by the address lines A0 to A14. Since this chip has 15 address lines in all, a 15-digit binary number applied to the address lines, has 2^{15} or 32,768 different possibilities.

So we can "address" 32,768 different spaces within the memory. Hence the expression "32K × 8" that you will see in a typical catalogue – the RAM chip can store an 8-bit number in 32,768 locations – it's a *32K memory*.

It's important to bear in mind that in this branch of digital electronics, "**K**" means ***kilobyte*** or 1,024 bytes (2^{10} bytes), and multiples of 1,048,576 (1,024 x 1,024) bytes are a ***megabyte*** **(Mb)** of storage. Compare with *kilohm* (**k**), which is 1,000 ohms.

A Super Address

To specify the address to write data to, we need to set a binary number on the address lines A0 to A14, where a logic 1 is +5V and logic 0 is 0V as usual. Easy!

Also, using hexadecimal to describe the number on the address "bus" is far easier than writing long binary numbers: hence we can say that we can **read data from**, or **write data to**, any address between 0000H ($0000) to 7FFFH ($7FFF). (See the section on "Hexadecimal Numbers" in *Lab Work* 10 if necessary.)

The Truth Table for this RAM chip shows how stored data will be read from the Data I/O when Output Enable ($\overline{OE}$) is *low* and Write Enable ($\overline{WE}$) is *high*. Conversely, data is written to the RAM when Output Enable is *high* and Write Enable is *low*.

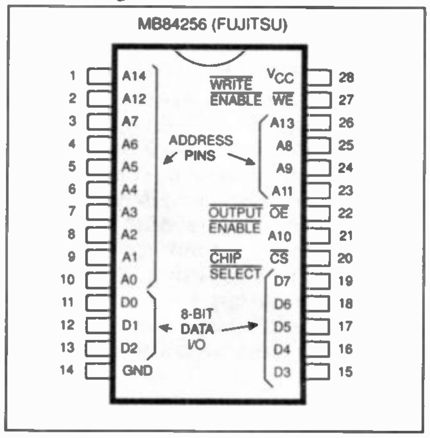


Fig.11.7. Pinouts for a 32K×8-bit CMOS static Random Access Memory (RAM) i.c.

Table 11.1: Truth Table for 84256 RAM chip (Fujitsu)

$\overline{CS}$	$\overline{OE}$	$\overline{WE}$	Mode	I/O Pin
H	X	X	Not selected	High Impedance
L	H	H	D_{OUT} Disabled	High Impedance
L	L	H	Read	D_{OUT}
L	H	L	Write	D_{IN}

X = "Don't Care"

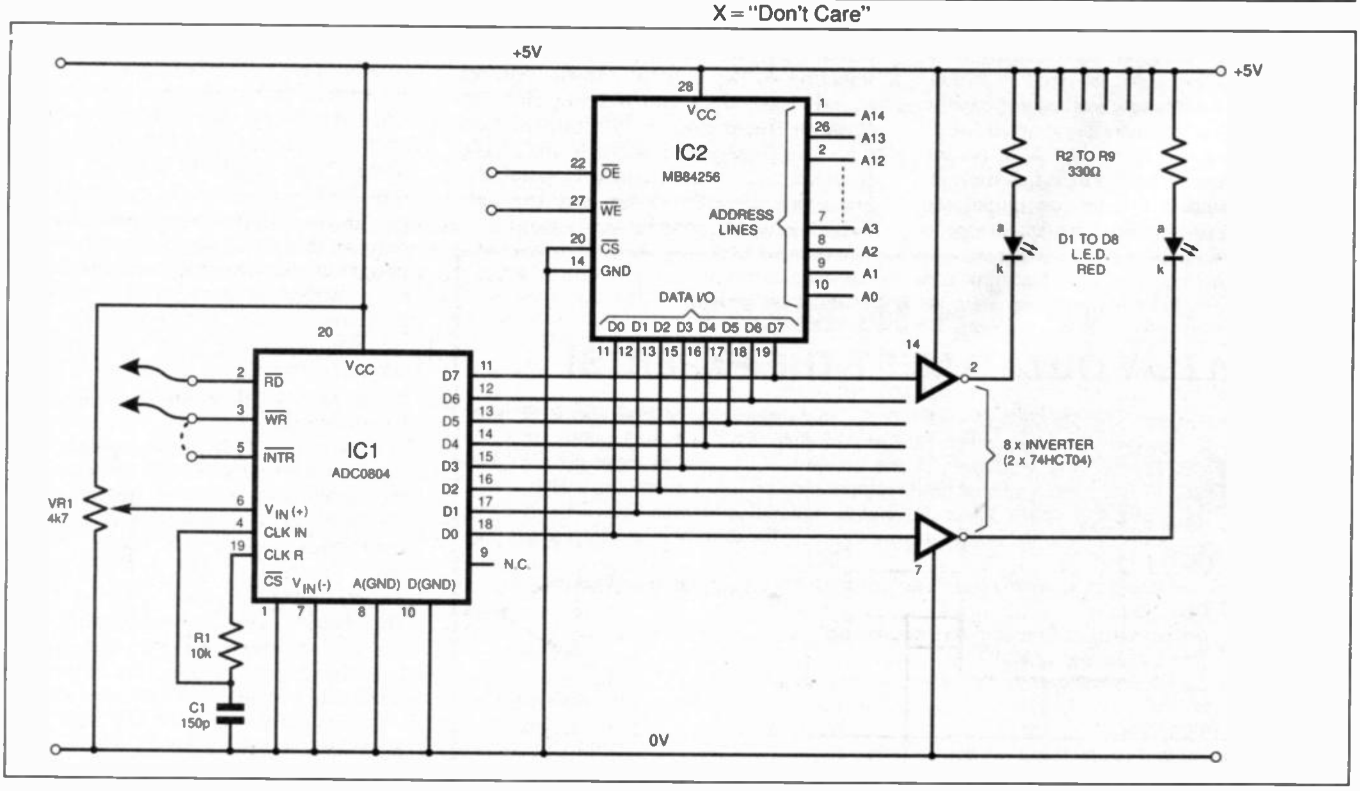


Fig.11.6. Demonstration circuit of a RAM chip being used to store data from an 8-bit ADC chip (see Lab Work 10, Fig.10.17).

A *Chip Select* (CS) pin is used as a "super address" signal in memory systems, so that we can read or write data to individual chips in larger memory arrays, turning any chip on or off as needed. CS must be low, to enable an individual memory device.

Practical Demonstration

The 84256 RAM chip we suggest is widely available for a relatively low cost. If you wish to utilise this device type, you can construct the demo circuit by adding the RAM chip to the ADC experiment of Lab Work 10.3, you may need a second breadboard. Remember that the memory device is CMOS and anti-static precautions should be used during handling.

Analogue-to-digital conversion is started by sending the ADC *WR* low and then back to logic 1. By connecting *RD* low, the result of the conversion is seen on the l.e.d.s.

(Note: in Lab Work 10 *we mentioned that we found that by letting the WR pin float, the display would change in real time in accordance with the input. We think this is due to noise and capacitive coupling between the write and interrupt pins, re-triggering the ADC and causing it to resample. By linking the two pins together, the ADC will "free run" and continually convert.)*

With the RAM chip connected, the result of the conversion can now be written to the memory chip. We must tell the memory chip the address where we want to write the data to, and this can easily be done by setting a 15-bit number on the address bus A0-A14. Simply use flying leads to hook the address pins either high or low.

All that remains is to write the data into the RAM. Do this by ensuring CS is low first, then send WE low and then return it to logic high (see Table 11.1). Once the ADC result is saved to memory, the ADC output is no longer needed, and thus its RD pin is returned to +5V, logic 1.

Later on, in the Echo Unit design, we describe how a bus transceiver chip – a sort of electronic isolator switch – can be used to prevent accidental access to the ADC outputs very easily.

To read a result from the RAM, set the desired address on the address bus, set WE high then connect OE low to output the result (CS must be low). The data stored at that address will be seen on the l.e.d.s.

Experiment by varying the analogue voltage, writing different binary data to various address locations in the RAM chip, and then try reading the data back. Prove that RAM addresses can be written to, or read from, in any order.

Memory Map

A **memory map** is a simple way of representing the contents of a memory system. It merely plots the address of a memory against its contents, charting the address (in hex) against the data stored at that location. An older PC running MS-DOS often has the DOS command "MSD" which enables you to see amongst many other things the memory map of the computer.

- The memory device we suggested is an SRAM or Static Random Access Memory. These use a form of latch to store each bit which, once set, remains set and uses very little power to retain the data in memory.

A DRAM - dynamic RAM – is used in personal computers due to their low cost per bit. Each DRAM memory cell is actually a form of tiny capacitor which needs constantly refreshing to retain its data.

- Both SRAM and DRAM are examples of "*volatile memory*" devices – the data it stores will be lost if the power is disconnected. A "*non-volatile memory*" such as a "**Flash**" memory card retains its data when power is removed.

Examples include digital camera memory cards, which store images for downloading onto a computer later on. Refer to the main *Teach-In* tutorial for extra information about memory device types.

Lab 11.2 – Digital-to-Analogue Conversion

We now enter the final phase of the *Lab Work* practical demonstrations that accompany *Teach-In*. The following demos are presented as "suggested circuits" which are intended to illustrate some practical applications.

Suggested circuits have usually been designed on paper but may not necessarily have been fully constructed and "debugged". The main thing is to learn from the ideas presented, but they also form good starting points for some practical exploration.

A suggested circuit to demonstrate a digital-to-analogue (DAC) chip, such as the National Semiconductor DAC0832, is given in Fig.11.8a. Binary data is captured and stored in the DAC using ILE (Interrupt Latch Enable), CS (Chip Select) and WR1 (Write 1).

To capture data, ILE is held high, CS is low and WR1 is high, and briefly sent low. The captured data is only converted and output when it is transferred from an internal "capture" register to the DAC register. To do this, WR2 is sent to logic 0 and XFER must receive a brief pulse from high to low.

This "two latch" approach is called *double buffering*. It allows data to be preloaded into the DAC for outputting at a controlled time later. See Fig. 11.8b simplified waveform diagram.

The op.amp we suggest is the LF353, which is a "dual" op amp. Pinouts are

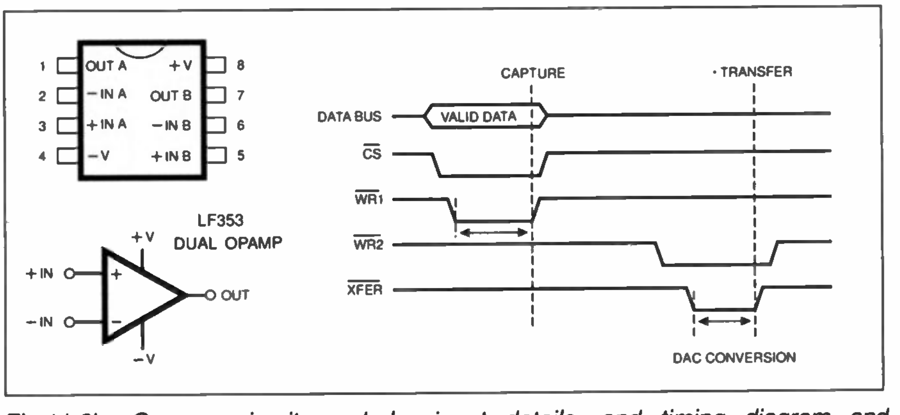


Fig.11.8b. Op.amp circuit symbol, pinout details, and timing diagram and waveforms associated with the DAC demonstration. This two latch approach is called double buffering and allows data to be pre-loaded for output and then output at a controlled time later.

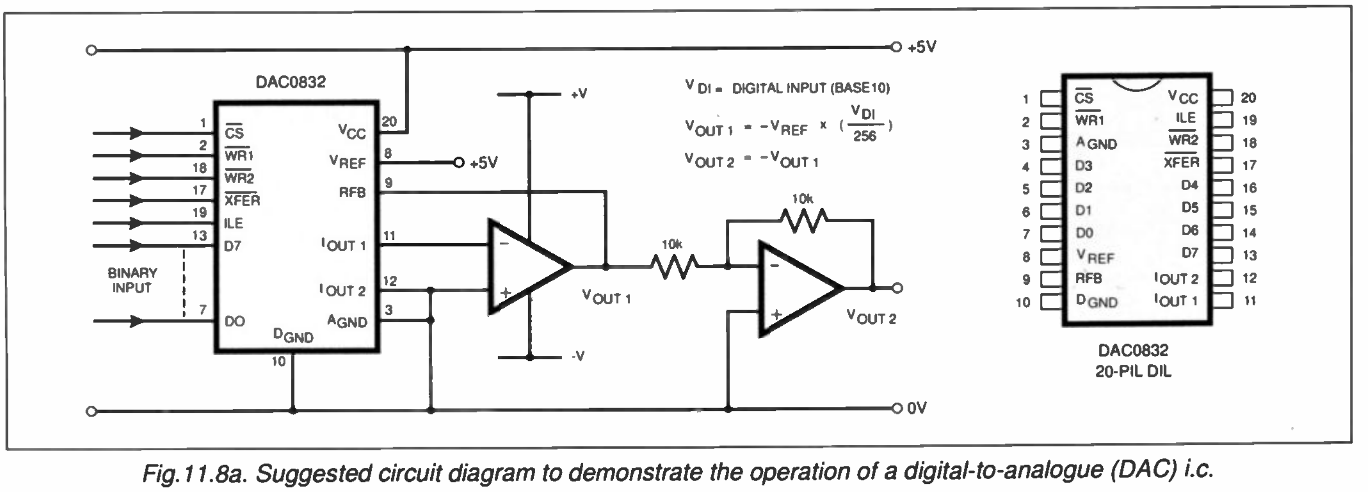


Fig.11.8a. Suggested circuit diagram to demonstrate the operation of a digital-to-analogue (DAC) i.c.

also given, so if you want you can go ahead and experiment with this circuit on your solderless breadboard. Try monitoring the op.amp output voltage with your digital multimeter, to see what happens when different binary numbers are sampled by the DAC chip.

Data Network

In real life, whether in industry, education or hobby, you will often be presented with problems related to developing a circuit, whether it's a simple DAC experiment or something much more advanced. Where do you start looking when you need information about a particular chip or application?

Usually, the answers lie in a manufacturer's data book or data sheet. Electronics students and enthusiasts have been blessed by the fact that all the major manufacturers are starting to publish data sheets on their Internet web sites: within the space of five minutes, we had the full data sheet for the DAC0832 printed and sitting on our bench.

If you have Internet access, an excellent data sheet for the suggested DAC can be obtained from the National Semiconductor web site at **http://www.national.com.** Adobe Acrobat reader is required.

The data runs to twenty pages and incorporates far more information than we can include here – and is full of useful information for the more ambitious or advanced reader who desires constructing the digital-to-analogue circuit.

Lab 11.3 Digital Echo Unit – Sound Bytes

Lord Faversham Wills, our intrepid electronics guru and landowner *extraordinaire*, decided that his noisy trombone-playing nephew should celebrate his freshly-honed musical skills by throwing an impromptu open-air concert. Sadly, during rehearsals, Lord F. became increasingly disenchanted with the reproduction of the mansion's antiquated sound system, and decided that some echo would greatly add to the general atmosphere of the proceedings.

Specially designed for Lord F., we proudly present this final Lab as our *coup de grâce*. Fig. 11.9 is a suggested circuit for a complete Digital Echo Unit which utilises many of the principles we have outlined in the series.

Close inspection reveals a collection of digital subsystems which are hopefully recognisable to the *Teach-In* student. It is usually the case that complex circuits can be broken down into easily-recognisable blocks in this way.

Circuit Details

The overall principle of operation is as follows. A simple "electret" microphone acts as a sound transducer whose tiny signal is pre-amplified using an op.amp, to produce a useful signal. The resultant audio signal is fed to an ADC, which will generate an 8-bit digital signal sample of the noisy nephew in full swing.

This will be stored into a 32K×8 SRAM chip (see Lab 11.7). Sequential storage location addresses are generated for the SRAM by a series of synchronous counters (Lab 9.2). This ensures that the digital outputs from the ADC are stored and retrieved in sequential order, in order to reconstruct a delayed version of the sound correctly. Finally, a simple mixer (summing amplifier) is used to mix the original sound with an echo, for output into the mansion's sound system.

The ADC controls the "conversion" time of the sound sample, with its own *RC*

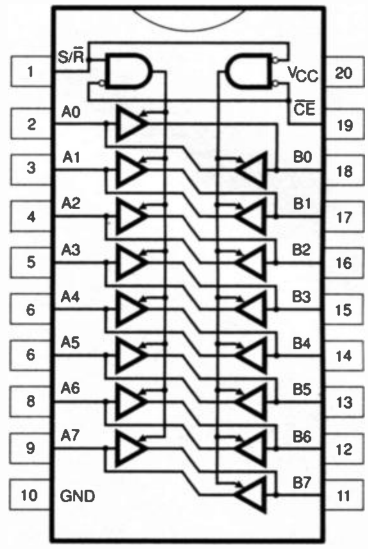


Fig.11.10. Pinouts for the 74LS245 Bus Transceiver i.c.

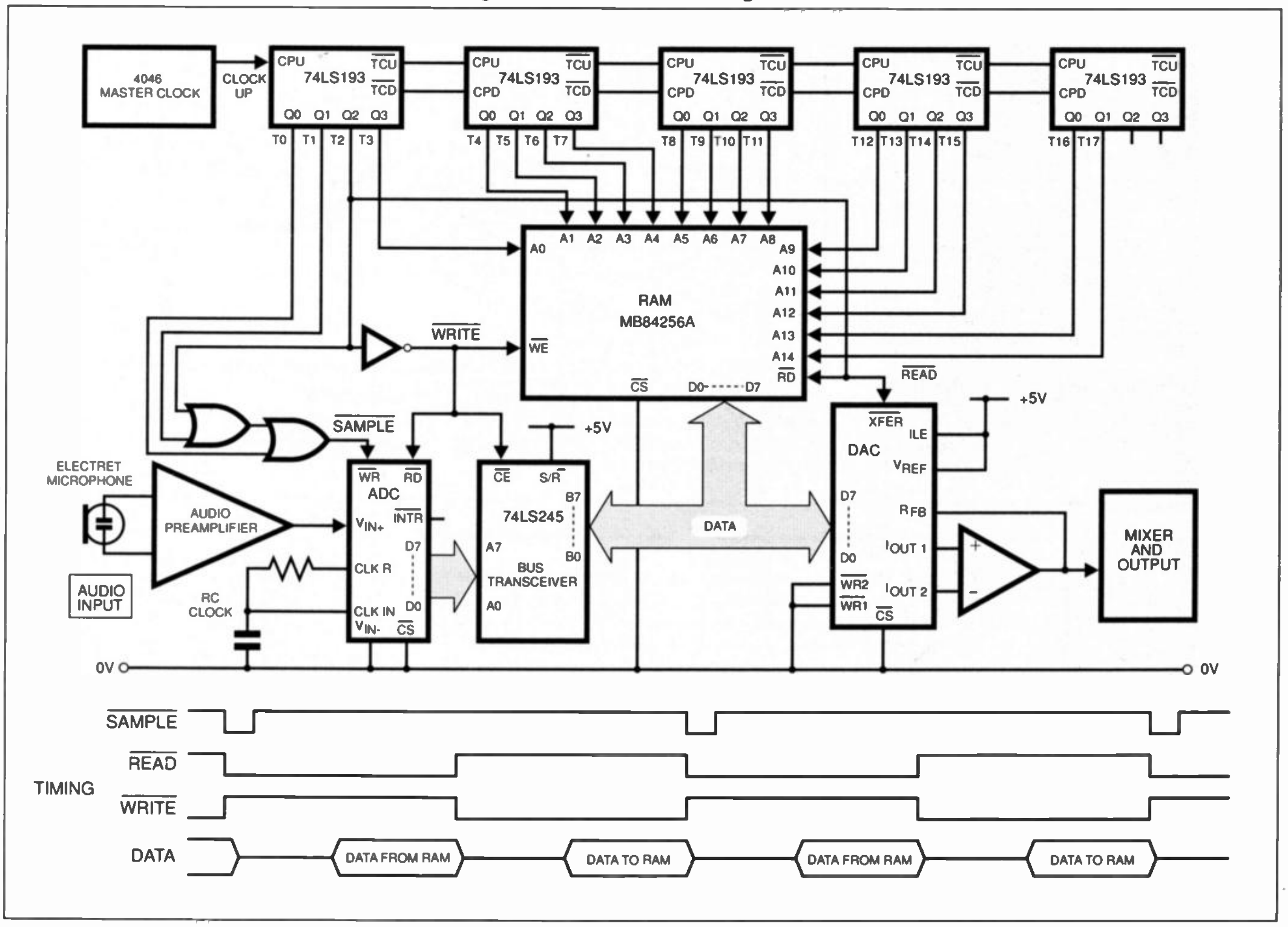


Fig.11.9. A block outline for a Digital Echo Unit, incorporating A/D conversion of input, delayed storage/reading from a 32K RAM i.c.

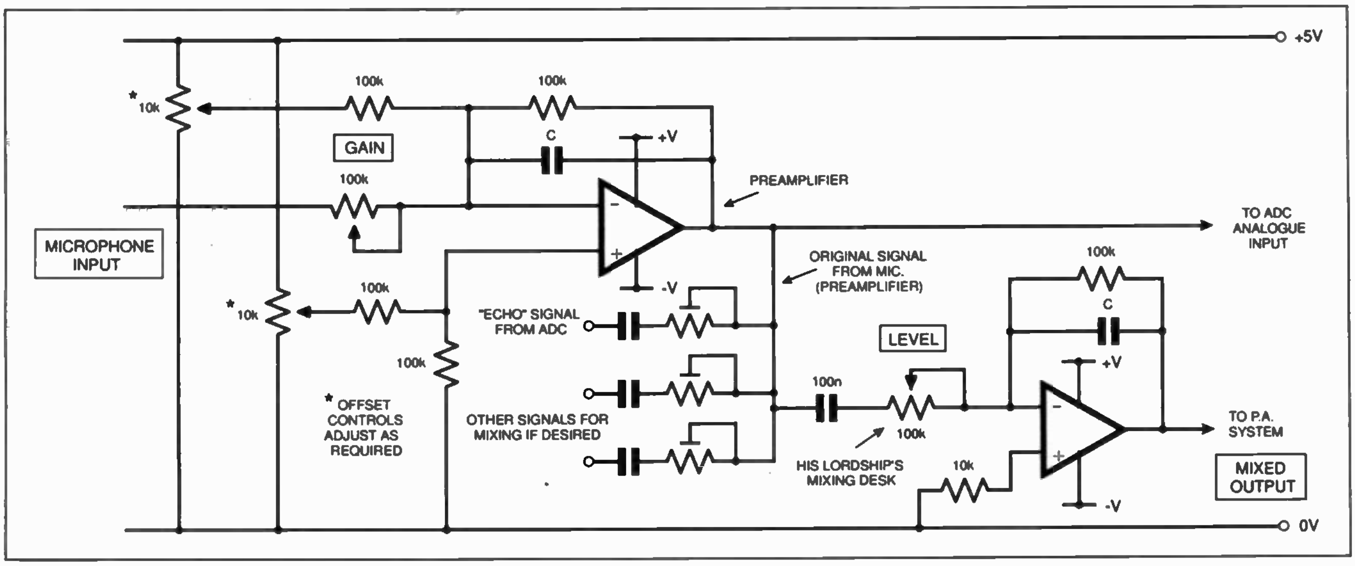


Fig.11.11. Circuit diagram for a simple audio mixer, which enables several echoes to be summed together.

network. In order to produce a "valid" sound sample, at least eight ADC clock periods are needed.

A master clock based around a 4046 is suggested to control the interval *between samples* and writing to the RAM chip. This relates to the time between initiating a conversion and a valid sample being available at the ADC output. To produce realistic multiple echoes with different delays, multiple copies of the storage and reconstruction process would be needed.

A 74LS245 bus transceiver chip is positioned between the ADC outputs and the RAM data I/O pins. The transceiver is nothing more than a series of tri-state buffers (see *Teach-In* Part 7) which are a form of electronic isolator switch. They are used to isolate one data path from another, and are bi-directional and very easy to wire (see pinout in Fig. 11.10).

Clocking-On

Going into more detail, the master clock is used to set the sampling frequency of the Echo Unit. A sample is taken every eight counts of the master clock, because the sample signal is only generated when T0, T1 and T2 of the first counter are at logic 0.

The sampling frequency is the master clock frequency ÷ 8. The rest of the synchronous counter chain is used to count upwards to generate sequential RAM addresses.

The length of the delay between the original sound and the echo, is controlled by the number of the counter *T* outputs (T0 to T17 etc.) which are connected to RAM address inputs. They must be connected in the order shown in the schematic diagram, but to halve the delay (for example), address A14 would be wired low rather than controlled by T17. Similarly, to quarter the delay, A14 and A13 would be connected low, and a one-eighth delay could be achieved by wiring A14, A13 and A12 low.

At the start of a sampling cycle, the ADC is triggered to start a conversion, which will take at least eight ADC clock cycles to complete; in the meantime the previously stored sound data is retrieved from RAM and stored in the DAC using the $\overline{\text{READ}}$ signal. The DAC outputs the

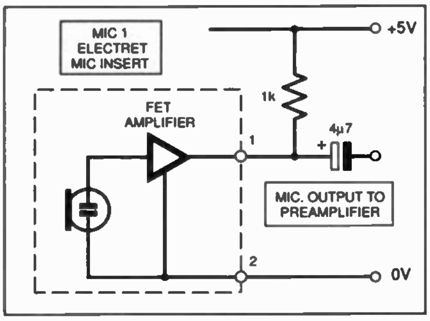


Fig.11.12. A simple preamplifier using a EM-60B sub-miniature electret microphone.

reconstructed piece of the sound waveform to the audio mixer.

After four master clock cycles have elapsed, the ADC is assumed to have finished its conversion. The $\overline{\text{WRITE}}$ control signal is then used to write the "new" sound data from the ADC into RAM, in the same location address as the data just retrieved. This process is also assumed to take four master clock cycles, and then the next sampling cycle is started.

To enable multiple echoes to be created, a bus transceiver chip allows several RAM chips to transfer data to their respective DACs without the worry of data conflicts; yet all RAMs would receive new data from the same ADC. Thus, by duplicating the RAM/DAC block, multiple delay outputs could be generated, to create multiple echoes of the same sound from the same sound sample.

An audio mixer (summing amplifier) is suggested in Fig.11.11 which enables several such echoes to be summed together, whilst Fig.11.12 is a simple suggestion for a pre-amplifier which could be used with an electret microphone insert. Unfortunately, space precludes us from showing the circuit diagram of His Lordship's valve-powered public address system, which is probably just as well!

Matter of Principles

The echo unit uses three principles. Firstly, any measurable waveform can be digitised, provided that:

(a) the digital output number contains *enough binary digits* to represent the variations in size of the waveform – the greater the bit width, the more accurate the digitised sample can represent the analogue waveform;

(b) the sequence is produced quickly enough to avoid missing any significant variations in size of the waveform.

The interval between digital outputs is known as the *sampling period* and the speed of digital outputs is called the *sampling frequency*, symbol *fs*. This is 1/T in Fig. 11.13 and is usually quoted as samples per second.

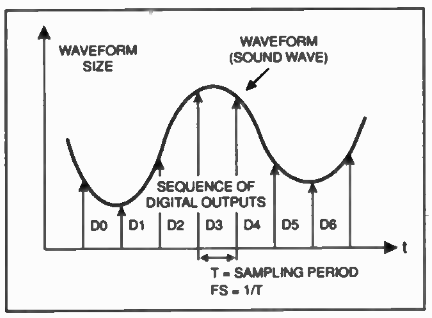


Fig.11.13. How an A-to-D chip "samples" an analogue waveform.

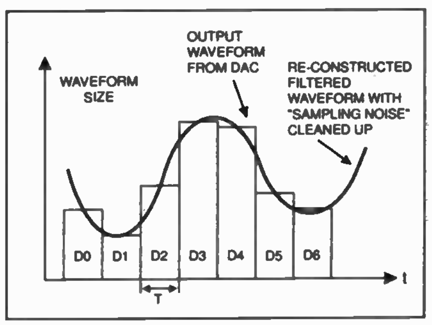


Fig.11.14. D-to-A conversion and back again, to reconstruct the original wave. Further filtering is needed to remove "noise" induced by the sampling process.

In general, the sampling frequency *fs* should be at least twice that of the expected waveform frequency (according to **Nyquist's Theorem**). This ensures that a sufficient number of samples are taken to produce a good digital representation of the waveform. For most practical systems, a sample frequency of five or ten times the original waveform frequency is achievable. An ADC does this!

The second principle is that by using a DAC, a digitised sample can be converted back to a sound wave or other waveform, with a controlled amount of distortion (see Fig. 11.14). Using an ADC followed by a DAC again is about as close as we get to the digital equivalent of a piece of wire! It is possible to include some filtering to remove the noise induced by the sampling process.

The third principle used in the echo unit is that a sequence of digital outputs can be stored for a known period of time and then "re-loaded" into the correct sequence order at their correct speed. We used a 32K RAM for holding digitised sound waves, and the sampling frequency and control of the sequence storage is controlled by a master clock and chain of synchronous counters. By duplicating the RAM and counter sections, multiple echoes can be achieved. We decided to leave His Lordship to determine the merits of using discrete logic in this manner, though.

Individual Logic

The suggested circuit is not necessarily entirely practical but it does illustrate the fact that you can achieve almost anything using individual logic chips to form a larger, more complex system. By analysing the system into smaller subsystems, easily-understood sections can be integrated together into a bigger picture.

The average *Teach-In* student will recognise many such sub-systems and a lot of the hardware which goes with them. However, it is often debatable whether one solution to a design is superior to another.

At the present time, it would be feasible for an individual to attempt to construct this echo unit using the discrete logic and memory components described. The parts are relatively cheap and accessible in one-off quantities, which pleases His Lordship enormously.

A completely different set of criteria would exist for a manufacturer contemplating blitzing the planet with millions of echo units. He would consider price, bulk discounts, general availability and "lead times" (how long to receive deliveries of parts), and manufacturing technologies such as printed circuit board fabrication or even the use of surface mount technology.

Not to mention, how to actually sell and distribute them, packaging, and what his own distributors require in terms of delivery time, quantities and price "breaks". This will determine his choice of components, design and manufacturing methods.

Electronics technology being what it is – the fastest-moving branch of science on Earth – there are many choices available to His Lordship concerning utilising the "right" technology for a particular application. He could readily build and wirewrap this echo unit using conventional methods.

He could perhaps "blow" the entire echo unit circuit onto a microcontroller, programmed from his personal computer (mansion power supply permitting) and then refine the circuit by re-programming the source code as desired and swapping the chip for an upgraded version. Digital control of time delay, number of echoes, sampling quality could easily be offered and monitored using a PC or a liquid crystal display readout.

Whilst the pace of electronic development and manufacturing continues unabated – the odd currency crisis apart – ultimately it is the job of the electronics engineer to meet the challenge of delivering appropriate technology to fulfil a required specification. One thing is for sure though – with so many new solutions around the corner, the electronics designer will never be bored!

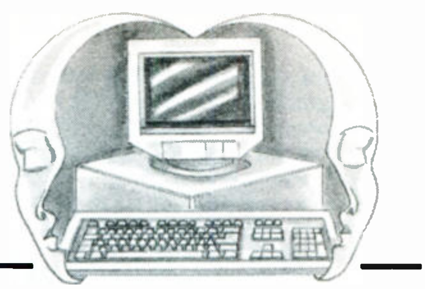
End of Term

This concludes our series *Teach-In – An Introduction to Digital Electronics*. If you have managed to stay the course, well done!

We hope we have entertained and enthused you, and that at least some of the material we have presented in *Teach-In* will be instrumental in encouraging you to explore and experiment further, perhaps in areas of more advanced digital systems including microprocessors and related technology. You can continue to contact us via the special E-mail box **Teach_In98@epemag.demon.co.uk**.

Ian Bell, Rob Miles, Tony Wilkinson – Department of Electronic Engineering, University of Hull, Alan Winstanley – *Teach-In* Co-ordinator.

INTERFACE



Robert Penfold

L.C.D. MONITOR FOR YOUR PC

THE SUBJECT of alternatives to a computer monitor has been covered in previous *Interface* articles, but until now the use of "intelligent" l.c.d.s with PCs has been pushed to one side by other matters. This month's article rectifies things, as we consider interfacing Hitachi l.c.d. modules to the parallel port of a PC.

One or two readers have requested information about interfacing these displays to the serial port of a PC, which is perfectly possible but rather more complex. Where a *parallel* port is available, this certainly represents a much easier way of driving these modules, and familiarising yourself with their method of operation. Driving l.c.d. modules from serial ports is a subject we will return to in a future article.

Face Value

On the face of it, there is no point in using any form of simple display with a PC that is equipped with a perfectly good monitor. In the normal way of things this is indeed the case, but in some circumstances it can be beneficial to switch off the monitor and opt for a more simple form of display.

The most common reason for switching to a more simple display is that the computer system will have to be left running for long periods of time, and will be left unattended for much of that time. Although a monitor does not consume vast amounts of power, running costs can be quite high if a monitor is left running for hours and hours per day. Also, monitors left unattended are generally considered to be a significant fire hazard.

Some modern PCs invariably have "green" power saving facilities and these go some way to answering the problems associated with intermittent use. However, an l.c.d. module often represents a more practical solution.

The current consumption is so low that the display can be left running continuously, and it can therefore be read immediately whenever necessary. An l.c.d. module does not represent a significant fire hazard.

Ins And Outs

An Hitachi LM016L l.c.d. module was used in the following experiments, and this display has two lines of 16 characters. The other modules in this series seem to have exactly the same control electronics, and they should work equally well with the method of interfacing described here.

Connections to the module are made by way of a 14-way edge connector. There should be no difficulty in sorting out the pin numbers because at least some of them should be numbered on the module's printed circuit board.

The LM016L data sheet provides timing diagrams for controlling the module, but when using the device with a latching parallel port the timing of the control lines is not a major problem. In fact, controlling one of these modules via a parallel port is very simple indeed.

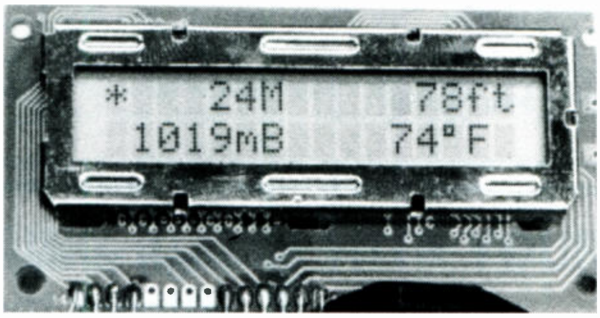
These are the functions of the 14 terminals on the edge connector:

1 – Ground (0V).

2 – Positive supply input (a +5V supply is suitable).

3 – Vo. This is a voltage that controls the contrast of the display.

4 – RS. Taking RS low results in any data fed to the module being interpreted as an instruction (e.g. clear the display). RS is taken high in order to write character data to the display.



Example of a 16-character 2-line l.c.d. module.

5 – R/W. This line is taken *high* to read status information from the display, or set *low* if data must be written to the display module.

6 – Enable. The enable input is really a form of strobe line. Once the data lines and the control lines have been set to the correct states, a positive pulse on the Enable line tells the module that fresh data is available. It then responds to the new instruction or displays the new character.

7 to 14 – Data inputs D0 to D7. These are eight TTL compatible inputs/outputs that are used to write data and instructions to the module, and to read status information from the module.

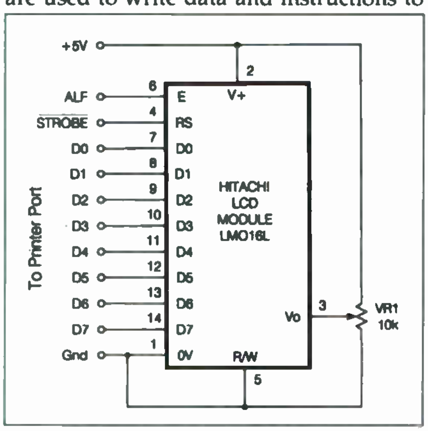


Fig. 1. Suggested method of interfacing the l.c.d. module to the printer port.

The default mode is for 8-bit transfers, but the module can be set up to operate using 4-bit transfers. Four-bit operation could be useful in situations where only a limited number of output lines are available to drive the module. Having to send each 8-bit instruction or piece of data as two separate nibbles clearly complicates matters, and it is advisable to use eight-bit operation wherever possible.

Right Connections

The obvious method of interfacing an l.c.d. module to the printer port is to drive the data inputs of the module from the data outputs of the port, and to drive the Enable and RS inputs of the module from a couple of handshake outputs. This is the method used in the circuit diagram of Fig.1.

The Enable and RS inputs are respectively driven from the ALF (automatic line feed) and Strobe outputs of the port. It would presumably be possible to drive the R/W input of the display from one of the other handshake outputs of the printer port, and to read data from the module provided the port was a bi-directional type. In practice it is not normally necessary to read data or status information from the module, and the R/W line can simply be connected to ground (0V).

Potentiometer VR1 provides a variable voltage to pin 3 of the module, and acts as a Contrast control. This control is set for optimum display clarity, and requires different settings for single or two-line operation.

A 5V supply is not available from the printer port, but a suitable supply for the module can be tapped off from either the keyboard port (pin 5) or the games port (pin 1). The connections to the printer port are made by way of a 25-way D-connector, see Fig.2.

It may not be possible to obtain a suitable edge connector for the l.c.d. module, and you will then have to improvise something or solder connecting leads (ribbon cable) direct to the module's terminal pads. You ***must*** bear in mind that these modules are static-sensitive, and the normal handling precautions are therefore required. Only make soldered connections to one of these modules using an iron having an *earthed* bit.

Software

The simple GW-BASIC test program is given in Listing 1. The user enters integers in the range zero to 255, and the program prints the corresponding ASCII characters on both the monitor and the l.c.d. display.

The addresses used in this listing assume the printer port has a base address of &H278. The addresses must be changed

Listing 1: L.C.D. Test Program

```
10 REM LCD MODULE DRIVER
PROGRAM
20 OUT &H27A,3
30 OUT &H278,48
40 GOSUB 160
50 OUT &H278,14
60 GOSUB 160
70 OUT &H278,6
80 GOSUB 160
90 OUT &H27A,2
100 INPUT A
110 PRINT CHR$(A)
120 IF A=0 THEN GOSUB 240
130 OUT &H278,A
140 GOSUB 200
150 GOTO 100
160 OUT &H27A,1
170 OUT &H27A,3
180 FOR D=1 TO 500:NEXT D
190 RETURN
200 OUT &H27A,0
210 OUT &H27A,2
220 FOR D=1 TO 500:NEXT D
230 RETURN
240 OUT &H278,1
250 OUT &H27A,3
260 OUT &H27A,1
270 OUT &H27A,3
280 OUT &H27A,2
290 RETURN
```

accordingly if the port you are using has a base address of &H378 or &H3BC.

At switch-on the module will go through a reset routine, but the software used to drive the module must include additional instructions to set the desired operating modes. Here the Enable and RS inputs are set low at line 20 (remember here, that both of these handshake lines are inverted by the printer port hardware). Taking RS low sets the module to the instruction mode.

The next part of the program writes three values to the data lines, and in each case a subroutine is used to pulse the Enable line high and load the instruction into the module. The first instruction sets the transfer mode, the character font, and the number of display lines (if the module supports more than one).

Once they have been set the font and number of lines cannot be altered thereafter, except by switching off the display and starting again "from scratch". A value of 48 selects 8-bit transfers, the normal 7×5 font, and single line operation. Use a value of 56 to set the two-line mode.

In the next instruction the display is turned on and a visible but non-blinking cursor is selected. Use a value of 15 if a blinking cursor is required.

The third instruction sets the entry mode, and this determines how data written to the module will be treated. Various clever effects are available, but in this case a value of six sets the normal mode where the cursor is moved one place to the right each time a byte of data is written to the display.

Line 90 sets the RS input high and sets the module to the mode where it is ready to receive character data.

The ASCII value is input at line 100 and printed on the monitor by the next line. Line 120, together with the subroutine starting at line 240, provides a means of clearing the l.c.d. module.

If a value of zero is entered, the subroutine writes an instruction value of one to the module. This has much the same effect as a CLS instruction in BASIC, with the screen being cleared and the cursor being taken back to its start position in the top left-hand corner. Any other valid value will be written to the data lines, and then written into the module by the pulse generated via the subroutine that starts at line 200. The program loops indefinitely so that further characters can be written to the display.

Monitoring

In most practical applications the display will not be used to show information entered by the user, but will instead show status information produced by the computer. The second GW-BASIC listing (Listing 2) demonstrates some basic techniques for using the l.c.d. module in this way.

The program monitors the Error handshake input at pin 15 of the printer port. It prints either "High" or "Low" in the middle of the first line of the display, depending on the logic level at the Error input.

The initial part of the program is similar to the equivalent section of Listing 1, but a value of 12 rather than 14 is used for the second instruction. This switches off the cursor, which is not really needed when the user is not entering data. In other respects the program initialises the display module in exactly the same fashion as before.

In Error

The Error input is read at line 110, and the result will be either eight (high) or 0 (low). This value is placed in variable "X". Line 120 tests to see if variables X and Y have the same value, and the program is looped back to line 110 if they have.

This is part of a routine that checks to see if the state of the Error line has changed since the last reading was taken. It ensures that the display is only updated if the input line has changed state, and this avoids possible problems with display flicker.

Variable Y is given a "nonsense" starting value at line 20 so that the display is not left blank until the Error line changes state. When X and Y are not equal, further tests at lines 130 and 140 direct the program to the appropriate sub-program where the correct message is printed on the display.

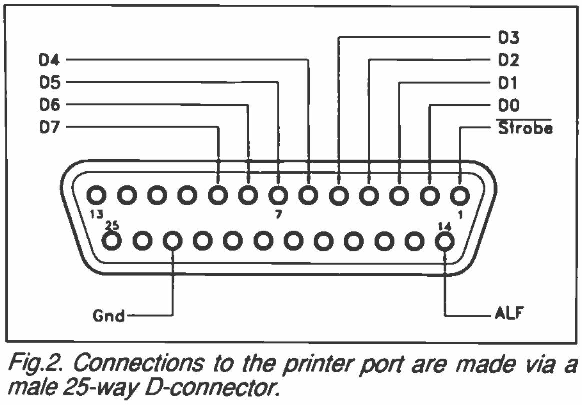


Fig.2. Connections to the printer port are made via a male 25-way D-connector.

The display could simply be cleared to remove the old message before printing the new one. However, like using a CLS instruction in the same way when using the normal monitor, this can produce pronounced display flicker. It is better to simply reposition the cursor and overwrite the existing message.

Using an instruction that has bit seven at logic 1 moves the cursor to a new position. The lower seven bits carry the new cursor address. In other words, the value used in the instruction is equal to 128 plus the new cursor address.

Listing 2: L.C.D. Demo Program

```
10 REM LCD MODULE DRIVER
PROGRAM-TWO
20 Y=4
30 OUT &H27A,3
40 OUT &H278,48
50 GOSUB 450
60 OUT &H278,12
70 GOSUB 450
80 OUT &H278,6
90 GOSUB 450
100 OUT &H27A,2
110 X=INP(&H279) AND 8
120 IF X=Y THEN GOTO 110
130 IF X=0 THEN GOTO 160
140 IF X=8 THEN GOTO 280
150 GOTO 110
160 OUT &H278,134
170 GOSUB 450
180 OUT &H278,76
190 GOSUB 400
200 OUT &H278,111
210 GOSUB 400
220 OUT &H278,119
230 GOSUB 400
240 OUT &H278,32
250 GOSUB 400
260 Y=X
270 GOTO 110
280 OUT &H278,134
290 GOSUB 450
300 OUT &H278,72
310 GOSUB 400
320 OUT &H278,105
330 GOSUB 400
340 OUT &H278,103
350 GOSUB 400
360 OUT &H278,104
370 Y=X
380 GOSUB 400
390 GOTO 110
400 OUT &H27A,2
410 OUT &H27A,0
420 OUT &H27A,2
430 FOR D=1 TO 500:NEXT D
440 RETURN
450 OUT &H27A,3
460 OUT &H27A,1
470 OUT &H27A,3
480 FOR D=1 TO 500:NEXT D
490 RETURN
```

In this example a value of 134 is used, which brings the cursor six places in from the left (128+6=134). This places the message at roughly the middle of the line. Using this method gives a very stable display, but you have to be careful to fully overwrite the existing message.

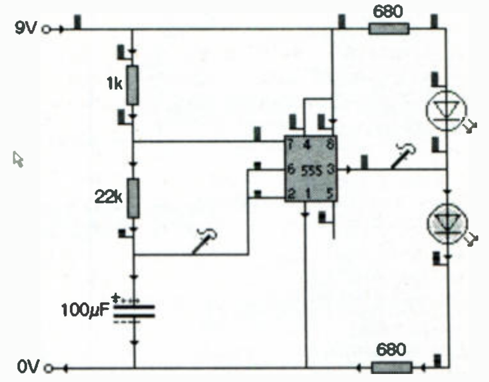
In this example, it is necessary to add a space character (ASCII value 32) at the end of the word "Low" in order to ensure that the letter "h" in the "High" message is over-written. The same basic technique is used when writing to the normal display, and it will probably be very familiar to most readers.

On Display

The display modules are produced in 16 and 40-line versions, but both versions would seem to have the same number of cursor positions. This means that with a two-line display of 16 characters per line the beginning of the second line is at cursor address 41, and not at address 17.

It is apparently possible to scroll a message that is too long for the 16-character display, so that the entire message can be read. For most monitoring applications this sort of thing is not necessary, and the basic technique of writing to the display described here should suffice.

If you want to know more about the various display "tricks" that are possible, the full instruction set is described in the data sheet that is often supplied with the display. It is also worth looking back through your old copies of *EPE*, because "intelligent" l.c.d. displays have been featured in several previous articles.



CROCODILE CLIPS

ROBERT PENFOLD

An educational software package that provides an early and relatively painless introduction to learning about electronics, well suited to the younger student.

CIRCUIT simulators generally fall into two categories, which are those intended for educational use, and those designed for "serious" use in the design and development of electronic gadgets. Crocodile Clips is very much an educational package which is of very limited use as a general purpose circuit simulator, and was not designed to fulfil this role. It is designed to provide an easy introduction to electronics theory.

The circuit to be tested is drawn up as a (more or less) standard circuit schematic, and it is then tested using virtual test instruments. Some of the components are animated when the circuit is run. For example, an l.e.d. circuit symbol turns the appropriate colour when the component is switched on.

IN ALL MODESTY

Crocodile Clips is designed to run on PCs, and by current standards it has modest hardware requirements. The minimum requirements are Windows 95/98/NT, 4Mb RAM, 486 with CD-ROM. A quick test showed that the program will run reasonably well using something close to the minimum recommended hardware, but things run more smoothly on a more powerful PC. There is also a Macintosh version of this program, but only the PC version is reviewed here.

The software is supplied on a single high-density 3·5-inch disk, and there is also a "Return" disk. The latter is loaded with the user's details during the installation process, and is returned to Crocodile Clips to register the software. Installing the software is very straightforward and proved to be problem-free.

There is the usual on-line help, plus an A5 size manual, which has about 160 pages (not supplied with the Student Edition), and a 32-page quickstart booklet. The manual is well produced, and contains numerous examples, which show how various facilities of the program are used.

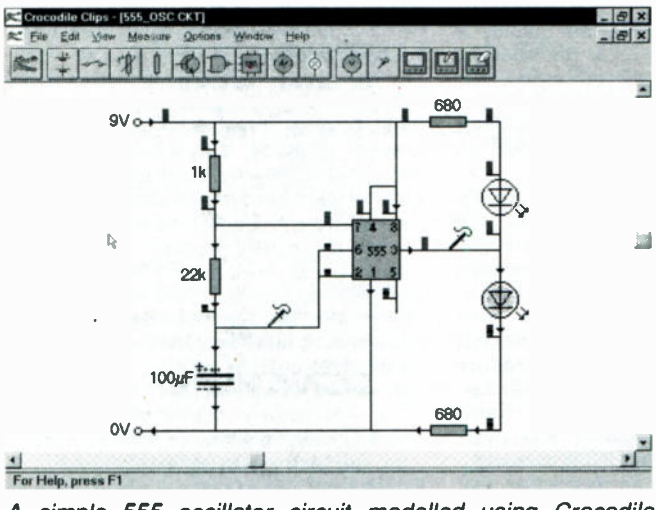
GETTING STARTED

Once the program is "up and running" you are presented with a conventional Windows screen arrangement having the usual title and menu bars at the top, plus some icons on the toolbar immediately beneath these. There is a status bar at the bottom of the screen, and the usual scrollbars are included, but the majority of the screen is available for circuit diagrams and the virtual test instruments.

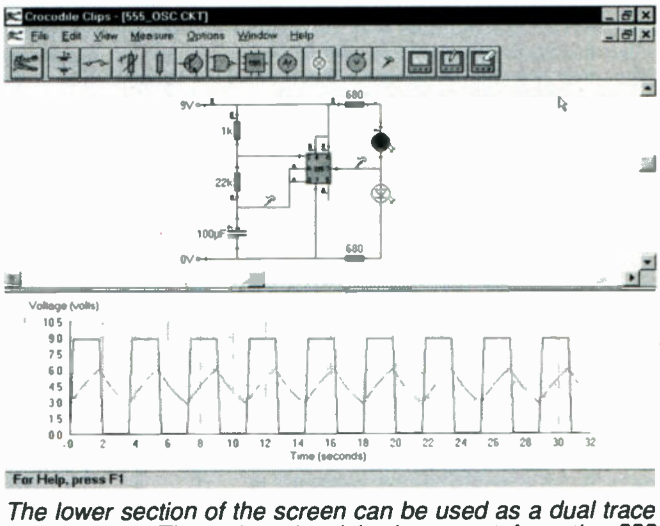
The icons provide access to the circuit symbols that are used when drawing circuit diagrams, and to the virtual test instruments, which can be used to check that circuits perform as expected. "clicking" on an icon brings up a fresh set of icons that give you a greater choice of symbols.

For example, "clicking" on the transistor icon brings up various transistor and diode symbols in various orientations. The required symbols are dragged into the drawing area, and "clicking" the left mouse button then produces a virtual reel of wire that can be used to connect the components together.

Producing the circuit diagrams is very easy, and editing them is also very straightforward. Components can simply be dragged around the screen using the mouse. However, any connections that have been made to them will be automatically deleted and must be replaced. It is therefore a good



A simple 555 oscillator circuit modelled using Crocodile Clips. The l.e.d.s flash when the simulation is run. Note the test prods monitoring the output signal and the signal across the timing capacitor.



The lower section of the screen can be used as a dual trace oscilloscope. The pulse signal is the output from the 555 and the triangular waveform is the signal across the timing capacitor.

idea to get all the component symbols in place first, and wire them up once you are reasonably sure that they are properly positioned.

It does not seem to be possible to flip or rotate symbols, and you must choose the version that has the correct orientation. Objects can be deleted by selecting the crocodile head icon, and then using it to "eat" the objects you wish to remove! There is also a more conventional method available via a pull-down menu. It is possible to produce quite neat diagrams, but they are slightly non-standard. In particular, the dots to show connection points do not occur at "T" junctions, but are included close to the circuit symbols.

This is presumably because they are part of the circuit symbols. It is only a minor point, but more conventional circuit diagrams would be preferable for an educational package.

and distortion analysis, and the like. Crocodile Clips operates at a lower level, and it is designed to enable users to see how things work, rather than to provide highly detailed and accurate circuit modelling. The virtual instruments are not in the form of accurate physical on-screen representations, as in Electronics Workbench for example (see the review in the July 1997 issue of *EPE*).

The main monitoring device is the dual-trace oscilloscope, and when this is activated the bottom section of the screen becomes the oscilloscope's display. This is clearly labelled on both the X (time) and Y axes, and is marked with graticule lines. You select the points in the circuit that are to be monitored by clipping virtual probes onto them.

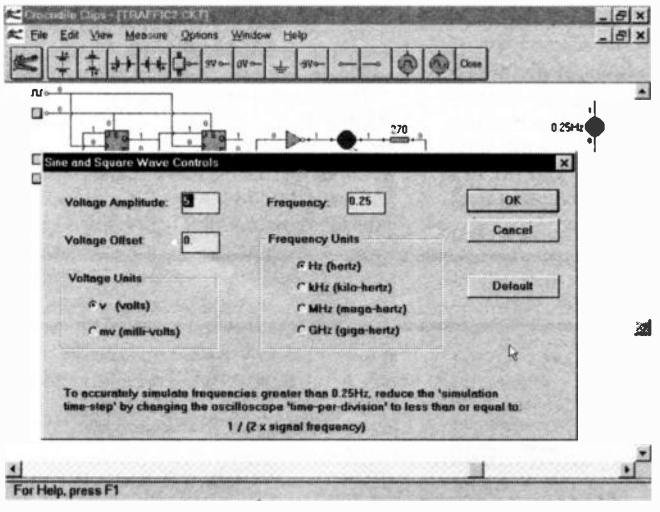
The oscilloscope's "controls" are altered via a dialogue box which is selected via a pull-down menu or the

step, which means that they are normally updated about five times per second.

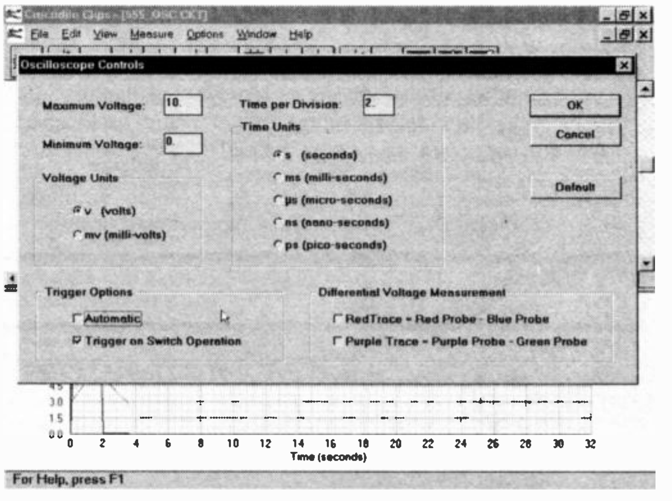
Logic circuits can be monitored via the oscilloscope, but each pin of every logic device has a simple built-in logic indicator. Each pin is labelled "0" or "1" to indicate its logic level, and these indicators change, as and when necessary, when a simulation is run.

A variety of signal sources is available, including batteries, d.c. power supplies, a pulse generator, and triangle and sinewave generators. The pulse generator can only generate squarewave signals, but this should be adequate for simple circuit simulations.

The signal generators are controlled by "clicking" on the frequency display to bring up a dialogue box. You can then alter the frequency and amplitude of the signal, and a d.c. offset voltage can also be applied to it.



The virtual signal generators are controlled via a simple pop-up control panel. In addition to control of frequency and amplitude, a variable d.c. offset can be applied to the output signal.



A pop-up control panel provides some basic controls for the virtual oscilloscope. Differential voltage measurement is available, as is a simple manual triggering facility.

RIGHT DIALOGUE

Changing component values from their defaults can be achieved very quickly, and "clicking" on a component symbol brings up an appropriate dialogue box. A wide range of components are available, including meters, relays, a motor, a buzzer (which will really make a noise if you want it to), a light dependent resistor, and various semiconductors.

The available integrated circuits are mostly logic devices, but the all-important 555 timer is also included. The only linear integrated circuit on offer is the standard 741C operational amplifier.

Although a useful range of components is available, these are mostly typical or idealised components and you are not supplied with a large range of real-world devices. For educational purposes this is not a major drawback, since plenty of interesting demonstration circuits can be produced using the available components. Crocodile Clips is only intended to provide an easy introduction to electronics, and is not intended for advanced students.

SIMULATIONS

The fact that Crocodile Clips is intended as an introduction to electronics is reflected in the simulations on offer. Circuit simulators normally handle phase and frequency response sweeps, noise

oscilloscope icon on the tool bar. This enables the user to set the maximum and minimum voltages on the Y-axis, and the time per division on the X-axis.

In both cases a very wide range is available, but the scaling is common to both traces. This makes it impossible to simultaneously display two waveforms if they have disparate amplitudes. Triggering can be automatic (continuous sweep), or manually via a virtual switch. Differential voltage measurement is catered for.

The oscilloscope's timebase controls the speed at which simulations are run, and things move on at about five steps per second. For long sweeps everything happens in something approximating to real-time, but at fast sweeps the action is slowed down to a rate that enables the progress of the circuit to be followed properly. If you set a sensible sweep speed for the waveform being monitored, this automatically sets the simulation speed to one that enables the action of the circuit to be followed.

There are other means of monitoring the circuit, such as using l.e.d. indicators, voltmeters, and current meters. The meters can be set to autorange, but they are limited to instantaneous and r.m.s. values with no average option. The meters are updated after each simulation

TEST RUN

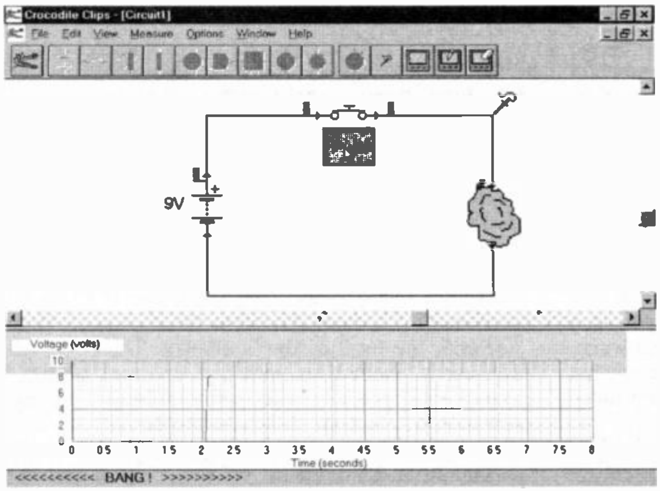
Results on a few test circuits were very much as expected. The only slight problem encountered was that of components occasionally "blowing" for no apparent reason when editing circuits. Components can be set as destructible or indestructible, and if the destructible option is used, any components that receive too much voltage, current, or power go up in a virtual puff of smoke!

Editing the value of a capacitor to give it a much lower value sometimes produces an excessive voltage which can result in components being "zapped." Presumably the charge on the original capacitor is transferred to the new lower value component, where it translates into a charge of lower current but higher voltage. Anyway, any "zapped" components are easily restored with the aid of the crocodile icon. When deleting a destroyed component the dialogue box tells you why it blew up.

CONCLUSION

Crocodile Clips is designed to be a relatively painless way of learning about electronics, and it certainly achieves this goal. There are now several sophisticated circuit simulators which offer schematic capture and virtual instruments, but getting started with these programs is still relatively difficult and time consuming.

A much easier introduction to electronics is offered by Crocodile Clips, and it is well suited to younger students. Many users will probably outgrow the package quite rapidly, but progressing to more advanced simulators and the "real thing" should not be difficult.



Components can be used in indestructible or real modes. This short lived resistor was used in real mode, and its demise is indicated by the virtual smoke!

BOOKMARK

The Crocodile Clips manual does not attempt to provide a course in basic electronics, but this software should be usable with most electronics textbooks. However, there is also a book produced for use in conjunction with the software, and this does provide a course on electronic circuits.

This book is called *Discovering Electronics*, and it is written by W.D.Phillips. It is an A4 size book which is spiral bound – a good format for this type of book.

Chapter one provides an introduction to the software and to some simple components, and chapter two covers voltage, resistance, Ohm's Law, etc. The next ten chapters cover various types of circuits, from simple potential dividers to oscillators, monostables, logic circuits, and basic operational amplifier circuits. The final two sections deal with some practical design examples, and include some stripboard and solderless breadboard layouts.

The book is quite easy to follow, and this is helped by the large numbers of illustrations. Its reliance on examples run on Crocodile Clips means that it is of relatively little value on its own, but together with the Crocodile Clips program it provides an excellent introduction to the basics of electronic circuit operation and design.

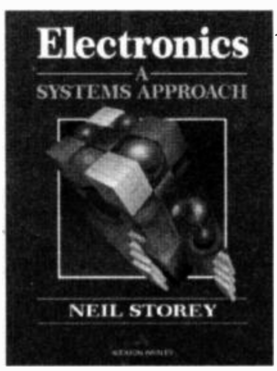
The Student Edition (for home use only) with no printed manual and which does not support printing costs £49.95 including VAT and is available from Maplin. The Professional Edition (for schools and industry) costs £175 plus VAT for a five user licence, this version will also run on Windows 3.1 and MAC. Available from Crocodile Clips Ltd., Dept. EPE, 11 Randolph Place, Edinburgh, EH3 7TA.

Discovering Electronics by W.D.Phillips (ISBN 0-9530129-0-5) is published by Educational Publishing for Design and Technology, Dept. EPE, 6 Limes Avenue, Mill Hill, London, NW7 3PA and costs £12 plus £2.50 p&p. *(Mail order only.)*

BOOK REVIEWS

Electronics – A Systems Approach

Author Neil Storey
Price £23.95 **Pages** 655 (170 × 235mm)
Publisher Addison Wesley **ISBN** 0-201-17558-4



THE author teaches electronics in the Department of Engineering at the University of Warwick, and wrote this book to offer undergraduates a complete grounding (forgive the pun) in electronic engineering. It assumes nothing more than a rudimentary knowledge of passive components and a.c. behaviour, and commences with the adoption of an easily-assimilated systems approach before delving into the application of amplifiers and feedback. Only then does the author investigate the physics of modern semiconductors – starting with the diode and then the MOSFET followed by the bipolar transistor and filters.

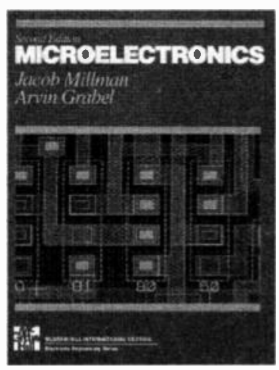
Hence the writer deliberately takes the unusual but rewarding "top down" approach by looking at the "big picture" of electronics applications before delving into the technical minutiae of discrete and integrated components. The latter half of the book then deals with digital systems, Boolean algebra, combinational and sequential logic, data acquisition and conversion and finally a section on microcomputer systems. Exercises are included (no answers though) along with design studies.

Electronics – A Systems Approach is crisply written and offers a very comprehensive foundation in electronics and is a worthwhile addition to the student or hobbyist bookshelf. Engineers and scientists from other disciplines will also find it invaluable. The best "all round" text I've found in a long time.

Alan Winstanley

Microelectronics (Second Edition)

Authors Jacob Millman and Arvin Grabel
Price £20.95 **Pages** 1001 (185 × 235mm)
Publisher McGraw-Hill **ISBN** 0-07-100596-X



THIS heavyweight work starts with an in-depth, highly structured analysis of semiconductors, leaving few stones unturned as it moves through the classical route of the physics behind the *pn* junction, the bipolar transistor and FET, before turning its unswerving eye onto basic digital circuits, combinational and sequential systems and VLSI.

As if to prove that "digital isn't everything", the book continues with an intensive study of amplifier circuits, op.amp characteristics and signal-conditioning techniques before concluding with a varied section on "large scale" electronics, including power supplies and power amplifiers. A wide variety of integrated devices as well as discrete components is introduced along the way, and even the humble 555 timer is included and whose operation is laid bare.

The book offers a complete analysis of many aspects of microelectronic circuit techniques which are glossed over, or ignored altogether, in less authoritative texts. More of a formalised academic work, *Microelectronics* will be heavy reading for the practically-inclined, having an intensively algebraic approach throughout which requires a good level of understanding of mathematics and physics, but which resolves down to the smallest details in its quest to "bottom out" the subject matter where other books tail off. Questions with selected answers are included. For the advanced engineer, higher-level student or scientist, very competitively priced.

Alan Winstanley

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A range of videos (selected by EPE editorial staff) designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes originate from VCR Educational Products Co, an American supplier.
(All videos are to the UK PAL standard on VHS tapes.)

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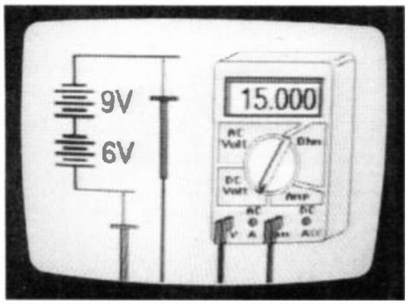

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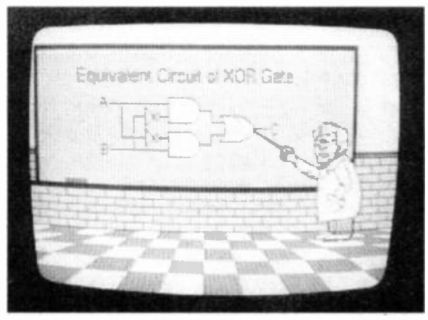

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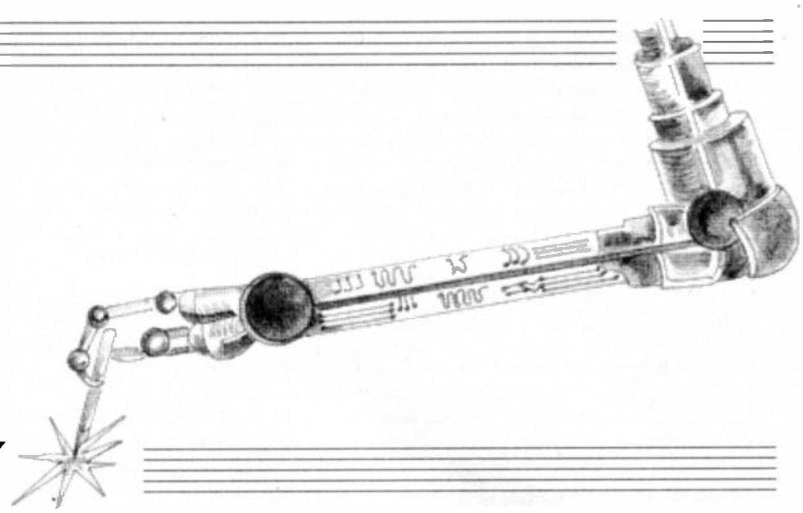


ALAN WINSTANLEY

We check out moving coil and digital panel meters, plus more on soft start and glow lamps.

Meter Stiff Resistance

I have a 1 Amp d.c. panel meter to which I would like to add some circuitry in order to produce a good range in measuring d.c. current, since my own multimeter is limited to only 250mA. I would like this panel meter to read up to 1A in ranges. The meter resistance is 0·1 ohms. I'd be very grateful for any help.

P. Jenkins,
Litherland, Liverpool.

There isn't a practical way in which your 1A d.c. meter can be converted to read full-scale currents of less than that. The reason for this is that in your case, the meter still needs to "see" a current of one amp to produce a full-scale deflection (f.s.d.). Even if we select a range of 250mA (say), 1A will still have to pass through the meter coil to deflect it.

The additional input circuit would have to amplify the input current and scale this up to 1A, so a hefty power source capable of supplying 1A peak would be needed. The situation is different if you have a *milliammeter* which you would like to be used to read higher currents.

In that case, meter shunts can be used in parallel with the terminals to act as a bypass for most of the current, with a small amount of current being diverted into the meter to provide the full-scale deflection. In other cases, a series resistor can be used to convert an ammeter into a voltmeter.

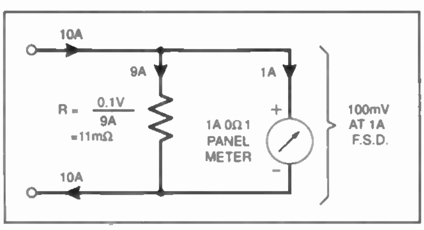


Fig.1. Adding a parallel "shunt" produces a 10A full-scale deflection meter using a 1A panel meter.

How the 1A meter could be made to read, say, 10A with the addition of a parallel shunt is shown in Fig.1. Using Ohm's Law, calculate the voltage developed across the meter at f.s.d. (1A × 0·1 ohms = 100mV). This also appears across the shunt resistor, whose value is 100mV/9A = 0.011 ohms.

A tiny value shunt like this would probably be wound using resistance wire, or try various combinations of parallel/series resistances. Don't forget power dissipation either – the shunt will dissipate (I^2R), about 0·9W.

How we can convert a milliammeter into a d.c. voltmeter, using a series dropper resistor, is shown in Fig.2. Let's take a typical 1 milliamp meter with a coil resistance of 400 ohms. How do we calibrate this meter to read, say, 25V instead?

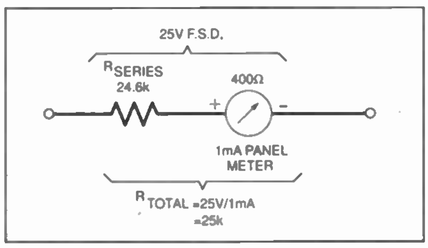


Fig.2. A series resistor converts a milliammeter into a 25V f.s.d. voltmeter.

This time, we look at the total resistance "seen" by the applied voltage at f.s.d., which is 25V/1mA or 25k. Of this, 400 ohms relates to the meter resistance leaving a value for the series dropper of 24·6 kilohms. (It would probably be adequate enough to use a straight 25k resistor, though.) This gives an overall meter sensitivity of (25k/25V) 1,000 ohms per volt.

A rule of thumb is that a meter resistance should be *ten times* larger than the load resistance if you are to avoid shunting it and introducing inaccuracies, but this circuit may be adequate for panel-meter use on a bench power supply. Using Mr. Jenkins' 1A 0·1 ohm panel meter, we obtain a series resistor of 24·9 ohms, and a meter sensitivity of precisely one ohm per volt, which sadly rules it out as a voltmeter!

Digital Panel Meters

These days, digital panel meters are popular and cheaper than ever. They have a very high input impedance which doesn't load the circuit under test, and they are accurate to at least 0·5%.

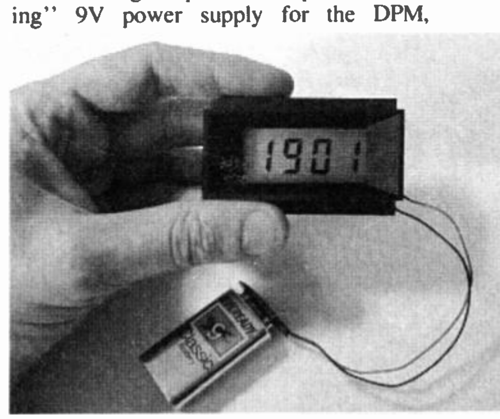
Vann Draper Electronics are listing an l.c.d. digital panel meter (DPM) and I have been trying one out on the *Surgery* bench (see photo). It is based on the ubiquitous 7106 chip, as used in many budget digital multimeters, and it is supplied configured as a basic 200mV 3½ digit unit with a highly legible 13mm readout.

This meter module has a series of solder pads to select the decimal point and polarity annunciator, and the instructions supplied describe the necessary links needed to turn the meter into a digital voltmeter capable of reading 20V, 200V or 500V. (I found it easier to solder some turned-pin s.i.l. sockets, enabling solid core jumper wires to be pushed-in or moved around as necessary.)

Scaling up the meter reading for higher ranges involves adding a simple potential divider to the input, so that the meter only ever "sees" 200mV. By the same method, you could use the meter to measure the voltage drop across a low-value series resistor, thereby producing an ammeter.

(Vann Draper tell me that their bench power supply uses two PM128 l.c.d. modules for displaying voltage and current.) I also toyed with the idea of adding a backlight but this could probably only be achieved using l.e.d.s mounted at the side.

As with similar 7106 or 7107-based designs, you must be aware that the module's input "ground" terminal should *not* be tied to its power supply ground. If you were thinking of using these or similar DPM modules on a bench power supply output (for example), and hoping to power the DPM from the same power supply, you should arrange to provide a separate "floating" 9V power supply for the DPM,



Digital panel meter from Vann Draper.

although I believe work-arounds are possible that involve some micro-surgery on the module. Their PM129B is a DPM which *does* have a common ground, although it is an l.e.d. display and runs from 5V.

Data sheets for the 7106/7 chip are available directly from the Harris web site: **www.semi.harris.com** in Adobe Acrobat PDF format. Contact Vann Draper Electronics on 0116 2771400.

Hardly a soft start

R.L.A. Latham of Stafford writes:

With reference to your item way back in the August 1996 issue, concerning soft-start lamp protection: you suggested using an NTC "surge protector" as a way of extending the life of filament light bulbs. I sent four letters and two phone calls to Electromail asking for quotations but it seems that several of these useful devices have been discontinued. Can you suggest another source?

The devices in question are negative-temperature co-efficient (NTC) thermistors (thermally-sensitive resistors) which are designed for series connection with a mains-powered load, such as a tungsten filament light bulb or a motor.

Regular readers will have seen the *Lightbulb Saver* project in August 1998 *EPE*, which uses an optically-coupled triac to provide a near zero-crossing switch. This neat design can be constructed within the wall light switch, and helps ensure that the bulb is switched when the mains a.c. sinewave is at its lowest part of the cycle.

Since tungsten filament bulbs have a resistance which actually *increases* when they get hot – they have a positive temperature co-efficient (PTC) of resistivity – then it is best to try to limit the "in-rush" current that flows when the filament is cold and its resistance is lowest (which is why bulbs often fail at switch-on). The *Lightbulb Saver* works by ensuring that the filament is not powered up when the a.c. cycle is nearest its peak.

A crude alternative is to use an NTC thermistor in series with the bulb. The resistance of the NTC thermistor actually decreases when its temperature rises. Thus the initial in-rush current is limited until the thermistor warms up through self-heating.

The disadvantage is that it can take up to a minute or more before the lamp brilliance reaches maximum intensity, which means it is not suited for room lighting; they also get very hot in normal operation. In fact, the in-rush limiter was suggested as a way of protecting expensive low-voltage halogen desk lights, where it has proved extremely effective.

To answer your question, the types I suggested are still listed in the RS Components (Electromail) catalogue under Resistors (210-673 *et al*), and furthermore they are all there on the £2 million RS Web site (**http://www.rswww.com**). I tracked down equivalent current-limiting suppressors from Farnell (606-730), listed under Sensors and Transducers (because they're thermistors). Manufacturers include Rhopoint "Surge-Gard" and Siemens.

The main specs. to check are the maximum continuous load current, and the typical resistance of the thermistor when hot and cold. This will indicate what effect the series thermistor will have on the load. In the case of a lamp, it may affect the maximum light intensity of the filament but hopefully this will be barely noticeable.

Finally from Farnell

Mr. Latham commented separately that "Farnell do not appear to accept orders paid for by cheque." (See August 1998 *Circuit Surgery* "Farnell Comes to Terms"). I have become increasingly baffled by the conflicting reports of the order terms operated by the world's largest catalogue-based distributor of components (they own Newark in the USA) so I checked this out.

Their printed terms are currently unclear, which is unhelpful. Their Sales Department say that they *do* accept orders accompanied by a cheque payment.

Many readers will be interested to hear that Farnell's previous "no minimum order" condition was actually an expensive misprint: their catalogue should also have added "for account customers". This meant that Joe Public could buy a ten pence transistor for ten pence, postage paid, plus VAT which is obviously not viable.

To their credit, for the duration of two catalogues, Farnell honoured the erroneous "no minimum order" clause but it is not surprising that the honeymoon is now over. I must say it took some doing, but both their Sales and their Marketing departments eventually confirmed their terms are:

a) Farnell do accept cheques with order, by post. Such orders receive the same-day despatch service as all other orders, and are carriage paid for standard deliveries. They also accept major credit cards.

b) "Cash with order" actually means "hard" cash, which will only be accepted at their Trade counter.

c) The minimum order value accepted for **non-account holders** is £10 excluding VAT, whether cheque with order or credit card.

d) For non-stock items – ones which they have to buy in specially – the cheque will need to clear before goods are despatched.

At the risk of sounding like a Farnell salesman, I hope that clears it up: I have made Farnell aware of the ambiguities in their printed terms.

Large catalogue companies do well to accommodate the hobbyist, as they are geared towards the needs of industrial and educational markets, so don't forget that there are legions of electronic component shops and mail-order suppliers who work extremely hard to meet the needs of the average *EPE* reader. It is always worth contacting them to see whether they can order parts in for you.

Glow Lamps

I received several letters back related to those mysterious neon "glow lamps" (July 1998 *Circuit Surgery*). These are neon bulbs which emit a green glow and they seem quite scarce, probably because it is usual to use l.e.d.s as power-on indicators for many applications.

Eventually I managed to get my hands on some (Farnell again – 883-232), and they appear to be an ordinary neon bulb with a phosphor coating inside. They emit a green glow and I detected a faint orange glow between the electrodes, so I guess they are ordinary neon-filled tubes which fluoresce.

They strike at about 70V and need a 180k series resistance for mains use. Take due care with these higher voltages if you decide to experiment! My thanks to all those who contacted me with their suggestions.

CIRCUIT THERAPY

Circuit Surgery is your column. If you have any queries or comments, please write to: Alan Winstanley, *Circuit Surgery*, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom. E-mail **alan@epemag.demon.co.uk**. Please indicate if your query is not for publication. A personal reply cannot always be guaranteed but we will try to publish representative answers in this column.

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M9/98

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BBC SELECTORS WITH SMART CARD SLOT AND VIDEO CRYPT Interesting new item in this week is this Selector. Originally made for the BBC to send encrypted video films to your VCR at night time. The project seems to have failed. Very complex units consisting of a smart card slot in the front plus several switches and an IR receiver. Fully cased and measuring 230 x 430 x 90mm, new and boxed. On the back of the unit is a scart socket plus a UHF input and output. A channel tuning control numbered 28 to 40 and an IR socket. Inside is a comprehensive tuner section, smart card reader mechanism and control electronics plus a power supply section.. These units are sold as strippers but we imagine you could use one to convert a monitor into a TV or maybe use the videocrypt side of things for something else. Supplied complete with manual and mains lead. Clearance price just £9.95 ref BBC1X.

INLINE RCB UNITS This in line minature earth leakage unit instantly shut off the mains supply in the event of any current flowing between live and earth thus preventing a potentially lethal shock. IEC plug one end, socket the other, fitted in seconds, reset button. The ultimate safety aid when working on electronic equipment, computers etc. As these units are fitted with an in-line IEC plug on one end and socket on the other than could even be used to extend standard IEC computer leads. **Pack of 3 £9.99 ref LOT5A**

THE ULTIMATE ENCLOSURE for your projects must be one of these! Well made ABS screw together beige case measuring 120 x 150 x 50mm. Already fitted with rubber feet and front mounted LED. Inside is a pcb fitted with other bits and pieces you may find useful. Sold either as a pack of five for £10 ref MD1, pack of 20 for £19.95 ref MD2

17 WATT 12V SOLAR PANEL A solar panel designed to give a nominal 12v. The solar cells are laminated within a high quality resin material! which offers excellent protection against UV and moisture. Mounted on tempered glass in an alauminium frame. The panel is ideal for charging sealed lead acid batteries and a protection diode in the circuit prevents reversed current flow. Mounting is by four adjustable hooks and connection is by screw terminals. Max power 17 wattts, 35 cells, 17vdc peak, 433x402x15mm, 1000mA max, 1.9kg. **Solar panel £115 ref SOL4**

SOLAR POWERED AM/FM RADIO A compact, AM/FM mono radio complete with earphone and a solar panel that recharges the built-in battery when placed in direct sunlight or under a strong lamp.It features a rotary Volume/On/Off control (which must be set to 'Off for recharging), AM/FM selector switch, rotary tuning control, metal belt clip and socket for external 3V DC supply. **Solar Radio £7.95 ref SR23**

MOTOR CYCLISTS RADAR DETECTOR New in is the **Whistler** 1560 Laser/Radar detector complete with a speaker for motorcycle helmets. Super wid band covering X,K and Ka plus lasers at 950nm+/-10nm. 360 deg total perimeter protection, detects laser, radar and VG-2 wherever they come from. **£159.95 ref RD4**

MAGIC EAR Unlike previous 'sound-magnifiers' we have offered, Magic Ear fits unobtrusively behind the ear itself. Magic Ear's micro technology is very advanced; its built-in microphone is extremely sensitive and there's also a volume control to help you adjust to all conditions in use, Magic Ear is startlingly effective. It'll help you to follow every word of conversation even at a distance, and enjoy theatre, cinema or live music with stunning new sound. Comes fitted with 3 long life batteries, a free travel pouch, plus a choice of 3 different ear pieces designed to fit all shapes of ear. **Magic ear £16.99 ref MAGE3**

RADIO METER Perhaps the best of the scientific knick-knacks of the past and well overdue for revival! Fascinating, soothing and educational. In the vacuum inside the inverted bulb like container the vanes revolve, driven round by light particles alone! (each vane is black on one side white on the other). **Radiometer £9.99 ref SC120B**

SATELLITE NAVIGATION £119 The GARMIN~ GPS 38~ is the one navigational tool for the great outdoors that offers big features in a small, lightweight package - all at a truly affordable price. Mark your favorite fishing spot, tree stand or camp site. Or retrace your steps back to the safety of your starting point using our all - new TracBack feature. The GPS 38 shows you exactly where you are, where you've been and where you're going. The GPS 38 features easy, one-thumb operation and weighs only 255g. There's a resettable trip odometer, graphic compass' and highway steering guidance. And it provides up to 20 hours of use on a set of 4 AA batteries. The GARMIN GPS 38. The affordable way to bring you back. £119 ref GPS1

DIFFERENTIAL THERMOSTAT KIT An electronic self assembly kit designed for use in solar heating systems, heat recovery systems etc. The principle of the kit is that it has two thermistors that are placed on the items to be measured (typically a solar panel and a water storage tank) the controller then operates a relay all the time one temperature is higher than the other. The temperature difference is adjustable. A typical use would be to operate a pump all the time a solar panel was at a higher temperature than the water storage tank. **Differential thermostat kit £29 ref LOT93.**

10 WATT SOLAR PANEL Amorphous silicon panel fitted in a anodized aluminium frame. Panel measures 3' by 1' with screw terminals for easy connection. One of these panels will run our solar water pump in full sunlight although we would recommend that for optimum performance two panels would be prefereable. **3' x 1' solar panel £55 ref MAG45**

12V SOLAR POWERED WATER PUMP Perfect for many 12v DC uses, ranging from solar fountains to hydroponics! Small and compact yet powerful. Will work direct from our 10 watt solar panel in bright sunlight. Max head:17 ft Max flow rate : 8 1pm Current :1 .5A (Ref AC8) £18.99

BOOST CELL PHONE RECEPTION ON THE MOVE! Compared to high-powered carphones, hand-portable mobile phones don't always work too well in moving vehicles. Sometimes the signal 'drops out' during a call, other times there's too much interference to get through at all. However, the affordable Cell Patch provides a major improvement, dramatically boosting signal reception without wires or batteries. The 9.5 x 9.5cm (3.3" X 3.3") microthin antenna adheres to your car window sunvisor, ideally within 61-122cm (2-4') of the handset, or can be carried in a pocket. Works with all types of portable cellular phone. Cell Patch £11.99 ref CEL1

CAT SCARER produces a blanket of high sonic and low ultrasonic sound, which is inaudible to humans, birds and fish - so it is ideal where you want to protect your bird table or fish pond against feline predators. It will deter cats from your garden and other protected areas. It will also deter foxes. mains operated, 10 m of cable. Running cost will be approximately 1 p per day. Garden watcher £42.45 ref GW2

VIDEO PROCESSOR UNITS?/6v 10AH BATTS/24V 8A TX Not too sure what the function of these units is but they certainly make good strippers! Measures 390X320X120mm, on the front are controls for scan speed, scan delay, scan mode, loads of connections on the rear. Inside 2 x 6v 10AH sealed lead acid batts, 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. £9.95 ref VP2X

SOLAR MOTORS Another new line for us are these tiny motors which run quite happily on voltages from3-12vdc. We have tried one on our 6v amorphous 6" panels and you can run them from the sun! 32mm dia 20mm thick. £1.50 each

TELEPHONES Just In this week is a huge delivery of telephones, all brand new and boxed. Two piece construction with the following features- Illuminated keypad, nice clear easy to use keypad, tone or pulse (switchable), reacall, redial and pause, high/low and off ringer switch and quality construction. Each telephone is finished in a smart off white colour and is supplied with a standard international lead (same as US or modem card sockets) if you wish to have a BT lead supplied to convert the phones these are also available at £1.55 each ref BTLX **Phones £4.99 each ref PH2**

INFRARED CAR PHONE KIT £7.99 interesting box of goodies! this kit was designed to convert car phones to enable hands free dialling, the kit contains the following items. 1) A keypad designed to mount in the centre of the steering wheel, it requires a 9v PP3 battery and transmits the numbers using three on board high power infra red LEDs. 140 x 120mm. 2) An infra red receiver module containing a IR photo diode, IR filter and control electronics 60 x 30 x 15mm (cased). 3) Control box (nice case) 100 x 170 x 35mm which we understand is the interface between the infra red and the car phone, it is also supposed to adjust the volume of your car stereo at the same time! made for Phillips car phones (but we don't know the model)Complete kit is £7.99 ref CP1

Hi power 12v xenon strobe variable rate flasher modules and tubes £6Useful 12v PCB fitted with control electronics and a powerful Xenon tube! just apply 12v DC to the input and the tube will flash. On the board is a small potentiometer which can be used to vary the flash rat! PCB measures just 70x 55mm and could be incorporated into many interesting projects! £6 ref FLS1 Pack of 10 is £49 ref FLS2

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 a certificate enabling you to reproduce the manuals as much as you like!£14 ref EP74

TALKING WATCH Yes, it actually tells you the time at the push of a button. Also features a voice alarm that wakes you up and tells you what the time is! Lithium cell included. £8.99 ref EP26A

POWERBEAM INFRA RED Lamp,All this lamp gives out is infra red light, and loads of it! perfect for supplimenting night sight and surveillance equipment. Most mono CCTV video cameras are infra red sensitive so used in conjunction with this lamp would greatly enhance their operating performance. Water resistant case and rubber covered switch make this unit perfect for all weathers. Krypton bulb. 4 D cells required. **Powerbeam lamp £29 ref PB1**

GIANT SCREEN VIEWER Turn your TV picture into a supersize screen! This high precision Fresnel lens converts even the smallest screen up to a massive 26', giving a crystal clear picture at a traction ot the cost of a big TV. Easily fitted in minutes.Also ideal for PC monitors etc £26.95 ref SVGA2

NOGALIGHT NIGHT VISION £129 Open up a new world of adventures and experiences. Wildlife enthusiasts and adventurers in the wilderness, amateur astronomers, hunters, wargamers, private eyes on surveillance, all find Nightspy indispensable for their use. Nightspy's unique features include a special tube protection device, to eliminate over exposure, and infrared illuminator used in total darkness, such as in cave exploration and operations in dark rooms. The Nightspy is light and hand held, or can be mounted on a standard tripod. It uses two standard AA batteries and can be operated by left or right hand users, with or without optical glasses. Optical:Magnification: X 1.7 Field of View: 10Degrees Focusing Range:25cm to infinity objective Focal Length: 50 mm F/N: 1.6 Diopter Range: +/- 3 Mechanical:Length: 182 mm Width: 65mm Height 100 mm Weight 700 gr. Electrical: Power Source: 3 VDC, 2AA batteries Battery Life: 40 hours Infra-red Illuminator: built-in Imaging Device: Night Vision Image Intensifier Tube. **£129 ref NOGA**

Register with us at www.bull-electrical.com for your free e-mail NEWSLETTERS!

DRILL OPERATED PUMP Fits to any drill in seconds, uses standard garden hose, will pump up to 40 gallons per hour! £8.99 ref DRL3

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

SECOND GENERATION NIGHT SIGHTS FROM £748

RETRON Russian night sight, 1.8x, infra red lamp, 10m-Inf, standard M42 lens, 1.1kg. £349 ref RET1

MAINS MOTORS 180 RPM 90X70mm, 50X5mm 50x5mm output shaft, start cap included. £22 ref MGM1

PC POWER SUPPLIES, CUSTOMER RETURNS, ALL FAN COOLED, OUR CHOICE, BARGAIN AT 8 PSU'S FOR £9.99 REF XX17

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

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

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

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

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

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

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

LIQUID CRYSTAL DISPLAYS Bargain prices,

20 character 2 line, 83x19mm £3.99 ref SMC2024A

16 character 4 line, 62x25mm £5.99 ref SMC1640A

TAL-1, 110MM NEWTONIAN REFLECTOR TELESCOPE Russian. Superb astronomical 'scope, everything you need for some serious star gazing! up to 169x magnification. Send or fax for further information.20kg, 885x800x1650mm ref TAL-1, £249

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

PHOTOMULTIPLIER TUBES Boxed and unused straight from the ministry of defence. Made by EMI with a MOD part no of 10/CV/5114 and packed almost 30 years ago..! Do you have a use? do you want to count light particles? They would look nice on the mantle piece!Offered to you at £15 each (we think the MOD paid more than this is 1958! £15 each ref PM3

CLOCK CAMERA WITH AUDIO Discretely monitor living rooms, reception, office, tills or any other area. Fully working clock houses an invisible spy camera complete with audio. Complete setup includes clock, camera, microphone, clock battery, 15 metres of cable, power supply, adapter for either scart or phono. Everything you need, no soldering required. Full instructions included. Easily installed in just a few minutes. Plugs straight into VCR or TV (scart or phono)Clock camera with audio £89.95 ref CC5

AUTO RECORD KIT This automatic system will instruct your VCR to start recording when movement is detected via the PIR. Recording will stop 30 seconds after your visitor has left which saves hours of tapes as the video only records what you want to see. Complete system with PIR, will work with all remote control video recorders. **£89 ref CVC2**

TELEPHONE VOICE CHANGER Changes your voice to a new or unfamiliar one. Simply place over the telephone mouth piece and speak into the changer. Fully adjustable for different voices. Supplied complete with batteries, ready to go. Unit measures 90 x 60 x20mm Telephone voice changer **£14.95 ref CC3**

EXTERNAL CAMERA Introducing the Bulldog model 4 vandal resistant camera in heavy steel case for interior or exterior use. Top quality case housing a 420 line camera module. Each camera is supplied with a 15m cable terminating in Scart and phono plugs. Multi angle bracket for easy installation in any situation. A 12vdc psu is also included. Easily installed in a few minutes, plugs straight into VCR or TV (phono or scart). **Bargain price £89.95 ref CC1**

GIANT INSULATORS Just in this week are some giant ceramic Insulators, each one measures 130mm high and about 170mm diameter. Finished in a high gloss brown and black glaze. In the base of each insulator is a threaded hole approx 1" diameter, rather like a mop/broom head thread. If you are into shortwave radio, crystal sets or high voltage experiments then these are for you. (We've got one as a door stop) Not too sure what their original purpose was, all we know is they were made for export about 25 years ago, never exported and been in store since then. **Price is £8 each ref INSX**

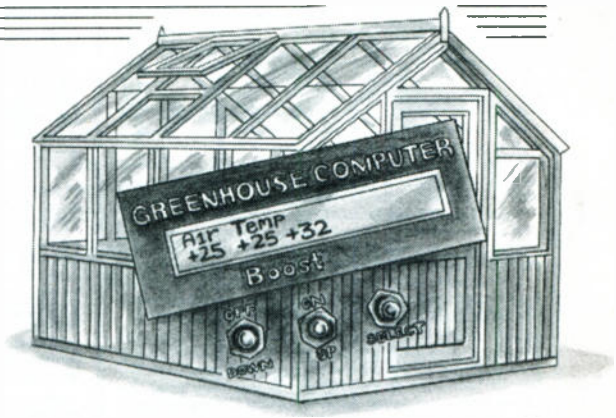
NATO RADIATION MONITORS Interesting new line! These are small modules that strap on your wrist (strap supplied) and monitor radiation. We have stripped one apart and they contain a small piece of "crystal" this could be something like Naphthalene or any other rare radiation sensitive crystal. When radiation strikes the crystal, it scintillates and a small amount of light is produced in the crystal in reaction to the radiation exposure. That light is then picked up by a micro pv cell measuring about 2mm square! Also in the unit is a sheet of foil, a circular metal plate (insulation between the two) and a small pair of additional parallel metal plates. NATO part no is 6665-99-225-2314 any information gratefully received!! Alternatively if you wish to buy one they are **just £3 each** ref NATOX

WE HAD 38,000 'HITS' ON OUR WEB SITE IN FEBUARY '98.....

BULL-ELECTRICAL.COM

See our live camera!

Constructional Project



GREENHOUSE RADIO LINK

COLIN MEIKLE

Monitor the well-being of your plants from your armchair.

THIS article describes a low power radio link which allows the *Greenhouse Computer* in *EPE* July and August '98 to be remotely monitored.

The radio receiver and transmitter are ready-made plug-in modules, thus avoiding any complicated setting-up and adjustments. Adding the transmitter to the *Greenhouse Computer* simply involves plugging a module into the existing printed circuit board. The Receiver unit is described here.

Information is sent to the receiver every 10 seconds and is shown on a liquid crystal display (l.c.d.). The displayed information is very similar to that on the computer's l.c.d., i.e. current temperature, soil moisture etc. The information is formatted differently, however, and more details are given, e.g. the current settings are displayed.

The information is also stored at preset intervals in an on-board EEPROM (electrically erasable read only memory). An optional RS232 port on the board allows you to upload the contents of the EEPROM to a PC-compatible computer, where it can be stored on disk. This can then be used, for example, to draw graphs of the temperature. The file format is suitable for loading into most spreadsheets, for simple post-processing.

It is not necessary, though, to have a computer in order to use the basic monitoring facilities of this radio link.

The complete unit can be powered either from an external 9V p.s.u. (e.g. an integrated plug type) or from a 9V battery. This keeps the size of the unit small, even pocket sized. Connection to a PC is only required to upload readings, therefore the unit does not normally require to be next to a PC.

Operation of the system is outlined in the block diagram in Fig.1.

RADIO MODULES

The radio modules comprise a self-contained receiver which operates with a matching transmitter module. The two modules provide a one-way communication link, over which a serial data stream can be sent (maximum 20K Baud).

The Transmitter and Receiver operate on a frequency of 418MHz. These modules are licence exempt and conform to the MPT1340 standard (see later). The range of the link is 50m to 200m, dependent on the operating environment and antenna configuration.

These modules are small and low powered, no setting-up is required and, being licence exempt, are therefore ideal for applications like this.

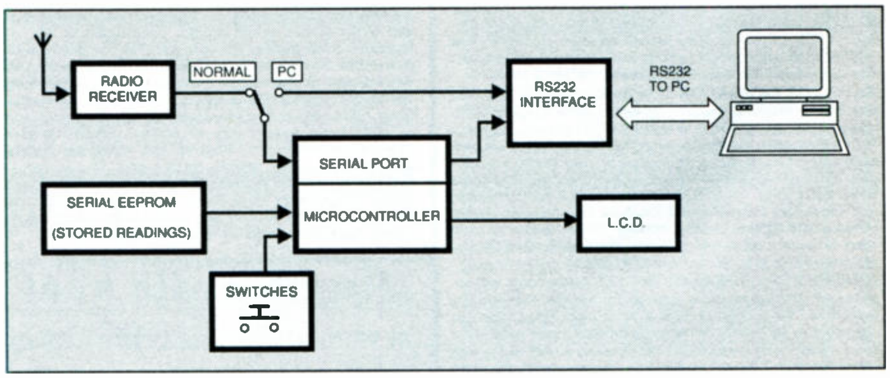
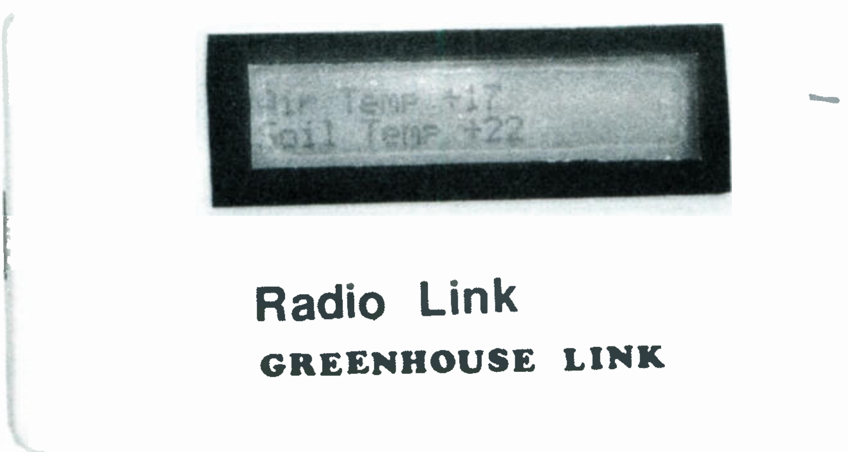


Fig.1. Block diagram for the Greenhouse Radio Link.



The transmitter is available in 3·3V ("F" version) and 5V ("A" version) varieties. Either can be used, although 3·3V is assumed. If you want to use the 5V transmitter you will need to remove the 3·3V Zener diode (D1) on the *Greenhouse Computer* p.c.b.

Note that ONLY the 5V version of the receiver module ("A" version) can be used – there is no provision to change its supply voltage to 3·3V.

The Transmitter circuit was shown integrated with the *Greenhouse Computer* in Fig.5 (last month). It is repeated here in Fig.2. The complete circuit diagram for the Receiver is illustrated in Fig.3.

Referring to Fig.2, a serial data stream is sent from pin P3.0 of the *Greenhouse Computer's* microcontroller (IC1)

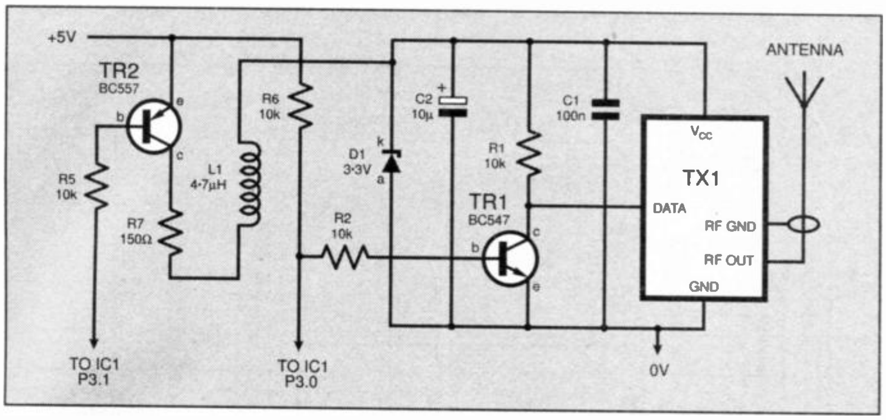


Fig.2. Transmitter circuit as used in the Greenhouse Computer.

via buffer transistor TR1 to the data pin of the transmitter module (TX1). This signal is automatically transmitted to the receiver module (RX1 in Fig.3) where a corresponding data stream appears on its data output pin.

Power to the transmitter is controlled by IC1 pin P3.1, via buffer transistor TR2. It is turned off between transmission bursts. Inductor L1 smooths the supply and Zener diode D1 limits it to 3·3V.

TRANSMISSION BLOCK

The format of each transmission data block is shown in Table 1.

Table 1. Transmission Format

Bytes 1 to 3	AAH	Instructs the receiver to "lock-on" to the incoming data
Byte 4	FFH	Ensures that the microprocessor's UART is empty
Byte 5	01H	Start Byte, signalling the start of the transmission
Byte 6	0EH	Address Byte, identifying the transmitter (the port is shared with the RS232 port – the PC interface uses a different address byte)
Bytes 7 to 27		Data from the Greenhouse Computer

Data from the *Greenhouse Computer* is received in order of:

Air Temperature, Soil Temperature, Soil Moisture, Enable Soil, Enable Water, Set Soil, Set Temperature, Water Amount, Water Time, Re-water, Boost

The link operates at a speed of 2400 Baud. Since only small blocks of data are being transmitted speed is unimportant (slow speeds increase the range).

Whereas the transmitter is only turned on when required, the receiver is powered permanently. The receiver produces a random output data stream when the transmitter is off, so the microcontroller must be careful to pick up the correct start sequence, as described.

GREENHOUSE LOGGING

The greenhouse logging function is optional. If you do not have a PC, you can use the receiver purely as a remote display.

The receiver board contains an EEPROM and a simple RS232 port. This enables the received measurements to be stored (up to 4088 sets of results) and then uploaded to a PC when required.

The interval between storing results is variable between 1 and 255 minutes. With the default time of 30 minutes between results, up to 85 days of readings can be stored. The interval is set via the software running on the PC.

A serial EEPROM (IC2 in Fig.3) has been used due to the input/output limitations of the processor. Since this device is non-volatile, if you lose power you will not lose your readings.

A pushbutton switch (S1) is provided to reset the Save counter if necessary. This switch is only operational during power-up, in normal operation it has no function (this stops accidental resets). This reset will not normally be necessary, as this function should be done via the PC interface. You may even omit the switch from your design if you prefer (it is omitted from prototype in the photographs).

The RS232 interface is a very simple design. It will work well as long as the cable length between the receiver and the PC is kept short (this should not be a problem since the receiver is portable). A typical cable length of about two metres should be satisfactory. The microcontroller's UART data-receive input is shared between the radio module and the RS232 port.

The mode switch (S2) is used to select between the functions. It will normally be set to the radio receiver, unless the PC interface is in use. Whilst the use of a manual switch could have been avoided by altering the design, the use of the switch ensures reliable operation of the serial port.

CONSTRUCTION

Component and track layout details for the printed circuit board are shown in Fig.4. This board is available from the *EPE PCB Service*, code 200.

Assemble the board in the usual order of links, diodes, resistors, capacitors etc. There are a number of polarised components – take care to insert them correctly. Make sure the orientation of the resistor module (RM1) is correct, the common pin (normally a dot on the resistor) is marked on the component overlay.

The radio receiver module (RX1) should be mounted in a socket. It is suggest that a 7-pin s.i.l. socket is cut to make the 2-pin and 5-pin sections needed for this.

Connector TB1 is a pin-header that provides connections to the pushswitch S1. If you prefer, you may solder wires directly to the board rather than using a connector.

The l.c.d. module connection is the same as on the *Greenhouse* control board; it is best to use a right-angled 14-way header (PL1) on the p.c.b. A 14-way ribbon cable with an IDC connector can then be used to connect to the l.c.d.

A window in the case for the l.c.d. can be made from a plastic CD case, this will protect the display.

If you do not need the PC interface, omit the components associated with the

COMPONENTS

Resistors

R1, R9	1k (2 off)
R2, R12	220Ω (2 off)
R3	4k7
R4 to R6, R10, R11	10k (5 off)
R7	10Ω
R8	100Ω
RM1	8 × 10k resistor module, s.i.l.

All 0·25W 5% carbon film or better.

Capacitors

C1, C2, C7	10µ radial elect. 16V (3 off)
C3, C6	10n ceramic (2 off)
C4, C12	100n ceramic (2 off)
C5, C10	1µ tantalum bead (2 off)
C8, C9	33p ceramic (2 off)
C11	100µ radial elect. 16V

Semiconductors

D1, D2	BAT54 Schottky diode (2 off)
D3	1N4148 signal diode
TR1	BC557 *pnp* transistor
TR2, TR3	BC547B *npn* transistor (2 off)
IC1	AT89C2051 pre-programmed microcontroller (see text)
IC2	X25160 16K serial EEPROM
IC3	78L05 100mA 5V regulator
X1	12MHz crystal
X2	2-line × 20 character l.c.d. module (0V/+5V supply)

Miscellaneous

L1	56µH inductor
S1	push-to-make switch
S2	d.p.s.t. toggle switch
RX1	SILRX-418-A 418MHz receiver module
TB1	4-way pin header
TB2	3-way pin header
TB3	14-way pin header
SK1	power supply connector, case mounting
SK2	9-pin D-connector, p.c.b. mounting

Printed circuit board, available from the *EPE PCB Service*, code 200; 8-pin d.i.l. socket; 20-pin d.i.l. socket; 7-pin s.i.l. socket (see text); antenna (see text); RS232 serial cable with connectors; enamelled copper wire for aerial coil, 0.5mm diameter; 9V power supply (see text); plastic case, 144mm × 81mm × 30mm; connecting wire; solder, etc.

Approx Cost Guidance Only £79
excluding RS232 cable, case and p.s.u.

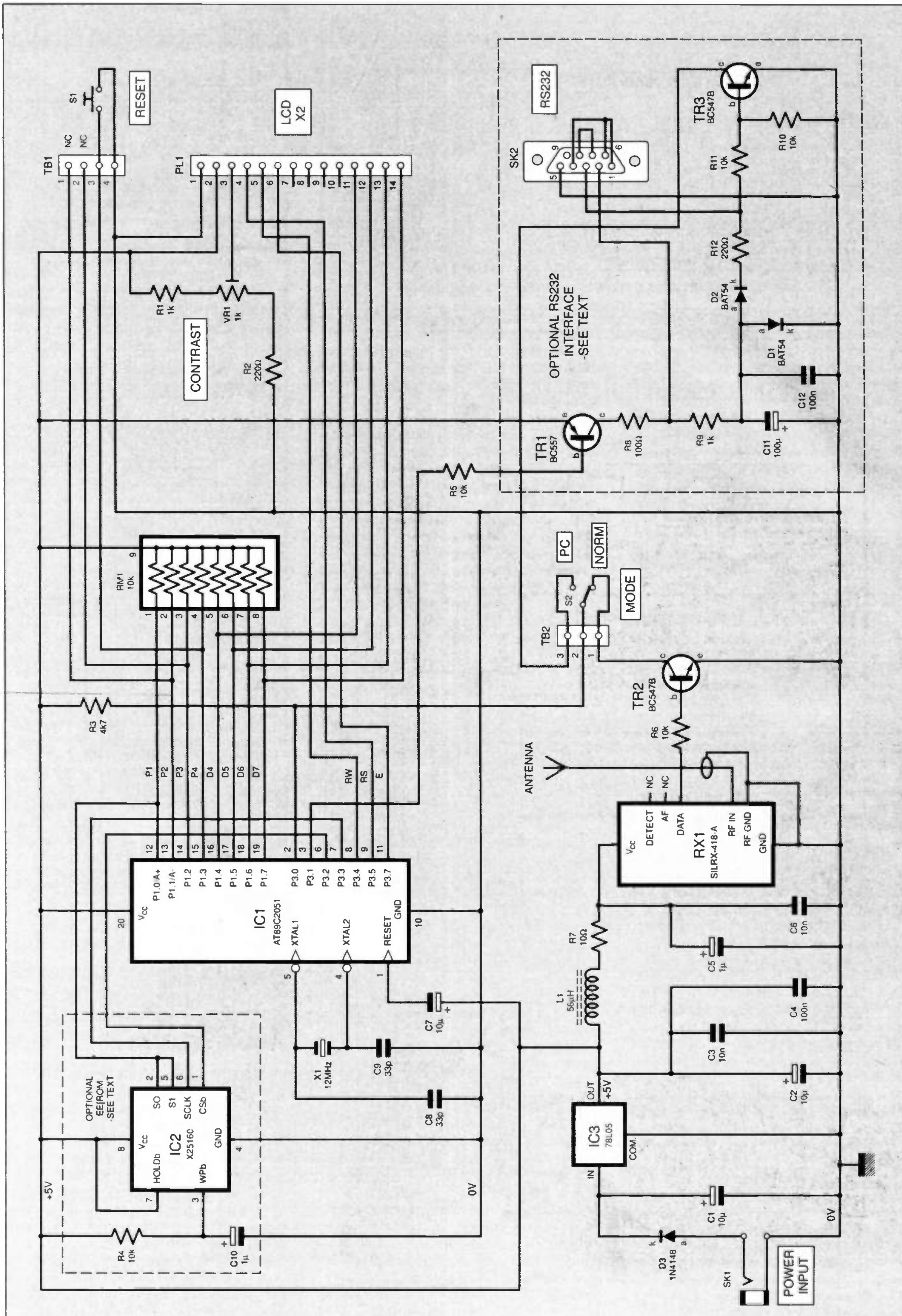


Fig.3. Complete circuit diagram for the Greenhouse Radio Link. X2 is a 2-line × 20 character l.c.d. module.

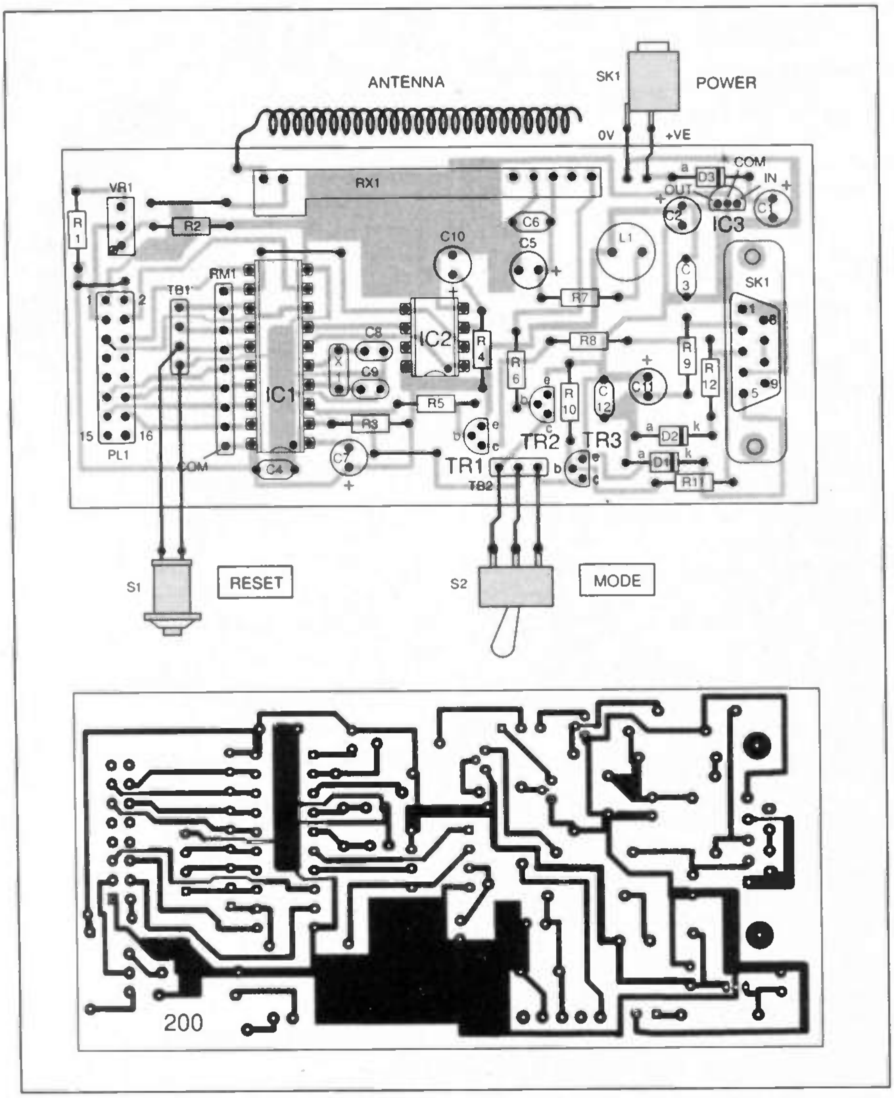
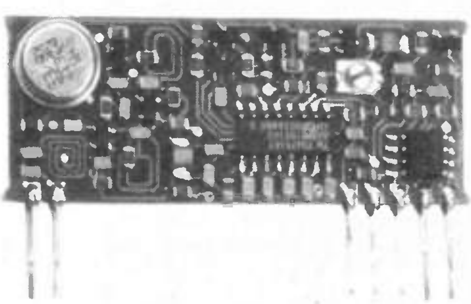
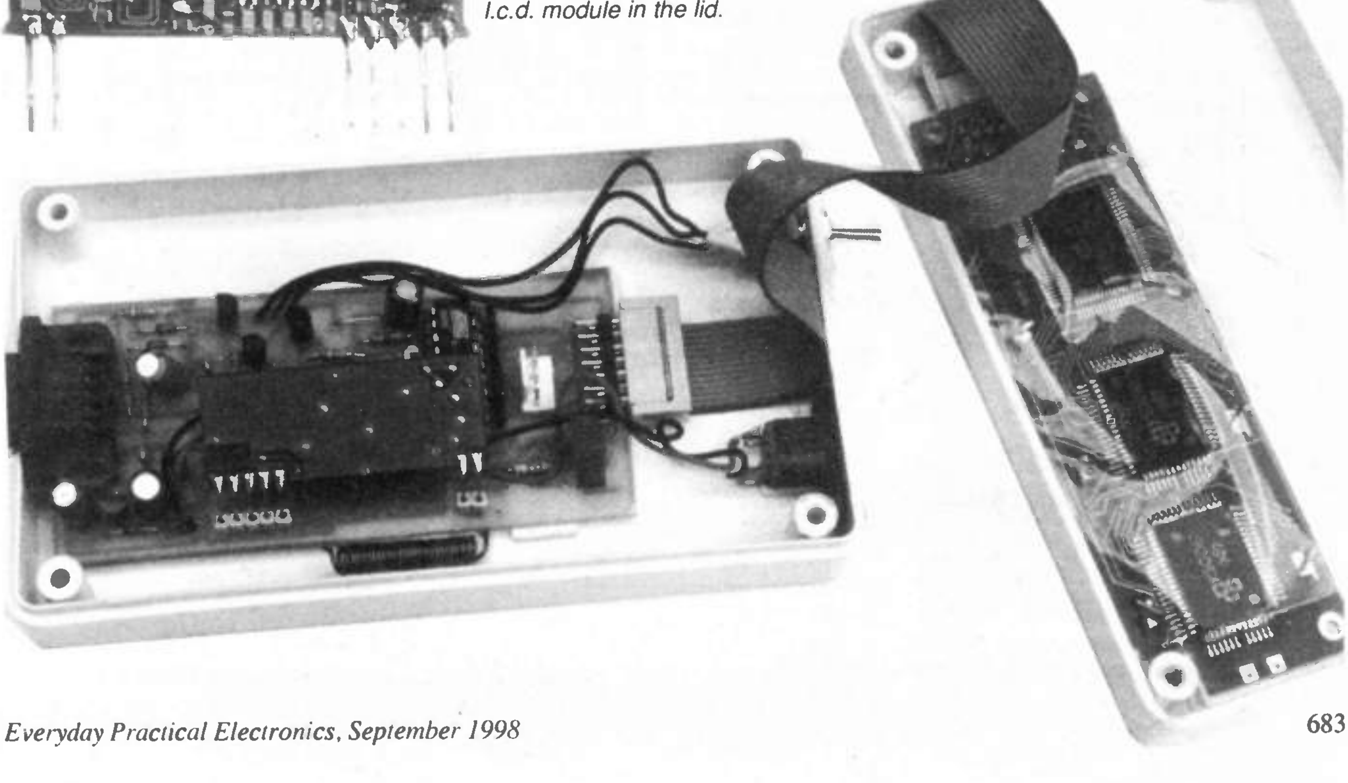


Fig.4. Printed circuit board component layout, wiring details and full size copper track master for the Greenhouse Radio Link.



Left: Ready-made receiver module.

Below: The fully assembled Radio Link in the base of its box, with the l.c.d. module in the lid.



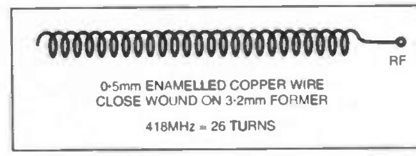


Fig.5. Recommended helical antenna.

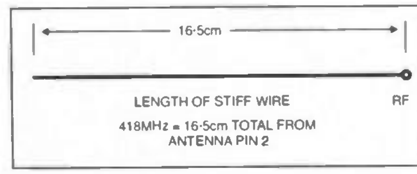


Fig.6. Alternative whip antenna.

RS232 interface and the serial EEPROM (within the dotted boxes in Fig.3). In this case replace the Mode switch (S2) with a link between positions 1 and 2. The reset switch (S1) should also be omitted.

ANTENNA

The type of antenna will determine the range of the system. The recommended construction for a helical antenna is shown in Fig.5. This applies to both the transmitter and the receiver.

The antenna coil can be wound around a small thin screwdriver, about 3·2mm diameter. One end, marked as *RF* in the diagram, should have the enamel scrapped off the wire so that it can be soldered to the p.c.b.

It should be soldered to the underside of the p.c.b. (directly to the corresponding pin on the module's socket). The antenna should be kept away from metal objects and should be bent so that it is at least 5mm away from the p.c.b., keeping it away from tracks and components.

When assembling the receiver into the box, try to make sure the antenna will not be close to any metal objects (such as a battery) as this will affect performance.

Note that the MPT1340 standard requires that the transmitter's antenna is a fixed internal item, i.e. you *must not* have an externally accessible connector for connecting an external antenna.

For the receiver only, an alternative to the helical antenna is to use a whip. This will give better range but is bigger and more awkward to mount. An example is shown in Fig.6.

FIRST TESTS

The receiver circuit is intended to be powered from an external power supply (e.g. an integrated plug type supplying 9V d.c.). For testing, though, it is best to use a bench supply so that the current consumption can be monitored, it should consume 50mA or less.

Before applying power, visually check the p.c.b. for shorts and check all the polarised components, etc. Do not plug the radio module, IC1 or the l.c.d. into the control board yet. Using a meter ensure there are no shorts between 5V and ground (IC1 socket pins 10 and 20), or across the power input.

Using a bench power supply, set it to 12V. If it has a current limit, set it to 100mA. Connect the supply to the p.c.b. Turn on the power and verify that there is 5V across pins 10 and 20 on the IC1 socket.

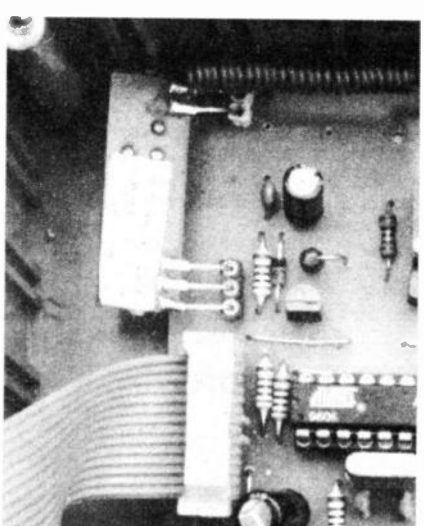
Turn the power off, plug in the pre-programmed processor (IC1) and the l.c.d. The latter must be a single supply variety, i.e. 0V/5V, the same as used with the *Greenhouse Computer* board. Ensure that the l.c.d. is plugged in correctly (it is easy to plug it in the wrong way).

Verify that the voltage across the positive and negative pins of the receiver is 5V. If all is ok, plug the receiver into its socket. The l.c.d. will not display messages until it receives a message from the transmitter. Once the transmitter is set up, the l.c.d. should show messages. If it does not, try adjusting the contrast preset VR1. If nothing appears, switch off and re-check.

TRANSMITTER

On the *Greenhouse Computer* control board plug in the transmitter module, having disconnected power from the board first, as the battery back-up will take over when the mains is powered off.

Reconnect the *Greenhouse Computer* supply and also apply power to the receiver; after 10 to 20 seconds it should start to display the greenhouse information as individual screens of data.



The transmitter module on the Greenhouse Computer *board.*

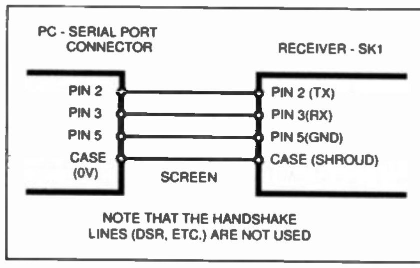


Fig.7. Connections required between computer and receiver.

To test the RS232 interface, connect the RS232 cable and set up the receiver to record once every minute (see later). Leave for 30 minutes and then try to load some results. Remember to change the switch setting to *PC* when "talking" to the PC and back to *Normal* as soon as you finish.

If you do not receive any data, check that all of the RS232 components are orientated correctly. Ensure that you are using the correct type of serial cable, which should be connected as in Fig.7. The cable should NOT have a "twist", i.e. not a Laplink cable.

SOFTWARE

The software for the receiver comes in two parts, the software that runs on the microcontroller (IC1) and the PC software. The PC software is optional and is only required if you want to log results. Both sets of software are available through the *EPE PCB Service* and via the *EPE* web site.

The microcontroller needs to be programmed before use. The AT89C2051 programmer in *EPE* June '98 is ideal for this. Alternatively, pre-programmed microcontrollers can be obtained from the author – see *Shop Talk* page for more information on this and the software.

Those of you with Internet access can also contact the author via E-mail at: **colin.meikle@virgin.net**

The source code for the microcontroller and the PC is written in C (Turbo C for the PC and Keil C51 for the microcontroller). A DOS executable file for the PC is also included.

SOFTWARE USE

Install the software into a suitable directory on your PC. You should always use the same directory, the software uses configuration files which it expects to find there.

Connect the serial cable between the PC and receiver. Set the Mode switch (S2) to *PC*.

From a DOS prompt navigate to the directory where you installed the software and type:

greenrx <filename>

Filename is optional – it specifies the file to which the results will be saved. The following (typical) menu should appear:

Remote Greenhouse Control Program

Recording results started FRI 23/4/98, at 22:35

No file name entered.
Using green.txt

1. **Change Display Update and Save Times**
2. **Upload Data to Screen**
3. **Upload data to file**
4. **Reset save counter**
5. **Select COM Port (default 1)**
6. **Quit**

Enter Choice >

The first line, after the header, tells you when the recording started.

OPTION 1

The first option allows you to change the interval between saves and also allows the display rate on the receiver l.c.d. to be changed. The receiver must be powered on then off to take effect.

OPTION 2

The second option uploads the data to the screen. You are prompted for a correction factor which is added to the data. You should upload the data with zero for the correction and then add an appropriate correction to correct any errors in the timing.

OPTION 3

This option allows you to upload the readings from the receiver. The readings are appended to the file specified when you invoked the program. If you do not specify a file, **green.out** is used as the file name. You may wish to upload weekly and use a separate file for each week or you may want one large file.

The data is output to the screen as well as written to the file. You are required to press the ESC key when all of the data is received. When you upload data, the receiver's EEPROM is not cleared, it continues from where it left off. You must use Option 4 to reset the internal counter.

OPTION 4

Option 4 resets the receiver's EEPROM, i.e. resets the start time. The receiver must

MPT1340 COMPLIANCE

For the completed unit to conform to the MPT1340 standard (MPT1340 December 1987), you must meet the following requirements:

All transmitters shall use integral antennas only. Receivers may use an external antenna or an integral antenna. In this specification, an integral antenna is defined as one which is designed to be connected permanently to the transmitter or receiver without the use of an external feeder.

The equipment in which the module is used must carry an inspection mark located on the outside of its case and be clearly visible. The minimum dimensions of the inspection mark shall be 10mm × 15mm and the letter and figure height must be no less than 2mm. The wording shall read "MPT 1340 W.T. LICENCE EXEMPT".

The adjustment control on the module must not be easily accessible to the end user. This control is factory set and must never be adjusted.

MPT1340 is the type approval specification issued by the RA (DTI) and may be obtained from the RA's library service on 0171 215 2072.

be powered on/off for this to take effect. You may wish to do this every time you upload data.

OPTION 5

Use Option 5 to change the COM port to which your serial cable is attached.

When finished set the Mode switch back to *Normal*.

Note: The software uses a configuration file to store the start times, if you delete the file you will get incorrect timings. You can reset the receiver and make it use the programmed defaults for display and save times by pressing the Reset switch (S1) and powering the receiver off/on.

The timer in the processor is not very accurate over a long period of time. The software allows you to add a correction factor when uploading data.

IN USE

In normal operation, the receiver is very simple to use: just turn the power on and the reading will be displayed (as long as you are in range).

The PC software for controlling the receiver is very basic. It does not draw graphs but simply produces a data file in the following format:

Air Temperature, Soil Temperature, Moisture, Save Interval, Day:Time

e.g. 19, 19, 3, 30, THUR:0:19

This can then be read into a spreadsheet where it can be processed. The graph in Fig.8 was produced using MS Excel, which allows easy formatting of the information to suit your needs.

Alternatively, readers who have any of the Basic dialects can set up their own plotting formats.

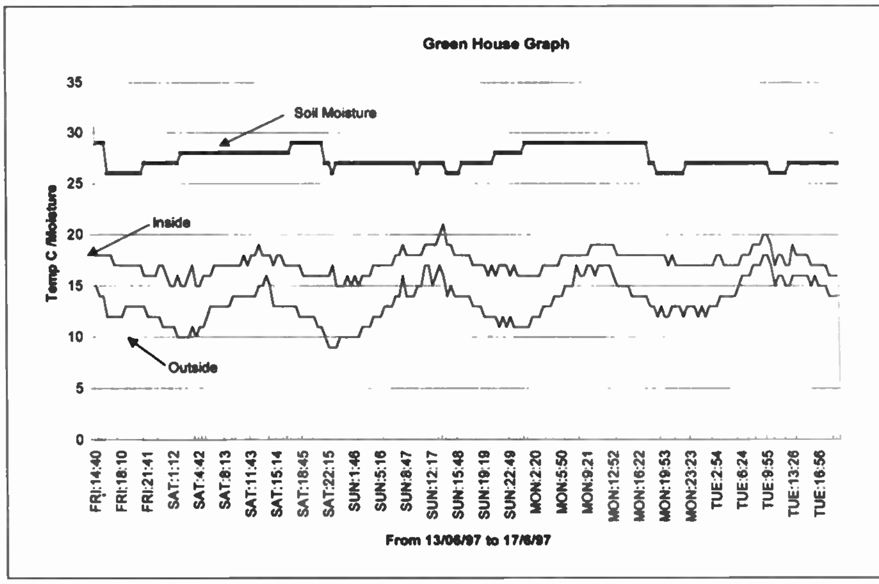


Fig.8. Typical greenhouse data plotted by a PC.

SHOP TALK

with David Barrington

PIC Altimeter

A number of components called for in the *PIC Altimeter* project needed some tracking down, most successfully but one a slight hiccup.

The only source we have come across in our search for the Sensym temperature compensated pressure sensor type SCC15AN has been **Farnell** (☎ ***0113 263 6311***), code 179-275. The device chosen for the model is the enclosed in-line pin version, denoted by the suffix N. Some suppliers may offer a non-enclosed SCC15A and this is perfectly acceptable.

Checking through catalogues shows that most of our components advertisers should be able to supply suitable pushswitches. They should be miniature or ultra-miniature types if they are to fit inside the case, the ones in the model are RS types with round buttons. The crystal should also be widely available.

For those readers who do not have the facilities to program their own PIC chips, a ready-programmed PIC16F84 (PIC16C84) microcontroller is available from **Magenta Electronics** (☎ ***01283 565435***) for the sum of £15 all inclusive. They also stock the 2-line 16-character intelligent l.c.d. module, as do many of our component advertisers.

If you wish to do your own PIC programming, the software listing (TASM – but may be translated to MPASM using the *EPE PIC16x84 Toolkit* from the July '98 issue) is available from the Editorial Offices, see *PCB Service* page 692 for details. If you are an Internet user, it is available Free from our FTP site: **ftp://ftp.epemag.wimborne.co.uk/pub/PICS/PICaltimeter**.

The printed circuit board is available from the *EPE PCB Service*, code 201 (see page 692).

This just leaves us with the case. A search was made to find a case with a cutout slot to suit the size of l.c.d. used and none could be found. The answer was a sloped panel case from RS which had a larger cutout that could be masked to size with little effort. This case is available from **Electromail** (☎ ***01536 204555***), quote code 222-828.

Greenhouse Radio Link

A ready-programmed AT89C2051 microcontroller for the *Radio Link* is available direct from the designer (*Mail Order* only): **Colin Meikle, 9 Coldstream Drive, Strathaven, Lanarkshire, ML10 6UD.** Make cheques payable to him. The price is £12, inclusive of UK postage. For overseas orders add £1.

The software is available from the Editorial offices on a 3·5 inch PC-compatible disk. See *EPE PCB Service* page for postage charges. It is also available Free from our web site: **ftp://ftp.epemag.wimborne.co.uk/pub/8051/Greenhouse**.

The Receiver module is obtainable from **Radio-Tech** (☎ ***01992 576107***). It **must** be the **5V** version, so quote order code SILRX418-A when ordering.

The only other component that is likely to cause sourcing problems is the 16K serial EEPROM type X25160. The only listing we have come across is from **Farnell** (☎ ***0113 263 6311***), code 788-673. The RS232 cable with connectors and pin-header connectors should be generally available. If you experience trouble, try **ESR** (☎ ***0191 251 4363***), who stock a large range of connectors.

The printed circuit board is obtainable from the *EPE PCB Service*, code 200.

Personal Stereo Amplifier

We had lined up a pair of low-cost, enclosed loudspeakers (used in the model), which also came with earphones and headphones, for the *Personal Stereo Amplifier* from **Maplin**, but unfortunately these have now been discontinued. However, we understand that some stores may still have stocks, so the order code to quote when you visit your local shop is CB50E.

All is not lost, another pair of speakers that have been tried with the unit, and from the same source, are some small "passive" multi-media types for computers. Quote code DX32K.

As recommended in the article, it is best to stick with the NE5534AN low-noise op.amp for best performance. If you have trouble tracking this device down, it is currently listed by **Electromail** (☎ ***01536 204555***), code 428-212.

The multi-project printed circuit board is available from the *EPE PCB Service*, code 932.

Mains Socket Tester

It is **vitally important** that only a capacitor rated at 250V **a.c.** or *better*, and capable of continuous operation across the **a.c. mains** supply, is used for the "mains dropper" in the *Mains Socket Tester* project. The one in the prototype came from **Maplin** and is listed as a Class X2 suppression type, code JE09K.

Nearly all the power supply "plug-boxes" we located are sold with plastic Earth pins. It is **most important** that you use one with a **METAL** earth pin. One with a *metal* earth pin, and at a very reasonable price, is being specially stocked by **Greenweld** (☎ ***01703 236363***). You must ask for the *Metal* Earth pin version when ordering.

PLEASE TAKE NOTE

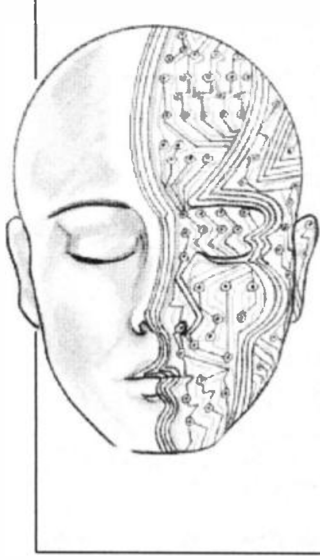
PIC16x84 Toolkit (*July 1998*)

Page 527, Fig.1. In the circuit diagram, l.e.d. D1 is shown the wrong way round. The cathode (k) should go to the +5V line. The p.c.b. layout is correct.

In Fig.3 and Fig.4, the annotations for resistors R10 and R11 have been transposed. R10 is the one that joins resistor R9. Both resistors have the same value (100k).

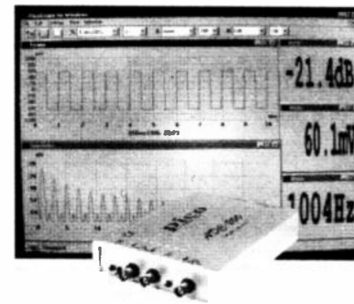
Also, in Figs. 3 and 4, resistor **R6** is shown as R3 connected to the base (b) of transistor TR3. R3 is the one that goes to pin 1 of IC3.

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 BH21 1PF.
They could earn you some real cash **and a prize!**



WIN A PICO PC BASED OSCILLOSCOPE

- 50MSPS Dual Channel Storage Oscilloscope
- 25MHz Spectrum Analyser
- Multimeter
- Frequency Meter
- Signal Generator

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.

Lucky Numbers – One in a million

WITH the odds of winning the lottery a massive 13,983,816 to 1, we could all use a helping hand in choosing our six numbers. The circuit described in Fig.1 (below) does just that, by controlling two rows of different coloured l.e.d.s, one numbered 0 – 4 (green) which represents the tens, the other numbered 0 – 9 (red) for units.

When switch S1 is closed, capacitor C1 discharges and allows current to flow so that IC1 produces clock pulses for IC3, a 4017 decade counter. The carry out pulse (pin 12) from IC3 produces one high pulse for every ten produced by IC1, and the carry-out is used to clock IC2. This is also a 4017 decade counter of which the first five outputs are used, and the result is displayed on a series of l.e.d.s with a common current limiting resistor.

When S1 is opened, C1 starts to charge and therefore allows increasingly less current through it. This has the effect of gradually reducing the frequency of ICI until it finally stops. The time taken for this to happen depends upon the value of C1, however, this could lead to problems if too high a value were used.

The circuit can operate from a 9V battery via an on-off switch. It is a proven winner having already netted me the huge sum of £10. However, I can make no promises for your good fortune!

Ian Hill, Plymouth, Devon.

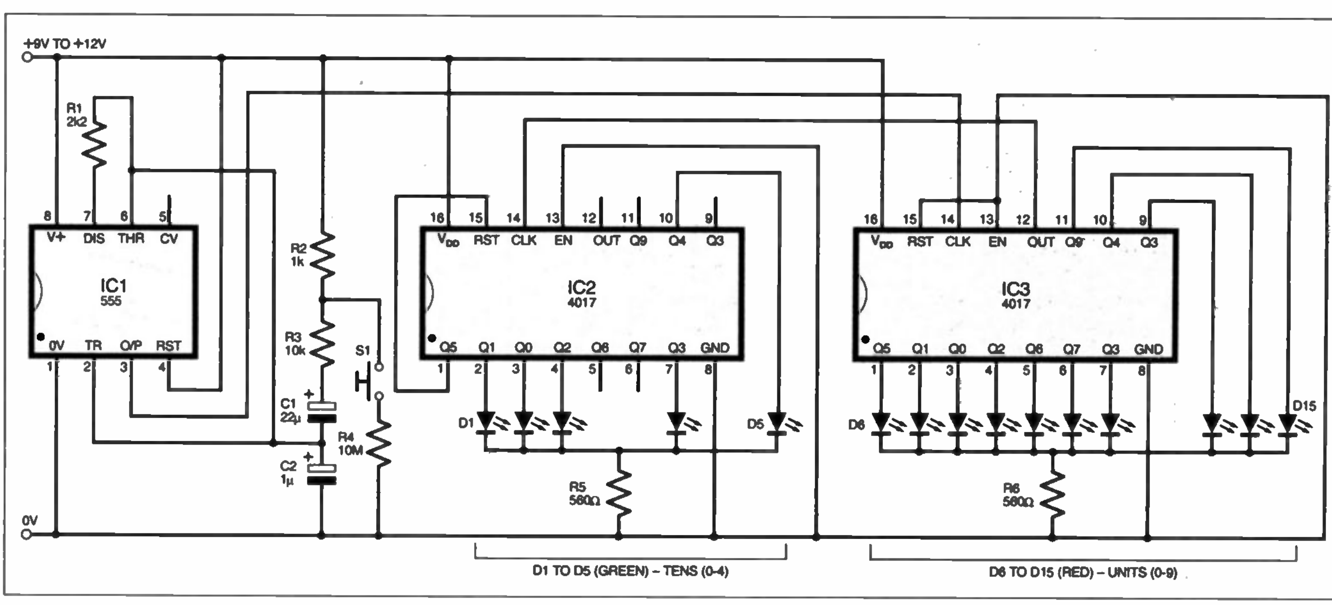


Fig.1. Circuit diagram for the Lucky Numbers generator.

D.C. Fan Equaliser – A Balancing Act

BRUSHLESS-TYPE d.c. fans generally do not run properly if wired in series, and failure can arise if one fan stalls for any reason. This condition can produce an excess voltage to the other fan due to the higher stall current flowing. In low voltage situations and where fan noise is an issue, sometimes neither fan will start, implying that you cannot reduce the overall produced noise very reliably.

The circuit diagram shown in Fig.2. was employed on a 24V rectified circuit in order to allow two cheaper, more commonplace 12V fans to be used. It addresses the possible problem of reliability, and the circuit could be extended for any number of d.c. brushless fans. The complementary transistor stage (TR1, TR2) is suitable for fans rated up to roughly 200mA.

Gerard La Rooy, New Zealand.

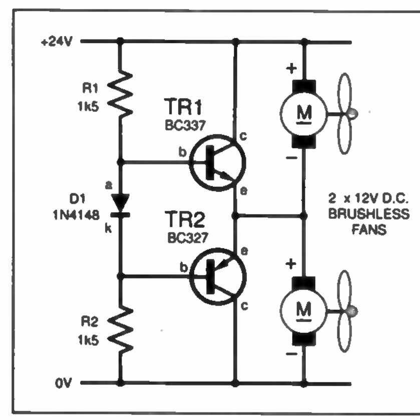


Fig.2. Circuit diagram for a D.C. Fan Equaliser.

Playback Amplifier for Micro-cassettes – Small talk

My wife and I take a "micro-cassette" dictation machine on holiday to record notes which form the basis of our holiday diary. When a "micro-cassette" transport mechanism became available from a defunct telephone answer machine, I made use of it to build a footpedal-controlled two speed transcription machine to make it easier to write up the diary back home; commercial machines cost £200 or more which we couldn't justify spending!

The tape deck mechanism required a playback amplifier and the circuit diagram of my solution is shown in Fig.3. Conventionally, high input impedance amplifiers are used for tape heads to avoid attenuation of high frequencies when the head impedance rises, but I found problems with mains hum, noise from the drive motor which is only 45mm from the head, and a regular "click" which originated from a toroidal magnet on the feed spindle to provide end-of-tape detection. A low input impedance differential configuration was more successful.

IC1a is a differential input amplifier formed from one half of an NE5532 low-noise amplifier, with a gain of 29dB. The tape head is connected to the input by a tightly twisted unscreened pair of flexible wires.

Resistors R1/ R2 and R3/R4 are preferably matched pairs for best common mode rejection ratio (CMRR). As the input impedance is only 11k2 the response will roll off as the impedance of the head rises, but tests showed there was no advantage in increasing the value of the resistors and every advantage in keeping them low to reduce their noise contribution. In any case the aim is intelligibility, not hi-fi!

No input capacitors are needed which would degrade the CMRR because the only d.c. flowing in the head is the input offset current, which for an NE5532 is only 10nA, and 100nA is generally considered safe. IC1b is the equalisation stage which presented a problem as information regarding the time constants used for micro-cassettes was scarce. The values used were derived from experimentation. Results are excellent, mains hum is non-existent and motor noise is inaudible at normal listening levels. The gain at 1kHz is 33dB approx. The switching configuration (S1) used to change the EQ for the two different speeds is deliberately chosen to avoid a momentary break of the feedback path.

Audio Amplifier

To feed a loudspeaker, an LM386 audio amplifier was used in a standard configuration. The headphone jack wiring puts stereo headphones in series and thus out of phase. This is not noticeable in practice and reduces the load on the LM386 from 4 ohms to 16 ohms if 8 ohm headphones are used.

The circuit required +12V and +8V rails. It was convenient to use two transformers for the power supplies, one for the NE5532 using 78L12 and 79L12 regulators, with the rest of the machine powered by the other transformer with a 7808 regulator for the LM386.

The only connection between the two supplies is at pin 4 of the LM386. Because of the high gain of the circuit (around 90dB at low frequencies) I found it essential to avoid ground loops and the motor supply must come directly from the reservoir capacitor and not be "daisy-chained" onto other circuitry.

B.J. Taylor,
Rickmansworth, Herts.

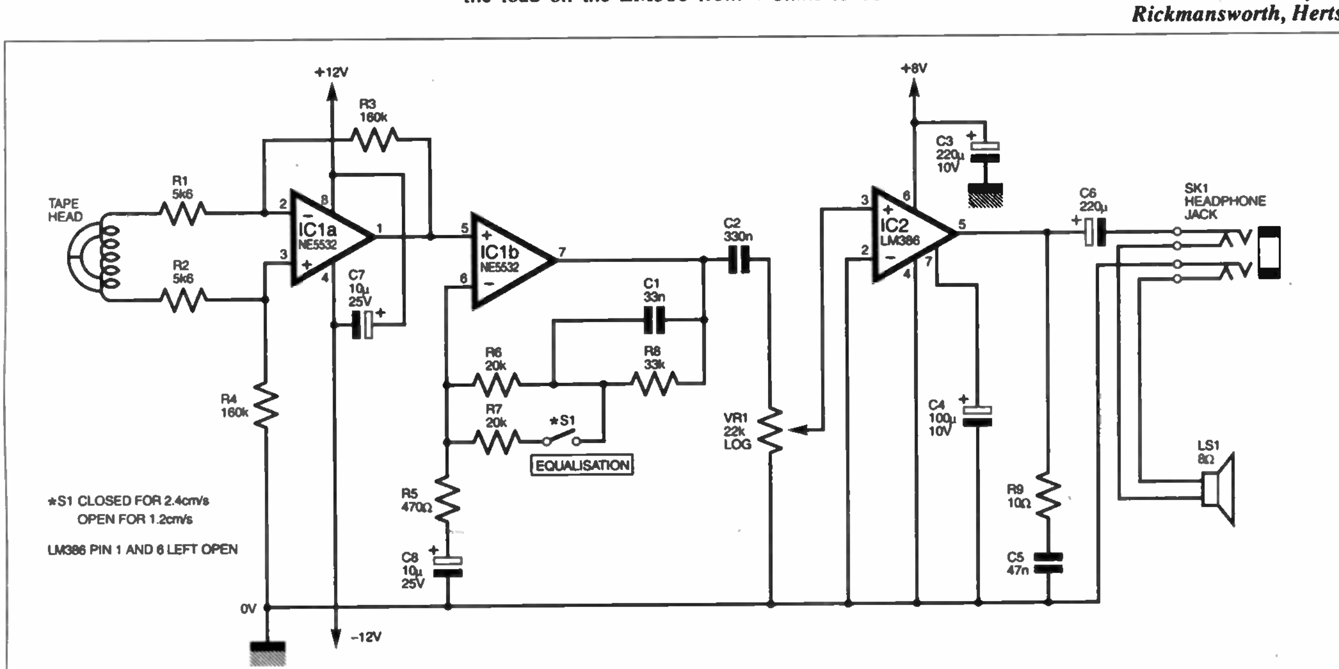


Fig.3. Circuit diagram for a Playback Amplifier for a Micro-cassette dictation tape recorder.

DVM Current Shunt – Adds Current

Older or cheaper digital multimeters only read volts and resistance. If desired, such meters can be converted to read *d.c. current* by simply measuring the voltage dropped across a known, low-value "shunt" resistance.

A very simple arrangement permitting readings from 100mA to 1A d.c. is shown in Fig.4. The range is selectable using a flying lead terminated in a crocodile clip or a wander-plug. Normal switches have too high a contact resistance, or may not be able to cope with higher currents.

The resistors should have as tight a tolerance as possible. Using the values shown, a full-scale deflection (f.s.d.) of 100mV will be produced, and you can then interpret the display as a current reading.

G.A. Bobker,
Unsworth,
Bury.

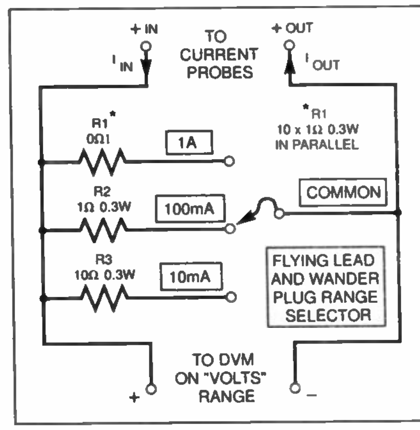


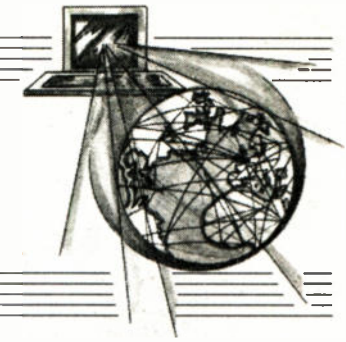
Fig.4. Adding a current range to older type Digital multimeters.

INGENUITY UNLIMITED

BE INTERACTIVE

IU is *your* forum where you can offer other readers the benefit of your Ingenuity. Share those ideas and earn some cash and possibly a prize!

SURFING THE INTERNET
NET WORK
ALAN WINSTANLEY



NET WORK is the monthly column for *EPE* readers having access to the Internet. Our Internet service has quickly become an indispensable aid to many readers. Our web site keeps you up to date with the latest news from *EPE*, and the FTP server allows you to fetch a variety of files by FTP (file transfer protocol), which is a boon, particularly for overseas readers.

This month's *PIC Altimeter* and *Greenhouse Radio Link* project files are available for *free* access from the FTP site at **pub/PICS/PICaltimeter** and **pub/8051/Greenhouse**.

Chat Zone

Coming very soon on the web site is the *EPE* Chat Zone, a web-browser based method of posting messages onto our "whiteboard" for others to read and perhaps follow up. This way, you will be able to communicate with your fellow readers and other electronics enthusiasts from around the world. Need any help? Looking for advice from other readers? Or would you like to pass on your views?

This English-language messaging system is subject to our "Acceptable Use Policy" and will be monitored to ensure that there is no abuse of any form, including the use of inappropriate language and also prohibiting commercial advertisements or other abuse. Students and schools are especially welcomed and we hope you will drop in and enjoy this added-value service! Watch for the special logos and follow the signs on the *EPE* web site, soon!

There is one final opportunity to register an interest for the proposed *Teach-In 98* "Meet" at the University of Hull. Further background information about the series, together with a fill-in form, is provided at our web site, or you can send a postcard directly to the University at the address given in the final part of *Teach-In 98*.

It is stressed that the meeting will only go ahead if a viable level of interest is apparent, after allowing for an estimated "drop out" rate. In any case, the *Teach-In* mailbox continues to be open for readers following up the series at a later date. The E-mail address is **Teach_In98@epemag.demon.co.uk**.

During June or July some readers will undoubtedly have noticed a degree of disruption to the *EPE* web and FTP sites. We're sorry about this. The service interruption was caused by a major relocation of equipment by our ISP to Telehouse Europe in London, home of LINX – the London Internet Exchange, which is the point where this country talks to the rest of the world.

Telehouse is an ultra-high security building on the River Thames which offers back-up facilities to many commercial and communications companies, rendering them impervious to catastrophe (e.g. fire or deliberate attacks). We also have dual-redundancy connectivity since our ISP (unlike many) has a choice of two bandwidth suppliers, which improves accessibility even more.

Generally, over the two years during which our Internet site has been established, operating problems have been impressively rare. I do, however, still receive a handful of queries or complaints each month concerning the availability of our Internet site. Usually, the complaint is that the site is "down" but when I test the sites myself using several ordinary dial-in accounts, I nearly always fail to replicate the reported problems.

Frequently Asked Questions

Based on several years' worth of reader feedback, here's a brief rundown of Frequently Asked Questions related to our web and FTP site. Ultimately, I will post this onto the web site and update it in light of further feedback. I hope you like the "FAQ" style.

Which version web browser should I use?

Any you like! There are some minor enhancements (colours or scrolling text) etc. which are only supported by Microsoft Internet Explorer. We don't make the web site browser dependent. A Version 3.0 or higher will be satisfactory. You could try Opera, which has some enhancements (e.g. zoom) for visually disabled users.

I can't access your web site at all.

In our experience it is very rare for our ISP servers to go down. Several major British TV networks use the same ISP and reliability is generally excellent. Occasionally some unexpected maintenance may be required or there may be circumstances beyond everyone's control which affects our server connection. These things happen, and if possible we will post a warning on the Home Page. Generally we have ample local bandwidth available at all times. Problems could well be due to general peak-time demands on national or international bandwidth. Also, ensure you are not mis-typing our URL – it's on the front cover of every issue! *(Note, there is no "u" in Wimborne – Ed.)*

How do I access your FTP site?

We recommend using proper FTP software such as WS_FTP Pro or Fetch for Macintosh. To use your browser, type in this URL: **ftp://ftp.epemag.wimborne.co.uk/pub** then hit "enter" and it will display the FTP "public" directory. Drill further down from here (not up to a higher directory), to access the required sub-directories and folders.

I got to the FTP site, what do I do now?

Firstly, read the file "whatsnew.txt" by clicking on the filename with your mouse. A text file will open, describing the latest additions to the FTP site. Also read the "readme.txt" located in the same place, for further provisos concerning the material stored on our FTP site. Then use your mouse to navigate around the FTP site, by clicking on folder names to open them.

How do I fetch microcontroller files?

Open the FTP site "public" directory in your browser window (see earlier). Click on the "PICS" or "8051" folder as appropriate, then choose the project folder in question. Click it to open it – a list of files will then display. To fetch them onto your local machine, right-mouse click, then choose "Save Target As . . .". Select where you want to save it on your PC. Ensure you fetch all files listed. As an "anonymous" user, you can't damage our FTP site so feel free to wander around, experimenting as needed.

I just can't access your FTP site!

There's a limit of 30 "anonymous" users at any one time. Peaks can occur when new projects are launched early in the month, when readers connect to fetch the source codes of microcontroller projects. Also ensure you are spelling the addresses (URL) properly and ***in full***. If you are on a LAN and behind a firewall, your sysadmin may prohibit anonymous FTP and you might need to try from another location.

What are those files that end in ".zip"?

They are files which have been compressed for convenience. This usually reduces their size and it groups a multitude of files into one, which is easier to fetch by FTP. Having fetched the file onto your system, you need a zipping/unzipping program such as WinZip from **www.winzip.com** or PKZIP from **www.pkware.com**. These are essential utilities for all Internet users.

I've still got a problem!

We'll try to help you out – please send an E-mail to **webmaster@epemag.demon.co.uk**. Include relevant information – your browser version, any symptoms or error messages, your local time or time GMT.

I hope that answers many questions. There is a variety of new suggestions for web site URLs, on the *Net Work* page of the on-line edition of the September issue.

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 ANOTHER SELECTION OF BOOKS SEE THE NEXT TWO MONTH'S ISSUES.

Note our UK postage costs just £1.50 no matter how many books you order! 3a

ELECTRONICS TEACH-IN 88/89
INTRODUCING MICROPROCESSORS
Mike Tooley B.A. (published by *Everyday Practical Electronics*)

A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc.

Sections cover Microcomputer Systems, Microprocessors, Memories, Input/Output, Interfacing and Programming. There are various practical assignments and eight Data Pages covering popular microprocessors.

And excellent introduction to the subject even for those who do not wish to take the City and Guilds assessment.

80 pages Order code TI-88/89 £2.45

ELECTRONICS TEACH-IN No. 7. ANALOGUE AND DIGITAL ELECTRONICS COURSE FREE SOFTWARE
(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.

If you are taking electronics or technology at school or college, this book is for you. If you just want to learn the basics of electronics or technology you must make sure you see it. *Teach-In No. 7* will be invaluable if you are considering a career in electronics or even if you are already training in one. The Mini Lab and software enable the construction and testing of both demonstration and development circuits. These learning aids bring electronics to life in an enjoyable and interesting way: you will both see and hear the electron in action! The Micro Lab microprocessor add-on system will appeal to higher level students and those developing microprocessor projects.

160 pages Order code T17 £3.95

Circuits and Design

ELECTRONICS PROJECTS USING ELECTRONICS WORKBENCH plus FREE CD-ROM FREE CD-ROM
M. P. Horsey

This book offers a wide range of tested circuit modules which can be used as electronics projects, part of an electronics course, or as a hands-on way of getting better acquainted with Electronics Workbench. With circuits ranging from 'bulbs and batteries' to complex systems using integrated circuits, the projects will appeal to novices, students and practitioners alike.

Electronics Workbench is a highly versatile computer simulation package which enables the user to design, test and modify their circuits before building them, and to plan PCB layouts on-screen. All the circuits in the book are provided as runnable Electronic Workbench files on the enclosed CD-ROM, and a selection of 15 representative circuits can be explored using the free demo version of the application.

Contents: Some basic concepts; Projects with switches, LEDs, relays and diodes; Transistors; Power supplies; Op.amp projects; Further op.amp circuits; Logic gates; Real logic circuits; Logic gate multivibrators; The 555 timer; Flip-flops, counters and shift registers; Adders, comparators and multiplexers; Field effect transistors; Thyristors, triacs and diacs; Constructing your circuit; Index.

227 pages Order code NE29 £14.99

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.

170 pages Order code BP285 £4.99

DISCOVERING ELECTRONIC CLOCKS NEW
W. D. Phillips

This is a whole book about designing and making electronic clocks. You start by connecting HIGH and LOW logic signals to logic gates. You find out about and then build and test bistables, crystal-controlled astables, counters, decoders and displays. All of these subsystems are carefully explained, with practical work supported by easy to follow prototype board layouts.

Full constructional details, including circuit diagrams and a printed circuit board pattern, are given for a digital electronic clock. The circuit for the First Clock is modified and developed to produce additional designs which include a Big Digit Clock, Binary Clock, Linear Clock, Andrew's Clock (with a semi-analogue display), and a Circles Clock. All of these designs are unusual and distinctive.

This is an ideal resource for project work in GCSE *Design and Technology: Electronics Product*, and for project work in AS-Level and A-Level *Electronics and Technology*.

194 pages, A4 spiral bound Order code DEP1 £16.50

DOMESTIC SECURITY SYSTEMS
A. L. Brown

This book shows you how, with common sense and basic do-it-yourself skills, you can protect your home. It also gives tips and ideas which will help you to maintain and improve your home security, even if you already have an alarm. Every circuit in this book is clearly described and illustrated, and contains components that are easy to source. Advice and guidance are based on the real experience of the author who is an alarm installer, and the designs themselves have been rigorously put to use on some of the most crime-ridden streets in the world.

The designs include all elements, including sensors, detectors, alarms, controls, lights, video and door entry systems. Chapters cover installation, testing, maintenance and upgrading.

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MICROCONTROLLER COOKBOOK
Mike James

The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages Order code NE26 £19.99

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world"

142 pages Order code BP332 £4.95

ELECTRONIC MODULES AND SYSTEMS FOR BEGINNERS
Owen Bishop

This book describes over 60 modular electronic circuits, how they work, how to build them, and how to use them. The modules may be wired together to make hundreds of different electronic systems, both analogue and digital. To show the reader how to begin building systems from modules, a selection of over 25 electronic systems are described in detail, covering such widely differing applications as timing, home security, measurement, audio (including a simple radio receiver), games and remote control.

200 pages Order code BP266 £3.95

PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Bridges the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias – tedious and higher mathematics have been avoided where possible and many tables have been included.

The book is divided into six basic sections: Units and Constants, Direct-Current Circuits, Passive Components, Alternating-Current Circuits, Networks and Theorems, Measurements.

256 pages Order code BP53 £3.95

Computing

WINDOWS 95 EXPLAINED
P. R. M. Oliver and N. Kantaris

If you would like to get up and running, as soon as possible, with the new Windows 95 operating system, then this is the book for you.

The book was written with the non-expert, busy person in mind. It explains the hardware that you need in order to run Windows 95 successfully, and how to install and optimize your system's resources. It presents an overview of the Windows 95 environment.

Later chapters cover how to work with programs, folders and documents; how to control Windows 95 and use the many accessories that come with it; how to use DOS programs and, if necessary, DOS commands and how to communicate with the rest of the electronic world.

170 pages Order code BP400 £5.95

INTERFACING PCs AND COMPATIBLES
R. A. Penfold

Once you know how, PC interfacing is less involved than interfacing many eight-bit machines, which have tended to use some unusual interfacing methods.

This book gives you: A detailed description of the lines present on the PC expansion bus. A detailed discussion of the physical characteristics of PC expansion cards. The I/O map and details of the areas where your add-on can be fitted. A discussion of address decoding techniques. Practical address decoder circuits. Simple TTL 8-bit input and output ports. Details of using the 8255 parallel interface adaptor. Digital to analogue converter circuits. In fact everything you need to know in order to produce successful PC add-ons.

80 pages Order code BP272 £3.95

EASY PC INTERFACING
R. A. Penfold

Although the internal expansion slots of a PC provide full access to the computer's buses, and are suitable for user add-ons, making your own expansion cards requires a fair amount of expertise and equipment. The built-in ports provide what is often a much easier and hassle-free way of interfacing your own circuits to a PC. In particlar, a PC printer port plus a small amount of external hardware provides a surprisingly versatile input/output port. The PC "games" port is less useful for general interfacing purposes, but it can be useful in some applications.

This book provides a number of useful PC add-on circuits including the following: Digital input/output ports; Analogue to digital converter; Digital-to-Analogue Converter; Voltage and current measurement circuits; Resistance meter; Capacitance meter; Temperature measurement interface; Biofeedback monitor; Constant voltage model train controller; Pulsed model train controllers; Position sensor (optical, Hall effect, etc.); Stepper motor interface; Relay and LED drivers; Triac mains switching interface.

179 pages Order code BP385 £4.99

HOW TO EXPAND, MODERNISE AND REPAIR PCs AND COMPATIBLES (Revised Edition)
R. A. Penfold

Not only are PC and compatible computers very expandable, but before long most users actually wish to take advantage of that expandability and start upgrading their PC system. Some aspects of PC upgrading can be a bit confusing, but this book provides advice and guidance on the popular forms of internal PC expansion, and should help to make things reasonably straightforward and painless. Little knowledge of computing is assumed. The only assumption is that you can operate a standard PC of some kind (PC, PC XT, PC AT, or an 80386 based PC).

The subjects covered include: PC overview; Memory upgrades; Adding a hard disk drive; Adding a floppy disk drive; Display adaptors and monitors; Fitting a maths co-processor; Keyboards; Ports; Mice and digitisers; Maintenance (including preventative maintenance) and Repairs, and the increasingly popular subject of d.i.y. PCs.

156 pages Order code BP271 £5.99

Theory and Reference

Bebop To The Boolean Boogie

By Clive (call me Max) Maxfield
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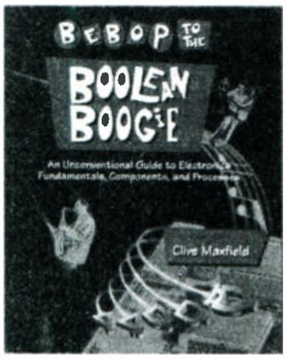

Specially imported by EPE – Excellent value

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....

DIGITAL ELECTRONICS – A PRACTICAL APPROACH

FREE SOFTWARE

With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality)
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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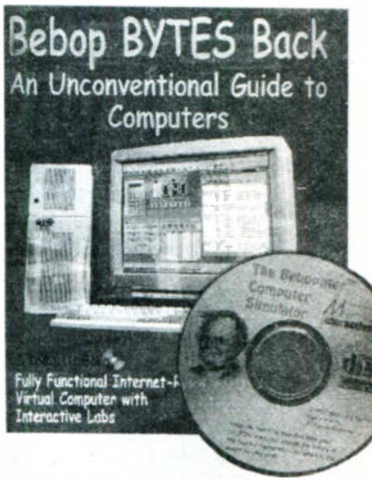

Specially imported by EPE – Excellent value

An Unconventional Guide To Computers

Plus **FREE CD-ROM** which includes: Fully Functional Internet-Ready Virtual Computer with Interactive Labs

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!

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**

Audio and Music

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**

ACOUSTIC FEEDBACK – HOW TO AVOID IT

V. Capel

Feedback is the bane of all public address systems. While feedback cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem.

Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce a reduced feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.

92 pages **Temporarily out of print**

PREAMPLIFIER AND FILTER CIRCUITS

R. A. Penfold

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases). The preamplifier circuits featured include: Microphone preamplifiers (low impedance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A. equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

Other circuits include: Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls.

92 pages **Order code BP309** **£4.99**

COMPUTERS AND MUSIC – AN INTRODUCTION

R. A. Penfold

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully

174 pages **Order code PC107** **£8.95**

ELECTRONIC PROJECTS FOR GUITAR

R. A. Penfold

This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.

110 pages **Temporarily out of print**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION

R. A. Penfold

Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages **Order code BP277** **£3.99**

Testing, Theory, Data and Reference

SCROGGIE'S FOUNDATIONS OF WIRELESS AND ELECTRONICS – ELEVENTH EDITION
S. W. Amos and Roger Amos
Scroggie's Foundations is a classic text for anyone working with electronics, who needs to know the art and craft of the subject. It covers both the theory and practical aspects of a huge range of topics from valve and tube technology, and the application of cathode ray tubes to radar, to digital tape systems and optical recording techniques.

Since *Foundations of Wireless* was first published over 60 years ago, it has helped many thousands of readers to become familiar with the principles of radio and electronics. The original author Sowerby was succeeded by Scroggie in the 1940s, whose name became synonymous with this classic primer for practitioners and students alike. Stan Amos, one of the fathers of modern electronics and the author of many well-known books in the area, took over the revision of this book in the 1980s and it is he, with his son, who have produced this latest version.
400 pages **Order code NE27** **£19.99**

ELECTRONICS MADE SIMPLE
Ian Sinclair
Assuming no prior knowledge, *Electronics Made Simple* presents an outline of modern electronics with an emphasis on understanding how systems work rather than on details of circuit diagrams and calculations. It is ideal for students on a range of courses in electronics, including GCSE, C&G and GNVQ, and for students of other subjects who will be using electronic instruments and methods.

Contents: waves and pulses, passive components, active components and ICs, linear circuits, block and circuit diagrams, how radio works, disc and tape recording, elements of TV and radar, digital signals, gating and logic circuits, counting and correcting, microprocessors, calculators and computers, miscellaneous systems.
Page 199 (large format) **Order code NE23** **£12.99**

TRANSISTOR DATA TABLES
Hans-Günther Steidle
The tables in this book contain information about the package shape, pin connections and basic electrical data for each of the many thousands of transistors listed. The data includes maximum reverse voltage, forward current and power dissipation, current gain and forward transadmittance and resistance, cut-off frequency and details of applications.

A book of this size is of necessity restricted in its scope, and the individual transistor types cannot therefore be described in the sort of detail that maybe found in some larger and considerably more expensive data books. However, the list of manufacturers' addresses will make it easier for the prospective user to obtain further information, if necessary.

Lists over 8,000 different transistors, including f.e.t.s.
200 pages **Order code BP401** **£5.95**

MORE ADVANCED USES OF THE MULTIMETER
R. A. Penfold

This book is primarily intended as a follow-up to BP239, (see below), and should also be of value to anyone who already understands the basics of voltage testing and simple component testing. By using the techniques described in Chapter 1 you can test and analyse the performance of a range of components with just a multimeter (plus a very few inexpensive components in some cases). Some useful quick check methods are also covered.

While a multimeter is supremely versatile, it does have its limitations. The simple add-ons described in Chapter 2 extended the capabilities of a multimeter to make it even more useful.
84 pages **Order code BP265** **£2.95**

ELECTRONIC TEST EQUIPMENT HANDBOOK
Steve Money
The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of the instruments are also examined.

Everything from Oscillators, through R, C & L measurements (and much more) to Waveform Generators and testing Zeners.
206 pages **Order code PC109** **£8.95**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold
This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.
96 pages **Order code BP239** **£2.95**

NEWNES ELECTRONICS TOOLKIT– SECOND EDITION
Geoff Phillips
The author has used his 30 years experience in industry to draw together the basic information that is constantly demanded. Facts, formulae, data and charts are presented to help the engineer when designing, developing, evaluating, fault finding and repairing electronic circuits. The result is this handy workmate volume: a memory aid, tutor and reference source which is recommended to all electronics engineers, students and technicians.

Have you ever wished for a concise and comprehensive guide to electronics concepts and rules of thumb? Have you ever been unable to source a component, or choose between two alternatives for a particular application? How much time do you spend searching for basic facts or manufacturer's specifications? This book is the answer, it covers resistors, capacitors, inductors, semiconductors, logic circuits, EMC, audio, electronics and music, telephones, electronics in lighting, thermal considerations, connections, reference data.
158 pages **Order code NE20** **£12.99**

PRACTICAL ELECTRONIC FAULT FINDING AND TROUBLESHOOTING
Robin Pain
This is not a book of theory. It is a book of practical tips, hints, and rules of thumb, all of which will equip the reader to tackle any job. You may be an engineer or technician in search of information and guidance, a college student, a hobbyist building a project from a magazine, or simply a keen self-taught amateur who is interested in electronic fault finding but finds books on the subject too mathematical or specialized.

The book covers: **Basics** – Voltage, current and resistance; Capacitance, inductance and impedance; Diodes and transistors; Op-amps and negative feedback; **Fault finding** – Analogue fault finding, Digital fault finding; Memory; Binary and hexadecimal; Addressing; Discrete logic; Microprocessor action; I/O control; CRT control; Dynamic RAM; Fault finding digital systems; Dual trace oscilloscope; IC replacement.
274 pages **Order code NE22** **£18.99**

AN INTRODUCTION TO LIGHT IN ELECTRONICS
F. A. Wilson
This book is not for the expert but neither is it for the completely uninitiated. It is assumed the reader has some basic knowledge of electronics. After dealing with subjects like Fundamentals, Waves and Particles and The Nature of Light such things as Emitters, Detectors and Displays are discussed. Chapter 7 details four different types of Lasers before concluding with a chapter on Fibre Optics.
161 pages **Order code BP359** **£4.95**

UNDERSTANDING DIGITAL TECHNOLOGY
F. A. Wilson C.G.I.A., C.Eng., F.I.E.E., F.I. Mgt.
This book examines what digital technology has to offer and then considers its arithmetic and how it can be arranged for making decisions in so many processes. It then looks at the part digital has to play in the ever expanding Information Technology, especially in modern transmission systems and television. It avoids getting deeply involved in mathematics.

Various chapters cover: Digital Arithmetic, Electronic Logic, Conversions between Analogue and Digital Structures, Transmission Systems. Several Appendices explain some of the concepts more fully and a glossary of terms is included.
183 pages **Order code BP376** **£4.95**

Project Building

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:

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**

45 SIMPLE ELECTRONIC TERMINAL BLOCK PROJECTS
R. Bebbington
Contains 45 easy-to-build electronic projects that can be constructed, by an absolute beginner, on terminal blocks using only a screwdriver and other simple hand tools. No soldering is needed.

Most of the projects can be simply screwed together, by following the layout diagrams, in a matter of minutes and readily unscrewed if desired to make new circuits. A theoretical circuit diagram is also included with each project to help broaden the constructor's knowledge.

The projects included in this book cover a wide range of interests under the chapter headings: Connections and Components, Sound and Music, Entertainment, Security Devices, Communication, Test and Measuring.
163 pages **Order code BP378** **£4.95**

30 SIMPLE IC TERMINAL BLOCK PROJECTS
R. Bebbington
Follow on from BP378 using ICs.
117 pages **Order code BP379** **£4.99**

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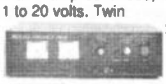

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PIC-project source code files: **/pub/PICS**

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EPE text files: **/pub/docs**
Basic Soldering Guide: **solder.txt**
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New readers and subscribers info: **epe_info.txt**
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Ni-Cad discussion: **nicadfaq.zip** and **nicad2.zip**
UK Sources FAQ: **uksource.zip**
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Note that any file which ends in **.zip** needs unzipping before use. Unzip utilities can be downloaded from :
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Published on approximately the first Friday of each month by Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Printed in England by Wiltshire (Bristol) Printers Ltd., Bristol, BS20 9XP. Distributed by Seymour, 86 Newman St., London W1P 3LD. Subscriptions INLAND £26 and OVERSEAS £32 standard air service (£49.50 express airmail) payable to "Everyday Practical Electronics", Subs Dept, Allen House, East Borough, Wimborne, Dorset BH21 1PF. E-mail: subs@epemag.wimborne.co.uk. EVERYDAY PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

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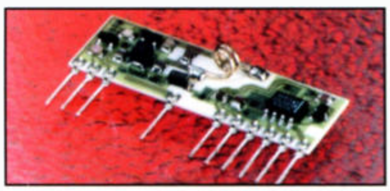

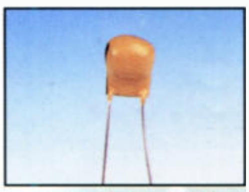

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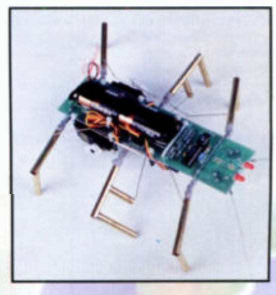

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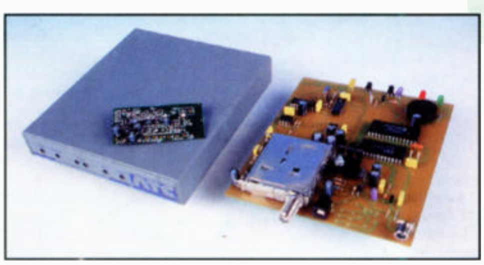

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