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EVERYDAY

Vol.31 No.11

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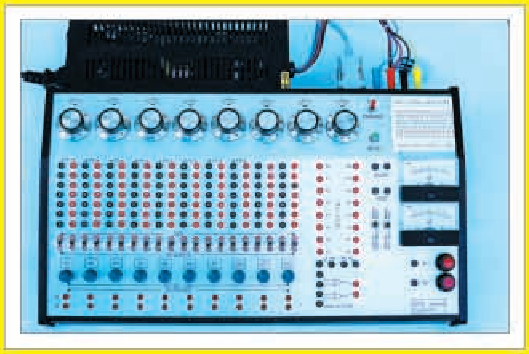

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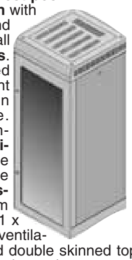

Made by **Eurocraft Enclosures** Ltd to the **highest possible spec,** rack features **all steel construction** with removable side, front and back doors. Front and back doors are **hinged for easy access** and all lockable with five **secure 5 lever barrel locks.** The front door is constructed of double walled steel with a **'designer style'** smoked acrylic front panel to enable status indicators to be seen through the panel, yet remain unobtrusive. Internally the rack features fully slotted reinforced vertical fixing members to **take the heaviest of 19" rack equipment.** The two movable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A **mains distribution panel** internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin **switched utility socket.** Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvres. The top panel may be removed for fitting of **integral fans** to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower rear for cable / connector access etc. Supplied in **excellent,** slightly used condition with keys. Colour Royal blue. some grey available – CALL – Can be supplied in many other configurations.

33U	**42U**	**47U**
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External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)	External dimensions mm=2019H x 635D x 603 W. (79.5" H x 25" D x 23¾" W)	External dimensions mm=2019H x 635D x 603 W. (88" H x 25" D x 23¾" W)
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Visible red, 670nm laser diode assembly. Unit runs from 5 V DC at approx 50 mA. Orginally made for continuous use in industrial barcode scanners, the laser is mounted in a removable solid aluminium block, which functions as a heatsink and rigid optical mount. Dims of block are 50 w x 50 d x 15 h mm. Integral features include over temperature shutdown, current control, laser OK ouput, and gated TTL ON / OFF. Many uses for experimental optics, comms & lightshows etc. Supplied complete with data sheet.

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Unless marked NEW, items in this section are pre owned.

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FARNELL 0-60V DC @ 50 Amps, bench Power Supplies	**£995**
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Wayne Kerr RA200 Audio frequency response analyser	**£2500**
INFODEC 1U, 24 port, RJ45 network patchpanels. #TH93	**£49**
3COM 16670 12 Port Ethernet hub - RJ45 connectors #LD97	**£69**
3COM 16671 24 Port Ethernet hub - RJ45 connectors	**£89**
3COM 16700 8 Port Ethernet hub - RJ45 connectors NEW	**£39**
IBM 53F5501 Token Ring ICS 20 port lobe modules	**£POA**
IBM MAU Token ring distribution panel 8228-23-5050N	**£45**
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE I/O	**£550**
ALLGON 8360.11805-1880 MHz hybrid power combiners	**£250**
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	**£POA**
Marconi 6310 Programmable 2 to 22 GHz sweep generator	**£4500**
Marconi 2022C 10KHz-1GHz RF signal generator	**£1550**
HP1650B Logic Analyser	**£3750**
HP3781A Pattern generator & **HP3782A** Error Detector	**£POA**
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	**£1800**
HP6264 Rack mount variable 0-20V @ 20A metered PSU	**£475**
HP54121A DC to 22 GHz four channel test set	**£POA**
HP8130A opt 020 300 MHz pulse generator, GPIB etc	**£7900**
HP A1, A0 8 pen HPGL high speed drum plotters - from	**£550**
HP DRAFTMASTER 1 8 pen high speed plotter	**£750**
EG+G Brookdeal 95035C Precision lock in amp	**£1800**
Keithley 590 CV capacitor / voltage analyser	**£POA**
Racal ICR40 dual 40 channel voice recorder system	**£3750**
Fiskers 45KVA 3 ph On Line UPS – New batteries	**£4500**
Emerson AP130 2.5KVA industrial spec.UPS	**£1499**
Mann Tally MT645 High speed line printer	**£2200**
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	**£945**
HP6030A 0-200V DC @ 17 Amps bench power supply	**£1950**
Intel SBC 486/125C08 Enhanced Multibus (MSA) **New**	**£1150**
Nikon HFX-11 (Ephiphot) exposure control unit	**£1450**
PHILIPS PM5518 pro. TV signal generator	**£1250**
Motorola VME Bus Boards & Components List. SAE / CALL	**£POA**
Trio 0-18 vdc linear, metered 30 amp bench PSU. **New**	**£550**
Fujitsu M3041R 600 LPM high speed band printer	**£1950**
Fujitsu M3041D 600 LPM printer with network interface	**£1250**
Siemens K4400 64Kb to 140Mb demux analyser	**£2950**
Perkin Elmer 299B Infrared spectrophotometer	**£500**
Perkin Elmer 597 Infrared spectrophotometer	**£3500**
VG Electronics 1035 TELETEXT Decoding Margin Meter	**£3250**
LightBand 60 output high spec 2u rack mount Video VDA's	**£495**
Sekonic SD 150H 18 channel digital Hybrid chart recorder	**£1995**
B&K 2633 Microphone pre amp	**£300**
Taylor Hobson Tallysurf amplifier / recorder	**£750**
ADC SS200 Carbon dioxide gas detector / monitor	**£1450**
BBC AM20/3 PPM Meter (Ernest Turner) + drive electronics	**£75**
ANRITSU 9654A Optical DC-2.5G/b waveform monitor	**£5650**
ANRITSU ML93A optical power meter	**£990**
ANRITSU Fibre optic characteristic test set	**£POA**
R&S FTDZ Dual sound unit	**£650**
R&S SBUF-E1 Vision modulator	**£775**
WILTRON 6630B 12.4 / 20GHz RF sweep generator	**£5750**
TEK 2445 150 MHz 4 trace oscilloscope	**£1250**
TEK 2465 300 Mhz 300 MHz oscilloscope rack mount	**£1955**
TEK TDS380 400Mhz digital realtime + disk drive, FFT etc	**£2900**
TEK TDS524A 500Mhz digital realtime + colour display etc	**£5100**
HP3585A Opt 907 20Hz to 40 Mhz spectrum analyser	**£3950**
PHILIPS PW1730/10 60KV XRAY generator & accessories	**£POA**
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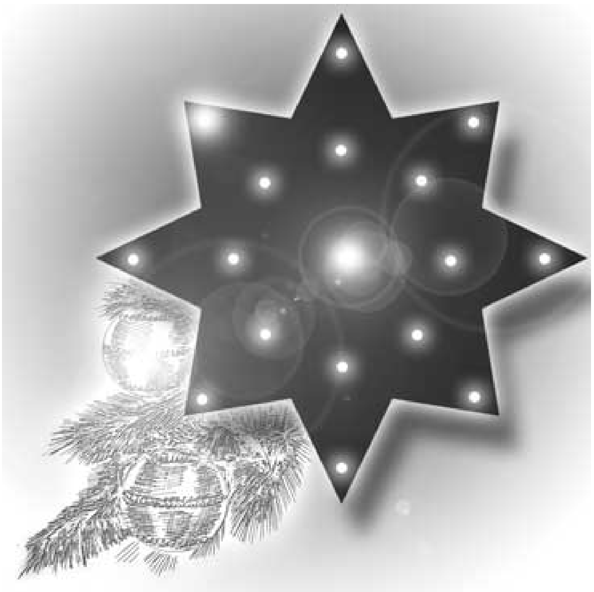
NEXT MONTH

VERSATILE PIC FLASHER

Ever wanted to make your Christmas decorations stand out from the crowd? Or maybe add a lighting effect to a ceiling? Well now you can with this PIC-based flasher. It can drive six or more l.e.d.s per output and it has eight outputs. It could also power strings of low voltage Christmas tree lights.
Switches control the speed, depth of modulation and brightness profiles from the program provided, or you could, of course, write your own program.
Make your Christmas sparkle!



DOOR DEFENDER

Whether we are brave enough to admit it or not, we probably all suffer varying degrees of paranoia when it comes to the doors in our life. Was that someone sneaking in the front door? Did we leave the back door open? Where's the padlock on the shed door?
Perhaps this project might help put some of our fears at rest. The Door Defender is a simple circuit intended to monitor the opening and closing of a single door, but it could easily be expanded into a comprehensive system. It can be used with any type of internal or external opening, and consumes very low current in standby. For instance, the long battery life would make it ideal for protecting a garden shed. On the other hand, its small size could allow it to be a portable unit for protection when travelling.

TRANSISTORS AND THEIR OTHER USES

Transistors have many uses which are well known, such as amplifiers, oscillators, and switches, but have many further uses, some of which are not as well known. A knowledge of these other uses can be helpful when a particular component is not immediately available but is required for gadgeteering or experimentation.
Transistors may also be used in place of signal diodes, rectifier diodes, Zener diodes, varicap diodes, tunnel diodes, constant current sources, and solar cells. In some cases a transistor pressed into such service may be superior to a purpose made part and may reduce the circuit's total parts count. This fascinating article looks at how to use transistors in these various ways.

PLUS

★ EPE Hybrid Computer – Part 2
★ Three more PICAXE projects
● Temperature Sensor ● Voltage Sensor ● VU Display ●

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Our electronic kits are supplied complete with all components, high quality PCBs (NOT cheap Tripad strip board!) and detailed assembly/operating instructions

● **2 x 25W CAR BOOSTER AMPLIFIER** Connects to the output of an existing car stereo cassette player, CD player or radio. Heatsinks provided. PCB 76x75mm. **1046KT. £24.95**
● **3-CHANNEL WIRELESS LIGHT MODULATOR** No electrical connection with amplifier. Light modulation achieved via a sensitive electret microphone. Separate sensitivity control per channel. Power handing 400W/channel. PCB 54x112mm. Mains powered. Box provided. **6014KT £24.95**
● **12 RUNNING LIGHT EFFECT** Exciting 12 LED light effect ideal for parties, discos, shop-windows & eye-catching signs. PCB design allows replacement of LEDs with 220V bulbs by inserting 3 TRIACs. Adjustable rotation speed & direction. PCB 54x112mm. **1026KT £15.95; BOX (for mains operation) 2026BX £9.00**
● **DISCO STROBE LIGHT** Probably the most exciting of all light effects. Very bright strobe tube. Adjustable strobe frequency: 1-60Hz. Mains powered. PCB: 60x68mm. Box provided. **6037KT £28.95**
● **ANIMAL SOUNDS** Cat, dog, chicken & cow. Ideal for kids farmyard toys & schools. **SG10M £5.95**
● **3 1/2 DIGIT LED PANEL METER** Use for basic voltage/current displays or customise to measure temperature, light, weight, movement, sound levels, etc. with appropriate sensors (not supplied). Various input circuit designs provided. **3061KT £13.95**
● **IR REMOTE TOGGLE SWITCH** Use any TV/VCR remote control unit to switch onboard 12V/1A relay on/off. **3058KT £10.95**
SPEED CONTROLLER for any common DC motor up to 100V/5A. Pulse width modulation gives maximum torque at all speeds. 5-15VDC. Box provided. **3067KT £12.95**
● **3 x 8 CHANNEL IR RELAY BOARD** Control eight 12V/1A relays by Infra Red (IR) remote control over a 20m range in sunlight. 6 relays turn on only, the other 2 toggle on/off. 3 operation ranges determined by jumpers. Transmitter case & all components provided. Receiver PCB 76x89mm. **3072KT £52.95**

PRODUCT FEATURE

COMPUTER TEMPERATURE DATA LOGGER
PC serial port controlled 4-channel temperature meter (either deg C or F). Requires no external power. Allows continuous temperature data logging of up to four temperature sensors located 200m+ from motherboard/PC. Ideal use for old 386/486 computers. Users can tailor input data stream to suit their purpose (dump it to a spreadsheet or write your own BASIC programs using the INPUT command to grab the readings). PCB just 38mm x 38mm. Sensors connect via four 3-pin headers. 4 header cables supplied but only one DS18S20 sensor.
Kit software available free from our website.
ORDERING: 3145KT **£23.95** (kit form);
AS3145 **£29.95** (assembled);
Additional DS18S20 sensors **£4.95** each

● **SOUND EFFECTS GENERATOR** Easy to build. Create an almost infinite variety of interesting/unusual sound effects from birds chirping to sirens. 9VDC. PCB 54x85mm. **1045KT £8.95**
● **ROBOT VOICE EFFECT** Make your voice sound similar to a robot or Darlek. Great fun for discos, school plays, theatre productions, radio stations & playing jokes on your friends when answering the phone! PCB 42x71mm. **1131KT £8.95**
● **AUDIO TO LIGHT MODULATOR** Controls intensity of one or more lights in response to an audio input. Safe, modern opto-coupler design. Mains voltage experience required. **3012KT £8.95**
● **MUSIC BOX** Activated by light. Plays 8 Christmas songs and 5 other tunes. **3104KT £7.95**
● **20 SECOND VOICE RECORDER** Uses non-volatile memory - no battery backup needed. Record/replay messages over & over. Playback as required to greet customers etc. Volume control & built-in mic. 6VDC. PCB 50x73mm. **3131KT £12.95**
● **TRAIN SOUNDS** 4 selectable sounds : whistle blowing, level crossing bell, 'clickety-clack' & 4 in sequence. **SG01M £6.95**

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● **PC CONTROLLED RELAY BOARD** Convert any 286 upward PC into a dedicated automatic controller to independently turn on/off up to eight lights, motors & other devices around the home, office, laboratory or factory. Each relay output is capable of switching 250VAC/4A. A suite of DOS and Windows control programs are provided together with all components (except box and PC cable). 12VDC. PCB 70x200mm. **3074KT £31.95**
● **2 CHANNEL UHF RELAY SWITCH** Contains the same transmitter/receiver pair as 30A15 below plus the components and PCB to control two 240VAC/10A relays (also supplied). Ultra bright LEDs used to indicate relay status. **3082KT £27.95**
● **TRANSMITTER RECEIVER PAIR** 2-button keyfob style 300-375MHz Tx with 30m range. Receiver encoder module with matched decoder IC. Components must be built into a circuit like kit 3082 above. **30A15 £14.95**
● **PIC 16C71 FOUR SERVO MOTOR DRIVER** Simultaneously control up to 4 servo motors. Software & all components (except servos/control pots) supplied. 5VDC. PCB 50x70mm. **3102KT £15.95**
● **UNIPOLAR STEPPER MOTOR DRIVER** for any 5/6/8 lead motor. Fast/slow & single step rates. Direction control & on/off switch. Wave, 2-phase & half-wave step modes. 4 LED indicators. PCB 50x65mm. **3109KT £14.95**
● **PC CONTROLLED STEPPER MOTOR DRIVER** Control two unipolar stepper motors (3A max. each) via PC printer port. Wave, 2-phase & half-wave step modes. Software accepts 4 digital inputs from external switches & will single step motors. PCB fits in D-shell case provided. **3113KT £17.95**
● **12-BIT PC DATA ACQUISITION/CONTROL UNIT** Similar to kit 3093 above but uses a 12 bit Analogue-to-Digital Converter (ADC) with internal analogue multiplexor. Reads 8 single ended channels or 4 differential inputs or a mixture of both. Analogue inputs read 0-4V. Four TTL/CMOS compatible digital input/outputs. ADC conversion time <10uS. Software (C, QB & Win), extended D shell case & all components (except sensors & cable) provided. **3118KT £52.95**
● **LIQUID LEVEL SENSOR/RAIN ALARM** Will indicate fluid levels or simply the presence of fluid. Relay output to control a pump to add/remove water when it reaches a certain level. **1080KT £5.95**
● **AM RADIO KIT 1** Tuned Radio Frequency front-end, single chip AM radio IC & 2 stages of audio amplification. All components inc. speaker provided. PCB 32x102mm. **3063KT £10.95**
● **DRILL SPEED CONTROLLER** Adjust the speed of your electric drill according to the job at hand. Suitable for 240V AC mains powered drills up to 700W power. PCB: 48mm x 65mm. Box provided. **6074KT £17.95**
● **3 INPUT MONO MIXER** Independent level control for each input and separate bass/treble controls. Input sensitivity: 240mV. 18V DC. PCB: 60mm x 185mm **1052KT £16.95**
● **NEGATIVE\POSITIVE ION GENERATOR** Standard Cockcroft-Walton multiplier circuit. Mains voltage experience required. **3057KT £10.95**
● **LED DICE** Classic intro to electronics & circuit analysis. 7 LED's simulate dice roll, slow down & land on a number at random. 555 IC circuit. **3003KT £9.95**
● **STAIRWAY TO HEAVEN** Tests hand-eye co-ordination. Press switch when green segment of LED lights to climb the stairway - miss & start again! Good intro to several basic circuits. **3005KT £9.95**
● **ROULETTE LED** 'Ball' spins round the wheel, slows down & drops into a slot. 10 LED's. Good intro to CMOS decade counters & Op-Amps. **3006KT £10.95**
● **12V XENON TUBE FLASHER TRANSFORMER** steps up a12V supply to flash a 25mm Xenon tube. Adjustable flash rate. **3163KT £13.95**
● **LED FLASHER 1** 5 ultra bright red LED's flash in 7 selectable patterns. **3037MKT £5.95**
● **LED FLASHER 2** Similar to above but flash in sequence or randomly. Ideal for model railways. **3052MKT £5.95**
● **INTRODUCTION TO PIC PROGRAMMING.** Learn programming from scratch. Programming hardware, a P16F84 chip and a two-part, practical, hands-on tutorial series are provided. **3081KT £21.95**
● **SERIAL PIC PROGRAMMER** for all 8/18/28/40 pin DIP serial programmed PICs. Shareware software supplied limited to programming 256 bytes (registration costs £14.95). **3096KT £10.95**
● **ATMEL 89Cx051 PROGRAMMER** Simple-to-use yet powerful programmer for the Atmel 89C1051, 89C2051 & 89C4051 uC's. Programmer does NOT require special software other than a terminal emulator program (built into Windows). Can be used with ANY computer/operating system. **3121KT £24.95**
● **3V/1-5V TO 9V BATTERY CONVERTER** Replace expensive 9V batteries with economic 1.5V batteries. IC based circuit steps up 1 or 2 'AA' batteries to give 9V/18mA. **3035KT £5.95**
● **STABILISED POWER SUPPLY 3-30V/2.5A** Ideal for hobbyist & professional laboratory. Very reliable & versatile design at an extremely reasonable price. Short circuit protection. Variable DC voltages (3-30V). Rated output 2.5 Amps. Large heatsink supplied. You just supply a 24VAC/3A transformer. PCB 55x112mm. Mains operation. **1007KT £16.95.**
● **STABILISED POWER SUPPLY 2-30V/5A** As kit 1007 above but rated at 5Amp. Requires a 24VAC/5A transformer. **1096KT £27.95.**
● **MOTORBIKE ALARM** Uses a reliable vibration sensor (adjustable sensitivity) to detect movement of the bike to trigger the alarm & switch the output relay to which a siren, bikes horn, indicators or other warning device can be attached. Auto-reset. 6-12VDC. PCB 57x64mm. **1011KT £11.95** Box **2011BX £7.00**
● **CAR ALARM SYSTEM** Protect your car from theft. Features vibration sensor, courtesy/boot light voltage drop sensor and bonnet/boot earth switch sensor. Entry/exit delays, auto-reset and adjustable alarm duration. 6-12V DC. PCB: 47mm x 55mm **1019KT £11.95** Box **2019BX £8.00**
● **PIEZO SCREAMER** 110dB of ear piercing noise. Fits in box with 2 x 35mm piezo elements built into their own resonant cavity. Use as an alarm siren or just for fun! 6-9VDC. **3015KT £10.95**
● **COMBINATION LOCK** Versatile electronic lock comprising main circuit & separate keypad for remote opening of lock. Relay supplied. **3029KT £10.95**
● **ULTRASONIC MOVEMENT DETECTOR** Crystal locked detector frequency for stability & reliability. PCB 75x40mm houses all components. 4-7m range. Adjustable sensitivity. Output will drive external relay/circuits. 9VDC. **3049KT £13.95**
● **PIR DETECTOR MODULE** 3-lead assembled unit just 25x35mm as used in commercial burglar alarm systems. **3076KT £8.95**
● **INFRARED SECURITY BEAM** When the invisible IR beam is broken a relay is tripped that can be used to sound a bell or alarm. 25 metre range. Mains rated relays provided. 12VDC operation. **3130KT £12.95**
● **SQUARE WAVE OSCILLATOR** Generates square waves at 6 preset frequencies in factors of 10 from 1Hz-100KHz. Visual output indicator. 5-18VDC. Box provided. **3111KT £8.95**
● **PC DRIVEN POCKET SAMPLER/DATA LOGGER** Analogue voltage sampler records voltages up to 2V or 20V over periods from milli-seconds to months. Can also be used as a simple digital scope to examine audio & other signals up to about 5KHz. Software & D-shell case provided. **3112KT £18.95**
● **20 MHz FUNCTION GENERATOR** Square, triangular and sine waveform up to 20MHz over 3 ranges using 'coarse' and 'fine' frequency adjustment controls. Adjustable output from 0-2V p-p. A TTL output is also provided for connection to a frequency meter. Uses MAX038 IC. Plastic case with printed front/rear panels & all components provided. 7-12VAC. **3101KT £69.95**

SURVEILLANCE

High performance surveillance bugs. Room transmitters supplied with sensitive electret microphone & battery holder/clip. All transmitters can be received on an ordinary VHF/FM radio between 88-108MHz. Available in Kit Form (KT) or Assembled & Tested (AS).

ROOM SURVEILLANCE

● ***MTX*** **- MINIATURE 3V TRANSMITTER** Easy to build & guaranteed to transmit 300m @ 3V. Long battery life. 3-5V operation. Only 45x18mm. **B 3007KT £6.95 AS3007 £11.95**
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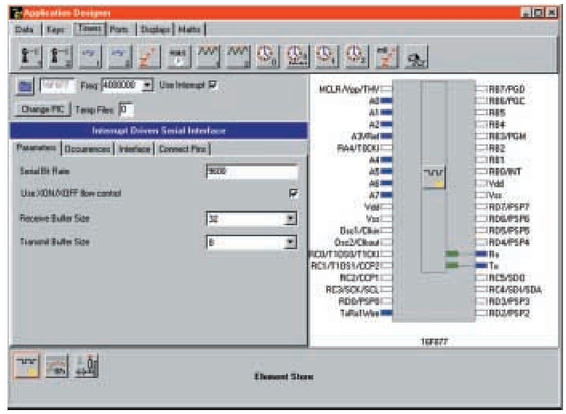

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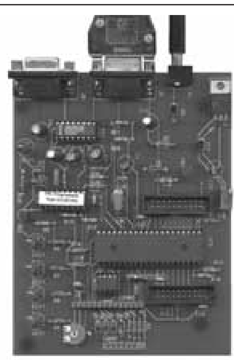

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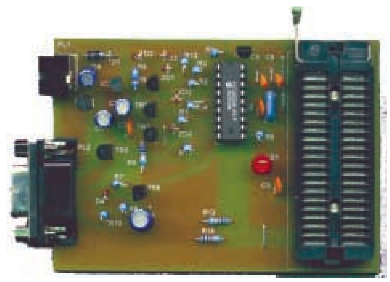

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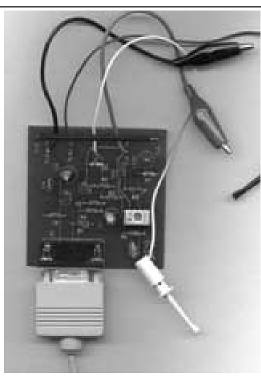

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PROJECT BUILDING

As most readers will realise, interest in electronics has waned somewhat over the years. Not so very long ago there were half a dozen UK magazines covering the subject, now the only one you will find on most newsagents' shelves is *EPE*. This trend has also been reflected around the globe with magazines folding or being merged in the USA and Australia, where there were also a good number of competing magazines not so long ago. Despite this, *EPE* is a very healthy magazine thanks to strong and loyal response from readers.

One thing I have often encouraged readers to do is to actually build some projects, as opposed to just reading about them, and over the last year it is encouraging to see that happening. Our p.c.b. sales are up by 75% year on year, so, even though there are fewer magazines, our readers are showing a growing interest in the constructional side of electronics, which can only be good for the future.

It is also interesting to see exactly what readers are building and p.c.b. sales show that PIC-based projects are very popular. Additionally, the old favourite of test gear remains high on readers' interests. In fact, eight of the top ten projects have been PIC-based and four of the top ten have been test gear.

It had become obvious to us which project was way out in front from the correspondence and general interest shown in it – *PIC Toolkit Mk3* (October and November 2001), which also gives a very clear indication of the way things are going.

PICs FOR ALL

Whilst we realise that PIC programming in assembler is not for everyone and a good number of readers simply buy pre-programmed chips, we would like to make sure everyone can benefit from using a programmable chip; hence our new *PICAXE Projects* series starting in this issue. Max Horsey has drawn on his experience in teaching GCSE students to bring us half a dozen projects that are not only easy to build but also very easy to program in BASIC. So if you are still hesitating to program your own projects we hope this will help you to "get your feet wet".

The first three projects in the short series are in this issue – six more will follow over the next two months.

Mike Kenward

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see opposite), from all UK newsagents (distributed by COMAG) and from the following electronic component retailers: Omni Electronics and Yebo Electronics (S. Africa). *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased and downloaded for just $9.99US (approx £7) per year available from **www.epemag.com**

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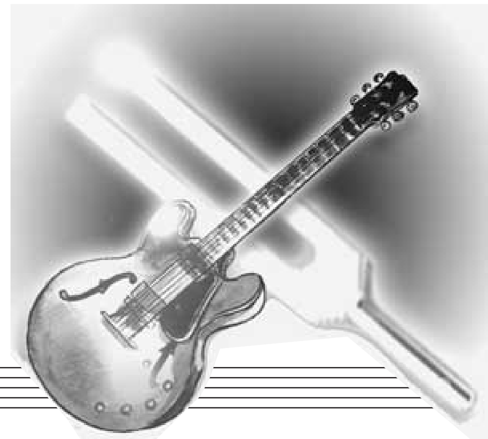
Constructional Project

TUNING FORK/ METRONOME



JOHN BECKER

Thrill everyone by at long last getting your instrument properly tuned!

PROCLAIMED the Bard, *"If music be the food of love, play on"*. Fine sentiments indeed, but only justified if the music's well tuned and on beat! This PIC-based design can help you ensure that your serenades at least start off with the correct notes – even if you do then play them in the wrong order.

The PIC microcontroller accurately generates the initial seven natural notes of an octave, A to G, any of which can be selected via a switch, as can one of two octaves, commencing at 220Hz or 440Hz. It can output the selected tone to headphones or a speaker, at a panel-controlled level.

It also compares its own tone with the frequency of an acoustically or electrically input note, and indicates via an l.e.d. (light emitting diode) how closely the two signals match. Lots of flashing and you're way off – no flashing and you're spot-on (or the battery's dead!).

A metronome mode can be selected in place of the tuning fork, and it outputs a "click-track" which can be set for different time signatures with an accented down beat.

This design originated at about the same time as the author's *StyloPIC* (July '02). Its software-generated tuning principles are based on the same additive technique as that design, in which fractions as well as integers are used to set the frequency. This allows greater tuning precision to be achieved than is possible with the more conventional integer-only additive techniques. The principle is discussed at greater length in the *StyloPIC* article.

CIRCUIT DIAGRAM

The Tuning Fork/Metronome circuit diagram is shown in Fig.1. Its upper section comprises the PIC microcontroller and the audio output stage. The lower part is for the audio input and tuning indicator.

It is intended that a 9V battery should be used to power this circuit, although any d.c. supply between about 7V and 12V could be used. The input voltage is reduced to 5V by voltage regulator IC3. This supplies power to most of the circuit, with the exception of the audio output amplifier, which is powered at the full supply voltage. This reduces the current load placed on IC3.

A PIC16F84 microcontroller (IC1) is used, operated at 4MHz as set by crystal X1. In Tuning Fork mode the PIC generates a square wave frequency on its RA0 output pin. The frequency is selected via the first seven positions of binary-coded-decimal (BCD) switch S5. The octave range is selected by switch S3.

The selected tone from RA0 is a.c. coupled via capacitor C7 to the amplifier stage around IC2a. Here the signal amplitude can be varied by potentiometer VR2. The gain range is from nil (no note heard) to a maximum of approximately ×0·5, in other words, an attenuation of the signal to about half its peak-to-peak level from RA0, from 5V pk-pk to about 2·5V pk-pk.

Op.amp IC2a is capable of supplying a current of about 1A and this is more than adequate to feed via socket SK1 to a pair of headphones or a small loudspeaker. Low or high-impedance headphones can be used, those known as "personal" headphones are ideal. The loudspeaker can be any between about 8Ω and 40Ω, but the latter is preferable to save on battery power. The unit may also be plugged into the line socket of any normal amplifier.

Components R9 and C11 prevent instability in IC2a. Note that this device is a dual power op.amp of which the second half is not used. It has been chosen because over the years the author has found it to be well-suited to applications such as this.

AUDIO INPUT

External frequencies can be input from acoustic or electronic musical instruments. For acoustic instruments, the circuit around op.amp IC4a is used. A small electret microphone, MIC1, picks up the audio signal from the instrument. It is a.c. coupled via capacitor C14 to the non-inverting input (pin 3) of IC4a, with resistors R12 and R13 setting the d.c. level at this pin to about 2·5V.

Resistors R14 and R15, plus capacitor C5, set the amplification of this stage to about 100. From IC4a pin 1, the amplified signal is output to switch S6, through which it can be routed to another gain stage based around IC4b.

Switch S6 can alternatively select the signal path to IC4b to be via socket SK2. It is here that electronically generated music signals can be plugged in, ideally with a peak-to-peak amplitude of about 1V, although signal amplitudes well to either side of this can be used.

From switch S6, the signal is a.c. coupled by capacitor C16 to potentiometer

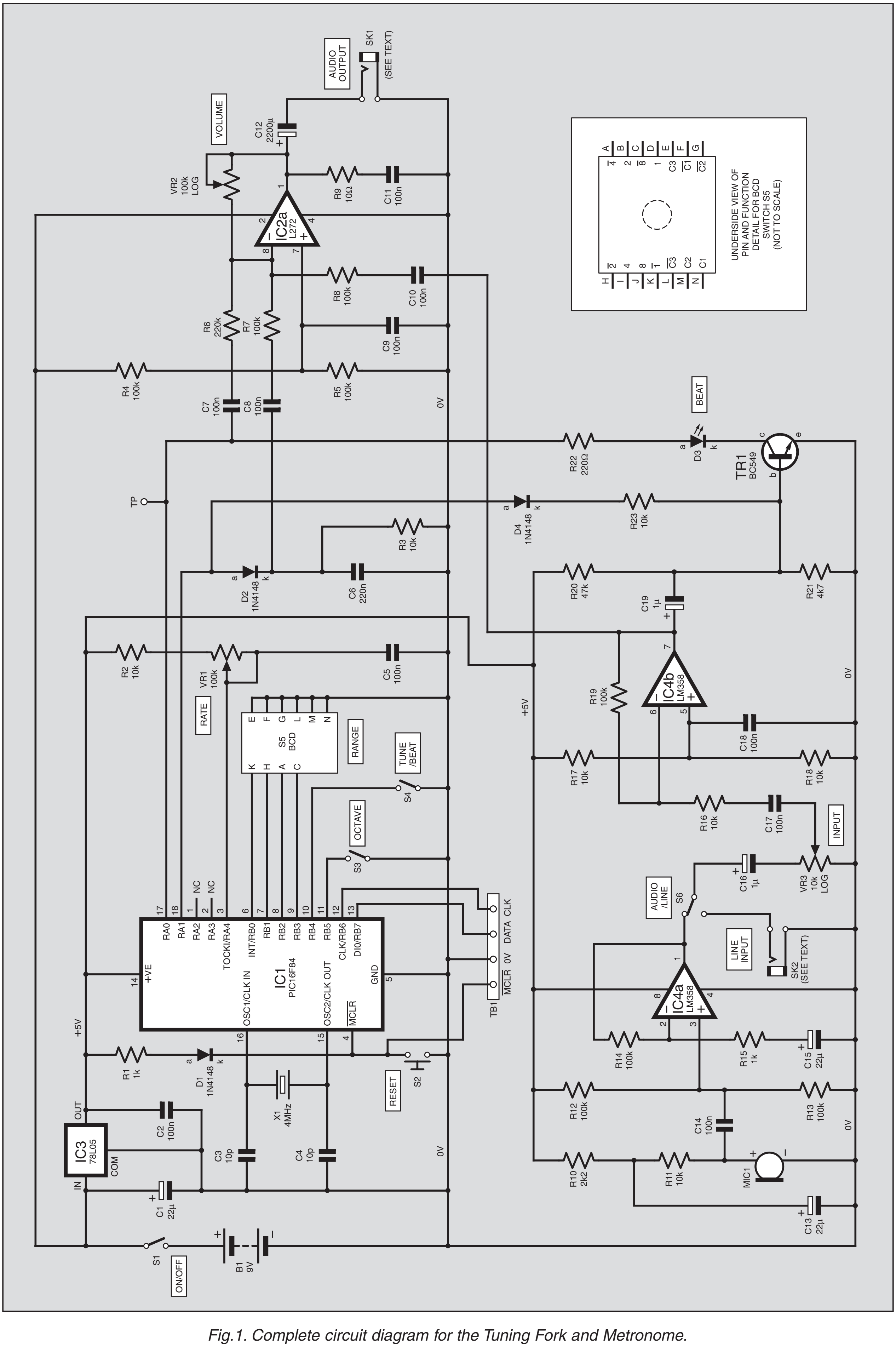


Fig.1. Complete circuit diagram for the Tuning Fork and Metronome.

VR3, which allows the input signal amplitude to be varied from nil to maximum. The signal is then a.c. coupled by C17 to the inverting input of IC4b (pin 6). This stage provides a gain of about ×10, as set by resistors R16 and R19. Resistors R17 and R18 set a midway reference level on IC4a's non-inverting input, pin 5.

From IC4b, the signal is a.c. coupled to the final stage, around transistor TR1, which is biased by resistors R20 and R21 to just below its "turn on" voltage of about 0·6V. In the presence of sufficiently strong signals from IC4b, TR1 is repeatedly switched on and off in sympathy with their high and low peaks. This causes l.e.d. D3 to turn on and off accordingly, provided that TR1's collector path via R22 and D3 is biased high via its connection to IC1 pin RA0, the same pin that sends the internally generated tone to IC2a.

Diode D3 will only turn on if RA0 is high (+5V) and TR1 is also turned on. In other words, TR1 behaves as an AND gate. It will be seen that if the frequencies applied to TR1 via RA0 and IC4b both have their phases high at the same time, D3 will turn on. If the phases are opposite to each other, one high the other low, D3 will be turned off.

EYE CATCHING

With widely differing frequencies at the two sources, the l.e.d. will be turned on and off at a rate faster than the eye can distinguish, so appearing to be fully on, although possibly not quite as bright. As the frequencies become more closely matched, the l.e.d. will be seen to flash at a progressively slower rate. When the two frequencies match identically, one of two situations will occur. If their phases are opposite, the l.e.d. will be held fully off. If the phases are the same, the l.e.d. will appear to be held fully on.

The art of tuning a musical instrument so that its frequency is the same as the PIC-generated one, is to keep tuning the instrument so that the l.e.d. is seen to flash at a progressively slowing rate, and then stop flashing when the two frequencies match. Whether the l.e.d. at that point is either on or off is irrelevant.

This tuning technique should be used intelligently! If one signal is the harmonic of the other, it may *appear* through observing the l.e.d. that tuning accuracy has been achieved. To make sure that this is not the case, briefly listen to the audio signal from IC2a and from your instrument. It should be apparent whether the instrument frequency is at the same fundamental tone, or simply producing harmonically related tones. If in doubt, alternate between the two settings of switch S6, and listen for differences between the single and dual tones.

The acoustic matching of tones, of course, is the technique by which musicians tune their instruments against each other, or against a mechanical tuning fork. This Tuning Fork can be used in this manner too.

MATCHING AUDIO BEATS

You are no doubt aware that when tuning an instrument to match another frequency, it is the harmonic relationships that you listen for. Just as the l.e.d. flashing rate changes as the separation of the two frequencies narrows, so the ear is hearing a slowing "beat frequency" as the frequency waveforms "slide over" each other, sometimes enhancing each other, sometimes cancelling. When the frequencies match, the beat frequency ceases, leaving just the identical fundamental frequency of each source.

This tuning method has also been provided as an additional facility. The amplified external signal from IC4b is also fed to the inverting input of IC2a, via C10 and R8. This causes it to be mixed with the PIC-generated signal, and the resulting beat frequency within the mixed tones at the output will be heard clearly, provided the amplitudes of the internal and external frequencies are similar.

As the external frequency will be roughly a square wave when it is output from IC4b, the tonal qualities of the two signals should be fairly well matched. (Acoustically comparing a sine wave with a square wave, for example, tends to be more difficult than comparing two sine waves or two square waves.)

METRONOME

The Metronome facility is selected by switch S4. In this mode, the PIC generates a series of pulses at its pin RA1 output. These are fed via diode D2 to amplifier IC2a from where they can be heard as clicks. Between them, diode D2, resistor R3 and capacitor C6 cause the click to start loudly and then die away.

There are eight click patterns that can be generated, in which a heavier click is heard at regular intervals. The heavier beat, the *accent*, is produced by the PIC generating a slightly longer pulse than the others in the sequence. The range is: 1/1 (no accent), 1/2 (accent every second beat), 1/3, 1/4, 1/5, 1/6, 1/7 and 1/8 (accent every eighth beat). Switch positions 9 and 10 also generate 1/1 and 1/2 patterns.

The accented beat also briefly turns on l.e.d. D3, by applying a biasing current to the base of transistor TR1 via resistor R23 and diode D4, with the collector current provided by RA0, as before. The l.e.d. should be a high brightness type so that the brief pulse shows more readily.

The rate of click generation is controlled by potentiometer VR1. Although the PIC is a device with digital-only input ports, it is possible to use them to respond selectively to varying external analogue voltages.

Resistor R2, potentiometer VR1 and capacitor C5 form an *RC* network whose charge rate can be controlled by varying the resistance of the VR1 path.

The PIC has been programmed to initially set output RA4 low, so discharging capacitor C5. RA4 is then set as an input which, being at a high impedance, allows C5 to recharge via R2 and VR1. The software constantly reads this input, initially responding to it as being at logic 0, because C5 has been discharged to below the input's logic 0 threshold.

When the voltage across C5 rises above the input's logic 1 Schmitt trigger threshold, this changed logic condition is recognised by the software, which again sets RA4 as an output, discharging C5, and the cycle repeats.

Each time the RA4 input change from low to high is recognised, the PIC outputs a pulse at RA1. A counter determines whether the pulse is short or long, i.e. normal or accented. The counter's roll-over value is determined by the BCD value set by switch S5.

It will be seen that by varying the resistance of VR1, the interval between pulses can be changed, so changing the metronome's click rate. The range on the prototype is approximately 28 to 360 beats per minute, depending on the exact value of capacitor C5 (which is likely to have a tolerance range of about 10 per cent). The maximum rate can be lowered by increasing the value of R2.

COMPONENTS

See SHOP TALK page

Resistors

R1, R15	1k (2 off)
R2, R3, R11, R16 to R18, R23	10k (7 off)
R4, R5, R7, R8, R12 to R14, R19	100k (8 off)
R6	220k
R9	10Ω
R10	2k2
R20	47k
R21	4k7
R22	220Ω

All 0·25W 5% carbon film or better

Potentiometers

VR1	100k rotary carbon, lin
VR2	100k rotary carbon, log
VR3	10k rotary carbon, log

Capacitors

C1, C13, C15	22µ radial elect. 16V (3 off)
C2, C5, C7 to C11, C14, C17, C18	100n ceramic, 5mm pitch (10 off)
C3, C4	10p ceramic, 5mm pitch (2 off)
C6	220n ceramic, 5mm pitch
C12	2200µ radial elect. 16V
C16, C19	1µ radial elect. 16V (2 off)

Semiconductors

D1, D2, D4	1N4148 signal diode (3 off)
D3	red l.e.d., high brightness, plus mounting clip
TR1	BC549 *npn* transistor
IC1	PIC16F84 microcontroller, preprogrammed (see text)
IC2	L272 dual power op.amp
IC3	78L05 +5V 100mA voltage regulator
IC4	LM358 dual op.amp

Miscellaneous

B1	9V PP3 battery and connecting clip
MIC1	electret microphone insert
S1, S3, S4	min. s.p.s.t. (or s.p.d.t.) toggle switch (3 off)
S2	min. push-to-make switch
S5	binary-coded-decimal switch
S6	min. s.p.d.t. toggle switch
SK1, SK2	3·5mm jack socket (2 off) (see text)
X1	4MHz crystal

Printed circuit board, available from the *EPE PCB Service*, code 374; plastic case, 150mm x 80mm x 50mm; p.c.b. mounting supports (4 off); knobs for VR1 to VR3, S5 (4 off); 8-pin d.i.l. socket (2 off); 18-pin d.i.l. socket; connecting wire; solder, etc

Approx. Cost Guidance Only **£30** *excl. batt.*

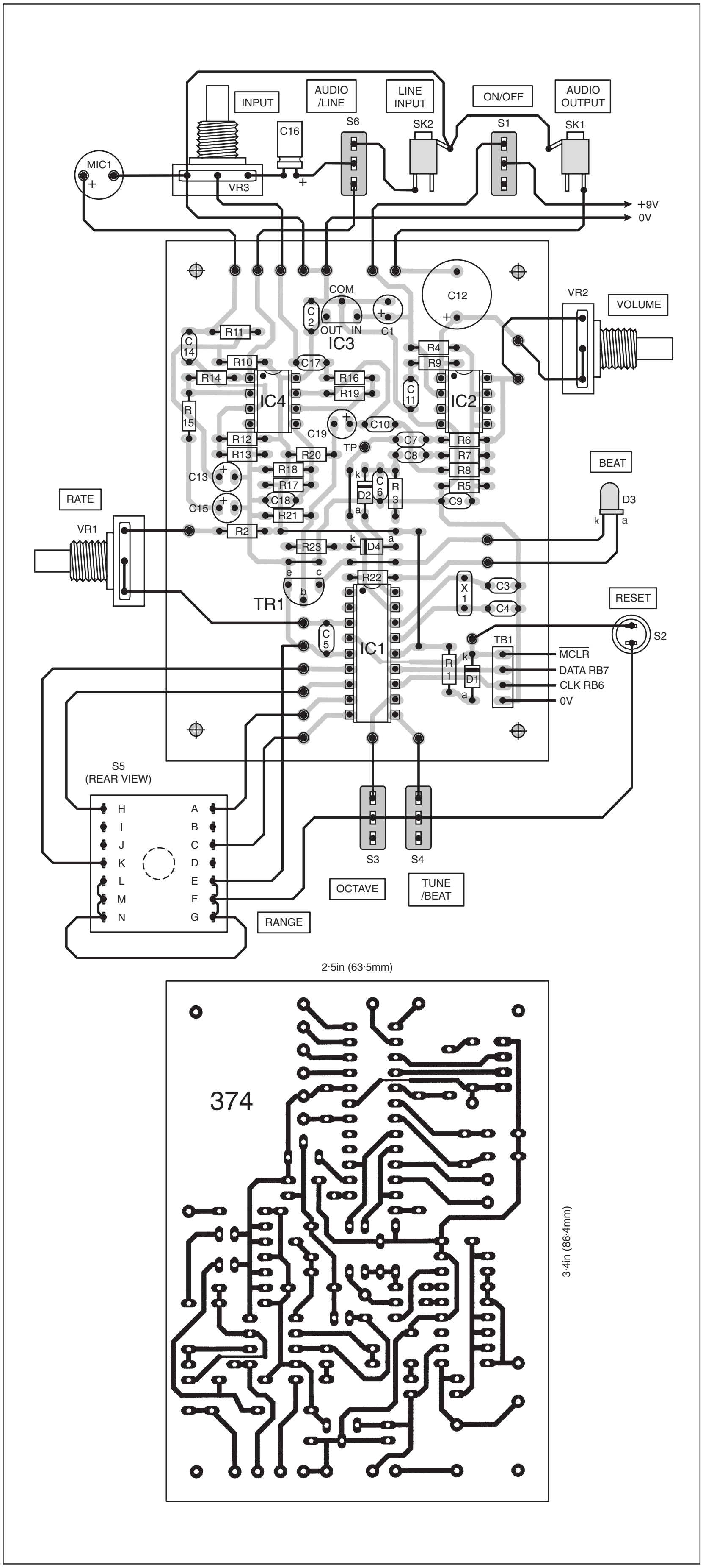


Fig.2. Printed circuit board component layout and full-size copper foil master track pattern for the Tuning Fork and Metronome.

As usual with the author's designs, pins via which the PIC microcontroller can be programmed, by Toolkit TK3 for instance, are included in the usual order and notated as TB1. Resistor R1 and diode D1 allow external PIC programming voltages to be safely applied.

SOFTWARE

The software is available for free download from the *EPE* ftp site. This is most easily accessed via the main page of the *EPE* web site at **www.epemag.wimborne.co.uk**. At the top is a click-link saying **FTP site (downloads)**, click it then click on **PUB** and then on **PICS**, in which screen you will find the Tuning Fork folder.

There are four files, suffixed ASM (TASM), OBJ (TASM), HEX (MPASM) and MSG. The HEX file includes embedded configuration data, plus embedded values for the data EEPROM. OBJ users should set the PIC configuration for XT crystal, WDT off, POR on. The MSG file holds the tuning data, arranged in the format suitable for loading into the PIC's data EEPROM via TK3's Message Send option, but this is only necessary if using the OBJ file.

The software can also be obtained on 3·5-inch disk (Disk 5) from the Editorial office. There is a nominal handling charge to cover admin costs. Details are given on the *EPE PCB Service* page, and in this month's *Shoptalk*, which also gives details about obtaining preprogrammed PICS.

CONSTRUCTION

Details of the component and tracking layouts for this design's printed circuit board (p.c.b.) are shown in Fig.2. This board is available from the *EPE PCB Service*, code 374.

Assemble in order of component size (or any order you have become accustomed to) and not forgetting the few link wires. Insert 1mm terminal pins for all off-board connections. Use a socket for IC1, and preferably for IC2 and IC4 as well. Make sure that all polarity sensitive components (electrolytic capacitors, diodes, transistor and i.c.s) are inserted the correct way round.

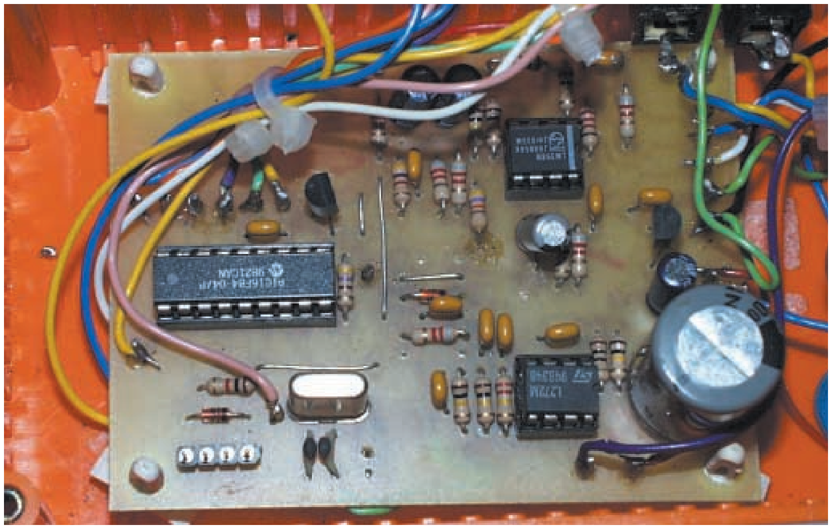
Only insert IC3 at this time. Don't insert the other i.c.s until the correctness of the 5V output from IC3 has been proved.

The prototype was housed in a plastic case measuring 150mm × 80mm × 50mm. The relative positions of the holes that need to be drilled can be seen in the first photograph. Don't forget the hole behind which the electret microphone is mounted – hot-melt glue was used to hold it in position in the prototype. If a larger case is used, a small speaker could be mounted inside, with suitable holes drilled to let the sound out.

The sockets were 3·5mm types in the prototype but should be selected to suit the equipment with which they are to be used.

The off-board wiring details are also shown in Fig.2. Note especially the connections to the BCD switch S5. The letters shown are also molded into the switch's body near its pins. The correct order of use must be followed. Ensure that the microphone insert is connected the right way round as it is a polarised device.

Double check the correctness of your component insertion and of your soldering before applying power. Having switched on, check that +5V is present at the output of IC3. Always disconnect the power if things are not as they should be and when inserting or extracting components.



When all is seen to be well, insert the two op.amps and the preprogrammed PIC, and check that all the controls do as intended.

TUNING ADJUSTMENT

It is likely that the tuning will be well within the range of that normally regarded as correct. However, there will be slight differences between clock rates of individual versions, due to the crystal-generated frequency not being at exactly 4MHz. As with other component types, crystal values have a manufacturing tolerance spread (quoted in their datasheets).

This section describes how you can change the overall tuning range. It should be done in conjunction with a highly accurate frequency generator or counter (having at least one decimal place in its displayed values), or against a good quality mechanical tuning fork or pitch pipes.

Tuning values for all 14 notes are held in two blocks within the PIC's data EEPROM (where they are placed during programming, or using the MSG file as referred to earlier). When the PIC has been newly programmed, the two blocks are identical, the second being regarded as the "author's default" values, those which held true with the prototype.

Pitch tuning can be shifted symmetrically across all 14 notes, both upwards and downwards. The author's default values can also be recalled to replace the user's own values should the need arise. Tuning of individual notes is not allowed for, nor is it desirable since the frequency relationship between each note is mathematically derived. Consequently, any frequency shift is applied relative to each note's mathematical ideal.

Thus if you increase lowest Note A from 220Hz to 221Hz, Note A at the next octave up (Concert A) is automatically increased from 440Hz to 442Hz, exactly twice that of the lower note.

To change the pitch of the entire 14-note block, set switch S5 to positions 8, 9 or 10, in which positions the unit ceases to generate an output frequency. Then press and release Reset switch S2, which causes the program to restart from the beginning. During the initialisation, it recognises if positions 8, 9 or 10 have been selected and the program jumps to an appropriate correction routine if they have.

If position 8 is selected, a decrease in pitch is performed, position 9 causes an increase in pitch, while position 10 results in the author's defaults being restored.

Any changes actioned are automatically stored back to the first block in the data EEPROM, where they remain even after power has been switched off, being recalled again when the unit is next switched on.

Tuning adjustment is in relation to the value held in the MSB (most significant byte) of the 2-byte tuning value in the author's default block. For example, if tuning upwards is needed, the author's MSB is retrieved from the EEPROM, halved and added to the LSB (least significant byte) of the value for the equivalent note in the user's block, automatically incrementing the user's note MSB if a carry (rollover of the LSB) results from the addition. The process is automatically repeated for all 14 notes in a single batch.

Similarly, if a decrease in pitch is required, half the value of the author's MSB is *subtracted* from the user's LSB. Restoration of the author's defaults simply entails copying their values into the user's EEPROM block.

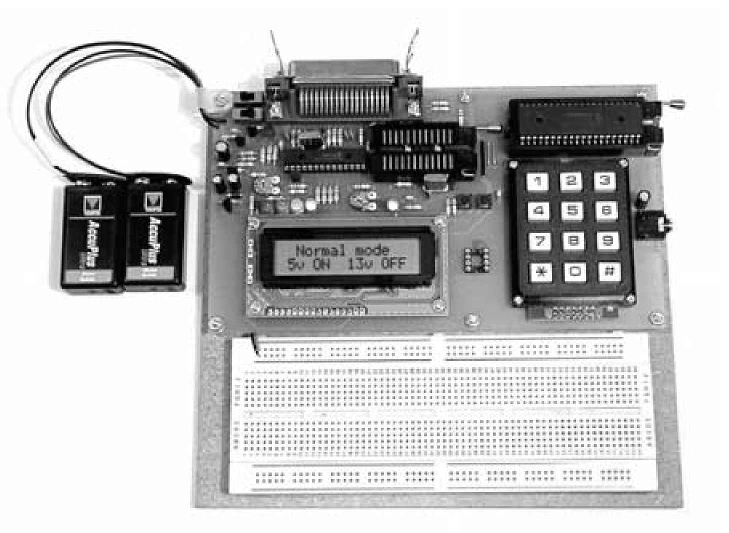
Each adjustment is only performed once for any call via the Reset option. The Reset switch may be repeatedly pressed with S5 in any of the correction positions. If it is position 8 or 9 that has been selected, repeated decrement or increment occurs.

After correction has been called, switching S5 to position 7 or lower causes the PIC to start generating its selected output frequency, using the newly changed values. Be aware that if S5 is already set to one of the corrective positions when power is being switched on, that too will cause a change to the tuning in the same way as caused by Reset switch S2.

CONCLUSIVELY HARMONIOUS

Once you are satisfied that the PIC Tuning Fork and Metronome are behaving correctly, you can at last get your instrument in tune. Then go and feed the heart of your loved one with a more appropriate musical diet than you've previously provided! □

Learn About Microcontrollers



PIC Training & Development System

The best place to start learning about microcontrollers is the PIC16F84. This is easy to understand and very popular with construction projects. Then continue on using the more sophisticated PIC16F877 family.

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Universal mid range PIC programmer module
+ Book Experimenting with PIC Microcontrollers
+ Book Experimenting with the PIC16F877 (2nd edition)
+ Universal mid range PIC software suite
.....+ PIC16F84 and PIC16F872 test PICs. £157.41
UK Postage and insurance. . . . . £ 7.50
(Europe postage & Insurance. . £13.00. Rest of world. . £24.00)

Experimenting with PIC Microcontrollers

This book introduces the PIC16F84 and PIC16C711, and is the easy way to get started for anyone who is new to PIC programming. We begin with four simple experiments, the first of which is explained over ten and a half pages assuming no starting knowledge except the ability to operate a PC. Then having gained some practical experience we study the basic principles of PIC programming, learn about the 8 bit timer, how to drive the liquid crystal display, create a real time clock, experiment with the watchdog timer, sleep mode, beeps and music, including a rendition of Beethoven's *Für Elise*. Finally there are two projects to work through, using the PIC16F84 to create a sinewave generator and investigating the power taken by domestic appliances. In the space of 24 experiments, two projects and 56 exercises the book works through from absolute beginner to experienced engineer level.

Ordering Information

Telephone with Visa, Mastercard or Switch, or send cheque/PO for immediate despatch. All prices include VAT if applicable. Postage must be added to all orders. UK postage £2.50 per book, £1.00 per kit, maximum £7.50. Europe postage £3.50 per book, £1.50 per kit. Rest of World £6.50 per book, 2.50 per kit.
Web site:- **www.brunningsoftware.co.uk**

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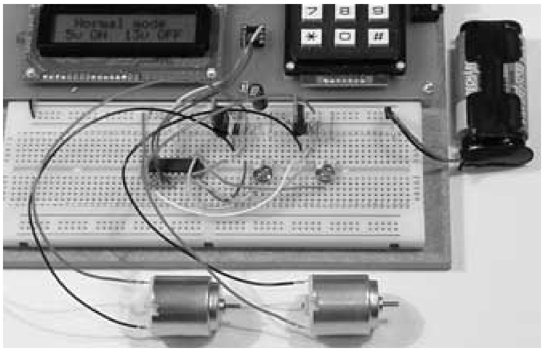
Hardware required

All systems in this advertisement assume you have a PC (386 or better) and a printer lead. The experiments require no soldering.



Experimenting with the PIC16F877

The second PIC book starts with the simplest of experiments to give us a basic understanding of the PIC16F877 family. Then we look at the 16 bit timer, efficient storage and display of text messages, simple frequency counter, use a keypad for numbers, letters and security codes, and examine the 10 bit A/D converter.

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News . . .

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

WHAT ARE TRIVISTORS?

Barry Fox asks if any readers know the answer

HOW many readers have heard of a "trivistor" valve or tube? A web search is likely to throw up only postings from people trying to find out more about trivistors.

The hare has been set running by British hi-fi company Musical Fidelity, whose new Tri-Vista 3000 stereo amplifier costs £4000 and delivers 340 watts per channel.

Musician Anthony Michaelson, who founded Musical Fidelity twenty years ago, says he also knows next to nothing about the trivistors he uses in the new amplifier. He bought what is believed to be the only remaining batch from an American dealer who is very secretive about his source. The unlabelled valves were made in 1982 (it is believed by Sylvania) after the US military found out that Russian fighters were using valves to withstand an electromagnetic pulse, the electrical shock wave generated by a nuclear explosion which fries microchips. So trivistors are literally bombproof.

They are tiny glass tubes with wires protruding from one end, for soldering to a p.c.b. Musical Fidelity reverse-engineered samples to find out the best drive voltages. The valves are used in the front end of the amplifier, can handle very high powers and withstand heavy shocks, without microphony. Overload and accelerated ageing tests suggest they should last for 100,000 hours.

Some web postings are sceptical, suggesting the whole thing is some sort of hoax. But Musical Fidelity has a good reputation in the hi-fi business and the Tri-Vista amplifier is getting a good reception from independent reviewers. Anthony Michaelson says he too is intrigued, and tried in vain to find out more about trivistors. If any reader has hard fact information we will pass it on to him.

SPONSORING STUDENTS

ELECTRONIC design specialists GSPK Design Ltd of Knaresborough have teamed up with the Department of Electronic and Electrical Engineering (EEE) at the University of Sheffield to help guide entrepreneurial students to realise their potential.

The University annually matches students to Yorkshire-based companies to give them the opportunity of a work placement over summer months and GSPK Design Ltd are a dedicated sponsor of this scheme.

For further information browse **www.gspkdesign.ltd.uk**.

SEHR GUT!

THE Friwo AA rechargeable NiMH battery with 1400mAh capacity has been awarded the top rating of "Sehr Gut" ("very good") by the German Consumer Magazine *Stiftung Warentest*. Now available with a remarkable 2000mAh capacity, the cost savings through using it are said to be "enormous". It is quick-charge capable and suitable for 1·5V applications.

Haredata, who sent us the press release, comment that from an environmental point of view the correct choice is NiMH batteries because they do not contain heavy metals such as cadmium, lead or mercury. The batteries can be recycled and in some countries there are recycling schemes.

For more information contact Haredata, HSP Ltd., Hyde House, Victoria Avenue, Harrogate HG1 1DX. Tel: 01423 543000. Fax: 01423 543017.

Email: sales@haredata.co.uk.

Maplin's Catalogue

MAPLIN Electronics have recently launched their 2002/2003 catalogue, introducing over 2300 new products, over 1400 price reductions and "exciting new product ranges for the radio enthusiast".

New to this edition, which is in its 30th year, is the Information centre, packed with over 50 pages of hints and tips, including how to connect your communications equipment. The catalogue contains colour-code sections intended for easier use, and there is detailed product information.

Maplin say they have made internal changes to make it even easier to order, with the call centre now open seven days a week, 24 hours a day. Orders can be placed via mail order and the website as well as by visiting one of the 65 stores nationwide. Orders placed before 7.30pm will be despatched the same day.

To receive a copy of the catalogue, which costs £3.99, call the mail order line on 0870 264 6000, visit the website at **www.maplin.co.uk**, or visit your local Maplin Electronics store.

KEELOQ TRANSDUCERS

R.F. SOLUTIONS LTD tell us that they have introduced a chipset that gives an easy to use drop-in solution for designers of both radio and infra-red transmitter-receiver circuits. The devices, which have been designed to achieve the maximum possible range, use the KEELOQ code hopping protocol, to give highly secure operation.

The chipset is suitable for use in a wide range of applications that includes automotive alarm systems, gate and garage openers, electronic door locks and burglar alarms. The ability of the decoder to learn up to 50 encoder devices allows multi-user systems to be easily established.

Housed in 8-pin DIP (standard) or SOIC (surface mount) packages, the devices can be easily inserted into a circuit. The RF600E encoder requires only the addition of input switches and r.f. circuitry. The RF600D decoder has four digital outputs that may be configured as either momentary or latching to give 15 possible states. A serial data output is also provided.

For more information contact R.F. Solutions, Dept EPE, Unit 21, Cliffe Industrial Estate, South Street, Lewes, East Sussex BN8 6JL. Tel: 01273 488880. Fax: 01273 480661. Email: sales@rfsolutions.co.uk. Web: www.rfsolutions.co.uk.

WATERPROOF INDICATOR

LASCAR Electronics have expanded their range of 4-20mA loop powered process indicators by introducing the DPM742-BL. The indicator has a 3·5 digit display with 12·7mm digit height and programmable decimal points. L.E.D. backlighting is available (requiring a separate power supply) ensuring a visible display in low light conditions.

An optional 1P67 rated bezel protects the indicator against moisture and particles in hostile environments. Calibrated by two multiturn potentiometers, the indicator offers a wide adjustment range and has a low drift bandgap reference circuit for accurate readings over a wide temperature range. Prices start at £42.45.

For more information on the DPM742-BL and all Lascar's digital panel meters and data loggers, contact Lascar Electronics Ltd., Module House, Whiteparish, Salisbury, Wilts SP5 2SJ.

Tel: 01794 884567. Fax: 01794 884616.

Email: lascar@netcomuk.co.uk. Web: www.lascarelectronics.com.

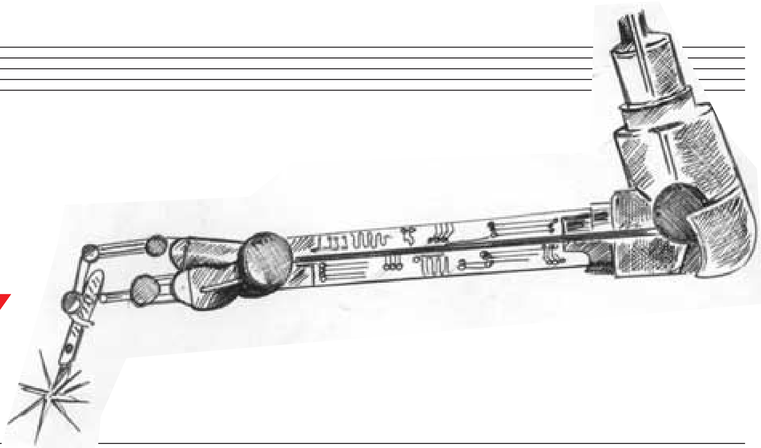
STUCK-UP PIRACY

By Barry Fox

SURELY the oddest idea yet for preventing Internet piracy comes from Sony's Epic record label. Instead of getting an advance copy of the latest Epic CDs, music reviewers in the US have been receiving Walkman CD players with the discs already inside and ready to play through headphones. This is not a sudden flush of generosity from Sony. The lid of each Walkman has been glued shut and the headphone plug glued into its socket. The object is to stop the reviewer taking out the disc and making an MP3 copy to put on the Internet. The glued-in headphone plug is to stop people connecting the socket to a recorder.

Readers who use DIY glues may well think that the one thing all glues can be relied on to do, is come unstuck. Presumably Sony also assumes that no music reviewer is clever enough to cut through the headphone wire and attach it to a recorder.

CIRCUIT SURGERY



ALAN WINSTANLEY
and IAN BELL

We investigate the operating temperatures of l.e.d.s – just how brightly can a white l.e.d. safely glow? Plus a* Teach-In 2002 *follow-up using op.amps on single supplies.

Single Supply

Noel Harvey followed *Teach-In 2002* (our ten part series sub-titled *Making Sense of the Real World* – our guide to using sensors to measure the environment). He has been trying to adapt the circuits in Part Two, *EPE* December 2002 to single supply use. He writes by email:

"Once again, thanks for an excellent Teach-In 2002 *series. However, help on the following two points would be appreciated. My sensor (single-sided 5V supply) gives an output from 210mV to 4·87V. To take full advantage of an LM311 comparator (single-sided power supply 12V DC), the sensor signal is being sent through an LM358 op.amp with a gain of 2·15 to give an output range from 0·451V to 10·5V (keeping the maximum output at least 1·5V below the 12V power supply).*

The centre circuit (non-inverting amplifier) of your Fig.2.3 page 845 is being used with R1 = 6·63k and R2 = 7·63k. It works beautifully. However, could you suggest how the offset of 0·451V may be reduced, using a single-sided power supply? All the circuits I have seen doing this have double-sided power supplies."

Classic op.amp circuits are powered using two equal and opposite (positive and negative) supply voltages, with the signal referenced to ground (0V). This is not usually too much of a problem for mains powered circuits but can be a nuisance if you are using batteries. To give you an idea, the split-supply and single-supply circuits for a typical inverting amplifier are shown in Fig.1.

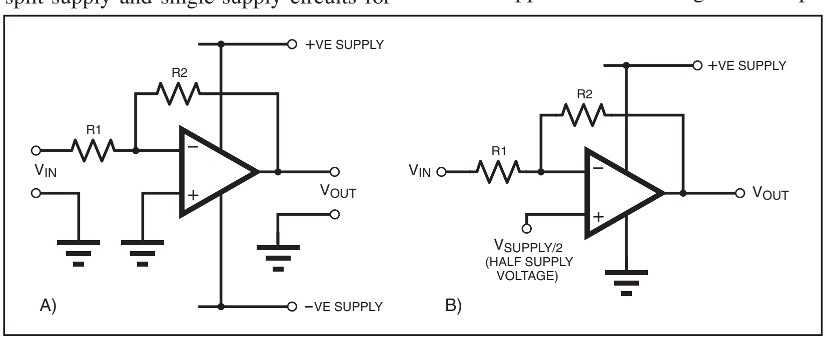


Fig.1. Split (a) and single (b) power supplies for an inverting op.amp circuit.

The half-supply voltage reference indicated in Fig.1b can be obtained using a simple potential divider as shown in Fig.2. Reasonably high value resistors should be used to prevent excessive power consumption. Noise on the supply line can get straight into the amplifier via the potential divider – a decoupling capacitor is used to help reduce this.

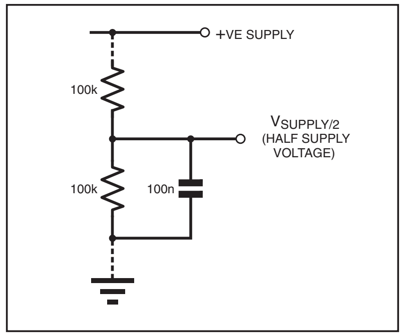


Fig.2. Half-supply voltage for single-supply op.amp circuits.

The split supply circuit is easy to use because signals referenced to ground are in the middle of the opamp's supply range. The signal can go either positive or negative without straying outside the acceptable input range. For a single supply circuit it is sometimes possible to reference signals to the half-supply voltage, but in many cases the system ground has to be used – equivalent to referencing the signal to the negative rail in a split supply system.

This means that decoupling capacitors may be needed to remove the d.c. offset to prevent the input signal going outside the op.amp's input range (e.g. if the signal goes negative with respect to system ground in Fig.1b). For relatively high frequency circuits this is not too much of a problem, but if the circuit is processing very slowly changing (effectively d.c.) signals, coupling capacitors may not be an option.

If we do not want to use coupling capacitors the op.amp circuit has to provide a d.c. shift as well as an amplify function. The basic specification of this type of circuit states a range of input voltages which are mapped onto a range of output voltages. In *Teach-In 2002* we used a split-supply circuit to do this (see Fig.2.6 on page 845, Dec. 2001). Only one form of circuit is needed – we can swap V_{in} and V_{ref} to obtain positive or negative gain.

For the single supply case the situation is a little more complicated. There are four situations (and four circuits) depending on (i) whether the gain is positive or negative (i.e. does the output voltage increase or decrease as the input voltage increases?); and (ii) whether the d.c. shift required is positive or negative.

We do not have the space to go into all the details here, but fortunately you can download a detailed design document on this subject by Ron Mancini of Texas Instruments. It is called "Single Supply Op Amp Design Techniques" and is available as a PDF at **http://www-s.ti.com/sc/psheets/sloa076/sloa076.pdf**.

For Noel Harvey's example we need to map an input range of 0·21V to 4·87V onto an output range of 0V to 10·5V the required circuit function is therefore:

$$V_{out} = m \times V_{in} - b = 2{\cdot}25V_{in} - 0{\cdot}4725V$$

This is obtained using the circuit in Fig.3, for which approximately

$$m = 1 + \frac{R_F}{R_G}$$

and

$$b = V_{supply} \times \left(\frac{R_F}{R_G}\right)\left(\frac{R_2}{R_1 + R_2}\right)$$

So we get $R_F = 1{\cdot}25R_G$ and $R_1 = 30{\cdot}75R_2$ for this application ($V_{supply} = 12V$). R_1 and R_2 must have much smaller values than R_F and R_G. If the op.amp's load is too small it may not perform properly when the output voltage is near the supply rails.

Single supply op.amps usually need an input common mode range that includes the supply rails and should have an output that can go all the way to the rails too. As battery operation is common in single supply operation, low minimum supply voltages are often required as well as low power consumption.

Before using any op.amp you must check the data sheet to determine the type of power supply it was designed for, and the ranges of supply, common mode input, and output voltages it supports. Op.amps not designed for single supply use, or even as the Texas Instruments document shows, "older generation" single supply opamps (including the LM358) may perform very poorly in single supply circuits, so take care! The recent increase in the use of mobile electronics means that a good selection of modern single supply, low power op.amps is now available. *IMB*.

● Note that there were corrections to some of the drawings and captions of Part Two of *Teach-In 2002*, see p.63 Jan. 2002.

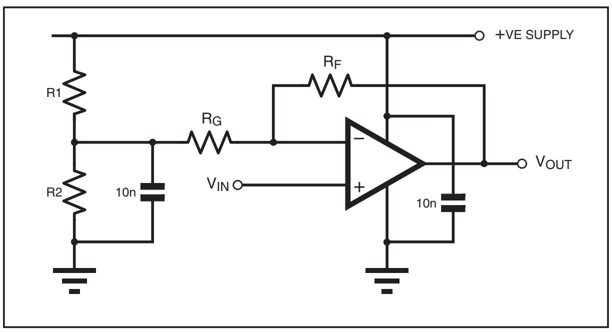


Fig.3. Single supply circuit to provide positive gain and negative d.c. shift.

L.E.D. Lamp Temperatures

I'm interested in the new high-brightness white l.e.d.s and Andy Flind's L.E.D Super Torch *published in* EPE *September 2001. I recently purchased a cycle lamp which uses one 5mm extreme brightness white l.e.d. in a purpose-designed plastic lens. The lamp uses four AA alkaline cells and contains a 47 ohm resistor in series with the light-emitting diode. I took the following measurements with my multimeter:*

Battery voltage: 6·3V off-load, 5·85V with load
Voltage across resistor: 2·25V
Voltage across l.e.d.: 3·6V
Current: 55mA.

I expected to find a higher value resistor in the above circuit. Would you advise the use of rechargeable Ni-Cad cells to reduce the risk of premature l.e.d. failure? ***John Anderson , London****.*

The question arises, just how brightly can you force an l.e.d. to operate without damage? Is there a safe maximum figure for current? The trick for manufacturers is to know just how high a forward current can flow without compromising reliability. Let's examine some of these factors in more detail.

The forward current is given in the manufacturer's data sheet. It is not known which brand of l.e.d. is used in your lamp but *average current* figures seem to be around 30mA or so according to a data sheet for the Hewlett Packard (now, Agilent) HLMP-CW range. However the data sheet also spells out a peak of 100mA absolute maximum rating at 25°C.

The main limiting factor is actually the *temperature rise* of the light-emitting semiconductor junction. Just like the thermal performance of a commercial p.c.b. which is designed to avoid "hot spots", the l.e.d. peak current relates to the *current density* in amperes per square centimetre. that the semiconductor chip can tolerate before being damaged. This is the ultimate measure of how hard you can drive an l.e.d., though for short high intensity bursts of light a more power-efficient strobed or pulsing signal of 100Hz to 1kHz would be used rather than driving an l.e.d. full-on with a d.c. source.

When any semiconductor device such as a power transistor or integrated circuit dissipates power, it's necessary to ensure that the temperature of the semiconductor chip is not permitted to rise above a maximum figure (say 125°C). Various materials get in the way and prevent heat from being carried efficiently away to ambient: plastic resins, internal connecting wires and steel transistor cans, for example. If we conduct the heat away fast enough by using heatsinks, then the chip temperature will be kept down to a safe level.

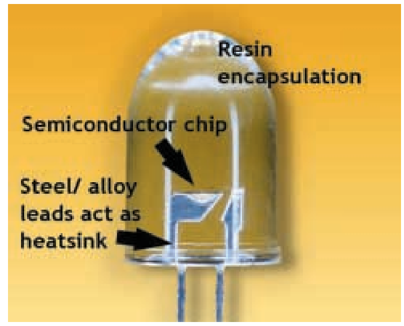
Unfortunately, plastic l.e.d. encapsulations are poor at conducting heat away from the light-emitting chip, and this shows in the l.e.d.'s high thermal resistance values compared with, say a power transistor

Calculate Temperature

Trying to figure out how hot an l.e.d. becomes is something generally ignored by hobbyist designers, but it can be an important part of the design process. If we know an l.e.d.'s ambient temperature and the thermal resistances in an l.e.d. assembly, we can calculate what the l.e.d. junction temperature is likely to be and compare it against maximum ratings. We can do this for the cycle lamp by utilising thermal resistance calculations as follows:

The power dissipation is measured in watts so the l.e.d. dissipates 3·6V × 0·055A = **0·2W**. We will assume an ambient temperature of **25°C** around the l.e.d. Let's assume a thermal resistance from the l.e.d. semiconductor junction to the mounting lead of 240°C/watt, as quoted in a typical data sheet.

We then need to include the thermal resistance from the p.c.b. copper track to ambient air, say at least 100°C/watt. This is because some of the heat will be conducted away courtesy of the p.c.b. tracks. For worst case calculations (e.g. very fine copper traces), increase this value two or three fold or more, because a higher system thermal resistance impedes heat flow away from the chip.



The internal structure of a typical l.e.d.

The total thermal resistance opposing the flow of heat from the l.e.d. chip to ambient is therefore at least **340°C/watt**.

The l.e.d. junction temperature T_J is given by (power in watts × total thermal resistance in (C/watt) + ambient temperature in Celsius.

i.e. T_J = (0·2 × 340) + 25°C = **93°C**.

Sun light

Now before we say that the value seems high, we don't know anything about the p.c.b. design (or even if there is one at all – which would increase the thermal resistance considerably), so these figures are for guidance only. The maximum junction temperature rating of a typical HP/Agilent 5mm white l.e.d. is 100°C so using that as an example it can be seen that the l.e.d. is working within its maximum limits. By pulsing the l.e.d. with a fast square wave instead, the average power dissipation will be lowered by the duty factor percentage: with a 25% duty factor T_J is just 42°C.

We don't know what the rated figure of the specified lamp l.e.d. actually is, or what heatsinking is available to the chip, but a forward current of 55mA seems to tally roughly with a figure I have seen for some components' $I_{D.C.\ MAX}$ d.c. absolute maximum currents of 50mA.

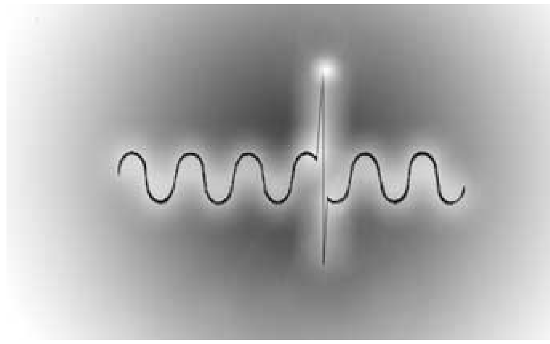
Obviously, lowering the voltage can only increase the l.e.d. reliability. The Ni-cad battery pack you suggested using will offer 4·8V instead of 6V and means the current through the l.e.d. will be reduced, but a Ni-cad's voltage follows a "plateau" so the brightness is likely to tail off without much warning. In practical terms this could happen at the most inconvenient time, whereas ordinary alkaline cells may give you more warning of their impending demise.

At this point I would add that in the UK such l.e.d lamps should not be used as a main source of lighting, but they can be used along with cycle lamps that comply with BS6102/3. Like many l.e.d. and halogen systems, your own l.e.d. lamp does not comply with the British Standard for cycle lighting.

As far as l.e.d. reliability goes, the MTBF (Mean Time Between Failure) of HP/Agilent's precision white l.e.d.s is quoted as 1·2 million hours at 74°C. I calculated that cycling at a constant 30 m.p.h. for this period (137 years) would take you 36 million miles – the distance between the planet Mercury and the Sun! *ARW.*

Constructional Project

TRANSIENT TRACKER



THOMAS SCARBOROUGH

Solve a "spiky" problem with this easy-build mains transient detector

DOMESTIC mains outlets provide a nominal 230V a.c. in many parts of the world – or in the USA, a nominal 115V a.c. It is not unusual, however, for sudden "skips" to occur in the mains voltage, measuring up to 1,000V (1kV) and higher. These are called *mains transients* – also referred to as *spikes*. Where such "skips" last longer than 10 milliseconds, they are referred to as *surges*.

It need hardly be said that a piece of equipment which has been designed to run off 230V a.c. could be seriously damaged by a 1,000V transient – in fact by far less than this. A typical transient waveform is shown in Fig.1a.

The point at which damage occurs to various kinds of electrical equipment is hard to quantify. This depends not only on the magnitude of a transient, but on its duration, and on the equipment itself. Having said this, however, the Transient Tracker described here will give a good indication as to when a risk is present, and will enable you, without the aid of expensive or sophisticated equipment, to determine whether such transients exist on your mains supply.

TRACKING TRANSIENTS

While it is very hard to quantify the damage that particular transients are likely to cause, it is possible to give some "ballpark figures" which roughly represent a general consensus. These will of course not apply in every case.

In the case of microprocessor controlled equipment (e.g. a computer system), repetitive transients of 100V (50V in the U.S.A.) are considered sufficient to cause permanent damage *over time*, while single transients of 1,000V (500V in the USA) may cause instant physical damage. According to some estimates, mains transients are responsible for between 70 and 90 per cent of all malfunctions in microprocessor controlled equipment!

Even the smallest power disturbances (as little as 10V or 5V in the USA) are not without peril. These are capable of causing operating errors, downtime, and data loss in microprocessor controlled equipment, which cost time and money. The effects of such disturbances on digital signals is shown in Fig.1b waveform. Other effects might include the spurious triggering of triac-controlled equipment, the resetting of digital clocks, or (in the author's case) the readjustment of a hi-fi system's volume.

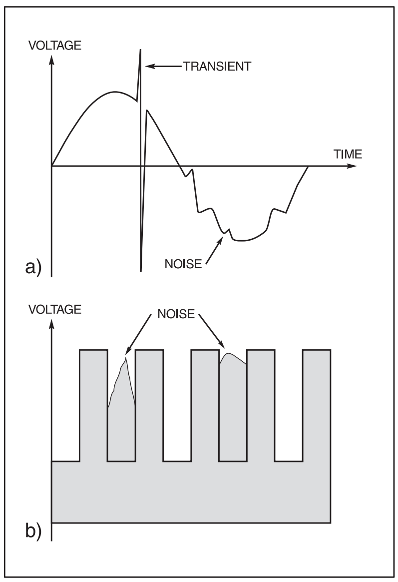


Fig.1a. A typical transient waveform and (b) power disturbance on digital signals.

The Transient Tracker detects mains transients above a selected level, which is adjusted by a front panel dial. It is capable of detecting transients down to less than 1µs, which compares favourably with the typical transient – an oscillatory event which continues for 6µs or 7µs. Its chosen scale of 0V to 270V (0V to 135V in the USA) covers the most active part of the range. This range may be expanded or compressed and will be explained later.

Mains transients are mainly caused by lightning on the one hand, or the discharge of stored energy in inductive or capacitve components on the other. The cause of transients in the second category might include (among other things) an electric drill, a mains transformer, or fluorescent lighting. The author has a desktop lamp which, during testing of the Tracker, produced up to 800V transients while switching on and off!

CIRCUIT DESCRIPTION

The Transient Tracker has three important building blocks and these are shown in the schematic diagram Fig.2. The first is a transformerless power supply, which is chosen for its ease of integration with direct measurements of the a.c. voltage. The second is a comparator (IC1a), which compares the mains voltage with a level selected by a potentiometer (VR2).

The third is an op.amp oscillator (IC1b), which is enabled by pulses at the output of IC1a. In this case, an op.amp oscillator is chosen specifically because it may be incorporated in a single i.c. with the comparator.

The full circuit diagram for the Transient Tracker is shown in Fig.3. The transformerless power supply is fairly standard – however, it has no transient suppressor, which would normally be wired across the Live and Neutral terminals. It goes without saying that a transient suppressor would not be a particularly good idea for a transient detecting circuit! For this reason, capacitors C1 and C2 have a

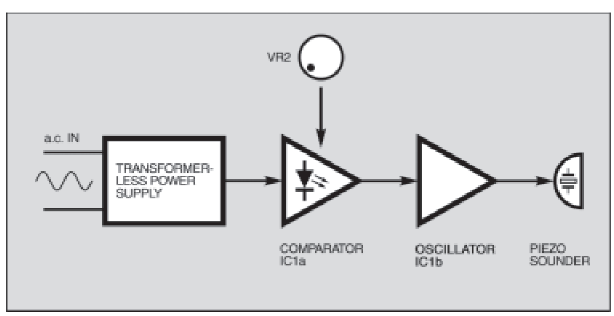


Fig.2. Block schematic diagram for the Transient Tracker.

higher "class Y" rating, which is better able to withstand the absence of the transient suppressor. These capacitors ***must*** be of the specified type and rating.

In brief, the flow of a.c. mains energy is considerably limited by the capacity of C1 and C2. Zener diode D3 then limits the positive voltage rectified by diode D2 to 10V, while diode D1 limits the negative voltage to 0·6V. Capacitor C3 maintains the "Zener voltage" during the mains negative half-cycle. The result is a power supply which provides about 6mA at 10V.

FIRST AID

Fuse FS1 is provided for safety, and resistor R1 limits instantaneous current in case the circuit is connected to the mains at a high voltage point. Resistor R1 additionally limits the absorption of transients by C1 and C2. R2 prevents "reverse shock" from C1 and C2 when the unit is unplugged.

Resistors R1 to R3 ***MUST*** be suitably rated, with a maximum overload voltage of at least 1,200V. For this reason, specific 2W types are specified in the Components listing.

It needs to be borne in mind that the reference voltage at IC1a pin 2 is compared with a representation of the *maximum* a.c. voltage. This is not the same as the 230V (115V in the USA) *r.m.s.* value of the mains voltage. The r.m.s. value is multiplied by the square root of 2 to obtain the maximum value, which is 325V (163V in the USA).

Front panel layout on the completed prototype.

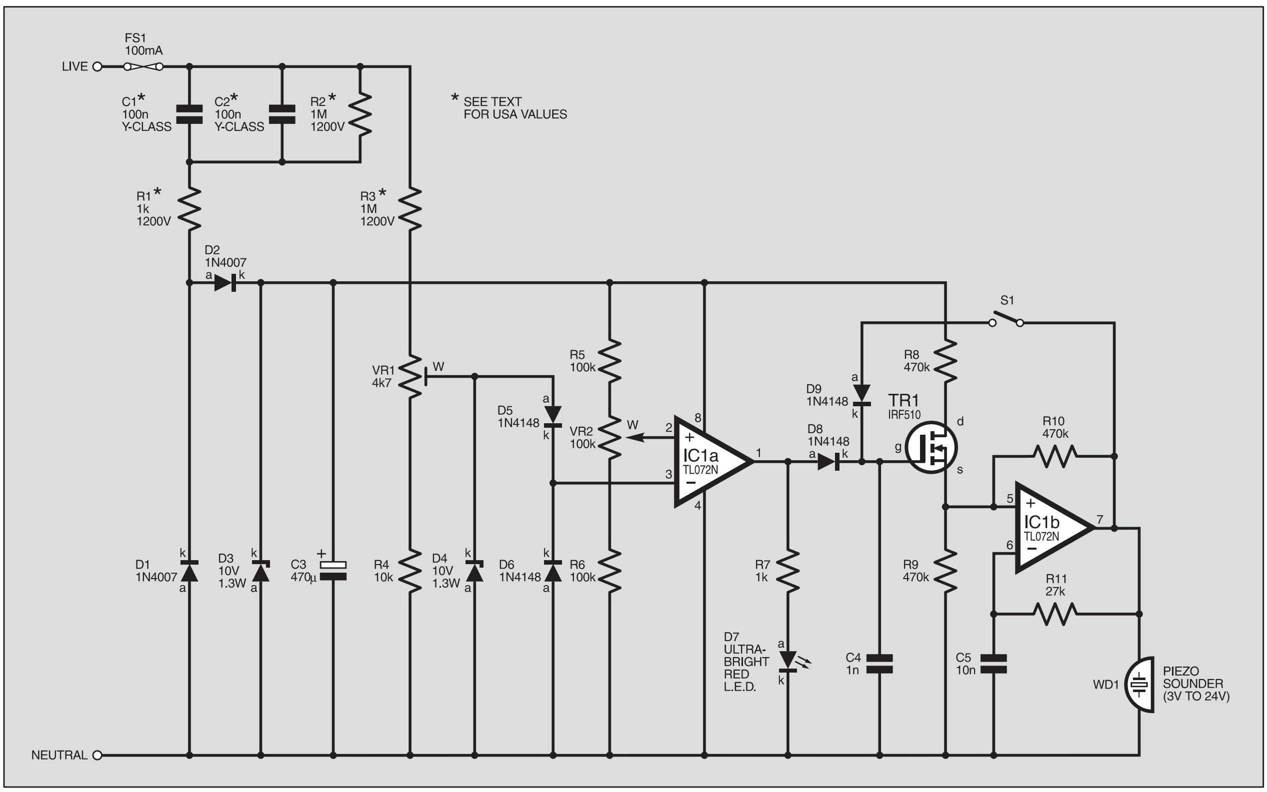


*Fig.3. Complete circuit diagram for the Transient Tracker. You **must** use high quality Class-Y capacitors and high voltage resistors where indicated – see text.*

IN COMPARISON

A simple comparator, formed by IC1a, compares the voltage of the mains potential divider network R3-VR1-R4 at the input pin 3 with the reference voltage at input pin 2. The reference voltage is set by potentiometer VR2, which provides detection of transients above a selected level between 0V and 270V (0V to 135V in the USA).

Zener diode D4 prevents over-voltages at IC1a input pin 3. Diodes D5 and D6 provide bi-phase rectification of the a.c. voltage at IC1a pin 3.

OSCILLATOR CIRCUIT

Op.amp IC1b forms a standard oscillator, which oscillates at a high audio frequency, determined by the values of resistor R11 and capacitor C5. This oscillator is enabled when transistor TR1 conducts. An IRF510 *n*-channel power MOSFET is chosen here, not for its power handling capability, but for its "logic MOSFET" characteristics.

Assuming that TR1 is conducting when power is applied to the circuit, capacitor C5 begins in a discharged state, with the result that IC1b's inverting input pin 5 is negative of the non-inverting input pin 6. The output (pin 7) of IC1b is therefore "high", causing resistor R10 to be effectively in parallel with R8. Two-thirds of the supply voltage is therefore present at non-inverting input pin 6. Capacitor C5 charges via resistor R11 until the voltage across it reaches two-thirds of supply voltage, whereupon the the op.amp output starts to go negative, and so on . . .

When TR1 is in its non-conducting state, input pin 5 of IC1b is held "low", so that IC1b is unable to sustain oscillation. When capacitor C4 is charged through a pulse from IC1a output pin 1, TR1 conducts, and IC1b is able to oscillate. As the charge on capacitor C4 drops, so does the conductance of TR1, causing the pitch of the oscillator to rapidly fall. Mains transients are thus reported with a falling "pioooo!" sound from the piezo sounder WD1.

Finally, diode D9 and switch S1 provide an important innovation. These return the output of oscillator IC1b to the "positive plate" of C4 when switch S1 is closed. This essentially turns D9 and C4 into a diode pump, and holds TR1's gate permanently "high" when a transient is detected. In this way, the Transient Tracker may be used as a simple "logger", which reports any transient above a selected level within a desired period.

Note that if the Transient Tracker is to be constructed in the USA, the following modifications need to be made:

Add two more 100n "Y-class" capacitors in parallel with C1 and C2.

Increase the size of the case as required.

Replace R2 with an identically rated 470k resistor.

Replace the 0V to 270V calibrated scale with a 0V to 135V scale.

COMPONENTS

See SHOP TALK page

Resistors

R1	1k 2W (1200V max. overload voltage)
R2, R3	1M 2W (1200V max. overload voltage (2 off)
R4	10k
R5, R6	100k (2 off)
R7	1k
R8, R9, R10	470k (3 off)
R11	27k

All carbon film 0·25W 10%, except R1 to R3

Potentiometers

VR1	4k7 enclosed carbon preset
VR2	100k rotary carbon, lin. with plastic case and spindle

Capacitors

C1, C2	100n Y-Class metallised paper or polypropylene 250V/275V a.c. (2 off)
C3	470µ radial elect. 16V
C4	1n radial tubular foil polystyrene
C5	10n ceramic

Semiconductors

D1, D2	1N4007 1000V 1A rec. diode (2 off)
D3, D4	10V 1·3W Zener diode (2 off)
D5, D6, D8, D9	1N4148 signal diode (4 off)
D7	ultra-bright red l.e.d.
TR1	IRF510 *n*-channel power MOSFET
IC1	TL072CN dual j.f.e.t. op.amp

Miscellaneous

X1	3V to 24V piezoelectric sounder
S1	s.p.s.t. mains rated slimline rocker switch
FS1	100mA 20mm cartridge fuse, with p.c.b. mounting holder

Printed circuit board available from the *EPE PCB Service*, code 372; plastic case, size 100mm x 62mm x 26mm approx.; 8-pin d.i.l. socket; plastic knob, with pointer, multistrand connecting wire; mains cable; cable grommet; cable tie; mains plug; nylon nuts and bolts; solder pins; solder etc.

Approx. Cost Guidance Only £15 excl. case

CONSTRUCTION

The Transient Tracker is built up on a small single-sided printed circuit board (p.c.b.), measuring 55mm × 80mm. Details of the topside component layout, together with the full-size underside master, are shown in Fig.4. This board is available from the *EPE PCB Service*, code 372.

Since this circuit is connected directly to the mains, it is of *crucial importance* that components should be correctly rated, inserted the right way round, and that there should be no solder bridges on the board. Also, apart from using nylon nuts and bolts to mount the p.c.b. inside the case, you should, for added safety, cover the underside mains-bearing copper tracks with insulating tape to avoid any possibility of shorting tracks together.

Alternatively, you can use self-adhesive plastic (nylon) stand-off "feet" to mount the p.c.b. inside the case. Metal mounting bolts ***must not*** be used as the "heads" will be exposed on the outside of the case.

Commence construction by soldering in position the solder pins and the dual-in-line (d.i.l.) socket on the board. Then solder the resistors, diodes, and l.e.d., continuing with the capacitors and transistor. Attach the "peripheral components" S1, VR2, D7, and WD1 to the solder pins via lengths of insulated multistrand wire.

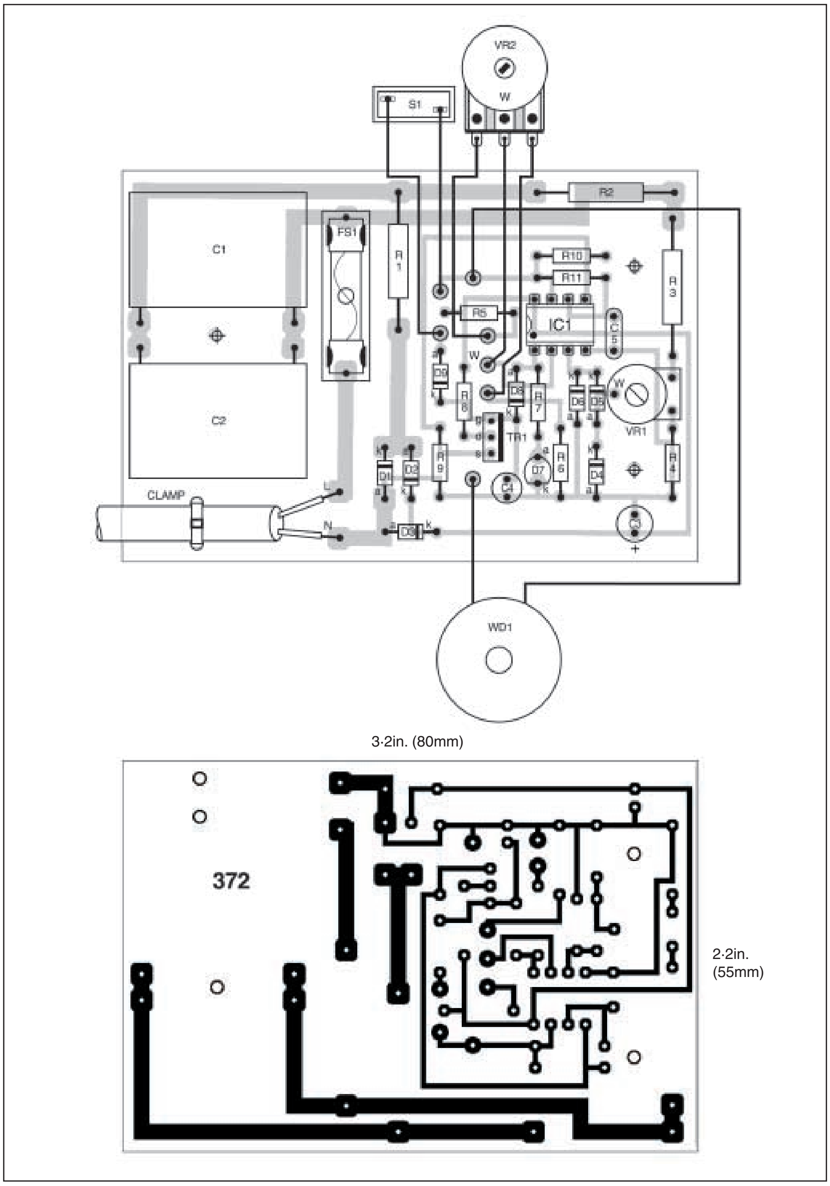


Fig.4. Printed circuit board topside component layout, wiring and full-size copper foil master for the Transient Tracker.

ASSEMBLY

A plastic case ***must*** be used to house the circuit board with no metal parts passing through the case to be exposed on the outside of the unit. The author used a small handheld type measuring just 100mm × 62mm × 26mm. This left no room for p.c.b. mounting plastic stand-off feet and the board was mounted using nylon nuts and bolts.

Attach a plug to a mains cable. Insert the mains cable through a grommet in the side of the case. Attach the Live and Neutral wires to the two solder pins as shown, using a cable tie to secure the mains cable firmly to the board (see photographs) – this is passed through the two holes provided. Finally, insert the 100mA fuse in the fuse-holder, and IC1 in the 8-pin d.i.l. socket. Fix a knob with pointer to the shaft of VR2, and add a calibrated scale.

TAKE NOTE

If R5 and VR2 are replaced with a 220k potentiometer, the scale is increased to 920V (460V in the USA). Alternatively, if VR2 is replaced with a 47k potentiometer and a 56k resistor in series (with the 56k resistor being connected to R5), the scale is reduced to 130V (65V in the USA).

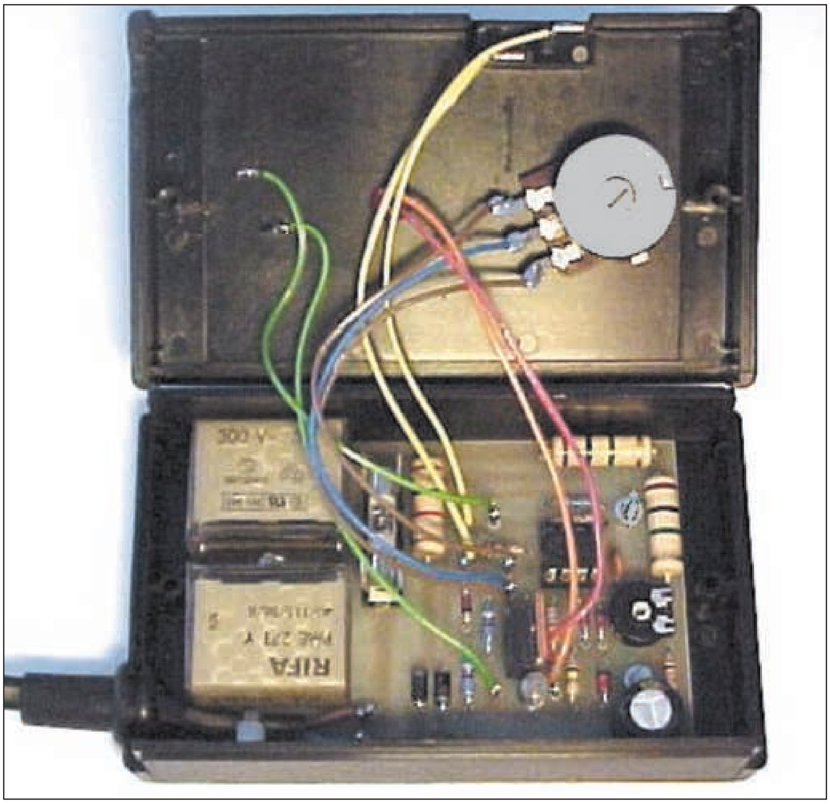
Component tolerances may vary, therefore if the piezo sounder WD1 remains silent at all settings of VR1 and VR2, increase the value of resistor R4. If it continually sounds, decrease the value of R4.

Since this circuit is directly connected to the mains, it is important that all components should meet the minimum ratings shown in the Components list.

CALIBRATION

Calibration is "a snap". First make sure that all electrical equipment in the home is momentarily switched off, and that there is not likely to be any electrical activity of any kind next door, or any electrical storms in the vicinity. Switch S1 to the "off" position. Turn preset VR1 to its mid position. Turn back potentiometer VR2 completely.

Plug the Transient Tracker into a nearby mains outlet. Piezo disc WD1 may or may not sound continuously. Holding one hand behind your back (so that the mains supply will under no circumstances find a path across the heart), and using an *insulated* screwdriver, adjust preset VR1 so that WD1 *just* stops sounding. ***Be careful not to touch any of the circuitry – a shock from the mains can kill you***.



Completed prototype showing wiring to top panel mounted components.

The Transient Tracker has now been set up. Securely close the case, ensuring that the p.c.b. is fully enclosed, and that no live circuitry can be touched. Ensure that the "peripheral components" are so positioned that there are no short circuits inside the case.

To test the unit, try plugging an inductive load (for instance, a vacuum cleaner or electric drill) into the same wall outlet as the Transient Tracker, switching this load on and off a few times. In all likelihood, this will trigger the Tracker – in some cases at its highest setting.

IN USE

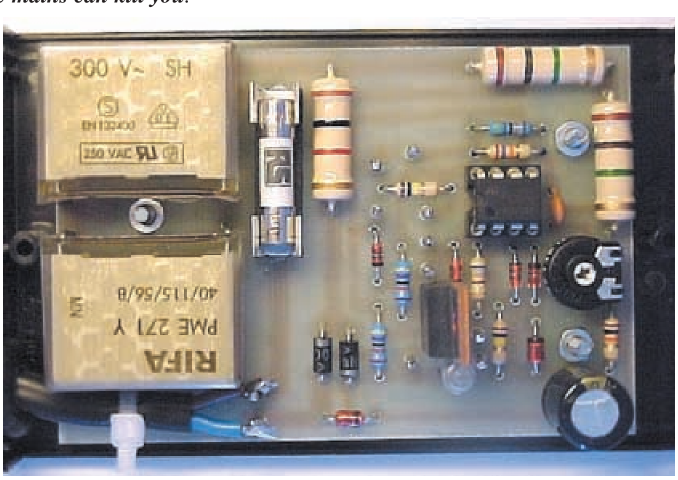
When a mains transient is detected above the selected level, the ultra-bright l.e.d. D7 flashes, and piezo disc WD1 sounds. Also, one may gain some impression as to the severity of a transient according to the intensity of the l.e.d.'s flash, and the pitch of WD1. The unit may respond to individual mains transients, or (more likely) streams of mains transients that will keep WD1 sounding for minutes at a time – especially at its lower settings.

The transients which hold the greatest risk may be those caused by equipment (such as the author's desktop lamp) which is plugged into the same mains outlet as the equipment wanting protection. This makes it a particularly bad idea, for instance, to run a vacuum cleaner and a computer off the same wall outlet. Electrical storms also pose a particular risk, and if these should draw near (three seconds between the lightning and thunder), it would be best to unplug your electrical equipment – particularly microprocessor controlled equipment.

TIME LOG

If switch S1 is in the "on" position, a transient above the selected level will cause WD1 to sound continually until it is switched off, thus acting as a "logger". The Tracker is much more sensitive in this "on" position, since feedback causes even the briefest of transients to register. Some transients may otherwise be so brief that they will barely be seen or heard. With switch S1 in the "on" position, the Transient Tracker is better suited to detecting spikes, while in the "off" position it is better suited to detecting surges.

It may soon become apparent what is causing mains transients, but in some cases these may be caused by electrical equipment that is hidden, such as a hot water heater, or even an item in a neighbour's home. By selecting a level of 100V (50V in the USA), one may identify sources of mains transients which may place microprocessor controlled equipment physically at risk – as well as testing protective measures such as surge suppressors and transient voltage surge suppression systems. □



Completed p.c.b. mounted in its case. Note the strain relief tie securing the mains cable.

New Technology Update

Optical illumination of crystals and nano-tubes reveals their data storage potentional.
Ian Poole reports

THE seed for a new idea for computer data storage has come out of some work being undertaken by researchers at the Max Plank Institute for Biochemistry.

The researchers have been using an infra-red near-field microscope to study the structure of crystals with resolutions down to nano-metres. The technique appears to have many applications. One will be for general materials research where it will reveal much about the nature of crystals under new conditions, but for the electronics industry the main focus of interest is for developing a new form of optical storage.

The new technique is different in that it uses near-field radiation. It is unlike more traditional forms of illumination that use far-field illumination. With this new approach it has been found that the response of a polar material changed very considerably, opening the new possibilities.

Concept

The researchers have used an infra-red laser beam to illuminate a nano-sized antenna to obtain resonance in a concept known as phonon resonance. The new technique enables nano-metric resolution to be obtained of the subject under observation and this enables more to be discovered about the chemical identity of the crystal, including its structural quality.

The use of infra-red wavelengths is crucial because crystals exhibit slightly different effects when illuminated by infra-red light. Under normal light they may be noted for their brilliance, but under infrared illumination they can reflect 100% of the illumination making them appear more like a metal in this respect. The reason for this can be found in the way that the lattice atoms vibrate under the influence of the waves. It is found that they vibrate against one another, preventing the light waves entering. This phenomenon is dependent upon the frequency and hence the wavelength of the incident rays. For these crystals it occurs in the infrared spectrum. In this way the response of the crystal changes dramatically when infra-red illumination is used rather than ordinary visible light.

To observe the effects a near field infrared microscope was used. This equipment which had been used previously was able to resolve details that were as small as a hundredth of a wavelength across. It also possessed the unique ability to distinguish the chemical composition of a crystal.

The basic technique that was used involved illuminating the needle of a scanning probe microscope with infra-red light. The needle is moved across the surface of the required crystal and in this way it builds up an image within the associated computer. Simultaneously the recorded infra-red light generates its image of the same area and this is used for evaluating the material composition.

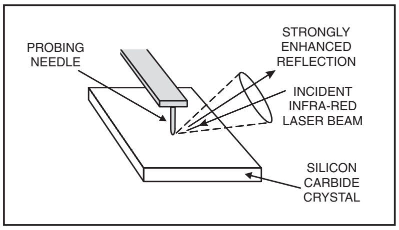


Fig.1. Diagrammatic representation of the probing needle and the laser beam illumination

The metallic needle in the microscope provides an essential function. It is found that it acts very much like a directive radio antenna, increasing the sensitivity of the system several fold.

The initial studies of the concept involved using a silicon carbide crystal. When performing measurements on this crystal it was found that the image they observed was enhanced considerably when the needle came within 30nm of the surface. This was compared with gold that is normally considered to be a very bright metal, and it was found that the silicon carbide provided an image that was two hundred times brighter.

The phenomenon is termed near-field surface phonon polariton resonance and it is only present when investigations use nanoscopic probing.

Applications

The practical applications of the phenomenon are expected to be considerable. One is in the examination of items like meteorites which are often made up from minute or nanoscale composites. Here the process would show the different composites up very easily.

However, in the electronics scenario many people are excited about the prospect of being able to use the phenomenon to provide ultra-high density storage or for use within optical integrated circuits. The high near-field signals that are obtained using silicon carbide could reliably provide a means for optical readout of data stored on the crystal. The data bits would occupy only nanoscale dimensions allowing for extremely high storage densities to be achieved. The high stability of silicon carbide both physically and chemically would mean that the storage would be very durable over long terms, providing an extremely reliable form of storage, especially for applications such as archiving.

Much work is yet to be done before these possibilities are realised. The first step is to enhance the work being undertaken on phonon enhanced near-field interaction on different materials including semiconductors and bio-minerals. Also work is required to investigate the responses achieved when different wavelength lasers are used.

Unfortunately this means that storage devices using this principle are some way off yet, but could become an important reality in the medium term future.

Nano-emitters

In another and totally distinct development, researchers at Rice University have discovered nano-tubes that emit light. These nano-tubes have been excited by absorbing light in the visible or ultraviolet portion of the spectrum and then emitting light in the visible portion of the spectrum. The discovery was actually made in October 2001, but sufficient work had to be completed to verify and quantify the results sufficiently before any publication was made.

It is hoped that this new discovery could see nano-tubes being excited electrically and being used in new forms of display. Here they could be included in a future generation of nano-scale integrated circuits.

The development has been a joint venture between two departments at the University. One department has been manufacturing the nano-tubes, whistle the other has been undertaking the measurements. In this way the attributes of both areas is utilised.

The nano-tubes have been created in a variety of diameters and it has been found that each one has its own characteristics, absorbing and emitting light at different wavelengths. The next stage in the development is to investigate the relationship between the size of the nano-tube and the resulting absorption and emission characteristics. As little or no data is currently available this will provide a sound basis for the next stage of the work.

Whilst this development is also in its initial exploratory stages, there are distinct possibilities that the emission of light in this way may form the basis of a new form of display for the future. In view of the minute size of the nano-tubes, it may be that the definition of a display based on this technology could provide a significant improvement in performance over anything that is currently available.

Constructional Project

EPE HYBRID COMPUTER

PETROS KRONIS

Part 1

Real-time computation of complex system behaviour is greatly simplified by combining analogue and digital processing techniques.

HYBRID computers employ both major categories of electronic systems, the analogue and the digital. As is true with every type of system, each has its advantages and disadvantages. The hybrid system is an attempt to combine the best of both worlds.

Many people imagine analogue computers to be antique units stored away in University laboratories. But not many people realise that in some cases the analogue computer can solve a problem with admirable elegance, ease and simplicity, while the solution of the same problem on the digital computer may be virtually impossible.

A few analogue amplifiers connected together in a few minutes can give the solution to a complex problem with the units producing results in real time. A similar problem may take months to be programmed on the digital computer, provided the programmer has the skill to solve the equations.

For the digital computer to execute the program, millions of iterations have to be performed, and not in real time. Granted digital computers are now very fast, but those tiny periods of time necessary to perform the iterations add up to considerable time periods. If anyone is still skeptical, visit the following site on the internet:

www.indiana.edu/~rcapub/v21n2/p24.html

There, you will meet Dr Jonathan Wayne Mills, associate professor of computer science at Indiana University, Bloomington, and director of the Adaptive Systems Laboratory, whose patented new analogue computer uses radically simplified electronic components and "continuous value logic" circuits, that make his computer able to work incredibly fast and process more sensory inputs than a digital computer can handle.

ANALOGUE COMPUTER

An analogue computer uses voltage as the *analogue* to represent a physical quantity, in the same way that the height of the mercury column of an old fashioned mercury thermometer represents temperature.

The analogue computer is designed to solve mathematical equations, in particular differential equations, which are especially difficult to solve manually. Differential equations describe the behaviour of physical systems, such as the suspension system of a motor car or the flight of a rocket.

The variables involved in such systems, such as the stiffness of the springs in the first example, or the thrust of the engine in the second, can be varied by simply turning the dial of a potentiometer. In this way the behaviour of the systems can be simulated, and many experiments carried out without going to the expense of constructing and testing real models.

Other advantages of the analogue computer are the speed with which it carries out the processing, and the relative simplicity with which one can formulate the problem on the computer. The disadvantage is that the range of voltage variation is limited and the measurement of that voltage is prone to errors. However, engineering is not an exact science and the analogue computer is a useful tool in the design of many engineering systems.

DIGITAL COMPUTER

In contrast to its analogue counterpart, the digital computer works by manipulating discrete voltage pulses, instead of continuously varying voltages. It has the advantage of high accuracy and repeatability of results. On the other hand, it is difficult and time consuming to program a digital computer to solve differential equations and, moreover, the programmer must

SPECIFICATION

- Ten analogue amplifiers
- Each amplifier can be operated as an Adder or Integrator
- Eight coefficient multipliers
- Over-voltage indicators on all amplifiers
- Three modes of operation, Compute, Hold and Reset
- Automatic or Manual mode control
- Offset null on all amplifiers
- ATOM microcontroller:
  - 8k Flash program memory
  - 384 bytes of RAM
  - 15 I/O pins
  - RS232 serial link
  - Analogue-to-digital converter
  - PWM and Timer functions
  - BASIC compiler programming
  - Integrated Development Environment (IDE)

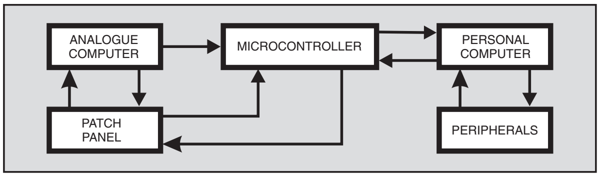


Fig.1. Block diagram of EPE Hybrid Computer.

have the mathematical ability to solve the equations in order to write the program.

The *EPE* Hybrid Computer employs an ATOM microcontroller system, which operates in conjunction with the analogue system and can be programmed to control it. Moreover, it can be programmed to analyse and transmit information to a PC for the display of results or for further processing if required. Fig.1 shows a diagram of the arrangement.

The analogue system is programmed by connecting its modules using wires through a patch panel. The microcontroller (MCU) has access to the control circuits of the analogue computer through the patch panel. Programming of the MCU is carried out in BASIC by means of a BASIC compiler resident in the PC (see later). Communication is through a serial link.

The MCU sends and receives data through its input and output ports and has the capability to convert analogue signals to digital by means of the built in analogue-to-digital converter (ADC).

MAIN UNITS

The heart of the analogue computer is formed around several high gain d.c. amplifiers, or operational amplifiers (op.amps). By connecting the op.amps to various input and feedback components, certain mathematical operations can be performed. These are, addition (and subtraction), integration, and multiplication by a constant. Differentiation can also be performed, but is generally avoided due to problems associated with noise generated by components.

Addition circuit

The diagram in Fig.2 shows the Addition circuit in which resistors are connected to the input and feedback loop of the op.amp to perform input voltage addition. The output voltage is given by:

$$V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3 + \frac{R_f}{R_4}V_4\right)$$

Integrator circuit

With the Integrator circuit (Fig.3), with capacitor C_f in the output voltage is given by:

$$V_o = -\left(\frac{1}{R_1C_f}\int V_1dt + \frac{1}{R_2C_f}\int V_2dt + \frac{1}{R_3C_f}\int V_3dt + \frac{1}{R_4C_f}\int V_4dt\right)$$

Coefficient Multiplier

The Coefficient Multiplier (Fig.4) is used to multiply a voltage by a constant number between zero and one. This mathematical operation is usually performed without the use of an op.amp. A potentiometer is connected as shown in Fig.4. At one extreme of the slider's travel $V_o = V_{in}$, i.e. V_{in} is multiplied by one, whereas at the other extreme $V_o = 0$, i.e. V_{in} is multiplied by zero.

Any intermediate value can be set up by moving the slider. The dial of the potentiometer can be calibrated to facilitate this. However, because of the effects of load resistance, it is usual practice to measure the potentiometer output after the circuit has been connected and to ignore the scale on the dial.

By choosing suitable values for the input and feedback components, Adders and Integrators can also be arranged to apply a multiplication factor to the input voltages. Fig.5 shows the symbols and the function of each unit used in the *EPE* Hybrid Computer.

The circuits just described form the fundamental building blocks of an analogue computer. Other specialised circuits, such as four-quadrant multipliers, and various non-linear circuits, can be used to simulate effects such as backlash, friction, dead space, absolute values, etc., although they are not the subject of this design.

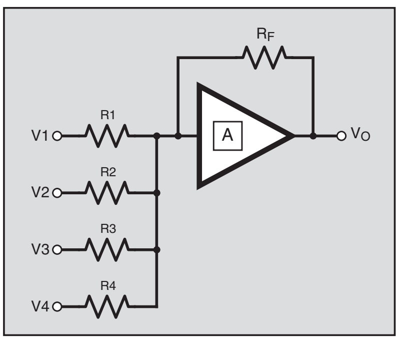


Fig.2. The Addition circuit.

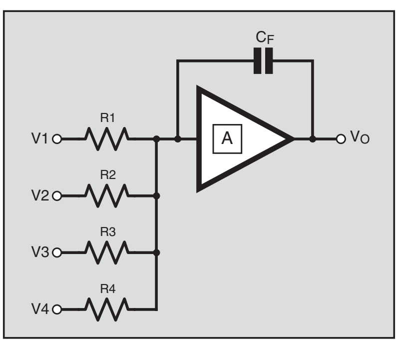


Fig.3. The Integrator circuit.

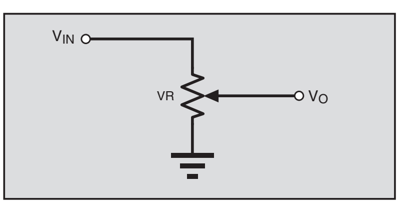


Fig.4. The Coefficient Multiplier

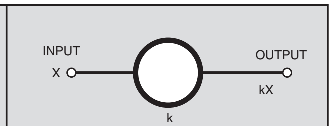
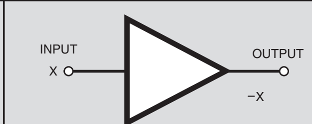
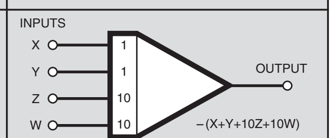
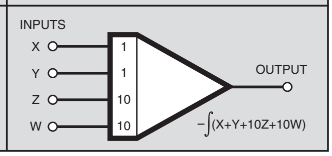
COEFFICIENT MULTIPLIER	MULTIPLICATION OF A VARIABLE BY A POSITIVE CONSTANT COEFFICIENT 0<k>1	
INVERTER	SIGN REVERSING, I.E. MULTIPLICATION OF A VARIABLE BY -1	
ADDER	ADDITION OF VARIABLES INCLUDING MULTIPLICATION BY 1 OR 10	
SUMMER INTEGRATOR	SUMMATION OF THE INTEGRALS OF VARIABLES WITH RESPECT TO TIME	

Fig.5. Analogue computer units, their function and symbols.

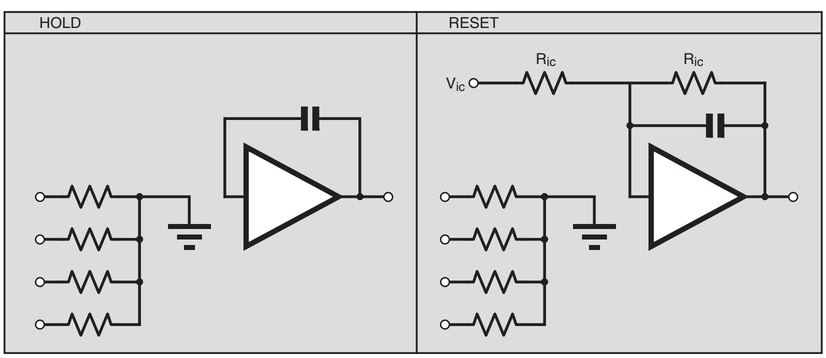


Fig.6. Circuit changes for integrators for the Hold and Reset modes.

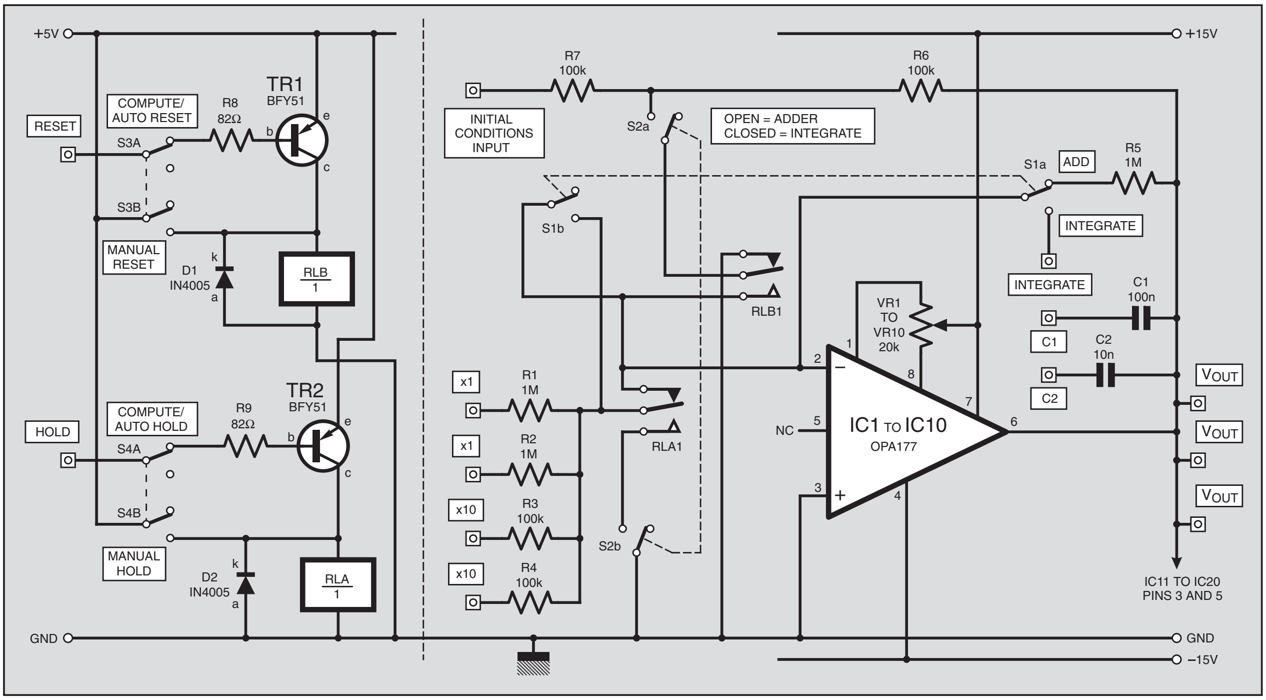


Fig.7. Circuit diagram for the Analogue Amplifier. Ten copies of this circuit are required to be built.

ANALOGUE COMPUTER CONTROL

Circuits which control the mode of operation of the analogue computer are necessary. The *EPE* Hybrid Computer can be operated in three modes, Compute, Hold, and Reset. In addition, an overload warning system is included which monitors the outputs of all amplifiers and gives a warning when they are about to saturate.

In the Compute mode the computer carries out the solution of the problem. Prior to this, the computer is placed in the Reset, or initial conditions mode in which the variables are allowed to take their initial values before computation begins. This mode of operation is also called "problem check". It is sometimes desirable to stop the computation to take some measurements. This is achieved by placing the computer into the Hold mode.

In the case of Adders, no change in the circuits is necessary for mode control. However, the Integrators have to be modified as shown in Fig.6.

ANALOGUE AMPLIFIER

The circuit diagram for the Analogue Amplifier is shown in Fig.7. Ten copies of this circuit are required.

Many op.amp i.c. types can be used to make an analogue computer circuit, from the ubiquitous 741, to advanced auto-zeroed chopper stabilised op.amps such as the Microchip TC901. The device selected for this amplifier is the OPA177 high precision op.amp, which gives very good performance at a reasonable cost.

Resistors R1 to R4 are the input resistors and R5, plus capacitors C1 and C2, are the feedback components. The values chosen give a multiplication factor of ×1 and ×10, to signals connected to the respectively notated inputs.

Moreover, when the amplifier operates as an Integrator, the programmer can choose C1 or C2 to be the feedback capacitor, by connecting leads to the appropriate patch panel sockets. If C2 is selected then input signals are multiplied by an additional factor of 10. In computer jargon this is known as an amplifier with a "nose gain" of 10. This means that input signals connected to resistors R1 or R2 will be multiplied by a factor of 10, whereas signals connected to R3 or R4 will be multiplied by a factor of 100.

Switches S1a, S1b, S2a and S2b, and relays RLA and RLB enable the amplifiers to be operated as Adders or Integrators, and additionally allow the selection of the three modes of operation. Relays are used instead of solid state switching to provide the total signal isolation as required. Table 1 shows the positions of these switches and relays to achieve these conditions.

Table 1. The position of switches and relays for mode control.

	Adder			Integrator		
Switch	**Compute**	**Hold**	**Reset**	**Compute**	**Hold**	**Reset**
RLA	1	2	2	1	2	2
RLB	1	1	2	1	1	2
S1a	1	1	1	2	2	2
S1b		Closed			Open	
S2a		Open			Closed	
S2b		Open			Closed	

Switches S4 and S3 are used to operate relays RLA and RLB respectively. In the position shown in the diagram the amplifiers are operating in the Compute mode but if the patch panel sockets are connected to the ATOM I/O (input/output) pins, then the ATOM has control and can place the analogue amplifiers in the Hold or Reset modes under program control.

Transistors TR1 and TR2 are necessary to amplify the signal, as the 10 relays can draw a large amount of current. Diodes D1 and D2 protect the transistors from the back e.m.f. created by the collapsing current in the coils of the relays as these are switched OFF.

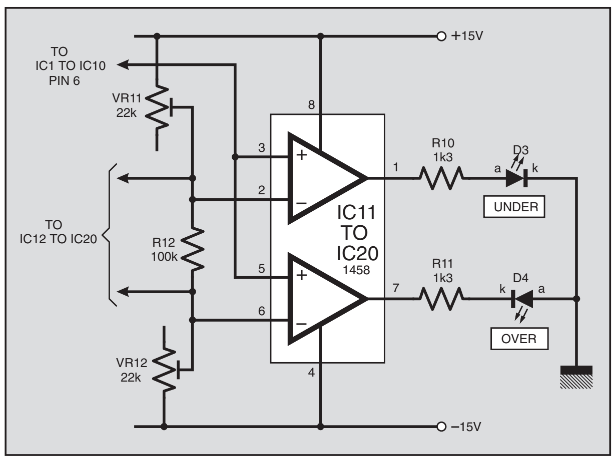


Fig.8. Overload warning circuit, ten are used.

OTHER SUB-CIRCUITS

Overload warning system

The Overload Warning circuit is shown in Fig.8 and is built around the 1458 dual op.amp. Reference voltages of +13V and –13V are produced across resistor R12 as set by potentiometers VR11 and VR12, and applied to the inverting inputs of IC11 to IC20. The output of each amplifier (IC1 to IC10) is applied to the non-inverting inputs

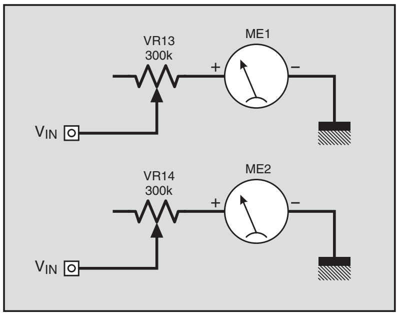


Fig.9. Analogue voltage monitoring circuits.

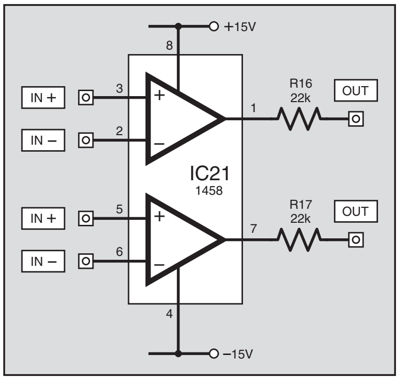


Fig.10. Reference Voltage Cross-Detection circuit.

of the overload op.amps (IC11 to IC20). Light emitting diodes (l.e.d.s) D3 and D4 are lit when the amplifier output voltage exceeds its reference voltage.

Analogue display

Panel meters ME1 and ME2, as shown in Fig.9, can be used to display the output of the analogue amplifiers. Potentiometers VR13 and VR14 provide sensitivity control. These units are useful when the programmer wishes to monitor an output without going to the trouble of transferring the results to the PC.

Reference voltage cross detection

The Reference Voltage Cross-Detection circuit in Fig.10 also uses the 1458 dual op.amp. It can be used to produce a control signal when a voltage crosses a predefined value.

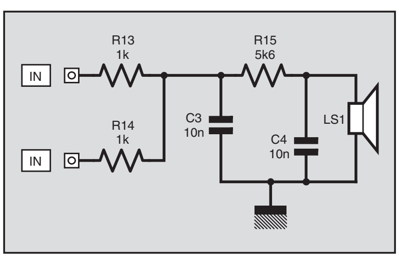


Fig.11. Audio circuit.

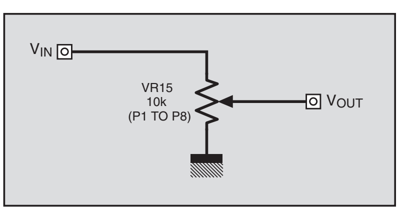


Fig.12. Coefficient Multiplier. Eight are used.

To give an example, assume that the computer has been programmed to simulate the landing of an aircraft. As the aircraft descends, the computer is unaware that the height cannot take a negative value and will continue the flight below ground!

To avoid this, a reference voltage of zero can be applied to the detection circuit to produce a signal when the value of zero is crossed. This signal can be passed to the microcontroller to take the appropriate action when this happens, e.g. to stop the computation.

Resistors R16 and R17 limit the current which will flow into the I/O pins of the ATOM.

Audio circuit

The Audio circuit, shown in Fig.11, has been included to allow the ATOM to produce audible warning sounds if required. The BASIC commands available allow the programmer to write code to play more complex sounds, and even music.

Coefficient multiplier

The Coefficient Multiplier is simply a single potentiometer, VR15, as shown in Fig.12. Eight copies of this circuit are required.

MICROCONTROLLER CIRCUIT

The circuit diagram for the Basic Micro ATOM microcontroller is shown in Fig.13.

The ATOM has the advantage of being programmable in BASIC, a simple but powerful language. Programs can be written and loaded into the ATOM at will, and the last program loaded remains resident even if the power is removed.

As can be observed, the circuit is simple as all the complexity is inside the chip. The only connections necessary are the I/O pins to the patch panel sockets and the serial link connections to socket SK1. A provision has been made for connecting a liquid crystal display (l.c.d.) for those who wish to use one, writing their own program to do so.

POWER SUPPLY

This design requires an external d.c. power supply, with outputs of +15V, –15V, +5V and 0V. The supplies of +15V and –15V must be regulated. The +5V supply does not need to be regulated as the ATOM microcontroller has an on-board voltage regulator. This is provided to the ATOM's V_{in} pin 24 (with its V_{dd} pin 21 being left unconnected). Power supplies can be constructed using the appropriate voltage regulator i.c.s (7815, 7915 and 7805).

For the prototype, an old PC computer power supply was used. These power supplies give +12V, –12V, +5V and various other output voltages. The voltage range is slightly reduced, but it is a convenient solution for those who do not want to build their own power supply.

PRINTED CIRCUIT BOARDS

To reduce the amount of wiring inside the box, the double-sided printed circuit boards (p.c.b.s), of which there are two, were designed to accommodate all components, including the patch panel sockets and the mode switches. The exceptions are the Coefficient Multiplier potentiometers and the two panel meters with their associated input sockets and sensitivity potentiometers.

The fact that the mode switches are soldered on the p.c.b. and are also connected to the front panel, means that the p.c.b. lies about 15mm behind the front panel. The space between the front panel and the p.c.b. is just enough to accommodate the components with the switches effectively acting as the main support for the board.

The 1mm patch panel sockets used on the prototype were too short but this was easily solved by soldering small bare wire extensions to the sockets before soldering these on the p.c.b. The component layout for the main p.c.b. is shown in Fig.14, and that for the ATOM microcontroller board in Fig.17 later.

Track layout details for the boards are not shown separately as their size and double-sided requirement make them unsuited for normal hobbyist manufacture. Full-size photocopies of the printed circuit board track master patterns can be supplied to readers via the Editorial office on request. Enclose a self-addressed envelope, stamped to suit four A4 pages.

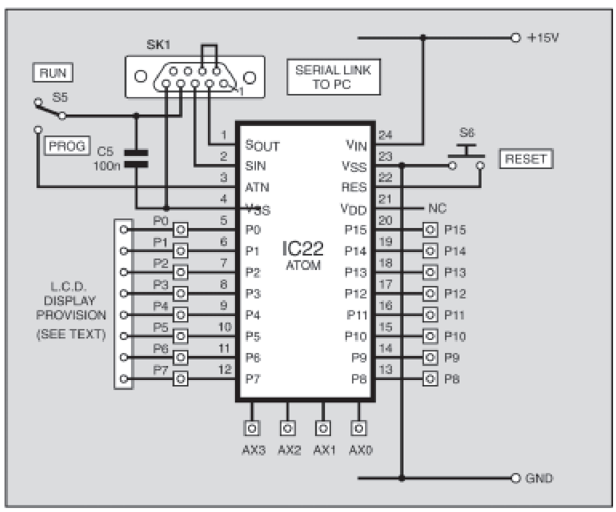


Fig.13. Connections to the Basic Micro ATOM microcontroller.

The boards are available ready-made from the *EPE PCB Service*, codes 375 (Main) and 376 (ATOM).

P.C.B. ASSEMBLY

Solder the components of the main p.c.b. in the following sequence:

Use double-sided solder pins, suited to 0·8mm holes, to connect the two sides of the p.c.b. Resistor off-cut wires will be satisfactory as an alternative.

Because alignment is critical, the mode switches and the l.e.d.s have to be soldered while being assembled with the front panel (shown in Fig.15.). Attach the switches to the front panel, position the l.e.d.s in the

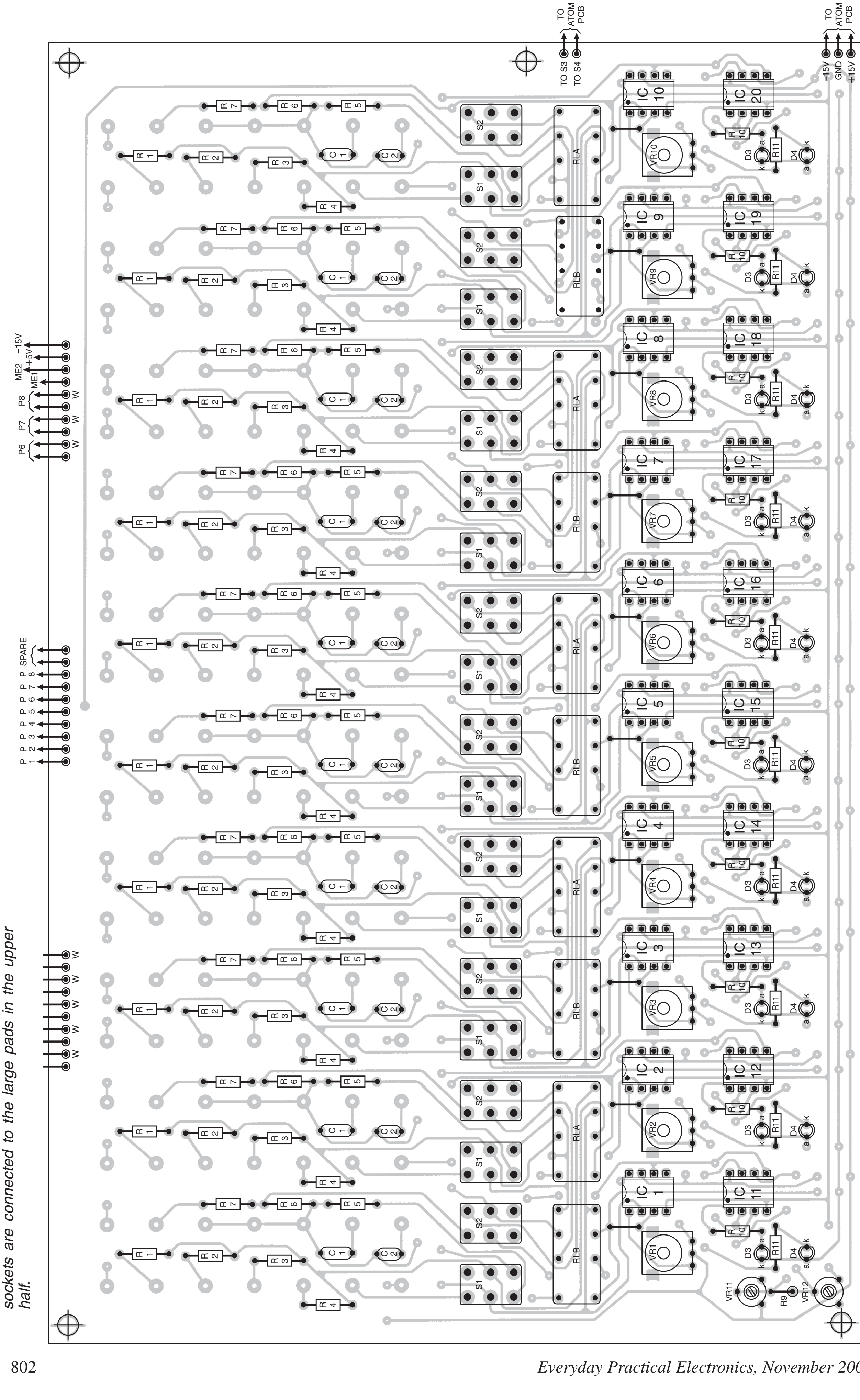
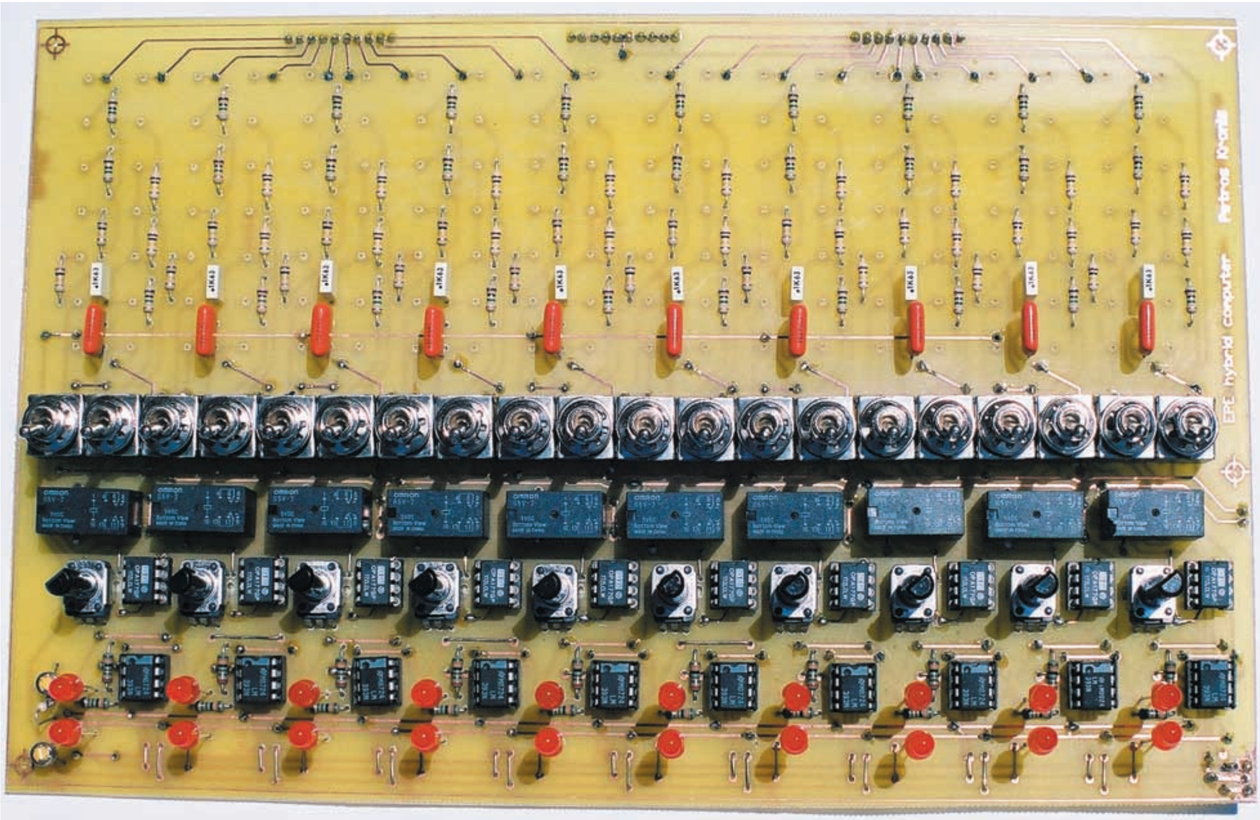


Fig.14. Component layout for the main p.c.b. The 1mm sockets are connected to the large pads in the upper half.

HYBRID COMPUTER MAIN P.C.B.



Care must be taken when assembling that the switches, potentiometers, l.e.d.s and sockets align with the front panel holes. The sockets need to be mounted last, their extension leads going into the holes just visible in the upper part of the above photo. A socket functions diagram will be given in Part 2.

COMPONENTS

Approx. Cost Guidance Only **£220** *excl. case*

See SHOP TALK page

Resistors

R1, R2, R5	1M 2% (30 off)
R3, R4, R6, R7, R12	100k 2% (41 off)
R8, R9	82Ω (2 off)
R10, R11	1k3 (20 off)
R13, R14	1k (2 off)
R15	5k6
R16, R17	22k (2 off)

All 0·25W carbon film, 5% except where marked.

Potentiometers

VR1 to VR10	20k (or 22k) lin., p.c.b. mounting, vertical, rotary (10 off)
VR11, VR12	22k, min. preset, round (2 off)
VR13, VR14	300k (or 330k) lin., panel mounting, rotary (2 off)
VR15	10k lin., panel mounting, rotary (8 off)

Capacitors

C1, C5	100n ceramic, 5mm pitch (11 off)
C2, C3, C4	10n ceramic, 5mm pitch (12 off)

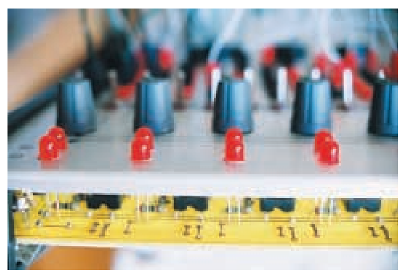
Semiconductors

D1, D2	1N4005 rectifier diode (2 off)
D3, D4	red l.e.d., 5mm (20 off)
TR1, TR2	BFY51 *npn* transistor (2 off)
IC1 to IC10	OPA177 dual precision op.amp (10 off)
IC11 to IC21	MC1458 dual op.amp (11 off)
IC22	Basic Micro ATOM microcontroller (see text)

Miscellaneous

RLA, RLB	d.p.c.o. relay, p.c.b. mounting, 5V coil (10 off)
S1 to S4	min. d.p.d.t. toggle switch, (22 off)
S5	min. s.p.d.t. toggle switch
S6	min. s.p.s.t. push-to-make switch
ME1, ME2	±100μA panel meter (2 off)
LS1	piezo buzzer
SK1	9-way D-type female connector

Printed circuits boards, available from the *EPE PCB Service,* codes 375 (Main), 376 (ATOM); 1mm patch panel sockets, black (84 off); red (88 off); power supply sockets (see text) (4 off); 0·8mm (dia.) solder pins (see text); plastic case with sloped panel, (see Fig.16); knobs with skirts marked 1 to 10 (8 off); small knobs (10 off); medium knobs (2 off); 1mm pin-header strips, cut to length required; connecting wire; solder; etc.



Edge-on view showing front panel and p.c.b. relationship.

correct orientation into the p.c.b. (note that the polarity of l.e.d. D4 is opposite to that of l.e.d. D3). Carefully press the p.c.b. onto the switches and then solder as required. Then align the l.e.d.s in position, and solder them.

Remove the p.c.b. from the front panel and solder the remaining components, i.e. capacitors, relays, potentiometers and 1mm pin-header strip connectors.

Thoroughly check for defects in component positioning and soldering. If everything is satisfactory, attach the p.c.b. back onto the front panel.

Pass the patch panel sockets into the front panel holes carefully (and patiently!) pushing their rigid wire extensions through the p.c.b. holes and solder in position.

Note that it is preferable to use patch panel sockets which have the securing nut on top, i.e. on the same side as the switches. Otherwise, if the nuts are on the opposite

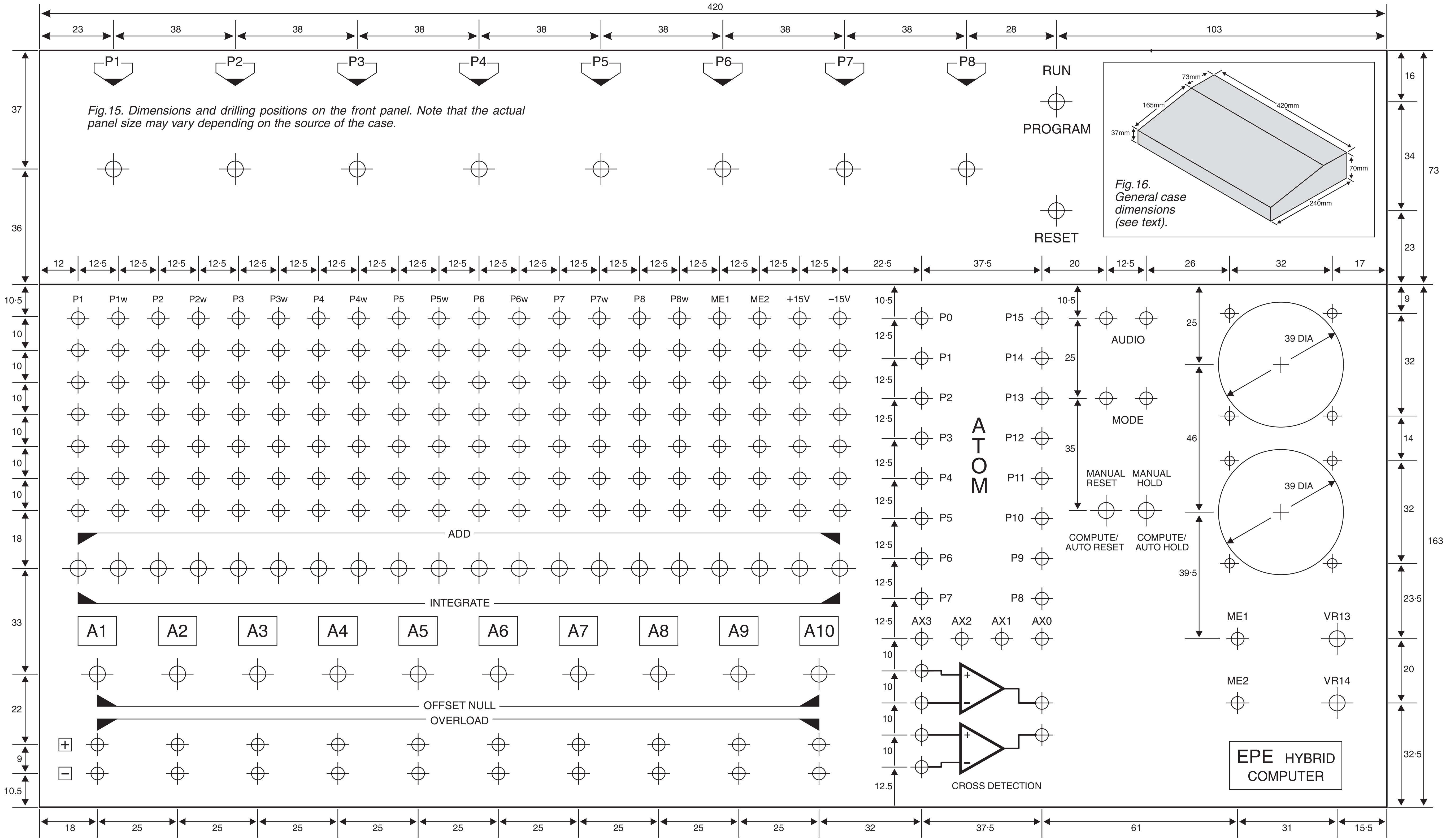


Fig.15. Dimensions and drilling positions on the front panel. Note that the actual panel size may vary depending on the source of the case.

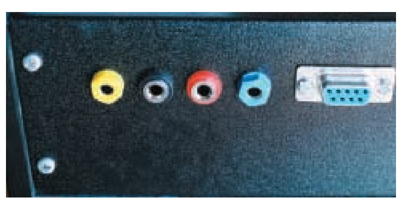
Fig.16. General case dimensions (see text).

side (behind the front panel), then once soldered the p.c.b. will not be able to be removed from the front panel.

FRONT AND REAR PANELS

The computer was housed in a box with a sloping front panel. Fig.15 shows the design of the front panel with all the locations necessary to drill the holes for the components.

The general dimensions of the box are shown in Fig.16, but may vary depending on the source of the case. The layout of the rear panel is shown in the photograph. The four power supply connectors were 4mm sockets in the prototype, and should be labelled appropriately. The 9-way D-type socket connects via a suitable lead to the PC's COM2 serial port.



Attach the panel meters, potentiometers, remaining switches and sockets to the front panel. Drill holes in the back panel to accept the power supply sockets and the serial link socket SK1. Cut ribbon cable to the required length and solder the ends to the appropriate connectors. Make cable harness to connect:

- Power supply sockets to the 1mm p.c.b. pin-header connectors.
- SK1 serial socket to p.c.b. connector.
- P.C.B. connectors to coefficient multiplier potentiometers and the return to earth.
- Panel meter wiring. Note that panel meters may have connectors for illumination of the dials. Use either the +15V or the –15V to supply the bulbs. This is useful as the panel meter lights function also as power on indicators.

Photographs of some aspects of the case assembly are in Part 2.

ATOM BOARD

The ATOM p.c.b. (Fig.17) is soldered to the front panel sockets in a similar

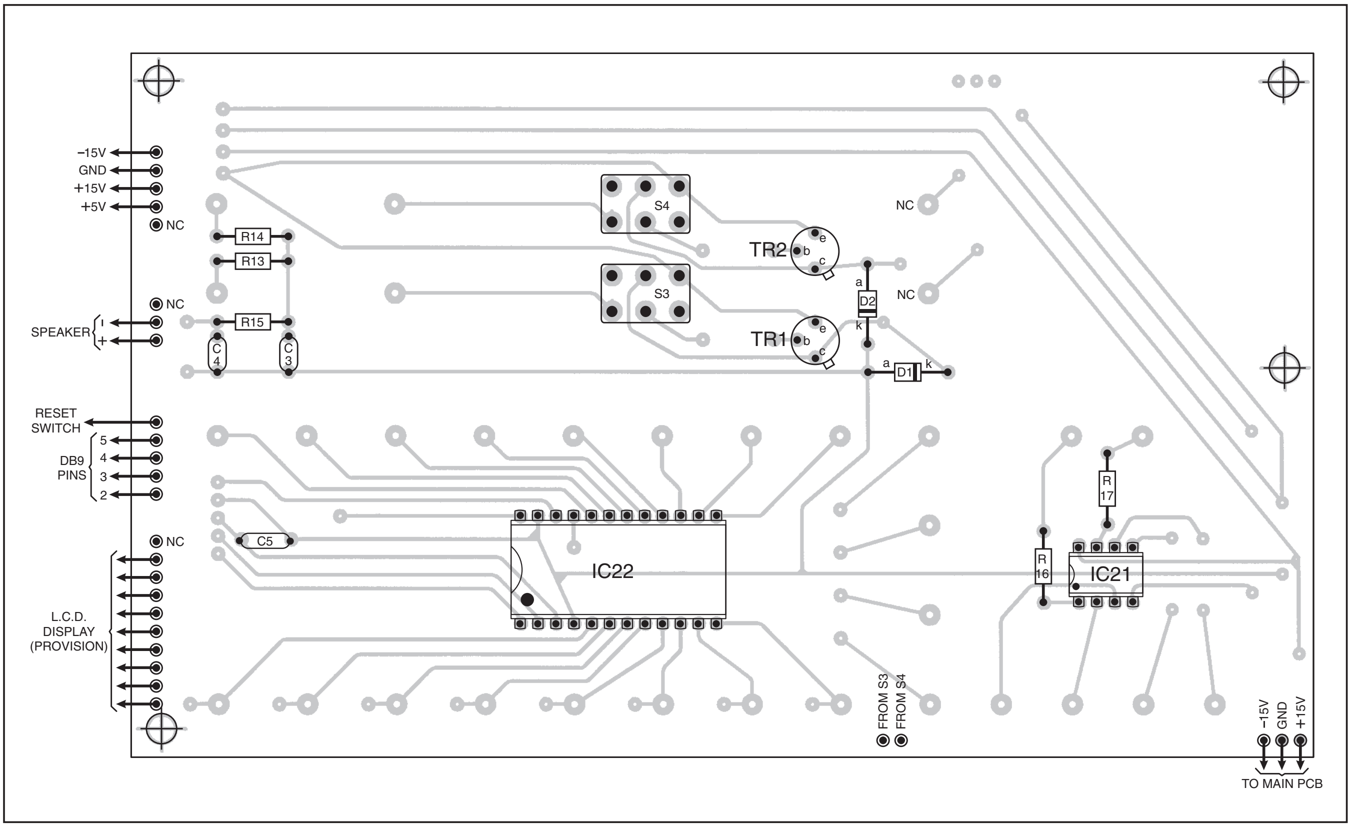


Fig.17. Component layout details for the ATOM microcontroller p.c.b.

way to the main board. The ATOM i.c. used in the prototype had four small pads at the back of it (these are the ADC pins), which must be connected with four short wires to the p.c.b. (see photo).

This is a very delicate operation and **must be done with extreme care** as the pads are tiny and very close together. Use a very small soldering iron tip and melt a small amount of solder onto the wire ends. Then looking through a magnifying glass hold the wire end on the pad and touch the tip of the soldering iron on the wire and pad momentarily to make the connection.

Whilst "carrying the solder" on the iron is not normally recommended, if you do so with sufficient haste (but with care) the solder quality should not deteriorate significantly.

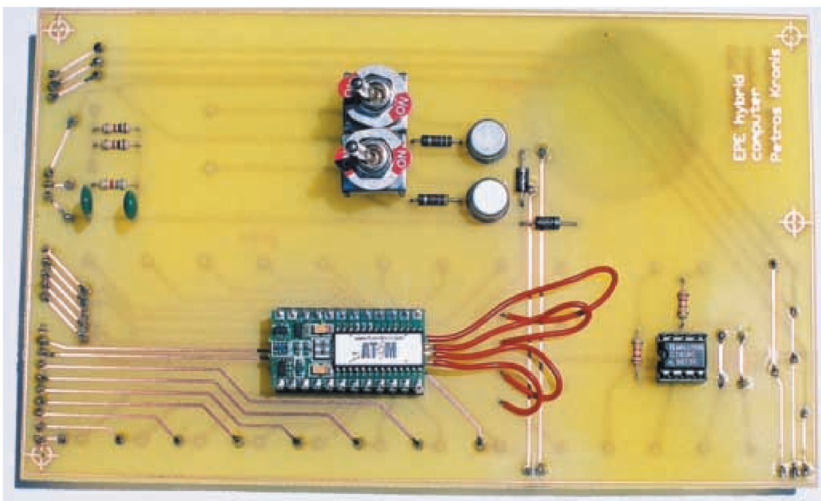
Once complete, use a multimeter to check that a solder bridge has not been made between the pads.

NEXT MONTH

In the concluding part next month, testing the various aspects of the design is described. Examples are then given illustrating how the computer can be used to simulate real-world engineering problems, such as encountered when loading a spring, or demonstrating the take-off and landing of a Harrier jump jet!

RESOURCES

VB6 software for this project is available for free download from the *EPE* ftp site, or on CD-ROM (for which a charge applies) from the *EPE* Editorial office, see the *EPE PCB Service* page for details. Software for the ATOM can be supplied on CD-ROM when you buy this microcontroller (see this month's *Shoptalk* page for details) or can be downloaded from **www.basicmicro.com**.



Prototype ATOM p.c.b.

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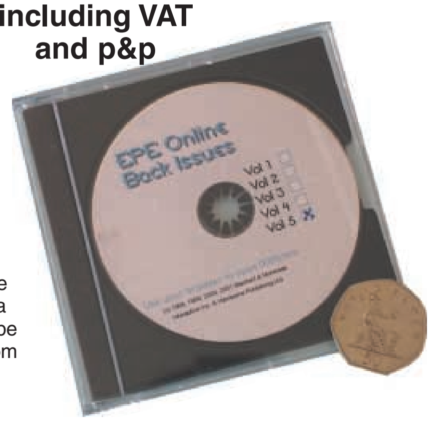

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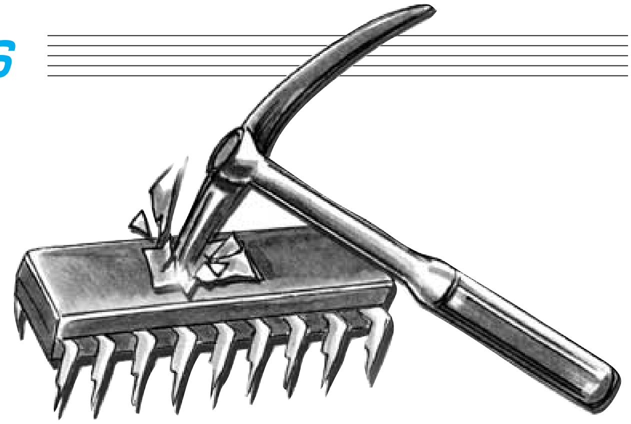
PICAXE PROJECTS



MAX HORSEY

Part 1 – Egg Timer, Dice Machine, Quiz Game Monitor

Using the PICAXE system, you do not need specialised equipment or knowledge to program the PIC microcontrollers used in these designs.

THE flexibility of PIC microcontrollers is considerable, and this series of articles is based around a variant of one of them, used with a general-purpose circuit and printed circuit board, allowing nine projects to be realised. The only major difference between them being the program code and casing layouts.

All the projects are based on PICAXE-18 microcontrollers. These are modified versions of Microchip's PIC16F627, a fairly recent addition to the PIC family. They have been modified by Revolution Education to allow them to accept program code written in a form of BASIC. These devices do not need special programming hardware and are simply programmed by means of a serial link to your PC.

IN A FLASH

The basic PIC16F627 and its PICAXE-18 derivative are flash reprogrammable, include an internal oscillator, and analogue as well as digital inputs. The designs presented here can be used with either device, although the standard PIC16F627 needs to be programmed using a conventional PIC programmer.

Details of obtaining the software and the PICAXE system are given later, as are details of obtaining preprogrammed PICs direct from the author, should you not have a computer but still want to build the designs.

The projects to be described are:

Part 1. Digital:
Egg Timer
Dice Machine
Quiz Game Monitor (4 inputs)

Part 2: Analogue:
Temperature Sensor
Voltage Sensor
VU Display

Part 3: Chaser:
Chaser (low voltage)
Interface Circuits
Mains Interface

WHAT IS PICAXE?

The PICAXE system allows you to program a PICAXE-18 device directly in your circuit by means of a 3-wire serial link from your PC-compatible computer. This is achieved by means of a 3-pin connector and 3-wire download cable. The cable is terminated with a 9-pin connector at the PC end, and a 3-pin socket at the circuit board end.

The steps required to construct a PICAXE circuit are as follows:

1. Build the circuit
2. Write the program (already done for you in this series)
3. Connect the circuit to the serial port of your PC
4. Connect the 5V power supply to the circuit
5. Download your program

The PC may now be disconnected from your circuit since the program is safely installed into the PIC. You can modify and download your program as many times as you like (although the PIC has a maximum limit of about 1000 reprogram cycles).

ADVANTAGES OF PICAXE

- Employs easy-to-understand BASIC
- No special programmer required
- Inexpensive
- Offers easy experimentation
- Three of the pins can be used as analogue inputs
- All software is available free of charge

DISADVANTAGES OF PICAXE

- Memory quite limited (128 bytes for the PICAXE-18)
- Limited to a fixed set of five input pins and eight output pins
- BASIC is an inefficient programming method to use with microcontrollers
- Functions such as interrupts are not available

Anyone who is familiar with all the benefits of a normal PIC, and is used to writing programs in assembly code, will see that the disadvantages are considerable. It is quite difficult (impossible?) to use the PICAXE to multiplex an array of 7-segment l.e.d.s., and the limited memory is a considerable problem – although this does encourage the use of more intelligently-written programs.

There is no suggestion that a PICAXE device can replace a conventional PIC in complex systems, but it does provide a very easy introduction to anyone not familiar with assembly code who wishes to join the PIC "club". If you have never programmed a PIC device, you will find that the PICAXE system offers enormous advantages over designing your circuit in a conventional way, i.e. using many logic gates etc.

Having mastered the essentials of the PICAXE system you may then want to progress to assembly code programming. This is quite a leap, but much help is available through, for example, the excellent *PICtutor* (now renamed as *Assembly for PICmicro V2*) by John Becker, available on CD-ROM as detailed elsewhere in this issue.

MASTER CIRCUIT

The general purpose circuit diagram for all the designs in this series of articles is shown in Fig.1.

The PICAXE-18/PIC16F627 microcontroller is shown as IC1. The power supply connections are via pins 5 and 14. Since the chip has an internal oscillator, all the remaining pins are normally available as inputs or outputs. However, to ensure compatibility with the PICAXE system Port A pins RA0, RA1, RA2, RA6 and RA7 are set as inputs, and all Port B pins (RB0 to RB7) are set as outputs.

Pins RA3 and RA4 are configured for serial programming using the PICAXE system. Pin RA5 is not used as a data input/output pin, but is used in its other role as the $\overline{\text{MCLR}}$ (reset) pin.

The 3-pin connector TB1 and resistors R1 and R2 are required for serial programming if the PICAXE version of the PIC is required. If in-circuit programming is not required then these three components can be omitted, though their inclusion will not otherwise affect the working of the circuit.

Resistor R3 maintains the $\overline{\text{MCLR}}$ pin at logic 1. If reset is required then pin 4 must be briefly connected to logic 0 (i.e. 0V). If reset is required only infrequently then a pair of terminal pins in the TP1 and TP2 positions will suffice, briefly shorting them together when reset is needed.

If reset is required for a particular project, (e.g. to reset the Egg Timer part-way during the timing period) then a pushbutton switch can be connected to TP1 and TP2. Reset also occurs each time you switch off and on.

The first three simple PICAXE projects.

Note that PICAXE may very occasionally lock up during programming unless a reset is performed.

INPUTS

The five digital inputs via Port A are shown connected to pushbutton switches, S1 to S5. In practice these can be any type of switch or a digital logic signal (0V/+5V). The programs assume that if the switch is not pressed then a logic 0 is present, since resistors R4 and R13 to R16 normally bias the inputs to 0V. The pins are held at logic 1 when the switches are pressed.

Note that the switches are labelled in numerical order from left to right, although their numbers as defined in the program are as follows:

S1: Input 2 (RA2)
S2: Input 1 (RA1)
S3: Input 0 (RA0)
S4: Input 7 (RA7)
S5: Input 6 (RA6)

OUTPUTS

The eight digital outputs (from Port B) are coupled to light emitting diodes (l.e.d.s), D1 to D8, via ballast resistors R5 to R12. Each output can supply about 25mA, which can light a standard l.e.d. quite brightly. Note that the maximum total current that the PIC can source or sink via its ports is 200mA.

The three projects discussed here in Part 1 assume that a beeper WD1 is connected to output RB7 in place of l.e.d. D8, with resistor R12 reduced to 12Ω.

The circuit is intended to be powered by a voltage of between 4·5V and 6V, by means of three 1·5V cells, or four 1.2V rechargeable cells. If a mains derived source is employed, then 5V is the ideal supply. The maximum safe voltage that the PIC can accept is 6·5V. Capacitor C1 decouples the supply.

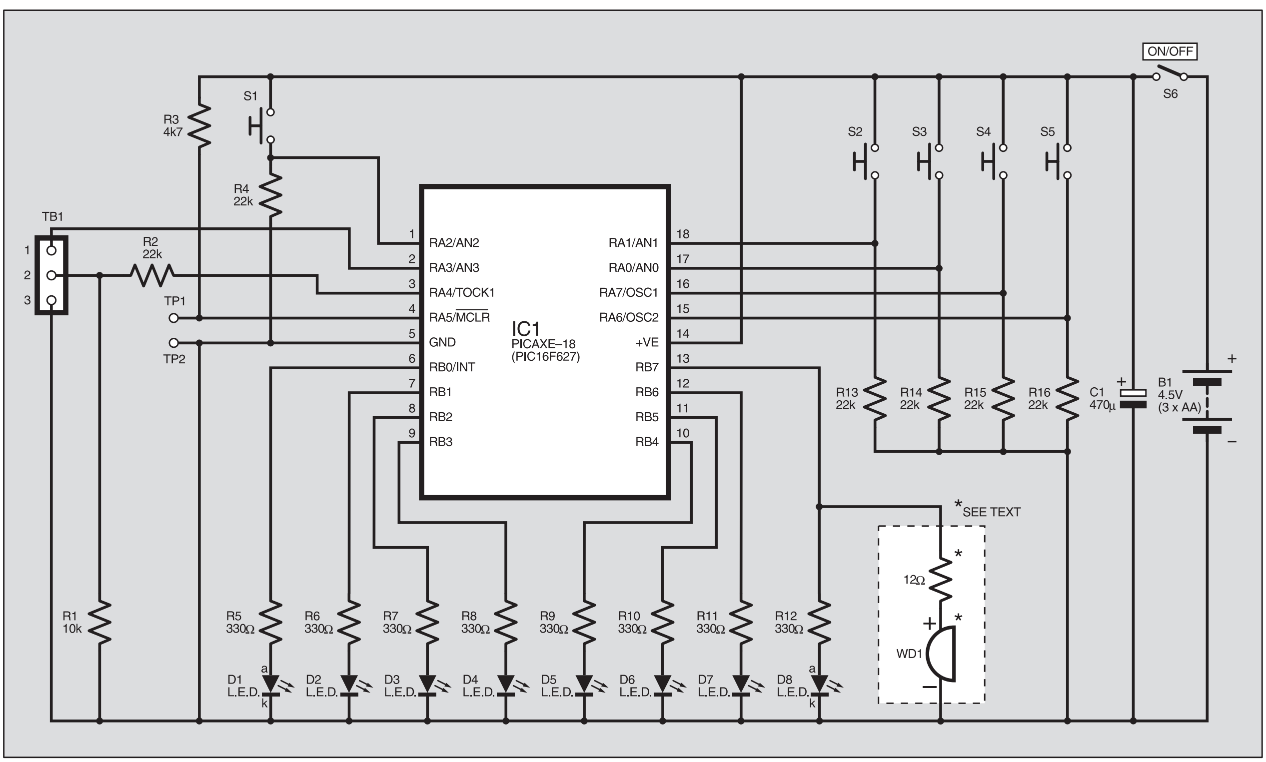


Fig.1. General circuit diagram for all the designs in this PICAXE series of projects.

EGG TIMER

The Egg Timer's design brief was to make a timer which is quick and easy to set (unlike some!), and accurate without the need for calibration. The use of a PIC ensures accuracy and a single pushbutton switch, S2, sets the time required.

When S2 is held pressed, the first seven l.e.d.s, D1 to D7, light one by one, with a brief delay between them responding, each indicating the countdown time required:

D1 1 minute	D5 3·5 minutes
D2 2 minutes	D6 4 minutes
D3 2·5 minutes	D7 4·5 minutes
D4 3 minutes	

When the required time is reached, release the switch and the countdown begins. The remaining time is displayed by the appropriate l.e.d. At the end of the timed period the beeper (WD1) sounds for five seconds. The beeper is connected in place of l.e.d. D8 and resistor R12 becomes 12Ω instead of the 330Ω needed for an l.e.d.

A pushbutton reset switch can be added, wired between TP1 and TP2, in case you wish to interrupt the timing cycle, although, as just said, momentarily turning off the power will also cause a reset. This switch was not included with the prototype designs.

Note that the program required for this timer is longer than needed for the other projects, and the full version will not fit into the PICAXE-18. Hence the BASIC program for serial PICAXE in-circuit programming is a cut-down version with just four l.e.d.s. The times chosen are 2·5, 3, 3·5, and 4 minutes. It is very easy to change the program to modify these times. The HEX code file for conventional programming provides the full range of times as described.

DICE MACHINE

With the Dice Machine, again only switch S2 and the first seven l.e.d.s are used, arranged in a pattern as used in dice. The beeper, WD1, is also required. Pressing S2 causes a random number to be displayed.

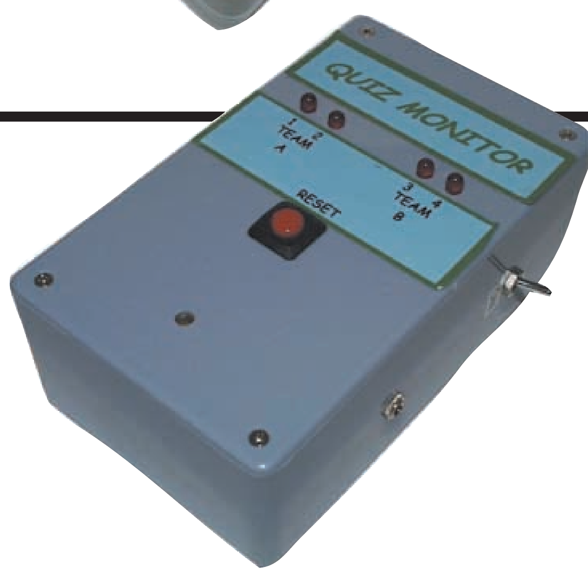
In practice it may be more fun to use a tilt switch instead of S2 so that tilting the circuit will "roll" the dice. Note that the switch must make contact for about a second, hence a vibration switch would not be appropriate.

An in-built delay prevents players from attempting to cheat by knocking the count on by one by tapping the switch quickly. The program counts through the six numbers at high speed, making the l.e.d.s flicker, and stopping when the switch is released. A random number is therefore obtained. The beeper sounds a number of times equal to the number displayed on the l.e.d.s. This provides fun for all, and could also be used by blind players.

QUIZ GAME MONITOR

The Quiz Game Monitor uses switches S1, S2, S3 and S5 for the contestants, and l.e.d.s D4 to D7 indicate who pressed first, mapped as S1/D6, S2/D5, S3/D4, S5/D7. Once more the beeper (WD1) is included in place of l.e.d. D8, operating whenever a contestant's switch is pressed.

Switch S4 is for the Quizmaster to reset the contestant l.e.d.s. Within the software, it simultaneously increments a counter. Although not implemented in the prototype, the value of this counter can be monitored by adding l.e.d.s. D1 to D3. The counter is in binary form and represents the numbers from 0 to 7 and can be used as a Question counter.



CONSTRUCTION

The same printed circuit board (p.c.b.) is used for all the projects in this series. Its full-size, copper foil tracking details are shown in Fig.2, together with all the component positions. The board is available from the *EPE PCB Service*, code 373.

Note that some designs do not need the full set of components, as will be seen from the later wiring diagrams. However, there is no reason why all components should not be included if you wish to experiment with different programs while using the same board.

The component positioning and interwiring details for this month's three circuits are shown in Fig.3 to Fig.5. If you prefer to build the board so that it is specific to the circuit function described, insert only those components that are needed (see Components list and relevant figures), and ignore the p.c.b. holes that are not used. Do make sure that you put the components into the correct holes!

Begin construction by fitting the 18-pin socket for IC1 (but don't insert the PIC itself at this time), followed by the resistors. As mentioned earlier, resistors R1 and R2, and connector TB1, are only required if you wish to use the PICAXE version of the chip and program it via a serial lead, otherwise they can be omitted.

Connector TB1 must be inserted the correct way round, with the plastic tongue nearer the line of l.e.d.s (see Fig.2). Capacitor C1 must also be fitted the correct way round. Attach wires for the l.e.d.s, switches and bleeper as required.

Note that the l.e.d.s have a common cathode (k) and so only one wire is required for all the cathodes as shown in their component layout diagrams. Terminal pins TP1 and TP2 are optional, as discussed earlier.

When assembly has been completed and *thoroughly checked*, insert the PIC the correct way round. If a PICAXE-18 is used, programming should be carried out via the 3-pin serial connector, described shortly. If a normal PIC16F627 is used, then it should have already been programmed using a normal PIC programmer.

COMPONENTS

See SHOP TALK page

Resistors

R1	10k
R2, R4, R13 to R16	22k (6 off)
R3	4k7
R5 to R11	330Ω (7 off)
R12	12Ω or 330Ω (see text)

Capacitor

C1	470μ, radial elect. 16V

Semiconductors

D1 to D8	red l.e.d. and mounting clips (8 off)
IC1	PICAXE-18 microcontroller (see text)

Miscellaneous

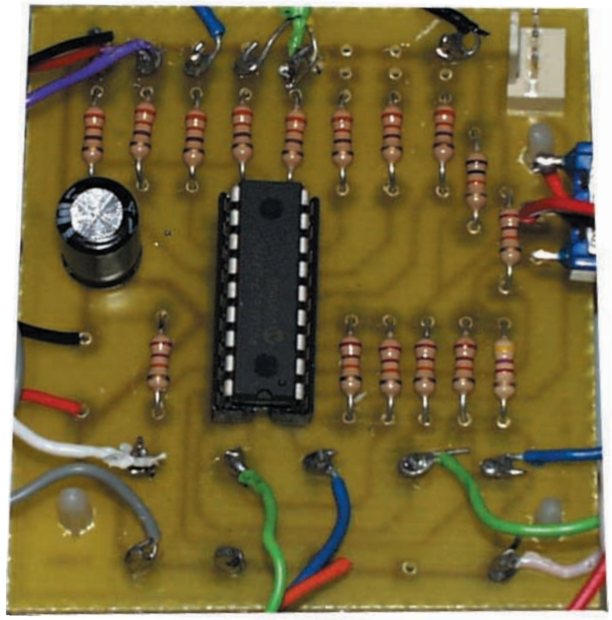
B1	4·5V battery (3 x AA) and clip (see text)
S1 to S5	min. s.p. push-to-make switch (5 off)
S6	min. s.p.s.t. toggle switch
TB1	3-pin serial connector (shrouded 3-pin header) (see text)
TP1, TP2	(see text)
WD1	active buzzer, 5V

Printed circuit board, available from the *EPE PCB Service*, code 373 (1 for each design – see text); 18-pin socket (1 for each p.c.b.); plastic case, size 140mm x 80mm x 30mm approximately (1 per p.c.b.); p.c.b. supports (4 off per p.c.b.); 1mm terminal pins; connecting wires; solder, etc.

Variants

R12 is 12Ω for designs in Part 1 but is 330Ω for some later designs in the series
D8 is not used in Part 1, but is in later parts
R5 to R7 are not used in Quiz Game Monitor (but see text)
D1 to D3 not used in the Quiz Game Monitor (but see text)
S1, S3 to S5 not used in Egg Timer and Dice Machine

Approx. Cost Guidance Only **£18** *excl. case & batts.*



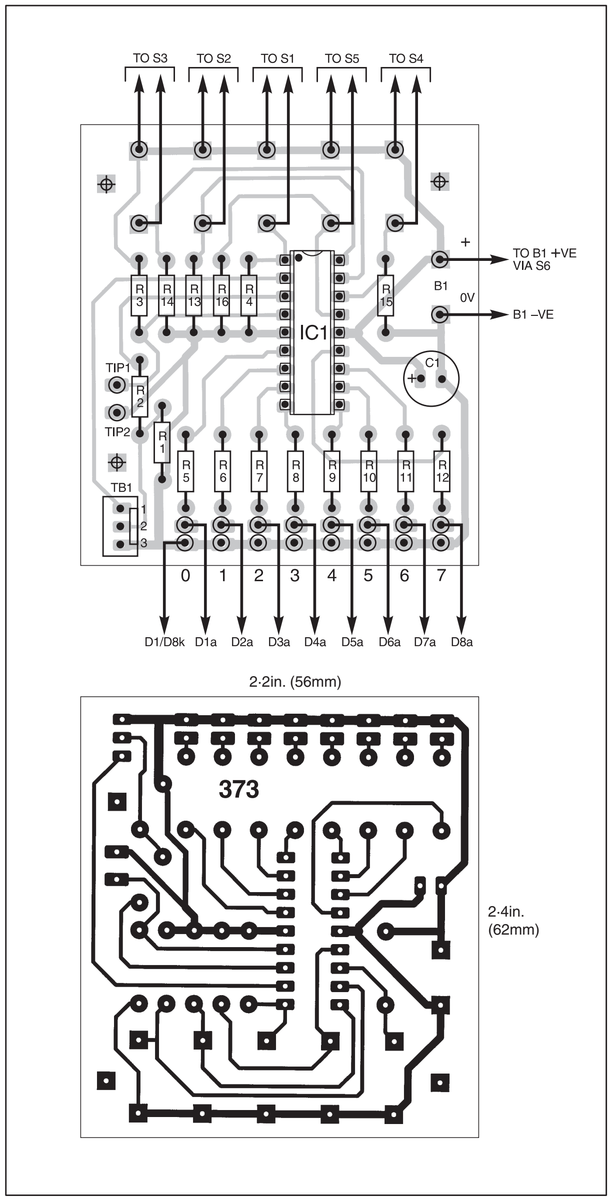
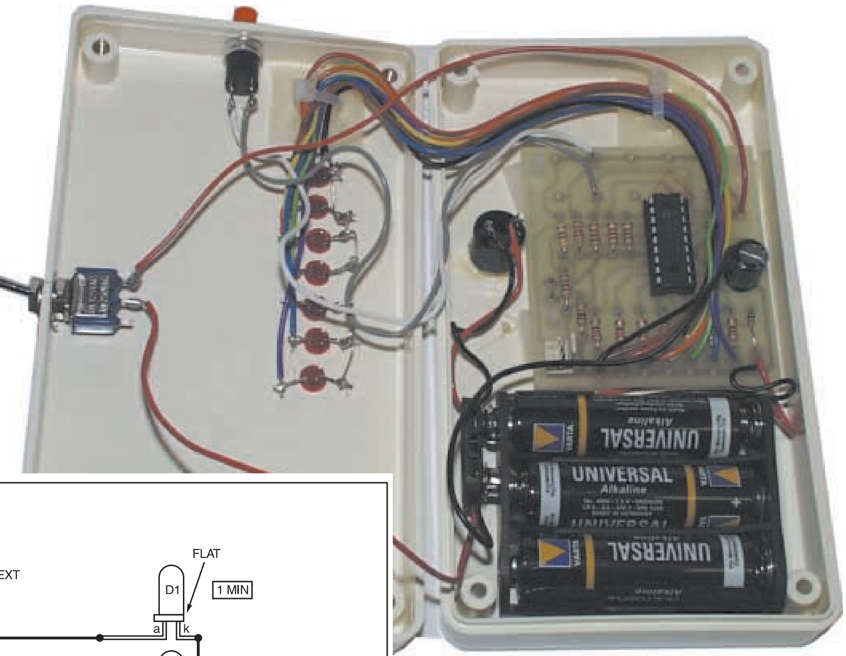


Fig.2. Multiboard topside component layout, full-size foil master and general wiring details.

All three projects described here were housed in plastic cases, measuring approximately 140mm × 80mm × 30mm.

EGG TIMER: This is intended to stand upright on a work surface, and so the batteries should be fitted near the base to aid stability. The component layout and off-board wiring details are shown in Fig.3.

DICE MACHINE: It is intended that this should sit flat on a surface so that the l.e.d.s can be observed from all angles. The component layout and off-board wiring are shown in Fig.4. As mentioned earlier, a tilt switch can be substituted for switch S2 if preferred. Remember that the switch must be closed for at least a second to activate the circuit.



Completed Egg Timer prototype showing general layout and wiring inside the case.

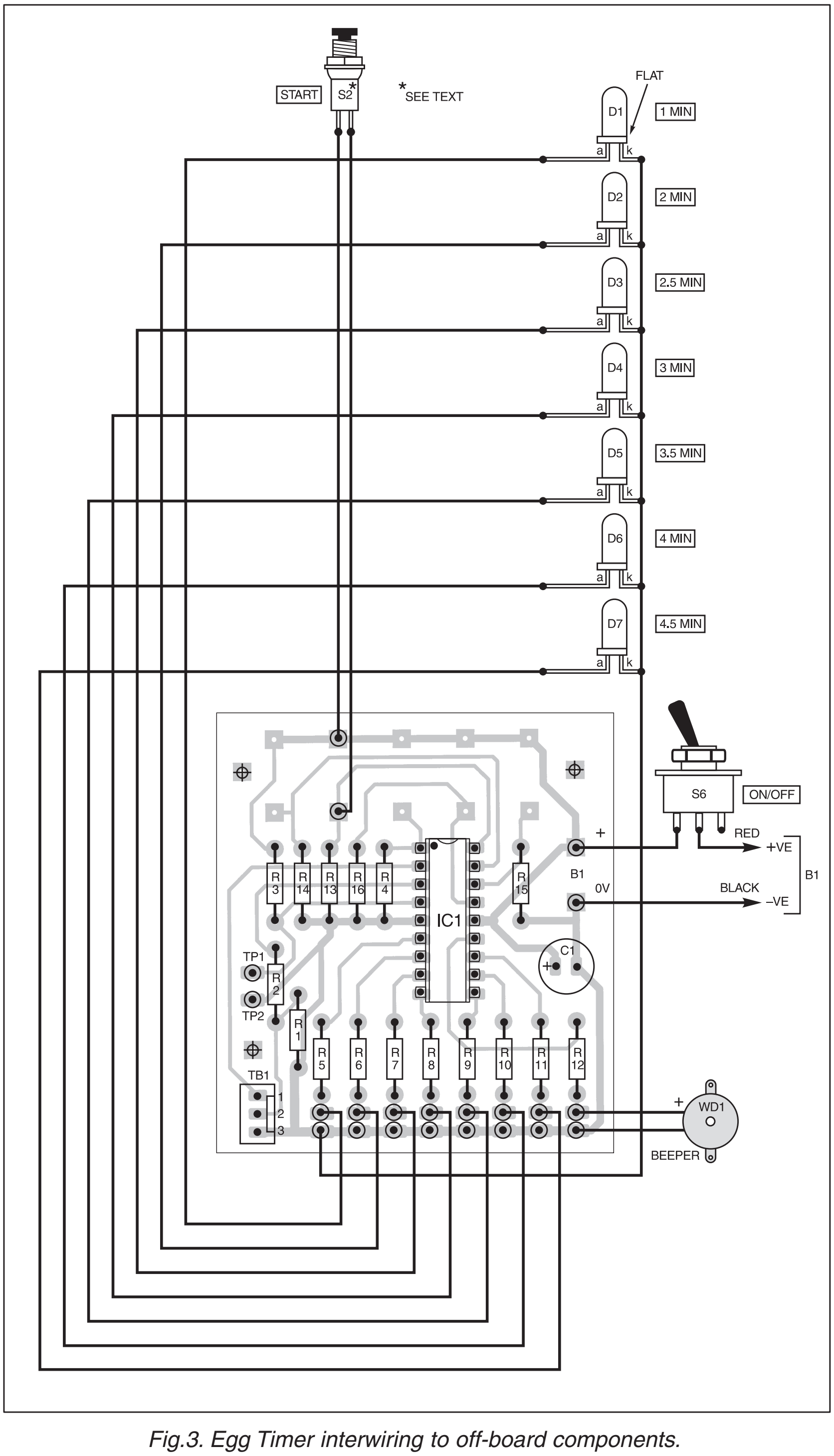


Fig.3. Egg Timer interwiring to off-board components.

QUIZ GAME MONITOR: The component layout and off-board wiring details for the Quiz Game Monitor are shown in Fig.5. Additional small cases are needed for this design, to house the contestant pushbutton switches, one for each contestant, although they could be mounted in pairs in a team contest. They can be directly wired to the main board, or could be connected via jack plugs and sockets if preferred, drilling case holes accordingly.

Note that although the pushbutton switches for the Quiz Game Monitor can all be connected individually to their respective pads on the p.c.b., in a paired situation one wire can be saved by sharing the positive lead as shown, since one side of each switch is connected to positive. This may be useful if the switches are at some distance from the master circuit and allows a 3-core cable to be used. It does not need to be screened.

If the three Question count l.e.d.s (D1 to D3) are required as described earlier, three more holes will need to be drilled in the Quiz Master's case than are shown in the photograph.

PROGRAMMING AND TESTING

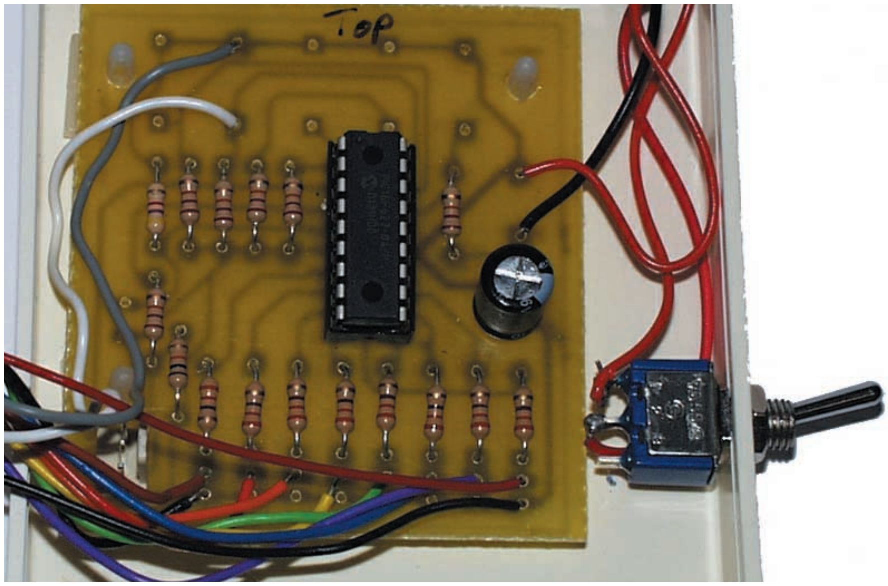
PICAXE-18 chips are intended to be programmed in-circuit, and this allows program changes to be made and tested very quickly. Read the instructions provided with the PICAXE system to understand what you need to do to program the code from your computer into the PICAXE-18. The files you need for the PICAXE system are all suffixed with .BAS.

If the computer cannot "find" the PICAXE-18, check the serial connection and see which port is in use. The port setting can be changed within the software at start-up. If the 3-pin connector is the correct way round, resistors R1 and R2 are the correct values and connected correctly, and if the PICAXE-18 is powered correctly from a supply of about 5V then programming should be successful.

Note that the type of serial cable required is that available at low cost from Revolution Education (whose contact details are given later).

Sometimes it may be necessary to reset the PICAXE-18 just before you send the program. Hold the PIC reset, send the program and release the reset control after about a second. Having released the reset control, the PICAXE then accepts the program.

Still no luck? Ensure that the PIC is a PICAXE chip. PICAXE-18 is a customised PIC16F627 and so the label on the chip will read PIC16F627. It is very easy therefore to get it mixed up with a "normal" PIC16F627. A "normal" PIC16F627 will not work as a PICAXE-18, nor will a PICAXE-18 chip which has been programmed by a standard PIC programmer since the PICAXE code will have been erased in the process.



Component layout on the Dice Machine circuit board.

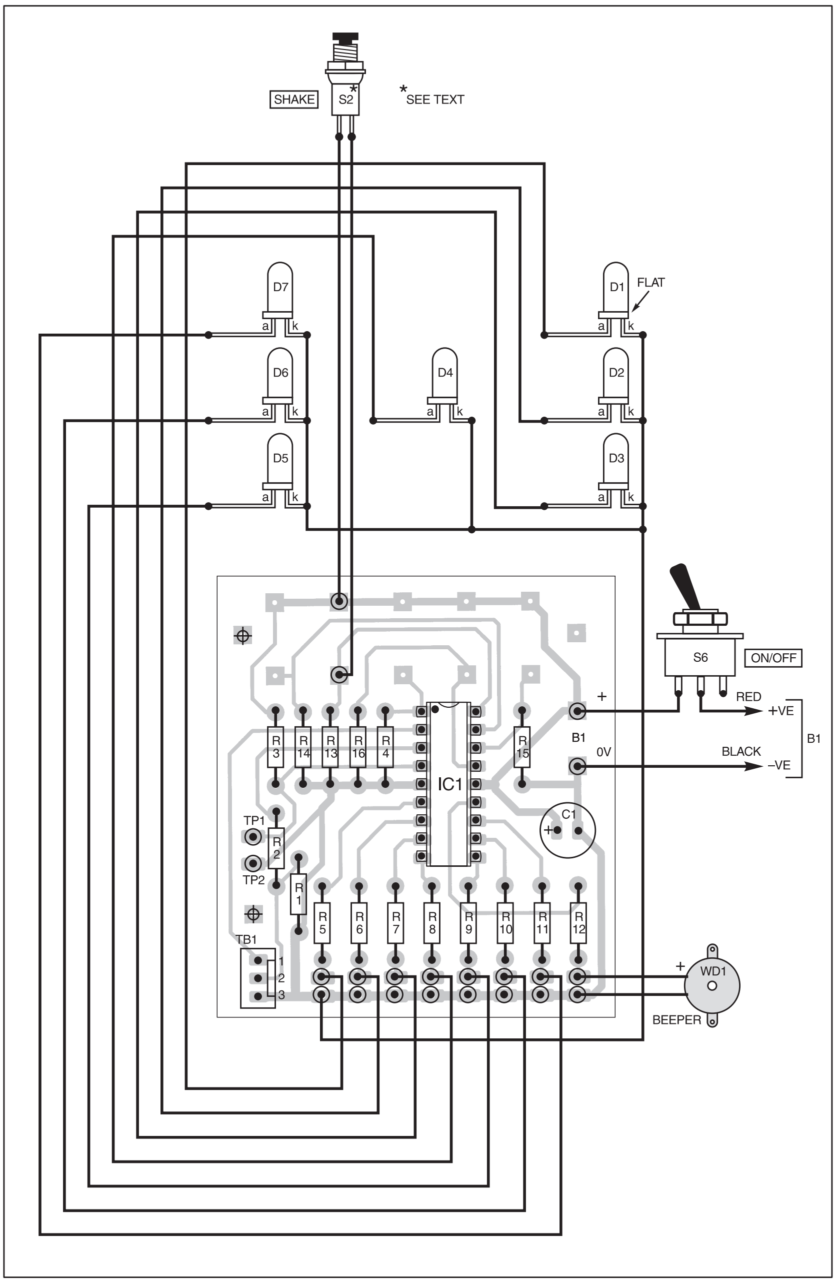


Fig.4. Dice Machine interwiring to off-board components.

Completed Dice Machine showing the front panel layout of the l.e.d.s.

Assuming that the chip has been correctly programmed, faultfinding can be achieved with a voltmeter whose common lead is connected to 0V in the circuit. Now use the positive voltmeter lead to probe around the circuit. Check the voltage at the PIC's power supply pins, then check the voltage at each output.

A +5V reading at any output pin should light the appropriate l.e.d. if it has been connected the correct way round, and assuming that the correct value resistors are fitted. A reading near to 0V should be obtained on pin 18, changing to about +5V (depending on your power supply voltage) when switch S2 is pressed.

Switch anti-bounce protection has been incorporated into each program. Because it causes a delay, it may be necessary to hold

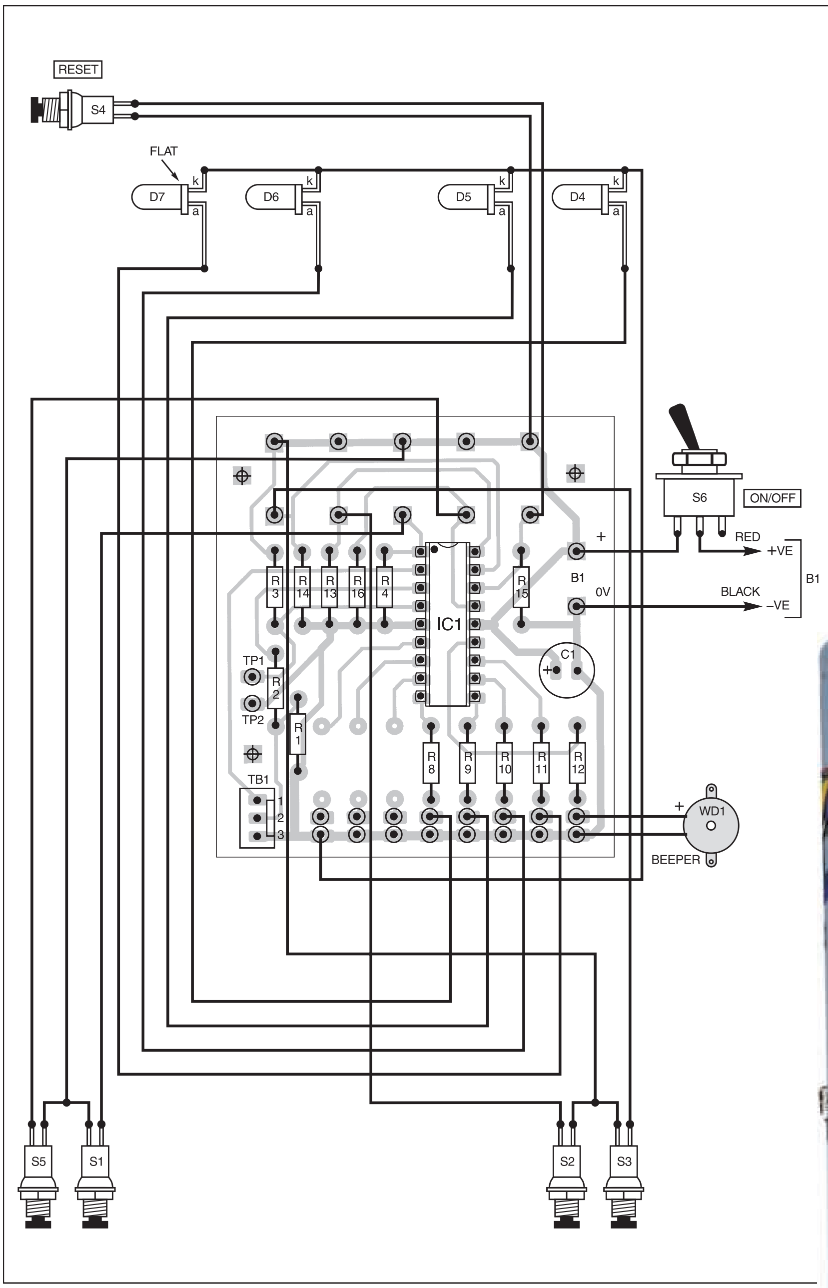


Fig.5. Quiz Monitor interwiring from the p.c.b. to off-board components. Note that "contestant" switches S1,S5/S2,S3 are housed in separate boxes – see photo.

the pushswitch pressed for a second or so. If you think that the PIC has "crashed" try resetting it as discussed earlier.

Note that if you are wishing to program a standard PIC16F627 via a normal PIC programmer, use the HEX file provided. The Watchdog Timer setting must be On.

CREATING A BASIC PROGRAM

We will describe the Egg Timer program (the cut-down version for PICAXE-18) as an example of how to program a PICAXE-18 device. Refer to Listing 1. All the BASIC programs will open in the Windows Notepad text editor and can be modified there.

Note that anything in a program listing which follows an apostrophe is ignored by the system and so is useful for making comments.

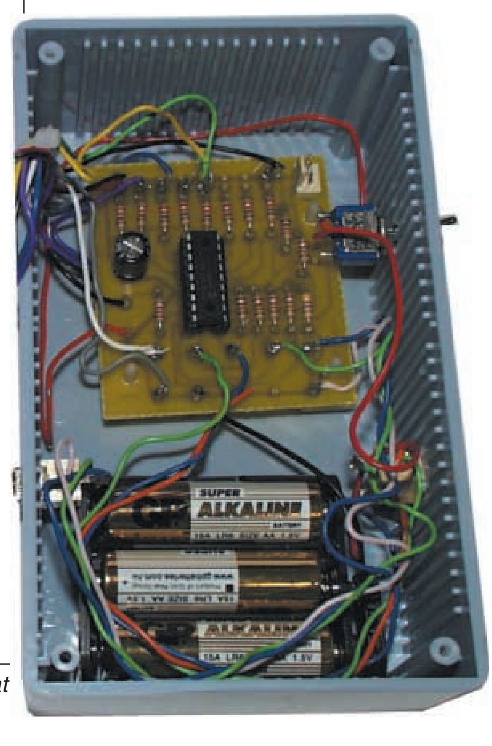
The first nine lines are statements to remind the (human) programmer how the circuit is configured. These lines are ignored by the PIC (or more correctly, the BASIC converter and compiler which generate the code required by the PICAXE-18 microcontroller).

The program begins with the routine starting at the **Make:** label. This examines the logic level at PIC pin 1 (**if pin 1 = 1**). If it is logic 1 (positive – caused by pressing switch S2) then the **Break** routine is entered. Otherwise the program loops back to the **Make:** label. The command **Sleep** is included to reduce power consumption (you will need to read the PICAXE documentation to understand how and why this happens).

NOTATIONS

You will have spotted that switch S2 is connected to pin 18, not pin 1. The command **pin** as used in the program refers to

General component layout in the "master" case.



LISTING 1. Egg Timer program – EGG8.BAS

```
'egg timer by MPH "egg8"  simple version for PICAXE-18),
with sleep added
'outputs 0 to 3 = l.e.d.s
'output:
'       0 = 2·5 min.
'       1 = 3 min.
'       2 = 3·5 min.
'       3 = 4 min.
'output 7 = buzzer
'input 1= push switch, high = 1

make:
        if pin1 = 1 then break      'check for switch to be
                                    pressed
        sleep 1                     'reduces power consump-
                                    tion
        goto make
break:  high 0
        pause 500
        if pin1 = 0 then twoh       'has switch been released?
        high 1
        pause 500
        if pin1 = 0 then three      'has switch been released?
        high 2
        pause 500
        if pin1 = 0 then threeh     'has switch been released?
        high 3
        pause 500
        goto four
twoh:   let b2 = 25                 'set time factor (2·5 secs)
        goto time
three:  let b2 = 30
        goto time
threeh: let b2 = 35
        goto time
four:   let b2 = 40
time:
        let b3 = b2+b2
        let b3 = b3+b2              'b3 =  b2 X 3
        for b0 = 1 to b3
        let b4 = b3 – b0            'b4 counts down as time
                                    elapses
        if b4<75 then twohl
        if b4<90 then threel
        if b4<105 then threehl
        goto fourl
twohl:  let pins = %00000001        'displays one l.e.d.
        goto hold
threel: let pins = %00000011        'displays two l.e.d.s
        goto hold
threehl: let pins = %00000111
        goto hold
fourl:  let pins = %00001111
hold:   pause 2000
        next
        let pins = 0
        high 7                      'sounds beeper
        pause 5000                  'for 5 seconds
        low 7
        goto make
```

the *input number*, and not the i.c. pin number. Fig.1 shows that pin 18 is connected to input 1 (RA1/AN1), so the command **pin 1** in the program refers to pin 18 in the schematic.

Now assume that S2 has been pressed and we have jumped to the **break:** label. The command **high 0** causes output 0 (RB0/INT), to switch high, to turn on the first l.e.d., D1. The system now pauses for 500 milliseconds (**pause 500**). If you release S2 during this time, the next command **if pin 1 = 0 then twoh** causes the system to jump to label **twoh:**. This sets a variable, **b2**, to 25, which will later translate into 2·5 minutes)

There is a limited range of variables in this system. You cannot, for example, state **let x = 25**. A full explanation is available in the help menu provided by the Revolution Education software.

A jump is now made to the label **time:**. The variable **b2** is multiplied by three, by repeated adding. The result is called **b3**. The system now enters a For-Next loop, using another variable, **b0**, (**for b0 = 1 to b3**).

Each time the command **next** is encountered, **b0** advances (increments) by the value of 1, until it reaches the value of **b3**. Variable **b4** counts down and determines the number of l.e.d.s which should be lit. So if **b4** is less than 75 (**if b4<75 then twohl**) the system jumps to label **twohl:**.

This causes Port B to output the binary number %00000001 via the command **let pins = %00000001**. The percentage sign allows the number to be written in binary. The effect is to light the first l.e.d. You could omit the percentage sign and simply use the decimal number 1, but when more l.e.d.s have to be lit, binary notation provides a more visual representation.

After lighting the appropriate l.e.d., a jump is made to **hold:**. This causes a pause for two seconds.

The mathematics of the timing may now be clarified; the original value for **b2** was 25, this was multiplied by three (making 75). The For-Next loop therefore counts from 1 to 75, each time pausing for two seconds. This provides a total delay of 150 seconds, equal to 2·5 minutes.

You may wonder why **b2** is multiplied by three in the program, rather than just stating **let b2 = 75** in the first place. The method was chosen to aid clarity in setting the times. If you look back at the line **twoh: let b2 = 25**, this sets a time of 2·5 minutes. The next setting is 30 (i.e. three minutes), etc.

You can select any time you like by choosing an appropriate number at this stage. Note, however, that no variable can exceed a value of 255, so if you require much longer times, then increase the value in the line **hold: pause 2000**.

When the For-Next loop has finished looping 75 times (i.e. 2.5 minutes) the command **let pins = 0** ensures that no l.e.d.s are lit, and the sequence **high 7, pause 5000, low 7** causes the beeper to sound for five seconds. Note that the command **high 7** has the same effect as **let pins = %10000000**, but is easier if only a single output is being switched. The program now goes back to the **make:** label.

Earlier in this description, during the **break:** sequence, it was assumed that the switch was released during the first 0·5 seconds, hence setting the timer to 2·5 minutes and lighting the l.e.d. connected to output 0. If the switch is held down longer, then the next l.e.d., D2 (output 1) will also light and we jump to a different point, the program thus setting **b2** to a higher number, 30 to achieve three minutes, 35 for three and half minutes or 40 for four minutes.

You can set any time required by changing this number, providing that when multiplied by three the result does not exceed 255.

MORE ON PICAXE

Fuller details on PICAXE programming can be found within the software issued by Revolution Education. Further examples on circuit design and program examples relating to PICAXE devices can be found on the CD-ROM *Modular Circuit Design* available from *EPE*, see CD-ROMs page in the current issue.

RESOURCES

Preprogrammed HEX versions of the PICs for these designs can be obtained from: M.P. Horsey, Electronics Dept., Radley College, Abingdon, Oxon. OX14 2HR. The price is £5 per PIC, including postage. Specify the project for which the PIC is required. Enclose a cheque payable to Radley College.

Software for these three designs (except the PICAXE programming software) is available on 3.5in disk (*EPE* Disk 5), for which a nominal handling charge applies, from the Editorial office. It is also available for free download from the *EPE* ftp site.

PICAXE programming software can be obtained from: Tech-Supplies, Dept. *EPE*, 4 Old Dairy Business Centre, Melcombe Road, Bath, BA2 3LR.

The telephone number of Revolution Education is: 01225 340563, and their web site is at: **www.rev-ed.co.uk**.

Next Month: Temperature Sensor ● Voltage Sensor ● VU Display.

READOUT

E-mail: editorial@epemag.wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

WIN A DIGITAL MULTIMETER

A $3^{1}/_{2}$ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a Digital Multimeter to the author of the best *Readout* letter.

★ LETTER OF THE MONTH ★

UNUSED PIC PINS

Following on from the subject of what to do with unused PIC pins raised in Readout *October '02, a number of readers wrote in with information. The following from Gerard Galvin seems to be the definitive answer:*

Dear EPE,

I asked Microchip for their advice on unused PIC pins, which produced the following from Richard Bratcher, Microchip's CAE Manager:

"When dealing with CMOS devices (such as our microcontrollers) you should terminate unused inputs to either high or low state. Most people pull unused inputs to ground through a resistor, but pulling the input to V_{dd} is also fine.

"The point of all of this is that current consumption in CMOS gates is directly related to switching frequency of the gate. When an unused input is left floating, charge can easily collect on the gate causing the input to go high and low, often oscillating between the two, thereby consuming unnecessary current within the gate. If you tie the input high or low, then you only have the static leakage current of the input.

"My preferred method of dealing with unused I/O pins is that I tend to make them outputs and have them drive low; that way the pin is not floating and you don't need to use an external connection to pull the pin to either high or low state."

Hope that is of use to our family of readers.

Gerard Galvin,
via email

That really most useful Gerard. Thank you for asking Microchip on our behalfs, and to Richard Bratcher of Microchip for responding. Some more thoughts follow below.

MORE ON UNUSED PINS

Peter Hemsley, Tony Horwood and Colin Barnard via email also added to the pool of knowledge about unused PIC pins:

Peter Hemsley: Unused pins on PICs are no different to other CMOS i.c.s in that if the pin is left unconnected, or an analogue voltage of about 1/2 Vcc is present, excessive current could be drawn by the input buffer. Unused pins can be tied directly to Vcc or 0V providing you can definitely ensure that the pin is not accidentally programmed as an output, in which case the output buffer could be short circuited.

Therefore I would recommend tying unused pins to 0V via a resistor of suitable value. An exception to this is any pin with an analogue input. When the input is set to analogue mode the digital input buffer is disabled thus preventing it drawing excessive current. The above explanation is the reason why pins with analogue/digital input capability default to analogue mode at power-on.

Tony Horwood: Some PICs have RA4/T0CKI available as an open drain output (it can only drive its output low, not high) so RA4 must be set to an output and programmed to output a 0. Early PICs such as the 16C5x range have T0CKI as input only so if this pin is not being used for external timer input it should always be connected to V_{dd} or V_{ss}.

Some PICs allow Port B to use internal port pullup resistors. If the software has enabled Port B pullups then any unused Port B inputs would be pulled up to V_{dd} and not float. It would not be advisable to wire these permanently to V_{ss} as a small amount of current would be drawn through the pullup resistor and go to waste, which may affect low power battery circuits.

Colin Barnard: Recently this subject was a topic of hot debate on another chat zone (the **PIClist**). The general consensus was, that it did not matter what you did with the pins so long as it was something.

The options discussed were: Setting the pins to outputs and leaving – the most widely used. Setting the pins to inputs and tying high or low. Setting the pins to inputs and tying high or low but via resistors.

The last two choices tended to be favoured by correspondents citing that they preferred to have the pins at a known state preferably using resistors as this negated damage to the PIC should someone or something short the pins. The first was used by those designers who wanted access to the pins at a later date and where the cost of resistors would add to the design.

Thank you to all of you.

PICKING UP PICS

I wish to build a project using PIC's, but my knowledge is minimal. Can you point me in the right direction of where to get information?

Ian J. Coughlin,
via email

Well Ian, my PIC Tutorial *series of Mar-May '98 is still regarded as the best inexpensive entry point for beginners, so I'm frequently being assured by readers. Back issue photocopies can be ordered from HQ or via our Online Shop. A slightly edited version of it is also included with my* Toolkit TK3 *software available for free download from our ftp site, but you won't get the benefit of being able to run the exercises on the intended p.c.b. that goes with the tutorial series, nor are pictures included.*

If funds permit, you might also care to consider the latest version of the CD-ROM tutorial that was based on my original and which I further developed with a commercial software company. It has its own superb ready-built multifunction board, and on-screen facilities that allow simulation of simple software routines. It's advertised on our CD-ROMs pages and called Assembly for PICmicros V2 *(formerly* PICtutor*), and its board is* Version 2 PICmicro MCU Development Board.

TIMELY INPUTS

Dear EPE,

I wonder if at some time in the future, you could present a "Basic Principles of Timing a Signal on a PIC Input" type of article. I have been thinking for some time about the subject as this could be the basis for an number of useful tools such as frequency meter, or measuring r.p.m. say from an optical or Hall Effect sensor.

Without asking you to write the code, it would be useful to get the basic idea. I can see that an interrupt would be good for catching one edge of the signal on the pin, but it would also be great for signalling TMR0 rollover. What if they both happen at once? How are these things dealt with in the real world?

Gerard Galvin,
via email

Well, well, Gerard, you are in the PIC-light this month – more power to you!

For simple stuff, I first reset a counter and then just read the pin until it first changes state, to high say, then read it again during that high and the entirety of the following low, incrementing the counter during these two states. It can also be done similarly but using the PIC's Timer option, depending on the PIC type. Knowing the PIC's clock rate, the total cycle duration is thus known from the count result.

Using interrupts is far more tricky – read Malcolm Wiles' Programming PIC Interrupts *of Mar/Apr 2002, back issues available at the usual price (elsewhere in this issue).*

As useful as timing techniques are, I don't think that the subject would really justify an article in own right.

BECKER SOURCE

Dear EPE,

I am a subscriber and am very interested in the series of PIC projects which are commonly published. I am particularly interested in interfacing PC to PIC hardware and currently interested in learning more about Visual Basic. I am therefore asking if you would please give the email address of John Becker who designed the *Morse Code Reader* (Sep '02) as I would like to ask him if he would send me a copy of the source code for his Visual Basic program to help me learn how to control the serial/parallel ports.

Lee Hewitt,
via email

Greetings Lee, I'm here at EPE*, where I have been for over eight years! All the software is on our ftp site. and includes the source code, not only for the PIC program but also for the VB as well. We always put all code up on that site. It's also available on 3·5-inch disk, for a nominal handling charge, from the Editorial office. Details on the* EPE PCB Service *page.*

I take this opportunity to say (yet again!) that if anyone wants to contact me (or who has technical queries relating to a published project), to do so directly via the Editorial office, not the Chat Zone. Whilst I do look in there occasionally, I don't guarantee it and I may miss your message. My direct EPE email is ***john.becker@epemag.wimborne.co.uk****, although* ***techdept@epemag.wimborne.co.uk*** *will also reach me directly.*

WINZIP

Dear EPE,

With reference to *Readout* January '02 and your reply to Ralph Llewellyn headed *TK3 and Winzip*, I went to upgrade my own Winzip version 7 and strangely it was no longer free! Below is the reply I got from Chuck Campbell of WinZip Technical Support:

"WinZip is, and has always been, distributed as shareware. Shareware is a "try before you buy" method of distributing software. If you use shareware beyond an evaluation period (which varies from product to product – for WinZip, the evaluation period is 21 days), you are expected to pay for it, just as you would pay for a copy of Microsoft Word that you bought from a store."

Pat Alley, via email

Thanks Pat – readers take note!

P.C.B. IMAGES

Dear EPE,

As someone who has created and etched many p.c.b.s, and who is also a long time reader of your excellent mag, I have followed all the discussions on creating and developing the initial artwork using acetates. As far as I am aware, no-one has mentioned the cheapest, easiest and I believe best way of doing this for an inkjet printer, which is to use A4 heavy gauge ($90g/m^2$) tracing paper which can be obtained from any Printing/Art shop for about £3 per 50 pages.

The quality of the print is excellent and extremely fine lines can be etched, also, where there is no ink on it, the paper is totally transparent to UV light.

Jim Gray (Senior Systems Analyst Retd), via email

Thanks Jim, yes, I've used it with success, but having discovered OHP (overhead projection) film through my local computer chain store I get better images and they don't smudge.

MORE SQUARE ROOTING

Dear EPE,

Peter Hemsley's feature *Square Roots* (Aug '02) reminded me of a square root routine I met in Leo Scanlon's *6502 Software Design*, over 20 years ago when I was learning to program the Compukit early computer. The square root of an integer is equal to the number of successively higher odd numbers that can be subtracted from it.

As an example, take the square root of 49:

* Deduct 1 and record one deduction. Remainder 48

* Deduct 3 from the remainder and record two deductions. Remainder 45

* Deduct 5 from the remainder and record three deductions. Remainder 40

* Deduct 7 from the remainder and record four deductions. Remainder 33

* Deduct 9 from the remainder and record five deductions. Remainder 24

* Deduct 11 from the remainder and record six deductions. Remainder 13

* Deduct 13 from the remainder and record seven deductions. Remainder 0

There is no remainder and seven odd numbers have been deducted. The square root of 49 is 7. Yes, this routine is only usable with integers, but one could multiply by 100 and divide the answer by 10, or multiply by 256 and divide the answer by 16.

I am not sufficiently familiar with PIC programming to design an appropriate routine but it should not be a problem.

Ken Beard, via email

Thanks Ken, that's interesting, though I wonder if when written in PIC it would take a lot of cycles to achieve an answer? Let's hear from you all on this!

In the meantime I shall continue with Peter's code which I find excellent, as are his multiply, divide, bin2dec, etc routines which we've publicised from time to time, and which are on our ftp site in the PIC Tricks *folder*

MPASM DIFFERENCES

Recently Andrew Chadler reported that he was having difficulties when using TK3 to program PIC16F627 chips whose code had been assembled through MPASM. An extra NOP command was appearing towards the head of the HEX file, as became apparent when the PIC's contents were disassembled through TK3.

I examined Andrew's ASM and HEX files, and then compiled his ASM through my MPASM V2.30. His and my HEX files were different. His had the extra NOP, mine did not. After sending him my HEX files, and discussing MPASM versions with him, he responded:

It is to do with the version of MPASM I'm using! When I use an older version (MPASM V02.30) I get HEX files identical to the ones you sent me, however when I use MPASM V03.10 (which comes with MPLAB IDE V5.62, released May 2002) there is an extra line at the start of the HEX file which reads:

:020000040000FA

The HEX files are otherwise identical. I'm using the default HEX file output format in both of the above versions of MPASM. However, it appears that in the older version the default is the Intel Hex Format (type INHX8M) whereas in the newer version the default is Intel Hex 32 Format (type INHX32), which has been causing all my problems.

Thanks for your help and your great *EPE* projects!

Andrew Candler, via email

I asked TK3 *to decode Andrew's above HEX line on its own.* TK3 *drew my attention to the "4" in it which, re-reading my Convert TASM Notes in* TK3*, is the flag for 32-bit. MPASM users take note!*

VINYL TO CD

Via our Chat Zone, Andy Flind recently offered the following comment with regard to the Vinyl to CD Preamplifier *(Sept '02):*

I have recently done this sort of copying and potential constructors may be interested in my experiences. I read in a computer mag that one had only to plug the line output of the amplifier into the line input of the sound card, and activate Microsoft's sound recorder or similar . . . oh yes?

Well, I spent much time cutting and shutting leads to get the connection into my amp, where all the outputs were already in use. I got the left and right connections swapped twice with the computer between the swaps, so all the balance sliders worked backwards! It didn't help that my computer's amplifier had a headphone socket which was also connected the wrong way round – internal mods were necessary.

With this sorted, I fired up the ensemble, to find that Sound Recorder will only record a maximum of one minute. More expensive software required. Such software should have facilities for editing out the pops and crackles of an old Vinyl record. For some time I've been using a version of EasyCD Creator, supplied with my CD-R drive when it was installed.

So I went forth unto PC World and purchased the Platinum Edition of this software, which says on the box it can record analogue and has the necessary editing facilities. You're supposed to click an edit button, then set up some sliders for the optimum results. Only, it didn't work. It went into something resembling severe positive feedback which built up until my PC protected itself by turning the sound card gain right down. I thought the card had blown up!

With huge difficulty I contacted the EasyCD Creator website – it refused to accept the passwords I supplied during registration so I was unable to access the usual tech support, and a form provided for those without such access crashed when I tried to use it. The only thing that seemed to work properly was the email to their sales department! I'm not sure which of my furious emails finally reached them, but eventually they replied to the effect of "it doesn't work, we know it doesn't work, there may be a patch available one day"!

PC World gave me a refund. I bought something called Clean. This came with a preamp like the one in *EPE*, only it gets power from the USB port! I thought it sent its signal through that too, until I began wondering why it also had an analogue connection to the sound card! However, it does work well, and simplifies the connection to a vinyl deck. It comes with a manual translated from a German original which was a bit difficult to follow, and the editing facilities could be better. However, it does clean up old recordings quite well. Bundled with it is something called Wavelab Lite, which is an excellent and intuitive editing suite. There is also a CD label creator – if anyone manages to figure out how to use this I'd love to hear from them!

Final warnings – it takes a long time to process an old vinyl into a reasonable CD. It's a real labour of love if you want to do it properly. And in the process you'll create huge files. At one point I had 1·6Gb of files for just one old LP. If you want to store them for future recordings you'll probably need to convert them into high-quality MP3s, and maybe keep these on CD. Hope this is of use to others inspired to try and convert their old vinyls after seeing this project.

Andy Flind, via the Chat Zone

JUMPING THE CLOCK

Dear EPE,

I see John Becker had a few minor problems with large tables when writing code for his *PIC World Clock* (Aug '02). I suspect he is using ADDWF PCL,F which is not the correct command to use for this purpose. By using MOVWF PCL,F a jump can be made to anywhere in program memory (assuming PCLATH is correctly set, of course).

Here is an extract of a table read I wrote some time ago. It is sequential access only, i.e. a call to RDTABL will return the next item in the list. It should not be difficult to write a random access routine if that is required. The data table is continuous and does not need to start at a sub-page boundary.

```
RSTTABL MOVLW HIGH TABLE ; Reset pointer to start of table
        MOVWF TPAGE
        MOVLW LOW TABLE
        MOVWF TPTR
RDTABL  MOVF TPAGE,W ; Set pclath to access table
        MOVWF PCLATH
        MOVF TPTR,W        ; Table pointer
        INCF TPTR,F        ; Increment pointer for next time
        SKPNZ
        INCF TPAGE,F       ; Roll-over: increment page
        MOVWF PCL          ; Go to data at pclath_pcl
TABLE   RETLW DATA1
        RETLW DATA2
```

In fact, a vision of another piece of code has also just appeared in my head, and here it is:

```
; Random access table read
; Table item number in INDEXL and INDEXH
RDTABL MOVLW HIGH TABLE
           ADDWF INDEXH,W
           MOVWF PCLATH
           MOVLW LOW TABLE
           ADDWF INDEXL,W
           SKPNC
           INCF PCLATH,F
           MOVWF PCL,F
```

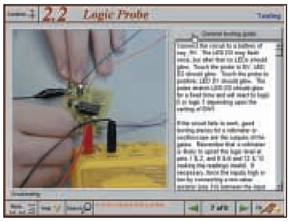
Peter Hemsley, via email

Yes, Peter, I do use ADDWF. When I wrote World Clock *I had not at that time used PCLATH and evolved the table jump code by trial and error – your comments are useful, thank you.*

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

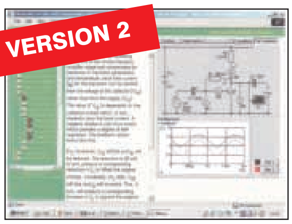
ELECTRONICS PROJECTS


Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture**, **circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

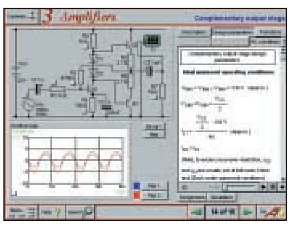
ELECTRONIC CIRCUITS & COMPONENTS V2.0

VERSION 2


Circuit simulation screen

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. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections 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.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

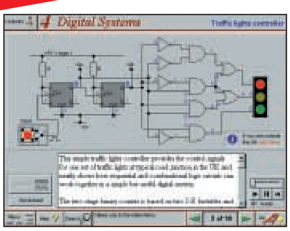
ANALOGUE ELECTRONICS


Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

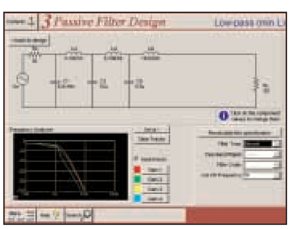
DIGITAL ELECTRONICS V2.0

VERSION 2


Virtual laboratory – Traffic Lights

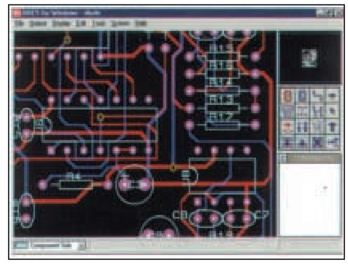
Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

FILTERS


Filter synthesis

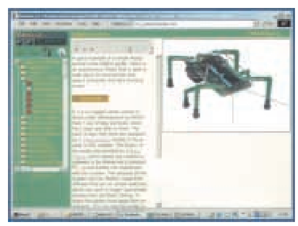
Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

ELECTRONICS CAD PACK


PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots. etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

ROBOTICS & MECHATRONICS


Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student ....£45 inc VAT
Institutional (Schools/HE/FE/Industry)..............£99 *plus* VAT
Institutional 10 user (Network Licence)..........£199 *plus* VAT
Site Licence..£499 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

PICmicro TUTORIALS AND PROGRAMMING

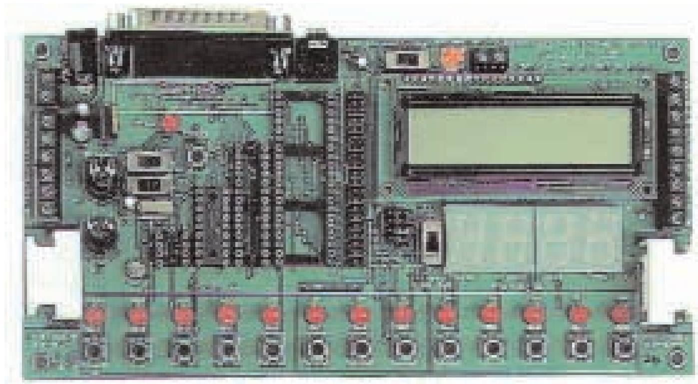
HARDWARE

VERSION 2 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 13 individual l.e.d.s, quad 7-segment display and alphanumeric l.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- All inputs and outputs available on screw terminal connectors for easy connection



£145 including VAT and postage

12V 500mA plug-top PSU (UK plug) £7

25-way 'D' type connecting cable £5

SOFTWARE

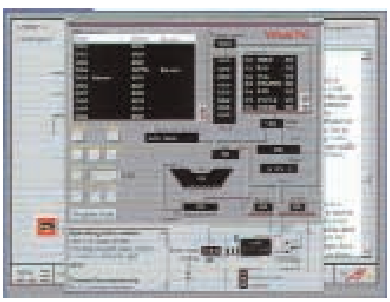
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V2

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V2.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 39 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.



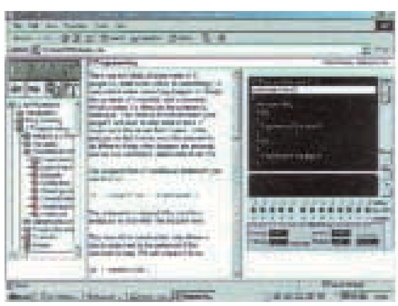
Virtual PICmicro

'C' FOR PICmicro VERSION 2

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

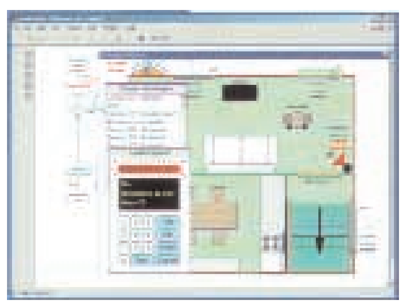
FLOWCODE FOR PICmicro

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and l.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming involved.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 2 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols (ISO5807) ● Full on-screen simulation allows debugging and speeds up the development process ● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 8, 18, 28 and 40-pin devices ● Institutional versions include virtual systems (burglar alarms, car parks etc.).



Burglar Alarm Simulation

PRICES

Prices for each of the CD-ROMs above are:

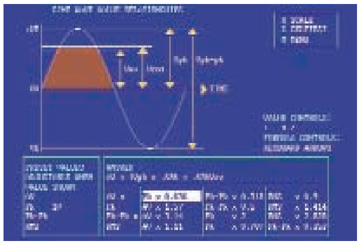
(Order form on next page)

Hobbyist/Student	**£45 inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99 *plus* VAT**
Flowcode Institutional	**£70 *plus* VAT**
Institutional 10 user (Network Licence)	**£249 *plus* VAT**
Site Licence	**£599 *plus* VAT**

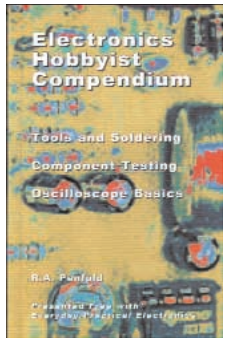
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

TEACH-IN 2000 – LEARN ELECTRONICS WITH EPE

EPE's own *Teach-In* CD-ROM, contains the full 12-part *Teach-In* series by John Becker in PDF form plus the *Teach-In* interactive software covering all aspects of the series. We have also added Alan Winstanley's highly acclaimed *Basic Soldering Guide* which is fully illustrated and which also includes *Desoldering*. The *Teach-In* series covers: Colour Codes and Resistors, Capacitors, Potentiometers, Sensor Resistors, Ohm's Law, Diodes and L.E.D.s, Waveforms, Frequency and Time, Logic Gates, Binary and Hex Logic, Op.amps, Comparators, Mixers, Audio and Sensor Amplifiers, Transistors, Transformers and Rectifiers, Voltage Regulation, Integration, Differentiation, 7-segment Displays, L.C.D.s, Digital-to-Analogue.


Sine wave relationship values

FREE BOOK WITH TEACH-IN 2000 CD-ROM

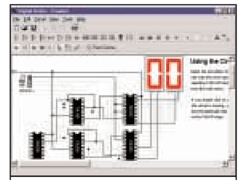


Each part has an associated practical section and the series includes a simple PC interface so you can use your PC as a basic oscilloscope with the various circuits.
A hands-on approach to electronics with numerous breadboard circuits to try out.

£12.45 including VAT and postage. Requires Adobe Acrobat (available free from the Internet – **www.adobe.com/acrobat**).

FREE WITH EACH TEACH-IN CD-ROM – *Electronics Hobbyist Compendium* 80-page book by Robert Penfold. Covers Tools For The Job; Component Testing; Oscilloscope Basics.

DIGITAL WORKS 3.0


Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning.
Hobbyist/Student £45 inc. VAT.
Institutional £99 *plus* VAT.
Institutional 10 user £199 *plus* VAT.
Site Licence £499 *plus* VAT.

ELECTRONICS IN CONTROL

Two colourful animated courses for students on one CD-ROM. These cover Key Stage 3 and GCSE syllabuses. **Key Stage 3:** A pictorial look at the Electronics section featuring animations and video clips. Provides an ideal introduction or revision guide, including multi-choice questions with feedback. **GCSE:** Aimed at the Electronics in many Design & Technology courses, it covers many sections of GCSE Electronics. Provides an ideal revision guide with Homework Questions on each chapter. Worked answers with an access code are provided on a special website.

Single User £29 inc. VAT. Multiple User £39 plus VAT
Student copies (available only with a multiple user copy) £6 plus VAT
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

ELECTRONIC COMPONENTS PHOTOS

A high quality selection of over 200 JPG images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details).

Also contains a **FREE** 30-day evaluation of Paint Shop Pro 6 – Paint Shop Pro image editing tips and on-line help included!

Price £19.95 inc. VAT

MODULAR CIRCUIT DESIGN

VERSION 3

Contains a range of tried and tested analogue and digital circuit modules, together with the knowledge to use and interface them. Thus allowing anyone with a basic understanding of circuit symbols to design and build their own projects. Version 3 includes data and circuit modules for a range of popular PICs; includes PICAXE circuits, the system which enables a PIC to be programmed without a programmer, and without removing it from the circuit. Shows where to obtain free software downloads to enable BASIC programming.
Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design. Over seventy different Input, Processor and Output modules are illustrated and fully described, together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc.

Single User £19.95 inc. VAT. Multiple User £34 *plus* VAT
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Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98/NT/2000/ME/XP, mouse, sound card, web browser.

CD-ROM ORDER FORM

Please send me:

- ☐ Electronic Projects
- ☐ Electronic Circuits & Components V2.0
- ☐ Analogue Electronics
- ☐ Digital Electronics V2.0
- ☐ Filters
- ☐ Electronics CAD Pack
- ☐ Robotics & Mechatronics
- ☐ Assembler for PICmicro
- ☐ 'C' for PICmicro
- ☐ Flowcode for PICmicro
- ☐ Digital Works 3.0

Version required:
- ☐ Hobbyist/Student
- ☐ Institutional
- ☐ Institutional 10 user
- ☐ Site licence

- ☐ PICmicro Development Board (hardware)
- ☐ Development Board UK plugtop power supply
- ☐ Development Board 25-way connecting lead

- ☐ Teach-In 2000 + FREE BOOK
- ☐ Electronic Components Photos
- ☐ Electronics In Control – Single User
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Note: The software on each version is the same, only the licence for use varies.

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ORDERING

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Student/Single User/Standard Version price includes postage to most countries in the world
EU residents outside the UK add £5 for airmail postage per order

Institutional, Multiple User and Deluxe Versions – overseas readers add £5 to the basic price of each order for airmail postage (**do not add VAT** unless you live in an EU (European Union) country, then add 17½% VAT or provide your official VAT registration number).

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01202 873872. Fax: 01202 874562
Goods are normally sent within seven days
E-mail: orders@wimborne.co.uk
Online shop:
www.epemag.wimborne.co.uk/shopdoor.htm

ee50b

SHOP TALK
with David Barrington

Transient Tracker

Readers will need to take special care when ordering parts for the *Transient Tracker* project. As mains voltages are involved, you ***MUST*** order new Class-Y type capacitors. These are made for continuous use across the a.c. mains supply and are usually rated at 250V a.c. to 275V a.c.

They are usually of metallised paper or polypropylene construction and most of our component advertisers should be able to supply suitable capacitors. If you do have problems finding a Y-Class type, the ones depicted in the photographs came from **RS Components**, stock code 311-1074, and can be ordered from any *bona-fide* RS stockist. You can order direct (*credit card only*) from RS on ☎ ***01536 444079*** or on the web at ***rswww.com***. We understand a post and handling charge will be made.

The opening comments also apply to the high voltage carbon film resistors. The ones used in the prototype are 2W types and have a claimed rating of 1200V max. overload voltage and came from RS, codes 131-659 (1k) and 131-700 (1M). However, there is a minimum quantity order, so try your local parts source first before ordering.

A plastic case must be used to house the printed circuit board (p.c.b.) with no metal parts passing through it to be exposed on the outside. The author used a small handheld type which was also obtained from the above source, code 239-7637. As the p.c.b. is such a tight fit, it might be wise to purchase a larger standard plastic snap-together case.

The slim-line rocker switch, code 197-7692, and the IRF510 *n*-channel MOSFET, code 395-6473 or 295-365, are stocked by RS. The printed circuit board is available from the *EPE PCB Service*, code 372 (see page 835).

Tuning Fork and Metronome

The rotary type binary-coded-decimal (BCD) switch called for in the *Tuning Fork and Metronome* project only appears to be available from **RS Components** and carries the stock code 327-939. It can be ordered through any *bona-fide* RS stockist or, using your credit card, direct from them on ☎ ***01536 444079*** or the web at ***rswww.com***. The rest of the components, including the semiconductors, should be widely available from local sources.

For those readers unable to program their own PICs, a ready-programmed PIC16F84 microcontroller can be purchased from **Magenta Electronics** (☎ ***01283 565435*** or ***www.magenta2000.co.uk***) for the inclusive price of £5.90 each (overseas add £1 p&p). The software is available on a 3·5in. PC-compatible disk (*EPE* Disk 5) from the *EPE* Editorial Office for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 835). It is also available *Free* from the *EPE* ftp site: **ftp://ftp.epemag.wimborne.co.uk/pub/PICs/TuningFork**.

The printed circuit board is available from the *EPE PCB Service*, code 374 (see page 835). Don't forget you need two LOG potentiometers.

EPE Hybrid Computer

Although it is one of our most ambitious projects for many years, most of the components for the *Hybrid Computer* appear to be mainly standard devices and only a few items could be classed as specials. Starting with the "heart" of the project, the BASICMicro Atom microcontroller compiled BASIC module can be purchased from **Milford Instruments** (☎ ***01977 683665*** or ***www.milinst.com***), code 1-316. Make it clear that it is the 24-pin version you want. When you purchase this microcontroller, also enquire about a CD-ROM containing the ATOM software.

Next in line is finding a suitable sloping-fronted console (case) to house the p.c.b.s and take the numerous controls, "patch" sockets and meters etc. We have been unable to find a plastic version, but we understand that a neat looking two-piece low-profile aluminium desktop case, with sloping front, is manufactured by **Boss Industrial Mouldings** (☎ ***01638 716101*** or web ***www.boss-enclosures.co.uk***). It is from their 2600 range and is coded part no. 2605. You will need to contact them for nearest stockist and price.

Regarding the Omron (G5V-2 series) 5V d.c. 50 ohms coil p.c.b. mounting relays, these were obtained from **Farnell** (☎ ***0113 263 6311*** or ***www.farnell.com***), code 179-350. They also supplied the vertical, snap-in, p.c.b. mounting rotary pots. (VR1 to VR10), code 918-878.

The large double-sided printed circuit boards (codes 375 (Main) and 376 (Atom)) are available from the *EPE PCB Service* – see page 835 for details and prices.

PICAXE Projects Pt.1 – Egg Timer ● Dice Machine ● Quiz Monitor

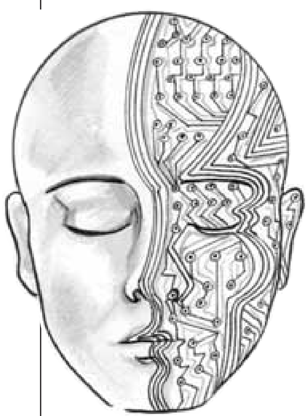
Ready-programmed HEX versions of the PICAXE-18 microcontroller for the *PICAXE Projects* can be purchased (*mail order*) from **M. P. Horsey, Electronics Dept, Radley College, Abingdon, Oxon, OX14 2HR**, for the inclusive sum of £5.90 each (overseas add £1 p&p). Specify for which project the PICAXE is wanted and *make cheques payable to Radley College.*

Software for these designs (except PICAXE programming software) is available on a 3·5in. disk (Disk 5) from the *EPE* Editorial Office for the sum of £3 each (UK), see page 835. It is also available for *Free* download from the *EPE* ftp site.

The "special" serial lead was supplied by **Revolution Education** (☎ ***01225 340563*** or ***www.rev-ed.co.uk***), stock code AXE025. They also supplied the PICAXE programming software.

The same master printed circuit board is used for all the projects in this short series. It is available from the *EPE PCB Service*, code 373. All other components appear to be "off-the-shelf" devices.

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 designs, not simply mechanical, electrical or software ideas. Ideas *must be the reader's own work* and **must 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 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., 408 Wimborne Road East, Ferndown Dorset BH22 9ND. (We **do not** accept submissions for *IU* via E-mail.)
Your ideas could earn you some cash **and a prize!**

Wien Oscillator – Don't Gang Up

CONVENTIONAL Wien bridge oscillators employ two-gang variable resistors (potentiometers wired in resistance mode) as the frequency-adjusting elements. Unfortunately, the two resistances seldom stay perfectly in step. The result is amplitude variation as the frequency is changed.

The circuit diagram shown in Fig.1a sidesteps the problem by using a single variable resistance (VR1). When VR is at zero resistance there is a normal Wien network in which Cl = C2 = C, and R1 = R2 = R, giving a tuned frequency $f_o = 1 / (2\pi CR)$: about 700Hz with the values shown.

When VR1 is turned up from zero resistance, the frequency falls. Analysis shows that the new frequency is the standard Wien frequency:

$$f_o = 1/(2\pi CR) \text{ divided by } \sqrt{(1+VR1/R2)}$$

When VR1 is very large then this is very close to $\sqrt{(VR1/R2)}$. The new frequency can then be approximated by inverting part of the equation and multiplying the standard frequency by $\sqrt{(VR1/R2)}$.

If R2 = 2·2 kilohms and VR1 = 1M then this gives:

$$f_o = 724 \times \sqrt{\left(\frac{2{\cdot}2}{1000}\right)} = 34Hz$$

The attenuation factor of the network falls from 3 when VR1 = 0, towards 2 when VR1 is infinite. This is compensated by feeding a correction signal (dependent on the setting of VR1) to IC1b via buffer IC1a.

To set up the circuit first set VR2 and VR3 midway. Set VR1 to maximum resistance. Adjust VR2 carefully to obtain oscillation with minimum peak clipping. Now set VR1 to zero and adjust VR3 for minimum clipping. Repeat the procedure for fine trimming. With care it should be possible to obtain sinewaves across the tuning range with only a trace of clipping.

The peak-to-peak output voltage is whatever amplifier IC1b can deliver at its overload point. For the op.amps shown, this gives about 3V r.m.s. for a 5V-0V-5V supply and 6·6V r.m.s. with 10V-0V-10V.

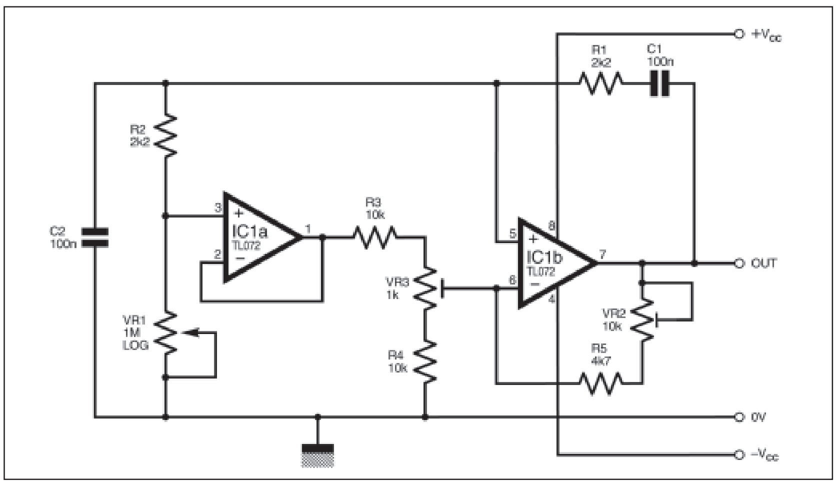


Fig.1a (above). Single control Wien bridge oscillator.

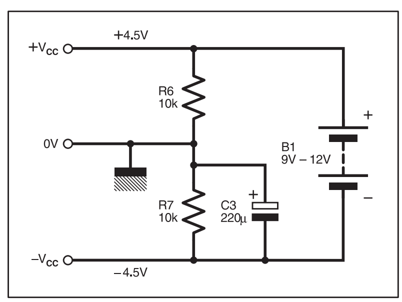


Fig.1b (right). Simple voltage splitter circuit.

If a centre-tapped supply is not available a single-ended supply can be split with the aid of the divider network shown in Fig1b. *(Note that the supply cannot then be used to lower a circuit having a negative earth.)* Operation down to 9V should be possible.

If capacitors C1 or C2 are changed the trimmers must be reset, which complicates the range switching. A possible solution might be to duplicate the circuit for each range, switching only VR1 and the output.

George Hylton, Worthing

MORE ON NEXT PAGE

WHY NOT SEND US YOUR CIRCUIT IDEA?
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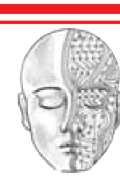


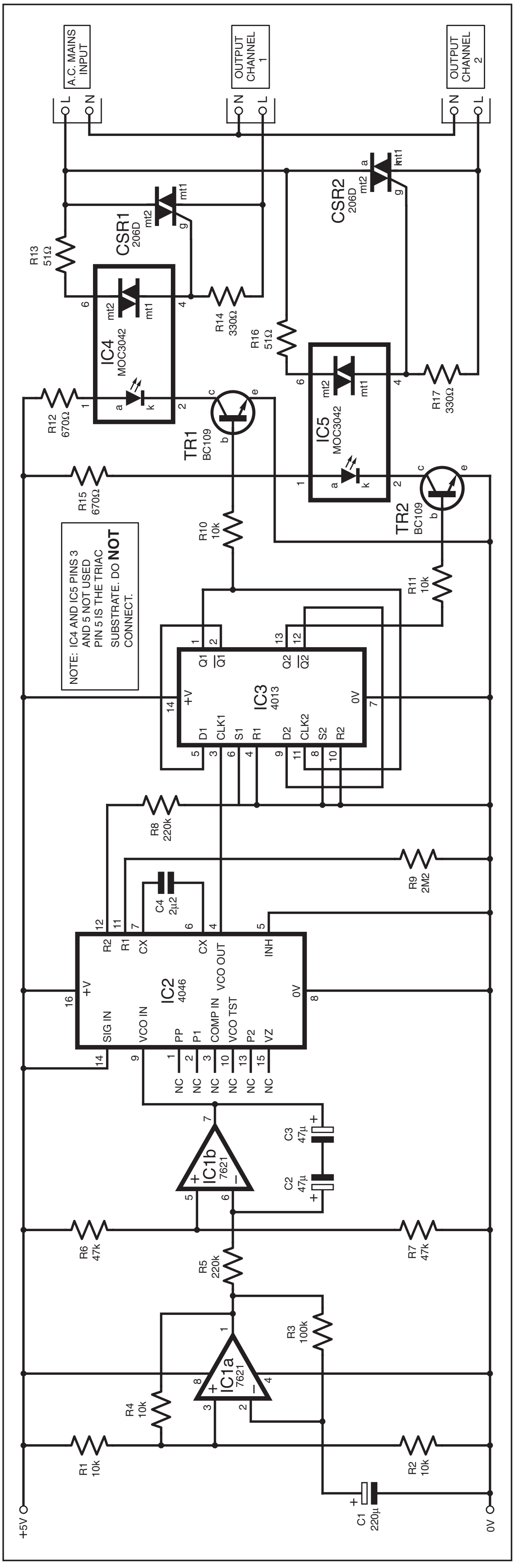


Fig.2. Two-channel Christmas Lights Controller circuit diagram.

Two-Channel Christmas Light Controller – Festive Flasher

THE circuit diagram shown in Fig.2 was designed to control two sets of Outdoor Christmas Lights. A friend had installed them across the front of his house but his little lad was disappointed that they did not do anything "interesting". This circuit was put together to liven things up a bit, and is presented in plenty of time to enable readers to construct it ready for the approaching festive season.

The 7621 op.amp IC1 forms a slow triangle waveform generator. The signal output at pin 7 of IC1b feeds into the voltage-controlled oscillator input of IC2, a 4046 phase-locked loop chip. The square wave output of the v.c.o. (pin 4 of IC2) cycles from a very slow rate up to about 2Hz to 3Hz.

Flip-flop IC3a slows things down a bit, and drives triac CSR1 via a zero-crossing optotriac arrangement, IC4. A second flip-flop IC3b divides by two again and controls the second output channel through another zero-crossing optotriac, IC5, and triac CSR2.

As mains voltages are present, readers must take special precautions to ensure that all mains-voltage components are insulated to prevent accidental electric shock. In particular, note that the metal tabs of the triacs are at mains voltage and MUST be fully isolated using the correct mounting kits as needed. Since they dissipate little power in this application, no heatsinks should be necessary.

When the circuit is set up and running, the varying speed and the binary effect is quite "engaging" – it certainly attracted comment from people waiting at the bus stop opposite!

Steve Dellow, Warwick

Budget Light Sensor – Topped

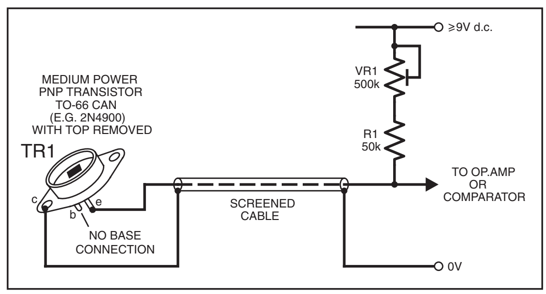


Fig.3. Simple light sensor.

HOBBYISTS often build electronic projects that are triggered when the ambient light level changes (say, arrival of dusk). A number of devices operate perfectly well in this role, including light-dependent resistors (l.d.r.s), photodiodes and phototransistors.

However, they are often housed in fiddly little packages that are difficult to mount where they needed (usually outside the house). The simple idea shown in Fig.3 solves this problem.

Ordinary bipolar transistors are in fact photo-sensitive and if the semiconductor wafer is exposed it will often behave as an effective phototransistor (*hence the old Mullard OCP71 germanium phototransistor – an unpainted glass OC71 device that was therefore slightly photosensitive – ARW*). Modern transistors are embedded in epoxy and accessing the transistor die is not possible, but older transistors were enclosed in metal cans. If the very top of the metal housing is carefully sawn off with a hacksaw or Dremel, a sensitive phototransistor maybe produced. ***Be aware that some semiconductor devices may contain toxic elements so, just to be safe, take care to avoid accidentally inhaling any dust or touching any swarf.***

It has been found best to use medium-powered silicon transistors, e.g. a TO-66 encapsulation which has a larger wafer area and a large metal housing that can be converted into a handy photosensor in this way. The real advantage is that these transistors come complete with a mounting plate, so it is easy to attach the device where it is needed.

Two of these were used on my EPE *Automatic Curtain Winder* project (*issues not available*) to detect night-time and daybreak. They were easily bolted to a small plastic box which, in turn, was screwed to the wall, a more elegant solution than the original which involved trying to stick some awkwardly shaped light-dependent resistors to the inside of the window-pane with sticky tape.

The opened device was protected from the elements using a plastic window (e.g. the bottom of a test-tube) glued in place, but, in my experience, these devices are stable for years even when exposed. Normally one would use an *npn* device, such as the 2N3054 which are more common, but nowadays a *pnp* device is often handier instead (see Fig. 3); the advantage is that the collector of the transistor (which is also the casing) is at ground potential. Use shielded cable if there is any substantial distance between the sensor and the control circuit.

Bruce Clothier, Oadby, Leics.

Talking Newspapers – Tone It Up

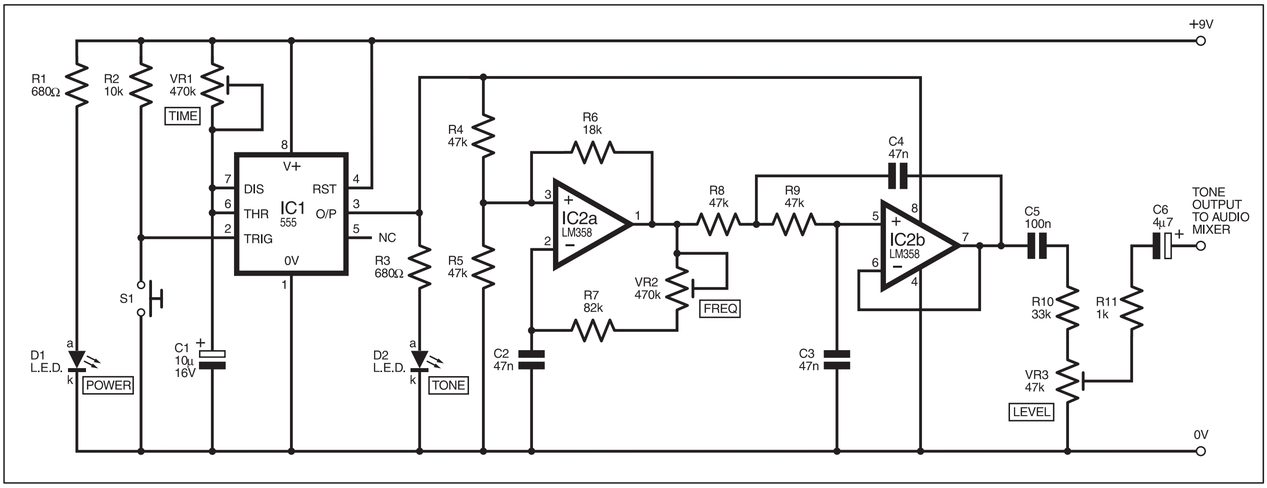


Fig.4. Circuit diagram for a simple tape tone index marker.

BEING in charge of the technical side of the *Whitecliffs Talking Newspaper* it came to the writer's notice that some visually impaired people had experienced "tone indexing" on their cassette tapes obtained in other areas of the UK. Not knowing if a commercial unit was available, nor having a circuit diagram available, it was decided to try and devise one for use by the *WTN*. Previous experience of applying a low frequency tone to a radio transmitter suggested that this technique might be a good starting point.

What is tone indexing? Tone indexing involves injecting a sub-audible tone of four seconds duration at suitable points on the cassette tape whilst it is being recorded. This allows listeners with "cue and review" facilities (fast forward or rewind, while monitoring the soundtrack) on their machines to hear a short "blip" at various points on the tape, helping them to navigate up and down the tape: the higher tape speed gives shorter time but a higher frequency of the tone.

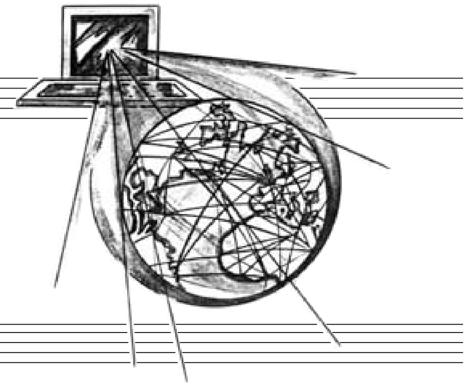
The circuit diagram suggested in Fig.2 comprises of a 555 monostable, IC1, which produces the four second burst, set by VR1 and visually seen at l.e.d. D2, and for the same period it enables the low frequency oscillator based around IC2. Trimmer preset VR2 gives some control over the audible tone heard through the cassette speaker, and the output level is set by VR3.

In use, the output should be taken from capacitor C6 and fed into one channel of an audio mixer (not shown), and the channel fader set to the recording level of the master recording deck. The tone index marker is then mixed in with the main soundtrack. To activate the unit just press and release push switch S1 at any appropriate time whilst recording.

Fred Knight (G4NJU), Deal, Kent.

SURFING THE INTERNET

NET WORK



ALAN WINSTANLEY

A Can of Worms

ONE of the most serious problems that e-mail users face today is that of unsolicited email or "spam". Usenet provided the first rich pickings for spammers, who developed techniques for harvesting users' email addresses from newsgroup articles and then from web sites. American marketers saw email as a legitimate way of communicating their "message" to the world, and we certainly get the message all right – thousands of them, mailed out blindly to irate users every hour of the day.

The embarrassment and the major waste of time and resources that spammers cause is reaching astronomical proportions. In one of the worst examples, one of the writer's regular email addresses was bombarded from a single source at the rate of many hundred mails over a few weeks, which effectively immobilised a mail account. Rejecting the email merely moves the problem elsewhere; it clogs mailservers to the point where some addresses (e.g. hotmail) are automatically assumed to be spam, and are rendered undelivered by ISPs.

Spam shows no sign of letting up in spite of US regulations, and one of the drawbacks of being a relatively early Internet user in the UK is having an email address that is now well-embedded in the junk mailers' databases. In Europe the possibility of compulsory opt-in email marketing is being discussed but this will have little effect on "foreign incoming" email.

Worse still are the various viruses and worms which are intended to damage a user's computer, or which mail themselves out again through their Windows address book. About 15 per cent of the writer's incoming unsolicited email contains a deadly worm or a virus. The situation is set to become far worse due to the always-on characteristic of high-speed broadband services.

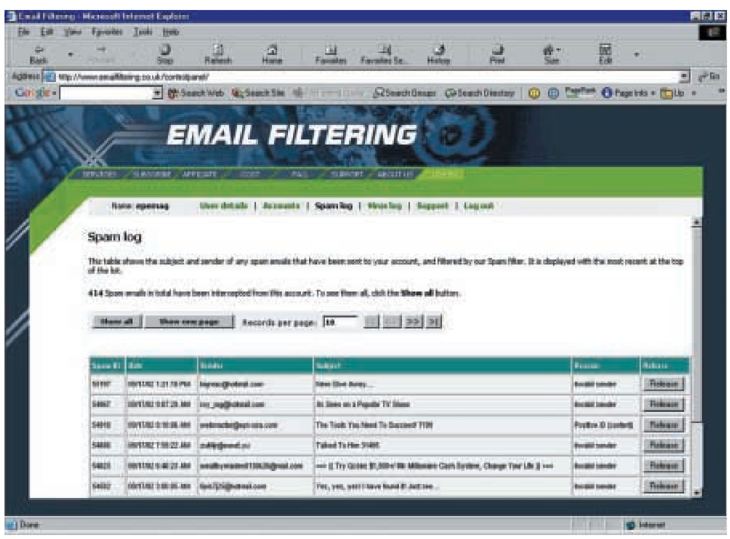
Attacking Tidal Waves

So how does one deal with this tidal wave of spam and viral attacks? You should always run up-to-date anti-virus software and a firewall of course, but it is sometimes best to interrogate the mailserver directly using programs such as Popcorn (free but unsupported, from **www.ultrafunk.com**) or JBMail (**www.pc-tools.net**). By simply glancing down the list of subjects and senders, you can then decide to delete unwanted mail directly before fetching the rest. This is a satisfying but ultimately time-consuming experience that can take up several hours of your time each month. The next problem is that genuine emails become buried in all the dross and are accidentally overlooked or deleted. A program called Mailwasher (**www.mailwasher.net**) has received good feedback from users, and more experienced users should download the trial.

It would be far better if the unwanted mail was screened out to begin with. This brings us to a relatively new technique for dealing with unsolicited or virus-infected mail. Commercial companies already use third-party organisations to intercept virus-infected email on the fly. For several months the writer has been testing a new email filter service from **www.emailfiltering.co.uk** which filters both spam and viral email. It costs £21.00 ($30) per mail account per year. The system logs into your mailbox and collects your mail, and then screens it for known spam or viri. The customer fetches the remaining emails from EMF's mailserver. Spam is detected by monitoring unsolicited emails received by a distributed farm of servers, which then flags any spam. The system quarantines any further such mails on customers' accounts and prevents them from being automatically delivered.

Fried Spam

So how good is email filtering? After a slow start, there has been a gratifying difference in the quantities of spam email delivered to the writer's main address. The system was not quite perfect when it was initially set up, filtering out only 60 per cent of junk. Neil Hammerton of company Emailfiltering (EMF) tells me that for some of their customers they manage to block 95-100 per cent of spam but for a few they initially only blocked about 50 per cent.



Screenshot of the email filtering system currently being tried by the author.

To address this issue, an opt-in spam filtering level was then introduced which reduced spam by a further 24 per cent or so, claims EMF. This option works by validating the sender's email address. If the email address is invalid (i.e not actually there, e.g. **9iz7p3ez@hotmail.com**) then it is assumed the email is spam and it is screened out, otherwise spam is screened on the message content. The chances of intercepting genuine emails are extremely remote, and I can confirm that after two months and 500 filtered emails only one of them was a semi-genuine email. This can be forwarded to your mailbox by hitting a "release" button. Otherwise the system has generally worked silently in the background, and EMF provides a webmail front end as well.

Perhaps more importantly, the EMF system has blocked 71 viral emails, mostly containing the tiresome W32-Klez worm but a number carrying the deadly BIOS-destroying CIH virus. For this reason alone the cost of the email filtering system could be justified for some users. The system genuinely gives ordinary mainstream Internet users a first line of defence against spammers and virus attacks. You can sign up online and enjoy a month's free trial.

Discovery Channel

Next month, I'll be surfing the web and taking a look at one area of consumer electronics that is largely undiscovered and is set to be the next big thing. What is it? Tune in next month to find out! You can email me at **alan@epemag.demon.co.uk**.

PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

THE time it takes to obtain every component for a project, right down to the last nut and bolt, has long been a sore point with electronic project constructors. Electronics kits were very popular in the past, even though they generally represented relatively poor value for money.

For many constructors the added expense was worth it for the greater convenience. You only had to order one item from one supplier in order to obtain a complete set of parts.

With mail order buying you also incurred a single charge for postage and packing, which in most cases partially offset the higher price of the product. When putting together a complete set of parts yourself it is often necessary to order them from two or three suppliers, with no single supplier stocking everything required.

Electronic kits are still around today and probably offer good value for money as well as convenience. However, it is a fact of project building life that most types of project cannot be obtained in kit form. Unless you are prepared to settle for a relatively small repertoire of projects it is necessary to do things the hard way and buy all the components from scratch. The "old hands" at electronic project building have a much easier time because they have a stock of popular parts, and in the main only have to order the more specialist components for each project.

Stock Answers

Beginners can make life easier by building up a stock of everyday components, but care has to be taken when selecting components for stock. It would be easy to waste significant sums of money on components that stood little chance of finding there way into a project. So which components are worth adding to your stock of parts and which should be avoided?

The obvious starting point is ordinary resistors having a power rating of about 0·25 watts. It is not a good idea to stock up with the more exotic resistors such as high-power and close tolerance types as they are little used in projects. In contrast, practically every project you build will require at least a few "bog standard" resistors, and some might require dozens of them.

The obvious problem with resistors is that they are available in a large number of different values, and a good stock of resistors includes several of each value. On the plus side, resistors are the cheapest components and stocking up with a substantial number should not cost all that much.

Some resistor values are used far more than others. The middle values tend to be used more than very high or very low ones. Within the middle range, values such as 4k7 (4·7 kilohms) and 10k are used more than values such as 5k6 and 8k2. It is clearly a good idea to buy more of the popular values.

The quick and easy way is to buy one of the resistor development packs that are available from some component retailers. These usually include larger numbers of the more popular values. It is likely that the popular values will still run out first, but you can take the opportunity to top up any dwindling values when buying the components for a project.

If you buy your own selection it is not really worthwhile buying a substantial quantity of every resistor value. Most projects for the home constructor use resistor values in the E12 series (1, 1·2, 1·5, 1·8, 2·2, 2·7, 3·3, 3·9, 4·7, 5·6, 6·8, 8·2 and their decades).

Resistors are also available in the E24 series, which consists of the E12 series plus 12 intermediate values (1·1, 1·3, 1·6, 2·0, 2·4, 3·0, 3·6, 4·3, 5·1, 6·2, 7·5, 9·1 and their decades). As these additional values are little used in electronic projects there is little point in holding a stock of them. Buy them as and when they are required, just like any of the other more specialised components.

Doubling Up

Back in the early days of *Everyday Electronics* it was often suggested that a stock of resistors should be built up by purchasing twice as many resistors as you actually needed. This remains a very good way of doing things. If a project needs (say) five 100k resistors you would actually order 10 of them.

You will not obtain a stock of components overnight using this method, and it will obviously take time to build up a useful stock of resistors. It is relatively painless though, because you will barely notice the additional cost each time you build a project.

The beauty of this method is that you automatically buy more of the popular values, and less of the little-used values. This weighting of the quantities obtained should accurately reflect the popularity of each value, resulting in a few components that are left unused for long periods.

Obviously the same method can be applied to other components, but it should be limited to the cheaper and more common components. This includes non-specialised capacitors and semiconductors. For example, many projects use inexpensive silicon diodes such as the 1N4148, and it is worthwhile having a supply of these.

It's A Bargain

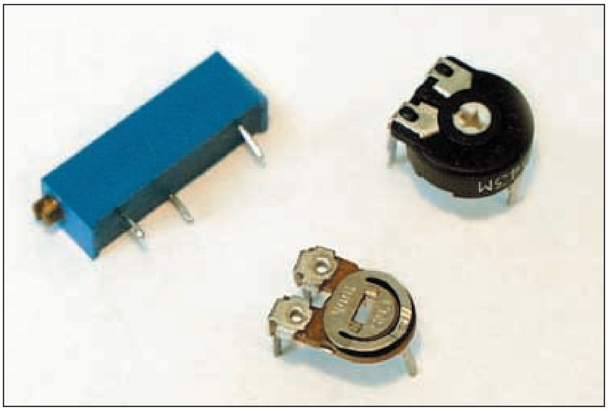
Bargain packs of resistors offer another alternative, but some are better than others. Although these packs usually offer excellent value for money, you may find that only a few values are included. Another potential problem is that the values included in the pack may be ones that you do not use very often. There is no point in having a huge stock of resistors if you still have to order most of the resistors each time you build a project.

Many of these packs also contain some odd values. All sorts of weird values are used in commercial electronic products, and the components in bargain packs will not necessarily have standard values. It would be acceptable to use something like a close tolerance 28·7k resistor instead of an ordinary 27k component, but with the low cost of resistors it would hardly seem to justify the effort.

Some resistor packs contain a lot of old and (or) high wattage resistors. It is probably pointless to produce a stock of "bargain" resistors that are not predominantly modern miniature types. Older and higher wattage resistors are simply too big to fit into most modern component layouts. Bargain resistor packs are perhaps better suited to experienced constructors who can sort the "wheat from the chaff".

Going to Pot

Small fixed value resistors are cheap, and are even cheaper if you buy a substantial quantity. Unfortunately, the same cannot be said for potentiometers, even though they are only available in a very limited range of values.



Miniature horizontal preset potentiometers (resistors) are normally used in projects. Multiturn types (left) are relatively expensive and little used.

A selection of potentiometers would be quite costly with the possibility that half of them would never be used. Bargain packs offer a possible solution, especially if you can find one that offers a good range of values with components that have standard mounting bushes and spindles.

Practically all the control knobs available to amateur users are intended for a spindle diameter of around 6mm to 6·35mm. A few knobs for smaller diameter spindles are available, and with something like control knobs it is possible to improvise if the "real thing" cannot be obtained.

However, a pack of potentiometers in weird and wonderful shapes could be more trouble than its worth, so stick with packs of reasonably standard components. Fixing nuts and washers for potentiometers, non-standard or otherwise, can be very difficult to obtain, so only buy packs that come complete with both of these.

Logarithmic (log.) potentiometers are used for volume controls but not much else. Linear (lin.) types are used for most applications other than volume controls, and are likely to be used more than logarithmic types. Incidentally, not all potentiometers carry "log" or "lin" markings these days, but instead have the letter "A" or "B" respectively.

Preset potentiometers (resistors) are significantly more expensive than ordinary resistors, but they are far cheaper than normal potentiometers. Also, like ordinary potentiometers they are only available in a limited range of values. Again, the quick and easy method of obtaining a stock of these components is to buy a "development" pack.

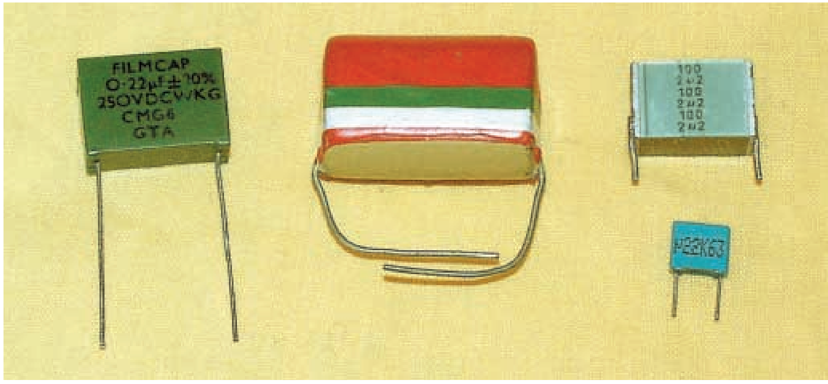
Presets are also a good candidate for the double-buying method of stock building. Incidentally, they are normally only sold in linear versions, which is understandable as they are not normally used as volume controls.

Overcapacity

Due to the very wide range of values available, together with the many different types in common use, buying a comprehensive stock of capacitors would be extremely expensive. In general, capacitors are not expensive, but they are not sold at the "give-away" prices associated with resistors. Unless a fair amount of money is available it will be necessary to make some compromises when building a stock of capacitors.

Higher value capacitors are almost invariably of the electrolytic variety, and it is certainly worthwhile obtaining a small stock of these. Electrolytic capacitors are produced in axial lead and radial (printed circuit board or p.c.b.) mounting varieties. The radial type seems to be somewhat cheaper these days, and it is this type that is used in most modern projects. Radial capacitors will usually fit quite well in place of axial types, so it is best to concentrate on these.

Electrolytic capacitors are only generally available in the E6 range of values, which is every other value in the E12 series (1·0, 1·5, 2·2, 3·3, 4·7, 6·8 and their decades). In practice it is only 1·0, 2·2, 4·7 and their decades that are used to any extent.



The two capacitors on the left have the same values as the modern equivalents on the right.

A basic stock of electrolytic capacitors could therefore be rationalised to something like 10 of each value from 0·47μF to 10μF, and five of each value from 22μF to 470μF. A working voltage of about 16V or more will suffice. Higher value types having high working voltages are relatively expensive and should be bought as and when they are needed.

Development packs are a good way of buying a stock of electrolytic capacitors, but you need to be careful when buying bargain packs. Electrolytic capacitors made a number of years ago tend to be much larger than their current equivalents, and might not fit into modern component layouts.

Spaced Out

There is potentially the same problem with bargain packs of non-electrolytic capacitors. Modern projects mainly use non-electrolytic capacitors of the printed circuit variety. These are the box-shaped capacitors and they are available with various lead spacings.

The 5mm spacing type are probably the most popular at present, and they can usually be persuaded to fit boards designed for 2·5mm or 7·5mm components. If you intend to do this it is important to obtain fully cased components and not the open construction variety. With the latter it is likely that one of the leads will break off when you try to form them into the required shape.

For low values of under 1nF the usual choices are ceramic plate and polystyrene capacitors. Polystyrene capacitors are used where good stability is important. Ceramic plate capacitors are generally smaller and cheaper than polystyrene components and are used in less demanding applications. You will probably not use these low values a great deal unless radio circuits are of particular interest.

It is probably not a good idea to stock up with large numbers of polystyrene capacitors, which are not exactly cheap and are relatively little used. A small selection of ceramic plate capacitors can be very useful though, and a development pack is also a good option. Development packs are a good choice with other types of capacitor if you can find a suitable selection at the right price.

Semiconductors

These days there are relatively few semiconductors that turn up regularly in projects, with specialist devices and microcontrollers now taking a more dominant role. Old favourites such as the 555 timer still turn up quite frequently, but this chip is now available in various low-power and high-speed versions, which rather complicates matters.

Another point to consider is that semiconductors have a habit of suddenly becoming obsolete. Apart from general-purpose silicon diodes it is probably not a good idea to buy semiconductors until you actually need them.

Bits and Pieces

Electronic project construction is not only about resistors, capacitors, and the like. Items of hardware, such as nuts, bolts, spacers, plastic stand-offs and battery connectors are essential to every project.

In the case of nuts, bolts, and spacers you will probably have to buy in fairly large quantities, so a small stock will soon start to accrue. Probably the most useful are the M2·5 and M3 screws from about 6 to 25 millimetres in length, together with matching nuts. Also useful are M2.5 and M3 spacers of around 6mm to 12mm in length.

It is a good idea to keep plenty of solder in stock. Ideally a 500g reel of 22 s.w.g. (0·7mm) solder should be obtained. This should avoid the frustration of running out of solder just as the shops shut, with your latest masterpiece almost completed.

Last and by no means least, buy or make suitable storage units for the newly acquired stock of parts. Searching for the required components in a bag of several hundred assorted parts will take a long time and result in unnecessary wear on the components.

Do-it-yourself shops or even the local Woolies store should have a selection of low-cost storage units that are ideal for electronic components. Alternatively, homemade storage trays are easily built for next to nothing. Clearly label everything so that any required component can be located quickly.

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The construction and use of a Tristate Continuity Tester, a Signal Tracer, a Logic Probe and a CMOS Tester are also included.

136 pages **Order code BP391** **£5.49**

TEST EQUIPMENT CONSTRUCTION
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This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

The following designs are included:-
AF Generator, Capacitance Meter, Test Bench Amplifier, AF Frequency Meter, Audio Mullivoltmeter, Analogue Probe, High Resistance Voltmeter, CMOS Probe, Transistor Tester, TTL Probe. The designs are suitable for both newcomers and more experienced hobbyists.

104 pages **Order code BP248** **£4.49**

AUDIO AND MUSIC

VALVE & TRANSISTOR AUDIO AMPLIFIERS
John Linsley Hood
This is John Linsley Hood's greatest work yet, describing the milestones that have marked the development of audio amplifiers since the earliest days to the latest systems. Including classic amps with valves at their heart and exciting new designs using the latest components, this book is the complete world guide to audio amp design.

Contents: Active components; Valves or vacuum tubes; Solid-state devices; Passive components; Inductors and transformers; Capacitors, Resistors, Switches and electrical contacts; Voltage amplifier stages using valves; Valve audio amplifier layouts; Negative feedback; Valve operated power amplifiers; Solid state voltage amplifiers; Early solid-state audio amplifiers; Contemporary power amplifier designs; Preamplifiers; Power supplies (PSUs); Index.

250 pages **Order code NE24** **£21.99**

AUDIO AMPLIFIER PROJECTS
R. A. Penfold
A wide range of useful audio amplifier projects, each project features a circuit diagram, an explanation of the circuit operation and a stripboard layout diagram. All constructional details are provided along with a shopping list of components, and none of the designs requires the use of any test equipment in order to set up properly. All the projects are designed for straightforward assembly on simple circuit boards.

Circuits include: High impedance mic preamp, Low impedance mic preamp, Crystal mic preamp, Guitar and GP preamplifier, Scratch and rumble filter, RIAA preamplifier, Tape preamplifier, Audio limiter, Bass and treble tone controls, Loudness filter, Loudness control, Simple graphic equaliser, Basic audio mixer, Small (300mW) audio power amp, 6 watt audio power amp, 20/32 watt power amp and power supply, Dynamic noise limiter.

A must for audio enthusiasts with more sense than money!

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RADIO / TV VIDEO

ELECTRONIC PROJECTS FOR VIDEO ENTHUSIASTS
R. A. Penfold
This book provides a number of practical designs for video accessories that will help you get the best results from your camcorder and VCR. All the projects use inexpensive components that are readily available, and they are easy to construct. Full construction details are provided, including stripboard layouts and wiring diagrams. Where appropriate, simple setting up procedures are described in detail; no test equipment is needed.

The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.

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SETTING UP AN AMATEUR RADIO STATION
I. D. Poole
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Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

An essential addition to the library of all those taking their first steps in amateur radio.

86 pages **Order code BP300** **£4.45**

EXPERIMENTAL ANTENNA TOPICS
H. C. Wright
Although nearly a century has passed since Marconi's first demonstration or radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour.

The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc. These materials are, in general, cheap to obtain and easily worked with simple tools, encouraging the trial-and-error philosophy which leads to innovation and discovery.

Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.

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Many people live in flats and apartments or other types of accommodation where outdoor aerials are prohibited, or a lack of garden space etc. prevents aerials from being erected. This does not mean you have to forgo shortwave-listening, for even a 20-foot length of wire stretched out along the skirting board of a room can produce acceptable results. However, with some additional effort and experimentation one may well be able to improve performance further.

This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers. Much information is also given on shortwave bands, aerial directivity, time zones, dimensions etc.

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AN INTRODUCTION TO PIC MICROCONTROLLERS
Robert Penfold
Designing your own PIC based projects may seem a daunting task, but it is really not too difficult providing you have some previous experience of electronics.
The PIC processors have plenty of useful features, but they are still reasonably simple and straightforward to use. This book should contain everything you need to know.
Topics covered include: the PIC register set; numbering systems; bitwise operations and rotation; the PIC instruction set; using interrupts; using the analogue to digital converter; clock circuits; using the real time clock counter (RTCC); using subroutines; driving seven segment displays.

166 pages **Temporarily out of print**

PRACTICAL OSCILLATOR CIRCUITS
A. Flind
Extensive coverage is given to circuits using capacitors and resistors to control frequency. Designs using CMOS, timer i.c.s and op.amps are all described in detail, with a special chapter on ``waveform generator" i.c.s. Reliable "white" and "pink" noise generator circuits are also included.
Various circuits using inductors and capacitors are covered, with emphasis on stable low frequency generation. Some of these are amazingly simple, but are still very useful signal sources.
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Contains all of the everyday information that anyone working in electronics will need.
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B. B. Babani
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OPTOELECTRONICS CIRCUITS MANUAL
R. M. Marston
A useful single-volume guide to the optoelectronics device user, specifically aimed at the practical design engineer, technician, and the experimenter, as well as the electronics student and amateur. It deals with the subject in an easy-to-read, down-to-earth, and non-mathematical yet comprehensive manner, explaining the basic principles and characteristics of the best known devices, and presenting the reader with many practical applications and over 200 circuits. Most of the i.c.s and other devices used are inexpensive and readily available types, with universally recognised type numbers.

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OPERATIONAL AMPLIFIER USER'S HANDBOOK
R. A. Penfold
The first part of this book covers standard operational amplifer based "building blocks" (integrator, precision rectifier, function generator, amplifiers, etc), and considers the ways in which modern devices can be used to give superior performance in each one. The second part describes a number of practical circuits that exploit modern operational amplifiers, such as high slew-rate, ultra low noise, and low input offset devices. The projects include: Low noise tape preamplifier, low noise RIAA preamplifier, audio power amplifiers, d.c. power controllers, opto-isolator audio link, audio millivolt meter, temperature monitor, low distortion audio signal generator, simple video fader, and many more.

120 pages **Order code BP335** **£5.45**

A BEGINNERS GUIDE TO CMOS DIGITAL ICs
R. A. Penfold
Getting started with logic circuits can be difficult, since many of the fundamental concepts of digital design tend to seem rather abstract, and remote from obviously useful applications. This book covers the basic theory of digital electronics and the use of CMOS integrated circuits, but does not lose sight of the fact that digital electronics has numerous "real world" applications.
The topics covered in this book include: the basic concepts of logic circuits; the functions of gates, inverters and other logic "building blocks"; CMOS logic i.c. characteristics, and their advantages in practical circuit design; oscillators and monostables (timers); flip/flops, binary dividers and binary counters; decade counters and display drivers.

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AUDIO AND MUSIC

INTRODUCTION TO DIGITAL AUDIO
(Second Edition) Ian Sinclair
The compact disc (CD) was the first device to bring digital audio methods into the home.
This development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.
This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product.

128 pages **Order code PC102** **£8.95**

PROJECTS FOR THE ELECTRIC GUITAR
J. Chatwin
This book is for anyone interested in the electric guitar. It explains how the electronic functions of the instrument work together, and includes information on the various pickups and transducers that can be fitted. There are complete circuit diagrams for the major types of instrument, as well as a selection of wiring modifications and pickup switching circuits. These can be used to help you create your own custom wiring.
Along with the electric guitar, sections are also included relating to acoustic instruments. The function of specialised piezoelectric pickups is explained and there are detailed instructions on how to make your own contact and bridge transducers. The projects range from simple preamps and tone boosters, to complete active controls and equaliser units.

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VALVE AMPLIFIERS
Second Edition. Morgan Jones
This book allows those with a limited knowledge of the field to understand both the theory and practice of valve audio amplifier design, such that they can analyse and modify circuits, and build or restore an amplifier. Design principles and construction techniques are provided so readers can devise and build from scratch, designs that actually work.
The second edition of this popular book builds on its main strength – exploring and illustrating theory with practical applications. Numerous new sections include: output transformer problems; heater regulators; phase splitter analysis; and component technology. In addition to the numerous amplifier and preamplifier circuits, three major new designs are included: a low-noise single-ended LP stage, and a pair of high voltage amplifiers for driving electrostatic transducers directly – one for headphones, one for loudspeakers.

488 pages **Order code NE33** **£26.99**

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Chas Miller
This book is an essential read for everyone working with antique radio and gramophone equipment, including dealers, collectors and valve technology enthusiasts the world over. The emphasis is firmly on the practicalities of repairing and restoring, so technical content is kept to a minimum, and always explained in a way that can be followed by readers with no background in electronics. Those who have a good grounding in electronics, but wish to learn more about the practical aspects, will benefit from the emphasis given to hands-on repair work, covering mechanical as well as electrical aspects of servicing. Repair techniques are also illustrated throughout.
A large reference section provides a range of information compiled from many contemporary sources, and includes specialist dealers for valves, components and complete receivers.

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Vivan Capel
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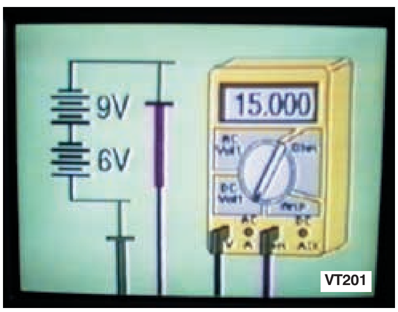

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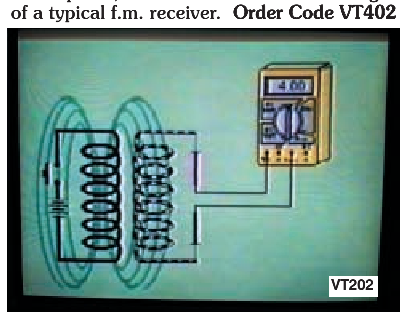

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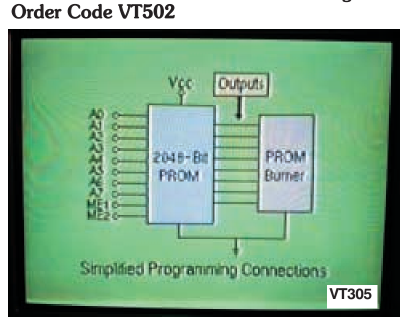

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Back numbers or photostats of articles are available if required – see the *Back Issues* page for details. We do not supply kits or components for our projects.

Please check price and availability in the latest issue.
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Boards can only be supplied on a payment with order basis.

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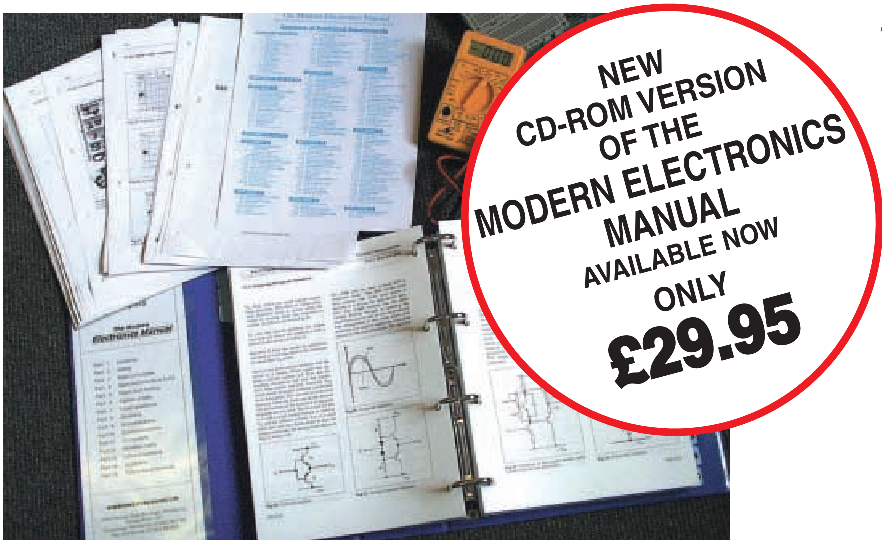

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