THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EVERYDAY
PRACTICAL ELECTRONICS

APRIL 2005

£3.10

SAFETY INTERFACE
A flexible interface for a PIC/logic/PC to mains controller

SIMPLE 550kHz TO 30MHz RECEIVER
Updated Spontaflex circuit for a.m. and s.s.b.

PIC 18F MICROCONTROLLER FAMILY
Using the new range of PICs

NEW SERIES

BACK TO LOGIC BASICS
Part 1 - Simple circuits using CMOS logic gates

04

9 770262 361126

www.epemag.co.uk

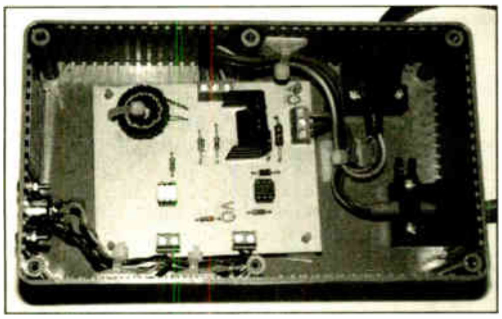
ISSN 0262 3617
PROJECTS ... THEORY ... NEWS ...
COMMENTS ... POPULAR FEATURES ...

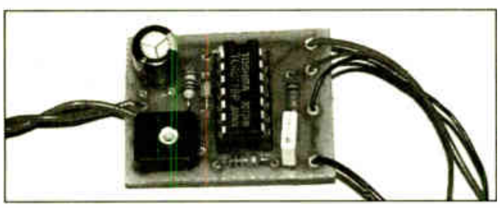
VOL. 34. No. 4 APRIL 2005
Cover illustration: Mike Agliolo/Science Photo Library

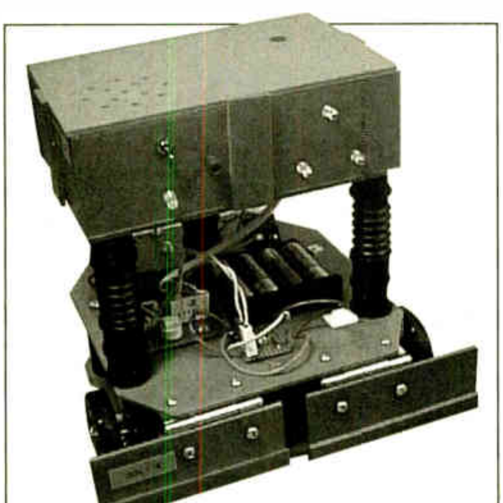
EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

www.epemag.co.uk
EPE Online: www.epemag.com







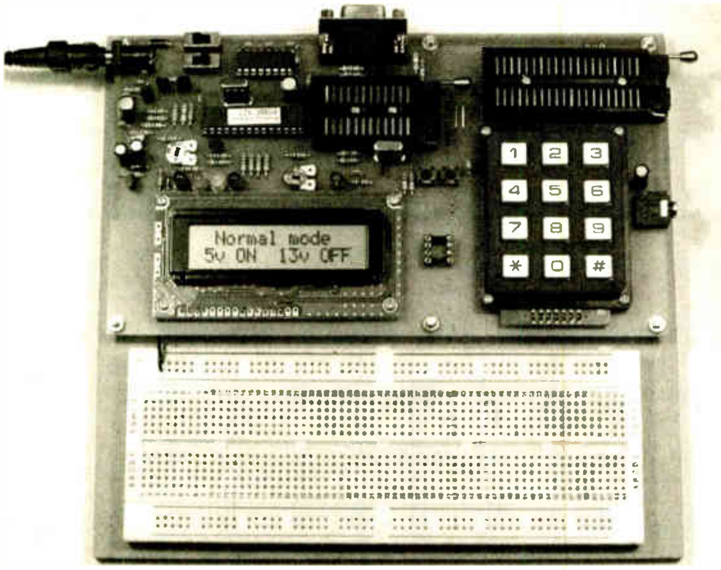
Our May 2005 issue will be published on Thursday, 14 April 2005. See page 227 for details

Projects and Circuits

Series and Features

Regulars and Services

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.

The heart of our system is two real books which lie open on your desk while you use your computer to type in the programme and control the hardware. Start with four very simple programmes. Run the simulator to see how they work. Test them with real hardware. Follow on with a little theory.....

Our complete PIC training and development system consists of our universal mid range PIC programmer, a 306 page book covering the PIC16F84, a 262 page book introducing the PIC16F877 family, and a suite of programmes to run on a PC. The module is an advanced design using a 28 pin PIC16F870 to handle the timing, programming and voltage switching requirements. The module has two ZIF sockets and an 8 pin socket which between them allow most mid range 8, 18, 28 and 40 pin PICs to be programmed. The plugboard is wired with a 5 volt supply. The software is an integrated system comprising a text editor, assembler disassembler, simulator and programming software. The programming is performed at 5 volts, verified with 2 volts or 3 volts applied and verified again with 5.5 volts applied to ensure that the PIC is programmed correctly over its full operating voltage. DC version for UK, battery version for overseas. UK orders include a plugtop power supply.

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 PIC16F870 test PICs....... £159.00
(Postage & insurance UK £10, Europe £15, Rest of world £25)

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 half a 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.

Hardware & Ordering Information

The programmer module for both systems connects to the serial port of your PC (COM1 or COM2). All our software referred to in this advertisement will operate within Windows 98, XP, NT, 2000 etc.

Telephone with Visa, Mastercard or Switch, or send cheque/PO. All prices include VAT if applicable.

Web site:- www.brunningsoftware.co.uk

PIC Project Modules

Our PIC Training & Development System is the ideal way for any newcomer to start learning about PIC microcontrollers. Now we have created our PIC Project Modules System to help with your next stage of learning.

The new system consists of five modules, a new book featuring one of the latest PIC Microcontrollers, software to run on your PC with ready made library routines, interconnecting cables and plugtop power supply (UK only):-

Module 1 - Programmer Module
with PIC programming software... £49.50
Module 2 - Display Driver Module....£43.30
Module 3 - Motor Control Module....£28.50
Module 4 - General I/O Module......£24.70
Module 5 - RS-232 Module
with PC assembler software......£37.60

Book PIC Project Modules..........£20.00
Plugtop PSU for UK...............£ 4.00
PC serial lead (9 way D)...........£ 3.80
Two 10 way interconnecting leads... £ 6.00

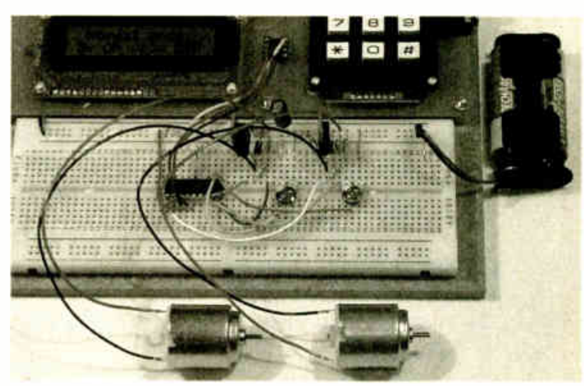
Total price for the complete system.. £135.00

The Motor Control Module although only 70mm by 42mm is the powerful king pin. Two outputs can each control a DC motor up to 12 volts at 4 amps continuous (or be used to switch DC for any other use such as mains switching relays). The speed of the two motors can be remotely controlled using the onboard serial port to connect directly to the Display Driver Module with its 16 character by 2 line display and keypad, or connected to your PC via the RS-232 module (40mm x 45mm). If you want to remotely control more motors or switch more relays that is no problem – daisy chain modules into the serial link and programme each of them with a unique code. The book explains how to do it.

The General I/O Module also has a serial port for daisy chaining into the same system. It has 3 CMOS or analogue inputs (connecting to the 10 bit analogue to digital converter), and two high current 5 volt outputs for switching relays or motors, or which can be linked to on board inductors for generating step up voltages or TENS or muscle exercise waveforms.

Modules 1, 2 and 3 have a DC input socket and regulator. One input will run the whole chain.

For the latest information and pictures see our web site. Only sold as a complete system.



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.

The PIC16F627 is then introduced as a low cost PIC16F84. We use the PIC16F627 as a step up switching regulator, and to control the speed of a DC motor with maximum torque still available. We study how to use a PIC to switch mains power using an optoisolated triac driving a high current triac. Finally we study how to use the PICs USART for serial communication to a PC.

Mail order address:

Brunning Software 138 The Street, Little Clacton, Clacton-on-sea, Essex, CO16 9LS. Tel 01255 862308

NEXT MONTH

CROSSWORD SOLVER

If, like the author, you are a crossword puzzle fan, you will have frequently found yourself stuck on words where you have a few letters but no ideas. A dictionary is of little use if you do not have the letters at the beginning of the word.
The Crossword Solver was created to help out. It stores a large dictionary – over 57,000 words – in a small flash memory i.c. Using a simple keypad you can enter the letters you do know for a word and the Crossword Solver will scan the dictionary and display all the words that match. It's very fast, taking only a few milliseconds to find each word.
Another feature is the anagram solver – type in the letters of the anagram, and the Crossword Solver will display all the words that use combinations of those letters. The results can be surprising!

20W AMPLIFIER MODULE

A versatile, wide band, low distortion building block

This single chip, easy to build design can deliver 11W per channel or 20W in full bridge mode. The frequency response is 10Hz to over 100kHz with distortion at 1kHz below 0·03%. It features short-circuit protection, thermal shutdown, has a clipping detector and on/off noise muting.
A very versatile module using the STA7360 integrated circuit.

DAB AERIAL

This simple quarter-wave aerial design costing less than £10 to build will give good reception of DAB signals when room, loft or outside mounted. The design can be easily modified for use on other v.h.f./u.h.f. bands, for instance the 2m and 70m amateur bands.
The prototype was conceived and built in about an hour and has improved reception of DAB signals from signal strengths of 40% to 50% to a solid 100% when loft mounted. Thus allowing reception of extra multiplex frequencies.

BACK TO BASICS 2

Two more simple projects using CMOS logic i.c.s. – A Water Level Detector and a Burglar Alarm

Water Level Detector
The Water Level Detector uses an a.c. voltage to sense the presence of a liquid, thus avoiding the probe corrosion problems of many simple detectors. Just one i.c. is used and the unit provides an audible and/or visual warning.

Burglar alarm
Providing circuits for both normally-open and normally-closed contacts the Burglar Alarm also provides entry and exit delays and can control both internal and external sounders. All this from one logic i.c., one transistor a few diodes and a handful of passive components.

see page 242

See page 304

MAY 2005 ISSUE ON SALE THURSDAY, APRIL 14

EPE PIC PROJECTS VOLUME 1 MINI CD-ROM

A plethora of 20 "hand-PICked" PIC Projects from selected past issues of *EPE*

Together with the PIC programming software for each project plus bonus articles

ONLY £14.45 INCLUDING VAT and P&P

The projects are:

PIC-Based Ultrasonic Tape Measure
You've got it taped if you PIC this ultrasonic distance measuring calculator

EPE Mind PICkler
Want seven ways to relax? Try our PIC-controlled mind machine!

PIC MIDI Sustain Pedal
Add sustain and glissando to your MIDI line-up with this inexpensive PIC-controlled effects unit

PIC-based MIDI Handbells
Ring out thy bells with merry tolling – plus a MIDI PIC-up, of course!

EPE Mood PICker
Oh for a good night's sleep! Insomniacs rejoice – your wakeful nights could soon be over with this mini-micro under the pillow!

PIC Micro-Probe
A hardware tool to help debug your PIC software

PIC Video Cleaner
Improving video viewing on poorly maintained TVs and VCRs

PIC Graphics LCD Scope
A PIC and graphics LCD signal monitor for your workshop

PIC to Printer Interface
How to use dot-matrix printers as data loggers with PIC microcontrollers

PIC Polywhatsit
A novel compendium of musical effects to delight the creative musician

PIC Magick Musick
Conjure music from thin air at the mere untouching gesture of a fingertip

PIC Mini-Enigma
Share encrypted messages with your friends — true spymaster entertainment

PIC Virus Zapper
Can disease be cured electronically? Investigate this controversial subject for yourself

PIC Controlled Intruder Alarm
A sophisticated multi-zone intruder detection system that offers a variety of monitoring facilities

PIC Big-Digit Display
Control the giant ex-British Rail platform clock 7-segment digits that are now available on the surplus market

PIC Freezer Alarm
How to prevent your food from defrosting unexpectedly

PIC World Clock
Graphically displays world map, calendar, clock and global time-zone data

PICAXE Projects
A 3-part series using PICAXE devices – PIC microcontrollers that do not need specialist knowledge or programming equipment

PIC-based Tuning Fork and Metronome
Thrill everyone by at long last getting your instrument properly tuned!

Versatile PIC Flasher
An attractive display to enhance your Christmas decorations or your child's ceiling

Order on-line from

www.epemag.wimborne.co.uk/shopdoor.htm
or www.epemag.com (USA $ prices)
or by Phone, Fax, Email or Post.

NOTE: The PDF files on this CD-ROM are suitable to use on any PC with a CD-ROM drive. They require Adobe Acrobat Reader.

EPE PIC PROJECTS CD-ROM ORDER FORM

Please send me .... (quantity) EPE PIC PROJECTS VOL 1 CD-ROM

Price £14.45 each – includes postage to anywhere in the world.

Name ....

Address ....

....

....

.... Post Code ....

☐ I enclose cheque/P.O./bank draft to the value of £ ....

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch

£ ....

Card No. ....

Card Security Code .... (The last 3 digits on or just under the signature strip)

Start Date .... Expiry Date .... Switch Issue No. ....

SEND TO: **Everyday Practical Electronics, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND.**
Tel: 01202 873872. Fax: 01202 874562.
Email: orders@epemag.wimborne.co.uk

Payments must be by card or in £ Sterling – cheque or bank draft drawn on a UK bank.

Normally supplied within seven days of receipt of order.
Send a copy of this form, or order by letter if you do not wish to cut your issue.

BECOME A PIC PROJECT BUILDER WITH THE HELP OF *EPE!*

VERSION 2 NOW AVAILABLE

EPE PIC RESOURCES CD-ROM V2

Version 2 includes the EPE PIC Tutorial V2 series of Supplements (EPE April, May, June 2003)

ONLY £14.45 INCLUDING VAT and P&P

The CD-ROM contains the following Tutorial-related software and texts:

- EPE PIC Tutorial V2 complete series of articles plus demonstration software, John Becker, April, May, June '03
- PIC Toolkit Mk3 (TK3 hardware construction details), John Becker, Oct '01
- PIC Toolkit TK3 for Windows (software details), John Becker, Nov '01

Plus these useful texts to help you get the most out of your PIC programming:

- How to Use Intelligent L.C.D.s, Julyan Ilett, Feb/Mar '97
- PIC16F87x Microcontrollers (Review), John Becker, April '99
- PIC16F87x Mini Tutorial, John Becker, Oct '99
- Using PICs and Keypads, John Becker, Jan '01
- How to Use Graphics L.C.D.s with PICs, John Becker, Feb '01
- PIC16F87x Extended Memory (how to use it), John Becker, June '01
- PIC to Printer Interfacing (dot-matrix), John Becker, July '01
- PIC Magick Musick (use of 40kHz transducers), John Becker, Jan '02
- Programming PIC Interrupts, Malcolm Wiles, Mar/Apr '02
- Using the PIC's PCLATH Command, John Waller, July '02
- EPE StyloPIC (precision tuning musical notes), John Becker, July '02
- Using Square Roots with PICs, Peter Hemsley, Aug '02
- Using TK3 with Windows XP and 2000, Mark Jones, Oct '02
- PIC Macros and Computed GOTOs, Malcolm Wiles, Jan '03
- Asynchronous Serial Communications (RS-232), John Waller, unpublished
- Using I²C Facilities in the PIC16F877, John Waller, unpublished
- Using Serial EEPROMs, Gary Moulton, unpublished
- Additional text for EPE PIC Tutorial V2, John Becker, unpublished

NOTE: The PDF files on this CD-ROM are suitable to use on any PC with a CD-ROM drive. They require Adobe Acrobat Reader – included on the CD-ROM

Order on-line from
www.epemag.wimborne.co.uk/shopdoor.htm
or www.epemag.com (USA $ prices)
or by Phone, Fax, Email or Post.

EPE PIC RESOURCES V2 CD-ROM ORDER FORM

Please send me .... (quantity) EPE PIC RESOURCES V2 CD-ROM

Price £14.45 each – includes postage to anywhere in the world.

Name ....

Address ....

....

....

.... Post Code ....

☐ I enclose cheque/P.O./bank draft to the value of £ ....

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch/Maestro

£ ....

Card No. ....

Card Security Code .... (The last 3 digits on or just under the signature strip)

Valid From .... Expiry Date ....

Switch Issue No. ....

SEND TO: **Everyday Practical Electronics, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND.**
Tel: 01202 873872. Fax: 01202 874562.
Email: orders@epemag.wimborne.co.uk

Payments must be by card or in £ Sterling – cheque or bank draft drawn on a UK bank.

Normally supplied within seven days of receipt of order.

Send a copy of this form, or order by letter if you do not wish to cut your issue.

BECOME A PIC WIZARD WITH THE HELP OF *EPE!*

MAGENTA
ELECTRONICS LTD

EE272 135 Hunter Street, Burton-on-Trent, Staffs. DE14 2ST
Tel 01283 565435 Fax 546932
http://www.magenta2000.co.uk
E-mail: sales@magenta2000.co.uk
All Prices include V.A.T. ADD £3.00 PER ORDER P&P. £6.99 next day

VISA

MAIL ORDER ONLY • CALLERS BY APPOINTMENT

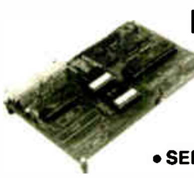
EPE PROJECT PICS
Programmed PICs for *EPE Projects
12C508/9 – £3.90; 16F627/8 – £4.90
16C84/16F84/16C71 – £5.90
16F876/877 – £10.00
All inc. VAT and Postage
(*Some projects are copyright)

EPE MICROCONTROLLER P.I. TREASURE HUNTER
The latest MAGENTA DESIGN – highly stable & sensitive – with I.C. control of all timing functions and advanced pulse separation techniques.
- High stability drift cancelling
- Easy to build & use
- No ground effect, works in seawater

- Detects gold, silver, ferrous & non-ferrous metals
- Efficient quartz controlled microcontroller pulse generation.
- Full kit with headphones & all hardware

KIT 847 ....£63.95

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



KIT 621
£99.95
- ON BOARD 5V REGULATOR
- PSU £6.99
- SERIAL LEAD £3.99

Stepping Motors


MD100..Std 100 step..£9.99
MD200...200 step...£12.99
MD24...Large 200 step...£22.95

PIC PIPE DESCALER
- SIMPLE TO BUILD
- SWEPT FREQUENCY
- HIGH POWER OUTPUT
- AUDIO & VISUAL MONITORING

An affordable circuit which sweeps the incoming water supply with variable frequency electromagnetic signals. May reduce scale formation, dissolve existing scale and improve lathering ability by altering the way salts in the water behave.
Kit includes case, P.C.B., coupling coil and all components.
High coil current ensures maximum effect. L.E.D. monitor.

KIT 868 .... £22.95 POWER UNIT......£3.99

MICRO PEsT SCARER
Our latest design – The ultimate scarer for the garden. Uses special microchip to give random delay and pulse time. Easy to build reliable circuit. Keeps pets/pests away from newly sown areas, play areas, etc. uses power source from 9 to 24 volts.
- **RANDOM PULSES**
- **HIGH POWER**
- **DUAL OPTION**

Plug-in power supply £4.99

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

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

KIT 856..........................£28.00

★ TENS UNIT ★

DUAL OUTPUT TENS UNIT
As featured in March '97 issue.
Magenta have prepared a FULL KIT for this. excellent new project. All components, PCB, hardware and electrodes are included. Designed for simple assembly and testing and providing high level dual output drive.

Set of 4 spare electrodes £6.50

KIT 866. . Full kit including four electrodes £32.90

1000V & 500V INSULATION TESTER


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

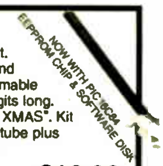
KIT 848............£32.95

EPE TEACH-IN 2000
Full set of top quality *NEW* components for this educational series. All parts as specified by *EPE*. Kit includes breadboard, wire, croc clips, pins and all components for experiments, as listed in introduction to Part 1.
**Batteries and tools not included.*

TEACH-IN 2000 -
KIT 879 £44.95
MULTIMETER £14.45

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

NOW WITH PIC16C84 CHIP & SOFTWARE DISK
EEPROM



KIT 849 ....£16.99

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

KIT 790 ....£29.90

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

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

KIT 861 ....£34.99
ALSO AVAILABLE Built & Tested. . . £48.99

MOSFET MkII VARIABLE BENCH POWER SUPPLY 0-25V 2·5A
Based on our Mk1 design and preserving all the features, but now with switching pre-regulator for much higher efficiency. Panel meters indicate Volts and Amps. Fully variable down to zero. Toroidal mains transformer. Kit includes punched and printed case and all parts. As featured in April 1994 *EPE*. An essential piece of equipment.

Kit No. 845 ....£64.95

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

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

KIT 812.............................£15.00

SIMPLE PIC PROGRAMMER
KIT 857... £12.99
Includes PIC16F84 chip disk, lead, plug, p.c.b., all components and instructions
Extra 16F84 chips £3.84
Power Supply £3.99

EVERYDAY
PRACTICAL
ELECTRONICS

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

VOL. 34 No. 4 APRIL 2005

Editorial Offices:
EVERYDAY PRACTICAL ELECTRONICS EDITORIAL
WIMBORNE PUBLISHING LTD., 408 WIMBORNE ROAD EAST,
FERNDOWN, DORSET BH22 9ND
Phone: (01202) 873872. Fax: (01202) 874562.
Email: enquiries@epemag.wimborne.co.uk
Web Site: www.epemag.co.uk
EPE Online (downloadable version of *EPE*): www.epemag.com
EPE Online Shop: www.epemag.wimborne.co.uk/shopdoor.htm
See notes on **Readers' Technical Enquiries** below – we regret lengthy technical enquiries cannot be answered over the telephone.
Advertisement Offices:
EVERYDAY PRACTICAL ELECTRONICS ADVERTISEMENTS
MILL LODGE, MILL LANE,
THORPE-LE-SOKEN, ESSEX CO16 0ED
Phone/Fax: (01255) 861161 Email: epeads@aol.com

The Wonderful World of Computers

Technology seems to be the bain of our lives. One of our main typesetting computers was getting a bit long in the tooth and struggling with the amount of work. When it started crashing too often we decided it was time for an upgrade – not particularly expensive these days but of course usually fraught with problems. We went for a "big" system running XP Pro. What we had not bargained for was that it would not take our old Zip drive – still used occasionally for incoming articles – that it would not run our subscriptions software, which was used on this machine for another magazine – and when it came to make PDFs to send to the printer we could not get it to produce them in the correct way. All the time and frustration became a major hastle and forced us to change the way we work. And this is progress!

Sometimes I wonder if all the technology we use in the office is actually saving us any time and cost. It is not as if we are technical virgins. At least we have some idea what to do when things go wrong, but we still need the help sections on the software – which of course never answer the questions we have – and the help lines, which never seem to be answered. We still have to sort out the set-up of Acrobat Distiller on our XP machine, which seems to be too clever for its own good.

To Chat Or Not To Chat?

Regular users of our Chat Zone (**www.epemag.co.uk**) will no doubt be aware that we have been suffering from regular Spam attacks – which keep our webmaster Alan Winstanley busy deleting the idiotic stuff that appears from nincompoops around the world. Why they feel it is necessary to post loads of rubbish that no one in their right minds bothers to read, and which goes nowhere, is totally beyond me. Unfortunately in the last few days the Chat Zone has been totally wiped out more than once. We have yet to discover the reason but it is becoming too time consuming to keep it up and running.

This means that, as I write, we are reviewing the whole thing. It is a very valuable resource which we are keen to keep going as it is a great way for hobbyists and engineers to help each other. Hopefully by the time you read this we will have sorted something out, though this may mean a totally new look Chat Zone where you might have to register to use it – something we had hoped to avoid in a effort to make it instantly available to anyone anywhere. I hope we can continue to provide this service despite the attempts by idiots to wreck it.

READERS' TECHNICAL ENQUIRIES
E-mail: techdept@epemag.wimborne.co.uk
We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply *must* be accompanied by a **stamped self-addressed envelope or a self-addressed envelope and international reply coupons.**

PROJECTS AND CIRCUITS
All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.
A number of projects and circuits published in *EPE* employ voltages than can be lethal. **You should not build, test, modify or renovate any item of mains powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.**

COMPONENT SUPPLIES
We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers (see *Shoptalk*). **We advise readers to check that all parts are still available before commencing any project in a back-dated issue.**

ADVERTISEMENTS
Although the proprietors and staff of EVERYDAY PRACTICAL ELECTRONICS take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are *bona fide*, the magazine and its Publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or in inserts.
The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture.

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

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 $10.99US (approx £7) per year available from **www.epemag.com**

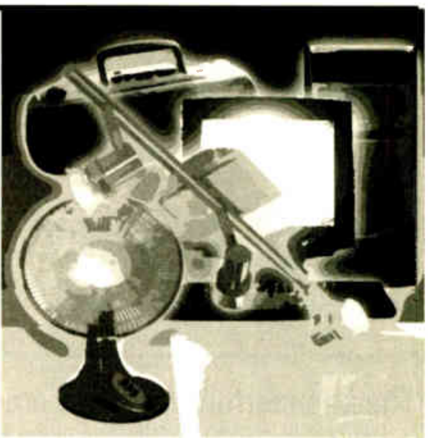
SUBSCRIPTIONS
Subscriptions for delivery direct to any address in the UK: 6 months £16.50, 12 months £31, two years £57; Overseas: 6 months £19.50 standard air service or £28.50 express airmail, 12 months £37 standard air service or £55 express airmail, 24 months £69 standard air service or £105 express airmail. To subscribe from the **USA** or **Canada** see the last magazine page.
Online subscriptions, for downloading the magazine via the Internet, $10.99US (approx £7) for one year available from **www.epemag.com.**
Cheques or bank drafts (in £ **sterling** only) payable to *Everyday Practical Electronics* and sent to EPE Subs. Dept., Wimborne Publishing Ltd. 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872. Fax: 01202 874562. **Email:** subs@epemag.wimborne.co.uk. Also via the **Web** at: **http://www.epemag.wimborne.co.uk.** Subscriptions start with the next available issue. We accept MasterCard, Amex, Diners Club, Maestro or Visa. (For past issues see the *Back Issues* page.)

BINDERS
Binders to hold one volume (12 issues) are available from the above address. These are finished in blue p.v.c., printed with the magazine logo in gold on the spine. Price £6.95 plus £3.50 p&p (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery – more for overseas.*

Payment in £ sterling only please. Visa, Amex, Diners Club, Maestro and MasterCard accepted. Send, fax or phone your card number, card expiry date and card security code (the last 3 digits on or just under the signature strip), with your name, address etc. Or order on our secure server via our UK web site. Overseas customers – your credit card will be charged by the card provider in your local currency at the existing exchange rate.

Constructional Project

Safety Interface



David Clark

A flexible safety interface for a PIC/Logic/PC to mains power controller

This project will enable the constructor to experiment in regulating power to, or simply switching on and off, mains powered equipment, via a PIC or logic circuit, or if used with *EPE*'s serial interface, a PC, in safety.

The advent of the PIC microcontroller has revolutionised electronics in recent years, and not least to benefit from this has been the hobby sector. The number of components needed for a control circuit has dropped dramatically, and controlling devices that operate at low voltages is relatively straightforward. Controlling mains powered devices, however, is generally not so straightforward, primarily for a very practical reason.

Breadboard Not Allowed

This reason is, of course, safety. Mains safety poses a particular problem for the experimenter – circuits with parts at mains voltage should certainly not be "lashed up" on a patch board, or "bread" board. When working with low voltages, inexperience, or an occasional lapse of concentration, is unlikely to have consequences that are more serious than needing to replace damaged components.

Working with higher voltages is a different matter, and needs consideration in several areas. Safe practice in using components operating at mains voltage applies not only to preventing an operator or user from touching parts at high voltage, but also to the "designing in" aspects of safety in terms of physically isolating the low voltage circuits from the high voltage ones.

The techniques that can be used to achieve this include using minimum distances between components, p.c.b. tracks and wiring, as specified in safety standards, and fixing wires in position so that safety cannot be compromised even if a connection breaks or comes loose, for example. They also include using optical or transformer isolation "within" components, and last but not least, ensuring that the device is housed in a suitable enclosure.

Flexible Dedication

The limitations imposed by not being able to use a breadboard can be overcome by building a dedicated mains interface, properly boxed, with appropriately isolated input and output connectors. This leaves another inconvenience to be considered, in that the interface required for a power regulator is different to one required for an on/off controller, and so at least two boxed devices would be needed to cover most experimenters' requirements.

This entails increased costs, not to mention the time and effort that needs to be spent in building them, time and effort that the electronics enthusiast would probably prefer to spend on experimenting.

The Safety Interface presented in this article provides a solution to these problems in one relatively simple project. By selecting which components to fit on a single p.c.b., the constructor can build a simple on/off controller, or alternatively a device that will provide either a power regulation controller function or an on/off controller function, by exchanging one socket-based component.

When built and used as described here, this interface can be safely connected to the controlling circuitry via an isolated five-pin DIN connector. Mains power for the interface is obtained by plugging a normal three-pin mains plug into a household mains socket, and the controlled mains output is available on a "flying" household mains socket hard-wired to the interface.

With the interface box cover properly fitted, no part at mains voltage is accessible. This device will allow a relatively inexperienced constructor to experiment safely with mains powered devices, and it should also be very useful to the more experienced user who wants a general-purpose interface to use at the design stage of a project.

It is essential to note that this mains powered unit should only be constructed by those who are suitably experienced or supervised.

Specifications

When used as a simple on/off controller, no separate low voltage supply is needed for this project; when used for power regulation a power supply that matches the voltage requirements of the controlling circuit, i.e. 5V for a PIC control circuit for example, is needed.

This power supply is provided to the interface via the same isolated DIN connector that carries the digital input and output control signals; voltage levels of up to 16V absolute maximum can be used, making the interface compatible with all commonly used logic types. The power supply drives one logic gate only, and it would be expected that this power would normally be derived directly from the power supply of the controlling circuit.

Details of connecting the interface to a control circuit will be given in a later section. Note that although the component that switches the mains (a triac) is rated at

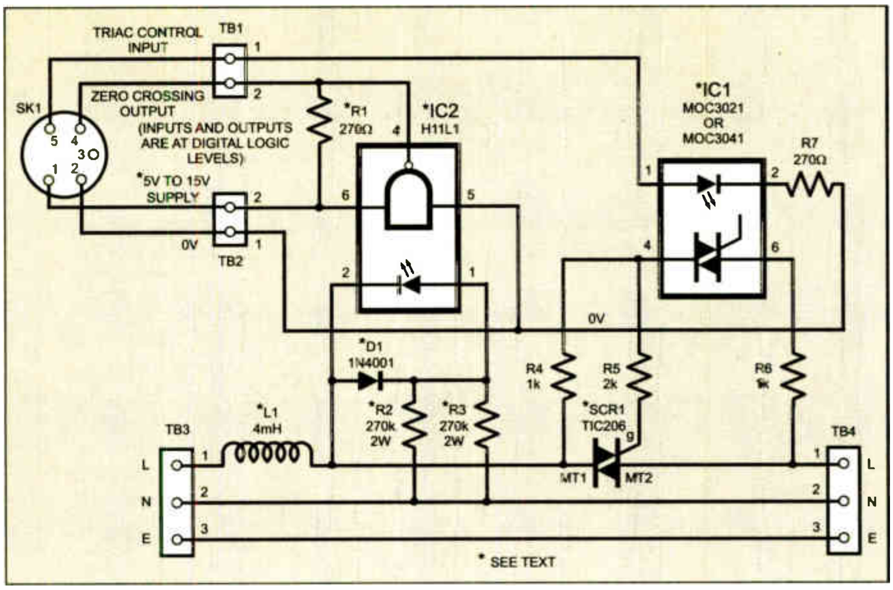


Fig. 1. Complete circuit diagram for the Safety Interface

400V and 4A, the circuit's physical design is such that it is recommended that loads of more than about 1A at mains voltage are not used.

This is because of the limitations imposed by the current carrying capacity of associated components, wiring and p.c.b. tracks, and the heat sinking requirements of the triac itself. Some advice (and some warnings) about modifying the design for higher voltage and current applications is given in a later section.

About Triacs

To control devices that use alternating current (a.c.) and consume significant amounts of power (i.e. those that use high voltage and/or high current), via semiconductor devices, a triac is generally used. Details of how these devices work was covered in *Circuit Surgery* March 2004, to which the reader is referred for a more detailed explanation.

The *Circuit Surgery* article also explains the basic principles behind how the triac is used in a basic light dimmer circuit. This article builds on that in the sense that the interface described here will enable the dimmer function to be implemented by a PIC microcontroller, which if programmed appropriately can give much better control of the light settings.

Isolation

To provide isolation between low voltage and high voltage circuits, opto-isolators are used in this interface. In the power regulation version an opto-isolated, dedicated zero-crossing detector provides logic level output pulses that indicate to the power regulation controlling circuit the moment when the mains voltage crosses the zero volts level.

Similarly, for both the on/off controller and the power regulation version, an opto-isolated triac controls the gate trigger current to the main power triac. There are two types of opto-isolated triac used. For simple on/off control a zero-crossing type is used. If power regulation is required however, a random phase type is used. The differences and how they are used in practice in this project will be described later.

Circuit Details

The circuit diagram for the full version of the Safety Interface is shown in Fig.1.

Overall, the interface can be considered to consist essentially of two distinct parts. The main part is the section that does the actual switching of mains power, and this is based around IC1 and SCR1. When the interface is being used as a simple on/off controller, IC1 is an MOC3041. This is an optically coupled, bilateral switch, light activated, zero voltage crossing, triac, as the data sheet puts it.

An in-built detector monitors the voltage across the internal triac, and, assuming a signal is being applied to the control input, triggers the triac into conduction, but only when the a.c. voltage across the triac next approaches zero. If the control voltage is removed, the triac stops conducting, again when the voltage across the triac next drops to zero. All triacs, incidentally, once switched on, continue to conduct until the voltage across them drops to around zero. The timing for this is shown in Fig.2.

For the triac in IC1 to actually conduct, there must be a voltage across it, of course; resistors R4 and R6 act as a voltage divider to provide this voltage. When the internal triac is not conducting it has a high internal resistance; there is therefore no current through the voltage divider, and so no current into the gate of the power triac, SCR1. SCR1 therefore does not conduct, and the voltage at the mains output connector (TB4) is zero.

If IC1's internal triac begins to conduct, however, there will be a pulse of current to the gate of SCR1 and it too will begin to conduct. Mains voltage will appear on the mains output connector, and a current will flow between the live and neutral terminals if a load is connected between them. The voltage across the MT1 and MT2 terminals of SCR1 will then fall, and a small current will continue to pass through the voltage divider and IC1's internal triac.

SCR1 will thus re-trigger at each half-cycle and so continue to conduct as long as there is a control voltage applied to the input of IC1. When this control voltage is removed, SCR1 will stop conducting at the end of the next half-cycle, when the mains input voltage is around zero volts once more.

Power Regulator

When the interface is being used to regulate power, an MOC3021 instead of an MOC3041 is used for IC1. This is a random-phase, opto-isolator, triac driver output, device. The operation of the circuit is similar to that described for the simple on/off controller, except that the MOC3021 does not force its internal triac to conduct only at the zero-crossing point, as its name implies.

It will begin to conduct when a control voltage appears on IC1's input, which of course triggers SCR1 into conduction at the same moment. In accordance with normal triac behaviour, both will stop conducting at the end of the next mains half-cycle.

In order to regulate the power to a load connected to the mains output connector (TB4) in a practical circuit, it is necessary to delay the point in each mains half-cycle at which the triac is triggered into conduction. The earlier in the cycle the triggering occurs, the more power is delivered to the load. The timing for this is shown in Fig.3.

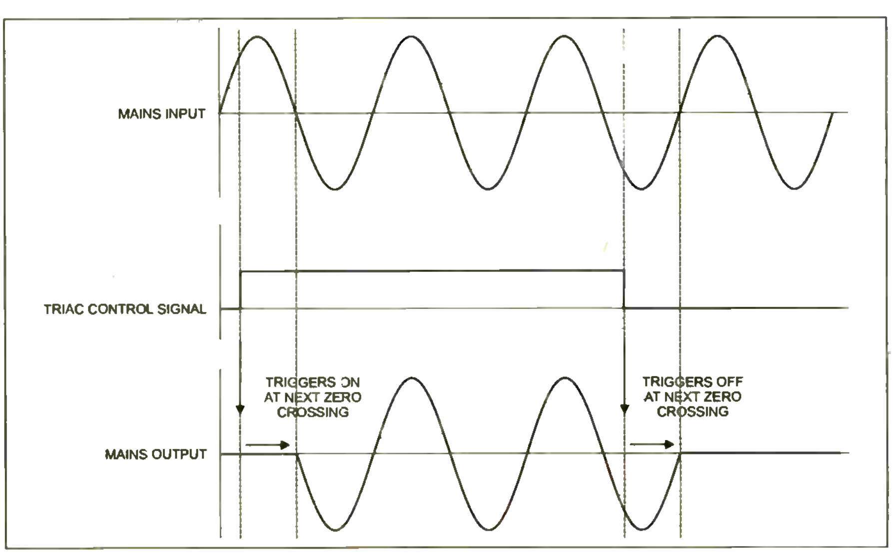


Fig.2. Example of triac-triggered waveform timing control

In fact, as Fig.3 shows, the mark and space periods of the zero crossing output are not equal, due to a limitation inherent in the simplicity of the design. The leading edge occurs slightly late, and the trailing edge slightly early, since the edge is only triggered once the IC1 l.e.d. current rises above or falls below a certain value, which is a characteristic of the opto-isolator operation.

This limitation can be partly overcome in the controlling software or electronics, by triggering according to the required delay after a rising edge only, and making the second trigger always occur 10 milliseconds after the first. (This is the time period of half a mains cycle, of course.) This approach brings with it the cost of a slight drop in maximum power output available during triac mid-phase switching, but this can itself be overcome by switching the triac "full on" once this limit is reached.

Similarly, the triac can be switched completely off at the other extreme. These techniques are used in the software for the example PIC Light Dimmer design given in the later PIC Control section. Fig.4 shows the irregular waveforms that can occur when these techniques are not used, and demonstrates how the performance is greatly reduced.

More detail of the working of the zero crossing circuit at component level is given in the next Zero Crossing section.

The final component of interest in this section is L1. This is a high frequency choke, used to limit the radio-frequency (r.f.) interference that can occur when a triac is triggered into conduction when the voltage across it, and the current through it, is high, as is usually the case in a power regulation function.

Zero Crossing

The second, zero crossing detection, part of the interface is based around IC2. Note that the timing information that this second part of the circuit provides is not required if only the simple on/off controller is being constructed, and so it is these components that are omitted in this case.

IC2 is a microprocessor compatible, Schmitt trigger, optically coupled, isolator, with its input connected across the live and neutral terminals of the mains input. Resistors R2 and R3 (power regulator version) limit the current through, and D1 the reverse voltage across, the input of the device.

Two resistors in parallel, each with a power rating of 2W, are used here in order to provide the required resistance value and power dissipation, given the limited range of values actually available at these ratings. A high voltage rating is necessary to operate at mains voltages of course, and the high power dissipation is needed because, even though only a few milliamps pass through the resistor, this corresponds to a relatively high power at these voltages.

As with the other opto-isolator devices used in this project, the input of IC2 is essentially an internal light emitting diode (l.e.d.). This triggers the rising and falling edges of the zero crossing detector as described earlier. The l.e.d. conducts during one mains half-cycle, producing a pulse from the device output.

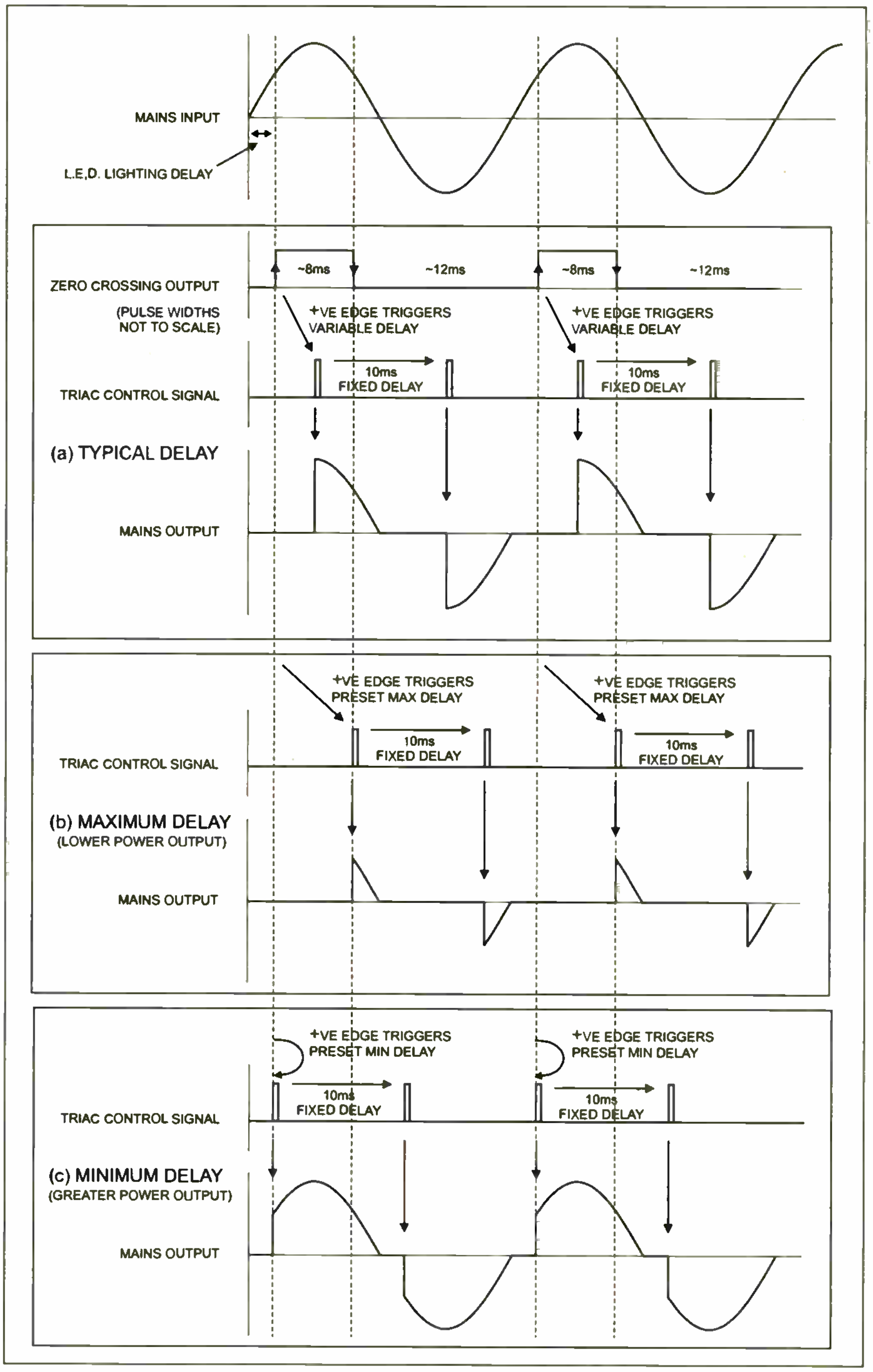


Fig.3. Power regulation using positive-edge-only interrupt trigger

The last component to be mentioned that is connected with the zero crossing detector is R1, which acts as a straightforward pull-up resistor. The choke, L1, can also be omitted if only the on/off control option is built, since in this case the use of a zero voltage crossing triac will minimise r.f. interference. Choke L1 then needs to be replaced by a wire link.

Timing Control

How the zero crossing output signal is used to begin timing the delay needed before generating the triac control input signal, and the implementation of the timing, depends of course on the application, and so is not specifically part of this article. For the PIC-controlled Light Dimmer example given later the delay is software generated.

Serious Health Warning

Although this project was designed with the less experienced constructor in mind, it is essential that those who have not built mains powered projects before ask a more experienced person to "look it over" before putting it into use. Always remember that mains voltages can be lethal.

There is no setting up required for this project, and so no reason for the device to be plugged in without the enclosure cover fixed in place. If the project does not work first time, again, ask an experienced person to check it over. Professionals working on mains powered equipment do so using a mains isolating transformer for protection; this is a luxury few hobbyists have.

Never work on a mains powered project while it is plugged into the mains

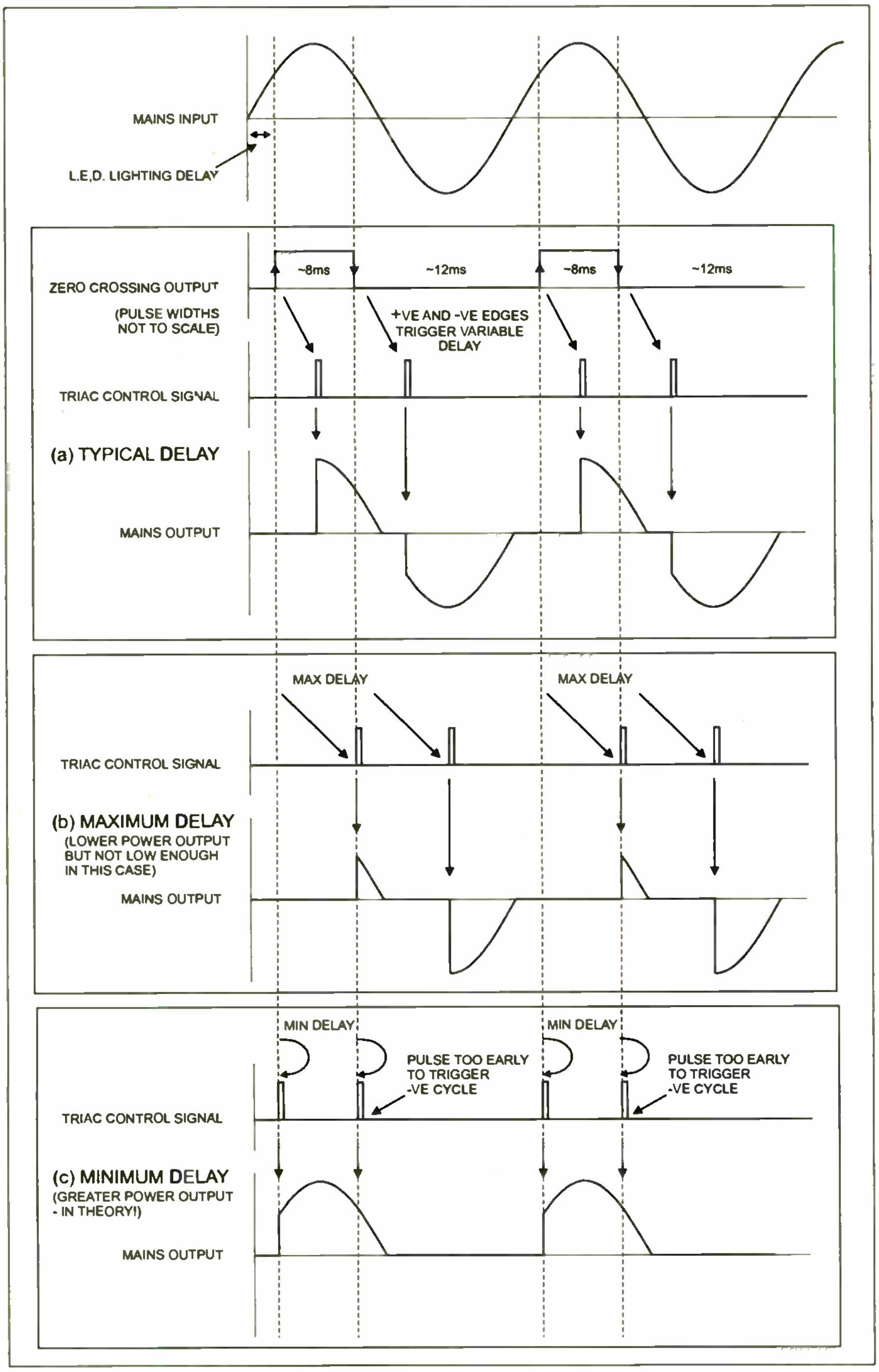


Fig.4. Power regulation using both positive and negative interrupt triggering can cause poor performance

unless you are ***absolutely sure*** you know what you are doing. If you are going to take the risk, the usual advice is to keep one hand in your pocket; this way mains current cannot flow across your chest, a path almost guaranteed to cause cardiac arrest. Another useful tip is to place a piece of A4 card with a "Danger – High Voltages" warning in large lettering near to, or preferably over, the circuit, as a reminder. And **never leave such a situation unattended** if another person, especially a child, might wander in.

Construction

The printed circuit board component side layout and wiring details, and the full size copper foil master for the Safety Interface are shown in Fig.5. This board is available from the *EPE PCB Service*, code 497.

If building the On/Off Only version, omit components R1 to R3, D1, L1 and IC2, and put a link wire in place of L1. The connections between socket SK1 pin 1 and TB2, and between SK1 pin 4 and TB1 are not required.

Fitting most of the components is straightforward. Having selected which components are needed according to which version is being built, fit them as usual in ascending order of height above the p.c.b., for ease of assembly. Resistors R2 and R3 (power regulator version) should be fitted "proud" of the p.c.b.; a clearance of a few millimetres will allow them to cool more effectively, though they should only become slightly warm even in continual use. (Do not be tempted to check how warm they are by touching them with the power on – see previous section!).

COMPONENTS

Resistors

R1, R7	270Ω (2 off)
R2, R3	270k 2W 5% 500V metal film (2 off)
R4, R6	1k (2 off)
R5	2k

All 0.25W, 5%, carbon film unless stated

See SHOP TALK page

Semiconductors

D1	1N4001 50V 1A rectifier diode
IC1	MOC3041 opto-isolator triac driver, zero-crossing or MOC3021 opto-isolator triac driver, random phase (see text)
IC2	H11L1 Schmitt trigger opto-isolator
SCR1	TIC206D triac, 4A 400V triac, non-isolated

Miscellaneous

L1	4mH choke, 250W, 0·9Ω
SK1	5-pin DIN socket, 240°, plastic, panel mounting
TB1, TB2	2-way p.c.b. mounting screw terminal block 5mm pitch (2 off)
TB3, TB4	3-way p.c.b. mounting screw terminal block 5mm pitch (2 off)

Printed circuit board, available from the *EPE PCB Service*, code 497; 6-pin d.i.l. socket (2 off); cable-tie (5 off) and base, self-adhesive, (4 off); plastic case (see text) 191mm x 110mm x 61mm; fixings; mains inlet cable clamp (2 off); 5-pin DIN free plug, 240°; stick-on feet as required; p.c.b. mounting pillars (4 off); rubber washer; TO-220 clip-on heatsink; connecting wire, solder, etc.

Approx. Cost Guidance Only **£15** *excl. mains connector*

Note the differing orientation of IC1 and IC2 (power regulation version only), with each pin 1 "pointing" towards the opposite end of the p.c.b. A socket will, of course, be needed for IC1 if both on/off and power regulator options are to be available in the same interface, to allow exchanging between an MOC3021 and MOC3041 i.c.

A clip-on heatsink (TO-220 style) can be fitted to the triac for better cooling. Less straightforward are the arrangements associated with the choke, L1. This needs to be firmly fixed in position as its mass means that it cannot be held safely by its

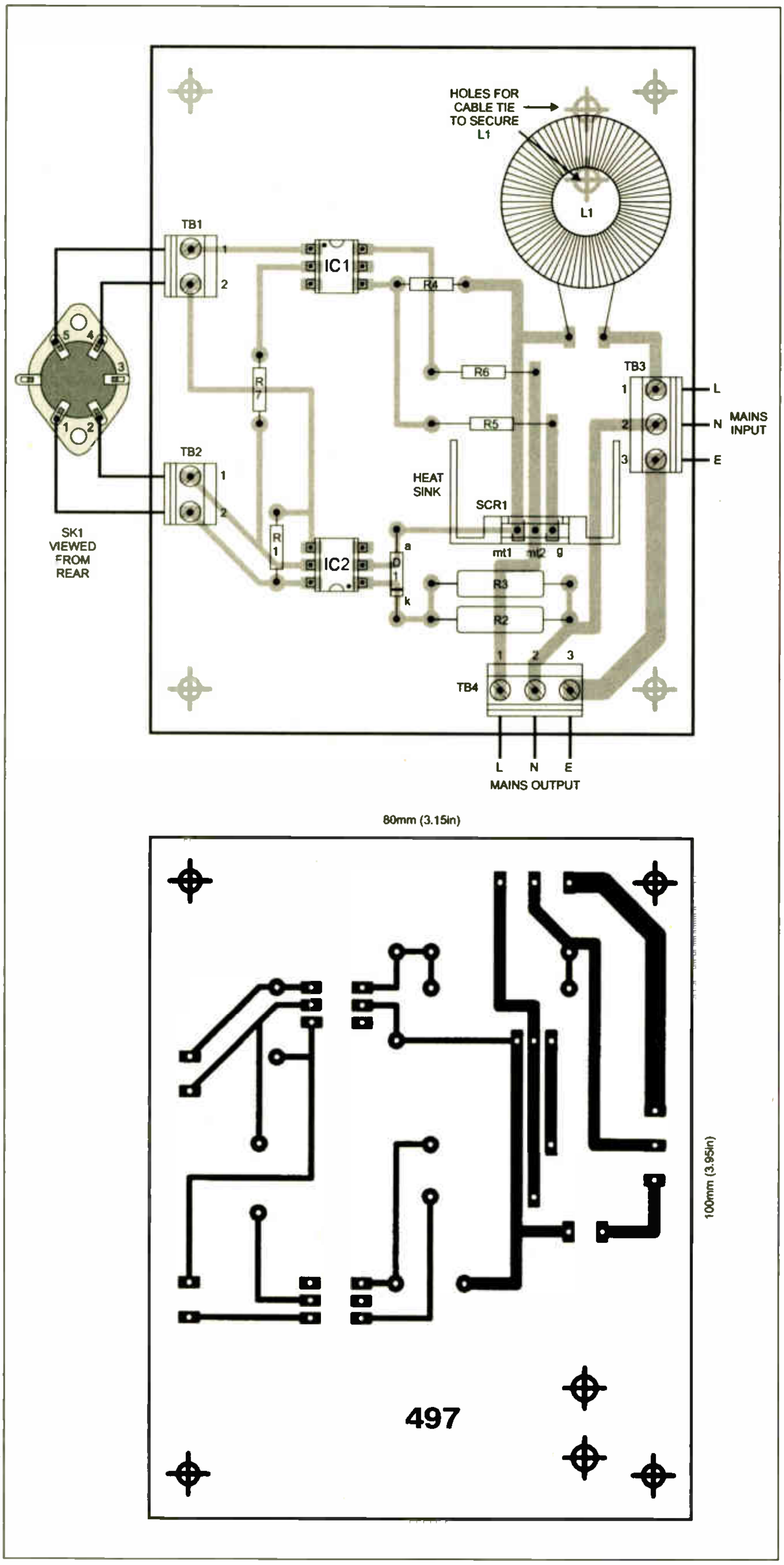


Fig.5. Printed circuit board component and track layout details

connecting leads alone. Any movement can soon lead to a broken wire, at mains voltage, "flapping about" inside the box and in danger of touching parts that are meant to be isolated from mains voltage.

Keep the leads as short as possible. The p.c.b. has been designed with two holes that will allow the choke to be held by a cable-tie-style fixing. Also, it was found that allowing the choke to rest directly on the p.c.b. generated a "buzz" at mains frequency. This was cured by positioning a plumber's rubber tap washer (the type with a centre hole) between the choke and the p.c.b. Finally, fix the p.c.b. in position in the housing with four self-adhesive stand-off pillars.

Wiring Up

The prototype was built into a plastic case, although a metal case, suitably earthed, may also be used. If using a plastic case **it is essential** that no metal parts pass through it, so all fixing screws etc must be made of nylon.

Great care needs to be taken when fixing the off-board wiring since, as has been mentioned, it must be impossible for any wire that comes loose to touch any component or another wire if that would compromise safety isolation. If the wiring paths as shown in Fig.5 and the photograph are followed, and the wiring is held in place, close to the terminal to which the wires are connected, by cable-ties, cable-tie bases, and cable clamps, then safety requirements will be satisfied.

Wiring to the mains plug and socket should of course follow normal electrical wiring standards. The socket for the prototype can be fastened to a wooden backboard if preferred. Whichever method is used, make sure there are no means by which a screwdriver, piece of wire, or anything else, can poke through any fixing holes and so possibly come into contact with parts at mains voltage. Finally, the use of stick-on rubber feet on both the main unit and the mains socket will prevent the units sliding around on the workbench.

In Use

If only one version of the interface is built, then once construction is complete and the cover fixed in place no further action is necessary, and only the relevant parts of the following sections need to be followed to use the device. If, however, the interface is to be used with both options available, then at some point the MOC3021 will need to be replaced by the MOC3041 or vice versa according to the required use. This will of course involve removing the cover.

Make absolutely sure the Interface is completely disconnected from the mains before doing this. As a precaution, it is useful to stick a warning label on both the outside and the inside of the cover as a reminder.

Remember to check the orientation of IC1 after changing it.

Circuit Examples

The following three examples assume the version that will provide both an on/off function and a power regulation function has been built. The first example, PIC-controlled power regulation, will only work with this full version. The logic on/off control and PC on/off control examples will work with either version of the interface.

No additional construction details are offered for the circuits shown.

PIC-Control Power Regulation

A PIC microcontroller is ideal for generating the timing delay necessary for power regulation. It is suggested that the zero-crossing output is used to generate an interrupt, and the timing then implemented by the interrupt service routine. Note that it is necessary to set within software whether a rising or falling edge will trigger the interrupt. A rising edge trigger should be chosen when using this interface for the reasons already covered.

The software for this example is available from *EPE* (see Resources section),

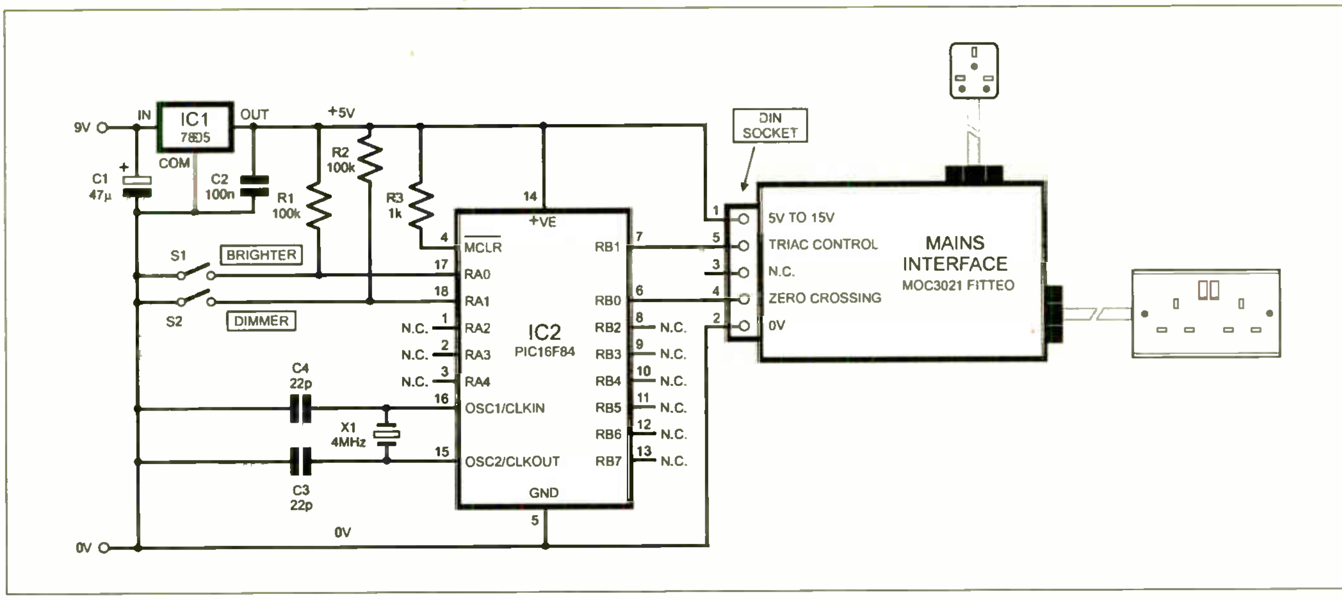
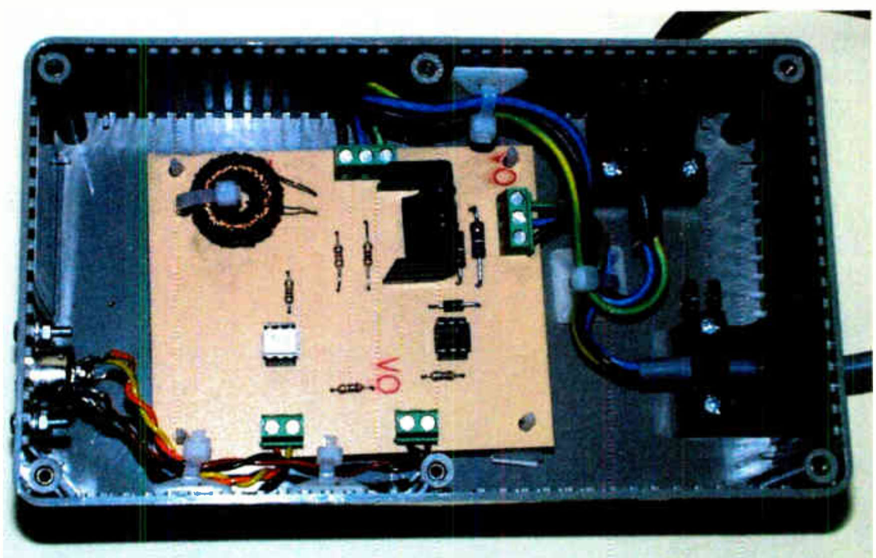


Fig.6. Suggested circuit for a simple PIC-controlled Light Detector



and a suggested circuit for a simple PIC-controlled Light Dimmer using this software is shown in Fig.6.

Logic On/Off Control

An example of a Light On/Off Timer circuit using a straightforward logic level to control the interface is shown in Fig.7. The light remains on for around 20 to 25 seconds with the component values shown. Many other options are possible, of course – it need not even involve logic; simple switch or relay control is an alternative.

PC On/Off Control

One thought the author particularly had in mind when designing this project was for its use in conjunction with Joe Farr's *Serial Interface for PICs and VB6* (Oct '03), and a PC running Visual Basic (or any other application allowing access to the serial port). This opens up an enormous number of possibilities. A very basic option is shown in Fig.8, where the RTS control line of the serial interface is used to switch a light on and off.

Visual Basic 6 needs to have been installed on the PC to use the Visual Basic software provided for this on/off controller. Joe Farr's Serial OCX software also needs to be present. Once again, this example Mains On/Off Controller is in a very basic form only, and is intended as a starting point for more imaginative uses.

Sophisticated Controllers

The author believes this interface will open up many useful project possibilities, the only limitation perhaps being the extent of the designer's imagination, and as is well known, *EPE* readers are noted for their ingenuity with electronics and software! So, over to you!

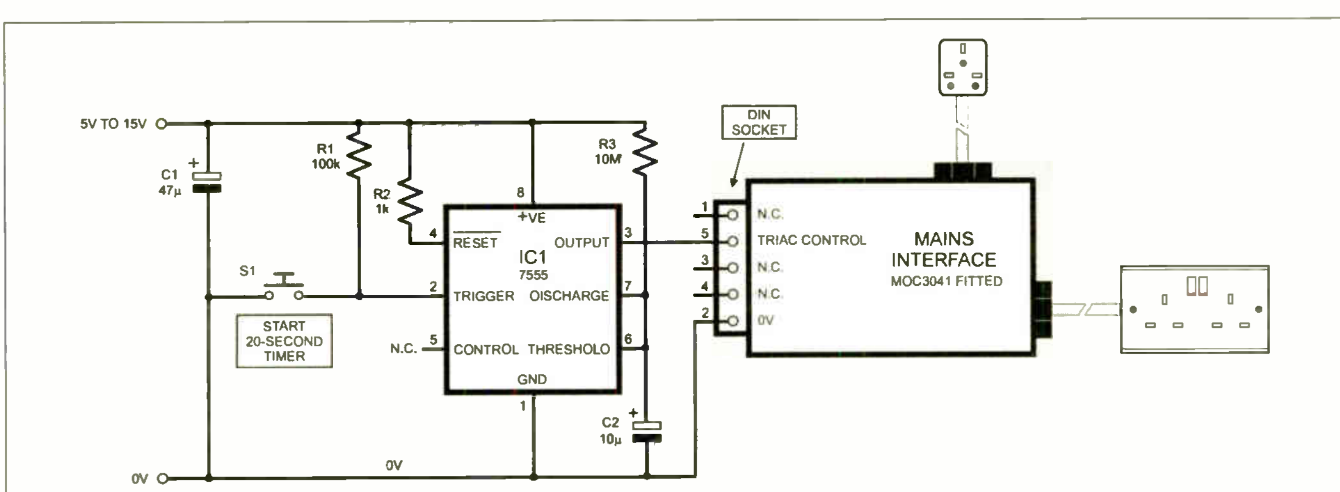


Fig.7. Suggested circuit for a Light On/Off Timer

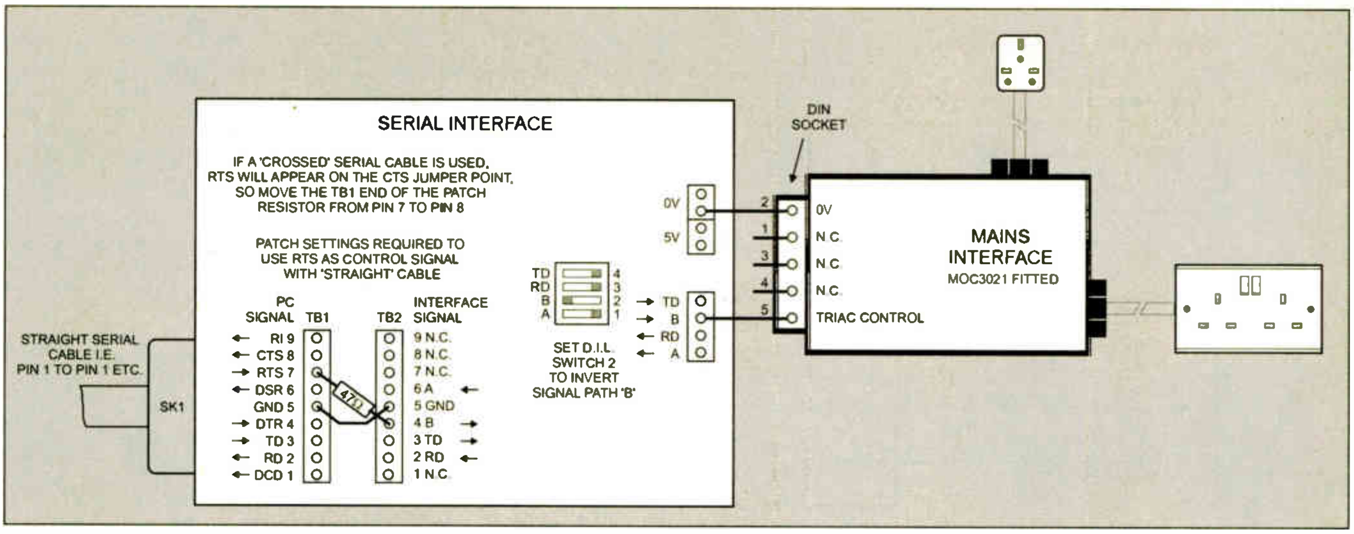


Fig.8. Connecting the Safety Interface to the Serial Interface for PICs and VB6 *board. Below, the VB6 control screen*

Modifications Advice

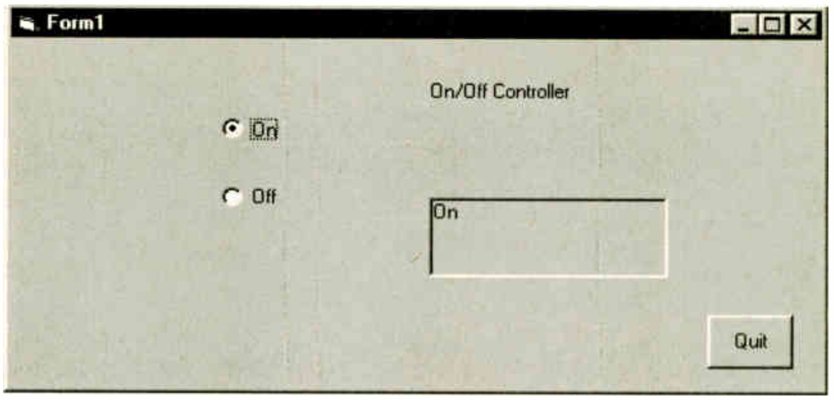
As already mentioned, it is recommended that this interface is not used with loads over about 1A. It should be fairly straightforward to increase the performance ratings, however, by increasing the p.c.b. track width, and up-rating the wiring, components and heat-sinking capabilities.

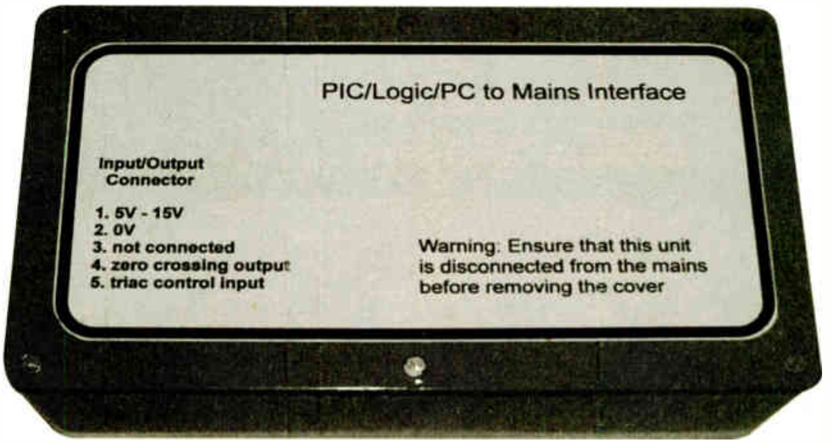
At all times, however, ensure that mains isolation from low voltage circuits is maintained through employing the techniques quoted at the beginning, and check that higher voltages and currents do not generate excessive r.f. interference. A simple check would be to operate the unit near a radio receiver.

Resources

Software, including source code files, for the Safety Interface is available on 3.5-inch disk from the Editorial office (a small handling charge applies – see the *EPE PCB Service* page). It can also be downloaded *free* from the *EPE* Downloads page, accessible via the home page at **www.epemag.co.uk**.

It is held in the PICs folder, under Safety Interface. Download all the files within that folder. This month's *Shoptalk* provides information about obtaining pre-programmed PICs from the author, and the sourcing of components. □





News . . .

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

HIGH DEFINITION TV SCREENS

Larger TV screens do not necessarily mean clearer viewing, but changes are afoot, as Barry Fox discusses

WINDOW-shop for electronics this weekend and the first thing you will notice is that TV screens are getting bigger and their cost falling. The second thing you may notice is how poor today's TV pictures can look when viewed on a big screen from close up. The coarse picture line structure becomes painfully obvious.

This is good news for the electronics industry. Big screens need clearer pictures from a new generation of TV tuners, cameras and recorders. It is good news too for Hollywood. Studio vaults are stuffed with movies that were shot on 35mm film, with very high picture quality, that can be re-packaged in better electronic formats.

The Time is Right, But ...

All in all, the time is now right for higher definition (HD) TV. But it is more right in some countries than others, and there are pitfalls for unwary consumers. This is because the world has for fifty years been divided into two TV zones.

The US and Japan use the NTSC system, often disparaged as Never Twice the Same Colour. Europe and Australia got colour TV later, with PAL, or Perfection At Last.

...What About Size?

NTSC pictures are built from 525 horizontal scanning lines, but only 480 are used in the visible area of the screen. Each line is built from 720 picture points or pixels. So each picture has less than half a million pixels and looks very poor on a big screen. What's more, each picture "frame" is built from two "fields" with only half the total lines. The fields must be rapidly "interlaced" on screen, to try and fool the eye into seeing a complete picture.

PAL builds interlaced pictures from 625 lines, of which 576 are visible, each with 720 pixels. PAL pictures are clearer, but by no means perfect.

The new plasma and l.c.d. panels, and video projectors, stretch a TV picture to well over a metre in size. (The average viewing distance is still what it was 15 years ago, 2·7 metres, because it is dictated by room size and layout.) So the coarse picture line structure, especially for NTSC, becomes all too obvious.

For HD the number of picture lines is increased to at least 720, and each line is built from at least 1280 pixels. The lines of each picture are displayed at the same time, so-called "progressive scanning", without the need for eye-fooling interlace. An HD picture has at least a million pixels and usually many more.

International Acceptance

After an early flirtation with an analogue HDTV system called Hi-Vision, Japan has for two years now had digital HDTV from satellites, cable and terrestrial transmitters. The US has had digital HD since 1998. In both countries the obvious improvement over NTSC is winning viewers.

Three million Japanese homes, 6% of all TV households, now watch HDTV. In the cities, 90% of state broadcaster NHK's programmes are in HD. After a slow start in the US, over a thousand stations across the country are broadcasting HD. Around 10 million homes are watching and a quarter of the 30 million TV sets sold in the US last year were HDTVs.

The downside is that HD needs around 20Mb/s of digital data, which takes up a full broadcast channel.

The situation in Europe is very different. After an analogue HD system called MAC flopped in the early nineties, Europe's electronics industry developed DVB, a digital system which lets existing "standard definition" PAL TV sets and recorders work with simple digital adaptors. Data rate is around 5Mbps so one broadcast channel can carry at least four digital TV programmes. (The UK has had huge success with Freeview, a free-to-watch DVB service that is now in five million homes. Although Australia has an HD service, only around 100,000 homes are watching; the rest seem happy with PAL.)

Redefining PAL

Standard definition PAL pictures can be dramatically improved to near-HD quality by new "interpolation" circuitry that combines the interlaced fields in chip memory, for progressive display, while intelligently adding extra pixel detail.

Although Panasonic is promoting blue laser discs for HD recording, the company recently announced a new Progressive PAL DVD player, saying "the result is stunning with high resolution images that are perfect for HD panels."

None of this will stop the broadcasters and electronics companies trying to sell HD in Europe, though.

Astra of Luxembourg has for a year now been broadcasting Euro1080, a free satellite channel with 1080 line pictures. German satellite channel Premiere will launch sports and movie HD channels this year, along with French broadcaster TPS. BSkyB will start UK HD in 2006.

The pitfall for consumers is that new research by analyst Screen Digest reveals that only around half of all plasma screens on sale in Europe are HD-capable, and almost none of the cheaper ones. This vital information is usually buried in the manufacturer's technical specification. Shops sell mainly on price.

Says David Mercer of Strategy Analytics: "It will be very interesting to see how Sky markets the new HD service. They will need to advertise a difference – but not disappoint viewers who cannot see any difference on their screens".

Compression Technologies

The BBC's R&D Lab at Kingswood Warren has been studying new compression technologies which let broadcasters transmit true HD programmes in little more airspace than today's standard definition programmes. HD pictures were compressed in several different ways: with conventional MPEG-2, as used for today's digital TV; with a new system called H264 based on more powerful MPEG-4; and with VC9, based on Microsoft's Windows Media.

For similar HD quality on screen, MPEG-2 needed 19Mb/s, but H264 and VC9 needed only 8Mb/s.

So the new systems give the same picture quality from half the bit rate, and the chance of more channels over the airwaves. The new systems will not work with today's receivers, though, which is why the BBC is not planning HD broadcasts until at least 2010.

Battery Iron

So new is the Antex SZ004WO battery powered soldering iron, that all Antex have had a chance to send us is a photo and a list of Leading Particulars:

Power supply 3 × 1.5V (AA) cells; battery life typically one hour; power 6W; tip temperature 350°C to 400°C; tip/element life greater than 40 soldering hours; heat up time 17 seconds; length 175mm; weight with batteries 110g. The list price is £18.62 including VAT.

Contact your local electronics supplier for more information about this product. Or contact Antex direct, as in the advert on the next page and, mention *EPE*!

PICO's New Logger

PICO Technology tell us that they have released the latest addition to their data acquisition range, the USB ADC-11 Data Logger. Its USB connectivity allows fast sampling rates and additional digital outputs. It is available in 10-bit and 12-bit versions.

The USB ADC-11 provides a cost effective solution for measuring and recording voltage signals, via 11 channels at up to 20,000 samples per second, onto any Windows-based PC or laptop. When used with PicoLog data logging software, a million readings can be recorded. The popular PicoScope can be used with both models. Pico, of course, are the sponsors of *Ingenuity Unlimited*, this year presenting a superb PicoScope3205 digital storage oscilloscope worth £599 to the winner of the best *IU* submission, as announced last month.

For more information about PICO's products contact: Pico Technology Ltd, Dept EPE, The Mill House, Cambridge Street, St Neots, Cambs PE19 1QB. Tel: 01480 396395. Fax: 01480 396296. Email sales@picotech.com. Web: **www.picotech.com**.

Quasar's Latest Cat

Quasar Electronics' latest catalogue has recently been received. Its introductory page reminds us all that, for over ten years, Quasar have been supplying electronics enthusiasts, professionals, education establishments and businesses worldwide with their range of high quality and innovative electronics projects and publications.

For your copy, contact Quasar Electronics Ltd., Dept EPE, PO Box 6935, Bishop's Stortford CM23 4WP. Tel: 0870 246 1826. Fax: 0870 460 1045. Email: sales@quasarelectronics.com. Web: **www.quasarelectronics.com.**

WCN Mini Cat

WCN Supplies 16-page catalogue issue 22 has been received, again detailing the latest in the way of bargain-priced electronics offers. You can visit WCN at The Old Grain Store, Rear of 62 Rumbridge Street, Totton, Southampton SO40 9DS. Tel/Fax: 023 8066 0700. Email: info@wcnsupplies.fsnet.co.uk. Web: **www.wcnsupplies.com**.

Mobile Phones Hazard Update

The National Radiological Protection Board (NRPB) has recently issued a further statement about the suggestion that radio frequencies, and mobile phone use in particular, might cause cancer. It is too lengthy a document to precis meaningfully here, but its general tone is that there is still no evidence to confirm such a link.

The full document can be read via the NRPB's web site at **www.nrpb.org**.

Latest PIC CD

Microchip have sent us their latest technical library CD ROM, the 2004/2005 edition. In fact, it's two CDs as usual, the Microchip range of PICs and many other devices having become so vast.

This news writer has been hoping for some weeks to receive this edition, and at last it has arrived. Both he, and all you PIC fanatics, will welcome its release.

To obtain your copy, either request one via **www.microchip.com**, or contact you local PIC supplier. Details of these are also on Microchip's site. The UK office address is: Microchip Ltd, Dept EPE, Microchip House, 505 Eskdale Road, Winnersh Triangle, Wokingham, Berkshire RG41 5TU. Tel: 0118 921 5869: Fax: 0118 921 5820. Email: euro.enquiry@microchip.com. Web: **www.microchip.com**


BS2-IC
BS2-SX
BS2E-IC
BS2P/24
BS2P/40
Parallax BASIC Stamps - still the easy way to get your project up and running!
Serial Alphanumeric and Graphic Displays,
Mini-Terminals and Bezel kits
www.milinst.com
Animated Head
3-Axis Machine
Six-Legged Walkers
Robotic Arms
Bipeds
Robotic models for both the beginner and the advanced hobbyist
Servo Drivers
Motor Drivers
On-Screen Displays
DMX Protocol
U/Sound Ranging
Animatronics and Specialist Interface-Control Modules
Quadravox
MP3 & Speech Systems
SensoryInc
Voice Recognition
Parallax
Ubicom Tool Kits
Tech-Tools
PIC & Rom Emulators
BASICMicro
PIC BASIC Compilers
Development Tools
Milford Instruments Limited Tel 01977 683665, Fax 01977 681465, sales@milinst.com

INTERFACE

Robert Penfold

COMPUTER-CONTROLLED POWER SUPPLY WITH CURRENT LIMITING

A SIMPLE computer controlled bench power supply unit was featured in the previous *Interface* article, and in this month's article the original circuit will be developed a bit further. The circuit is based on an AD557JN 8-bit digital-to-analogue converter chip, giving the unit 256 different output voltages. The actual output voltage range is from 0 to 12·75 volts in 50-millivolt (0·05V) increments. The unit is protected by a simple current limiting circuit, but this aspect of the design could be better.

The problem with the original current limiting circuit is that it only provides one limit current. This is adequate to protect the power supply unit against short-term overloads and even short-circuits.

Provided the output transistor has adequate heatsinking, the over-current protection will probably protect the unit against indefinite overloads. Unfortunately, an output current of just over one amp is sufficient to "fry" the delicate components used in many of today's projects. The circuit powered from the supply will usually be much more vulnerable than the supply unit itself.

Limited Choice

The obvious solution is to have either a variable limit current or the option of using one or two lower currents. The easiest solution is to have a few switched resistors in the current sensing circuit.

A suitably modified output stage is shown in Fig.1, where R3 to R5 are the current sensing resistors and S1 is the switch that is used to select the required limit current. The current limiting circuit starts to come into operation with a little over 0·5V across the sensing resistor, and this occurs with an output current of about 1A with resistor R3 selected using S1.

In order to obtain a lower limit current it is merely necessary to use a higher value sensing resistor. Resistor R4 has a value that is ten times higher than that of R3, and it therefore gives a limit current that is ten times lower at 0·1 amps (100mA). Resistor R5 is roughly 50 times higher in value than R3, giving a limit current that is about 50 times lower. This works out at about 0·02A (20mA).

A maximum output current of 100mA is suitable when testing or developing most low-power circuits, but a lower limit can be useful when dealing with expensive low-power devices.

Working out the required value for a given limit current is very straightforward. Simply divide 0·55 by the required limit current in amps. This gives the ideal resistor value in ohms.

In practice it will usually be necessary to compromise slightly and choose the nearest preferred value, or the exact value can be produced using two or more resistors in series. Note that the current limiting is introduced quite abruptly, but not in a "brick wall" fashion. Consequently, the short circuit current is typically about 10 percent more than the current at which the limiting is introduced.

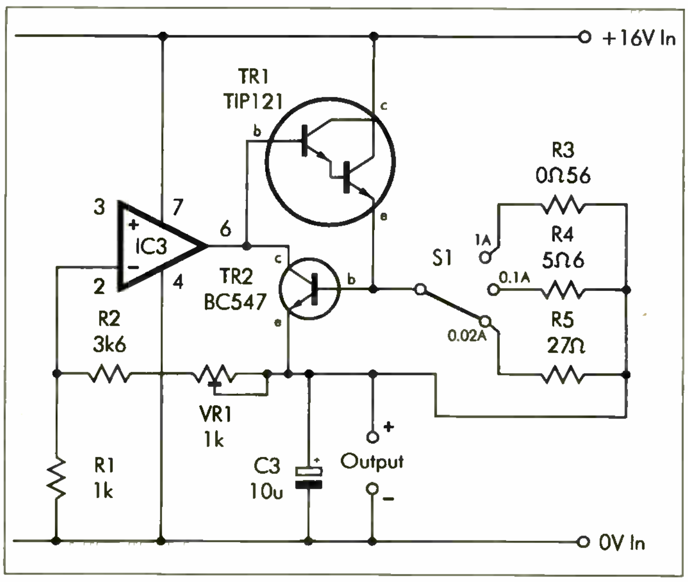


Fig.1. This modified output stage gives a choice of three limit currents

Central Control

The simple circuit arrangement of Fig.1 works well enough, but it has the obvious drawback of splitting control of the supply between the control program and the hardware. Virtual equipment is generally easier to use if everything is controlled from the PC.

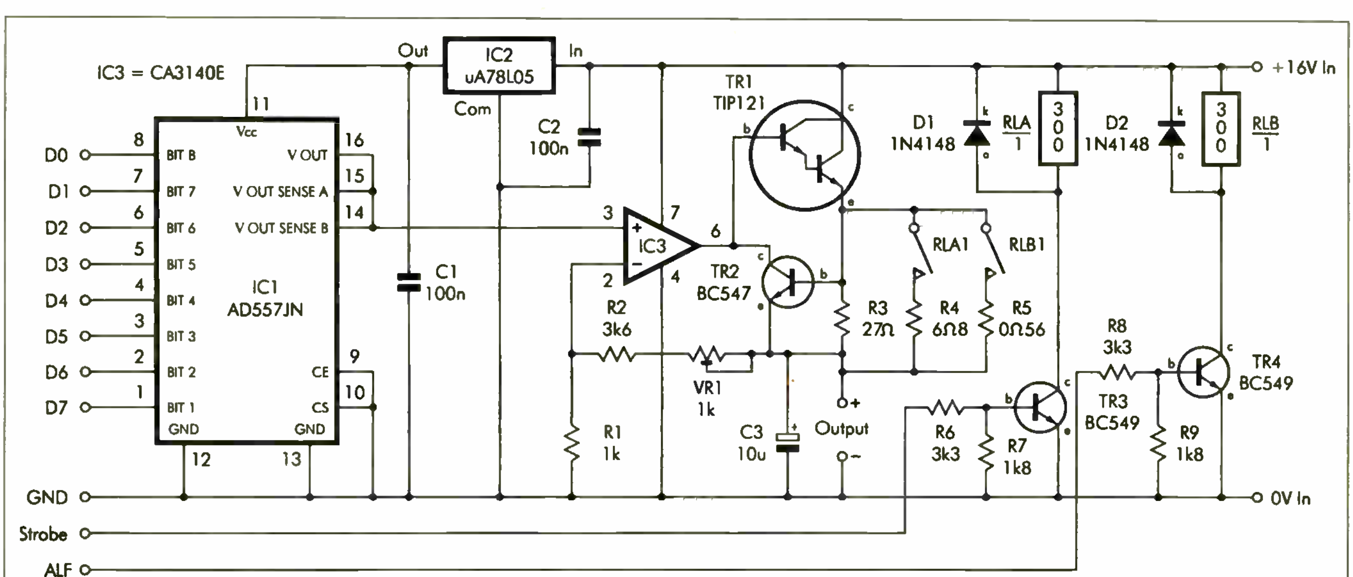


Fig.2. The complete circuit diagram for the Computer Controlled Power Supply.

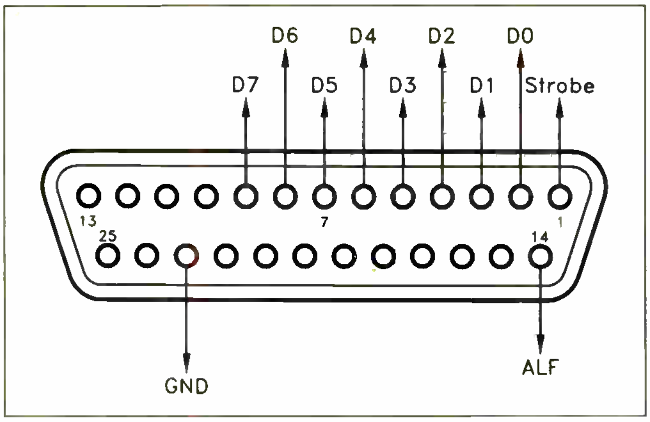


Fig.3. Connections to the printer port. A 25-way male D connector is needed to make the connections to the port

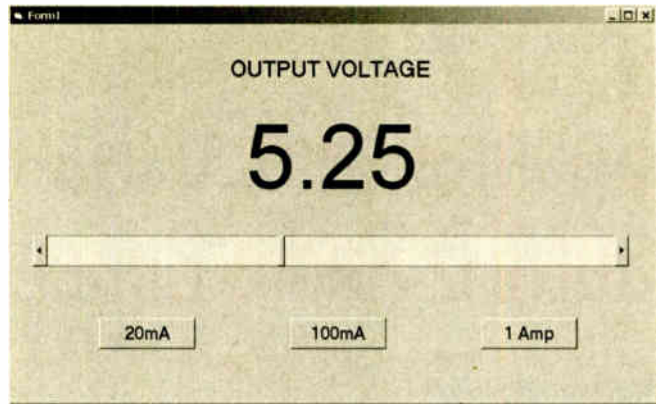


Fig.4. Screen shot showing the Visual BASIC 6.0 control circuit in operation

The digital-to-analogue converter uses all the data outputs of the PC's parallel printer port, but there are still has some spare outputs available. There are four handshake outputs that can be used to control some form of variable current limiting circuit.

On the face of it, electronic analogue switches could be used to give a range of switched limit currents. However, in practice there are a couple of major problems that make it difficult to use this approach. One is that the output current flows through the switch, and normal analogue switching devices are not designed to handle currents of up to an amp or so. The second problem is that the resistance through an electronic analogue switch is relatively high, and is likely to be at least a few ohms.

With many of these devices the "on" resistance is a few hundred ohms. This resistance is effectively added to the value of the current sensing resistor. Even a few ohms of additional resistance would be sufficient to prevent high limit currents from being obtained.

The current limiting circuit could probably be redesigned to use electronic switches, but a couple of relays are probably a more practical solution in this case. The contacts of a relay are isolated from the control circuit, have a negligible "on" resistance, and in most cases can handle d.c. currents of a few amps. This makes them ideal for the use in this design.

Final Circuit

The full circuit diagram for the new version of the Computer Controlled Power supply unit is shown in Fig.2. The switching of the current sensing resistors, R3 to R5, has been simplified slightly so that it can be achieved using two relays rather than three. Each relay has a single pair of normally open contacts. To achieve a limit current of 20mA, both relays are switched off and their contacts are therefore open. In this instance, R5 is then the only sensing resistor that is switched into circuit.

Relay contacts RLA1 are closed when a limit current of 100mA is required. This shunts R4 across R3 and provides a suitable parallel resistance from the two resistors. Note that the value of resistor R4 has been made higher than its equivalent in Fig.1 in order to allow for the shunting effect of R3, which remains connected at all times in the revised version of the circuit.

A limit current of one amp is obtained by closing relay contacts RLB1 so that resistor R5 is shunted across R3. Relay contacts RLA1 must be open so that R4 is switched out of circuit, and only R5 is connected across R3. The shunting effect of R3 on R5 produces a combined resistance that is fractionally lower than the ideal value, but the error is not large enough to be of any practical significance.

The two relays are controlled via simple common emitter switches based on TR3 and TR4. Diodes D1 and D2 are the usual protection devices that suppress the high reverse voltages generated across the relay coils when they are switched off.

In Control

The relays must have 12V coils with a resistance of 300 ohms or more, and at least one set of normally open contacts with a d.c. rating of two amps or more.

The relay drivers are controlled by the Strobe and ALF (automatic line-feed) outputs of the printer port, which are respectively at bits zero and one of the handshake output register. Note that both of these bits are inverted by hardware within the PC. Consequently, writing a value of one to this register closes RLB1, and a value of two closes RLA1. A value of three leaves both sets of relay contacts open. The following table shows the value that must be output in order to achieve each of the three limit currents.

Control Value	Limit Current
3	20 milliamps
2	100 milliamps
1	1 amp

The connections to the printer port are shown in Fig.3. A 25-way male D connector is needed to make the connections to the port. In an application of this type it is unlikely that high-speed data will be sent via the printer port, but it is still advisable not to use a connecting cable that is more than a few metres long.

Listing

```
Private Sub Command1_Click()
Out &H37A, 3
End Sub

Private Sub Command2_Click()
Out &H37A, 2
End Sub

Private Sub Command3_Click()
Out &H37A, 1
End Sub

Private Sub Form_Load()
Out &H37A, 3
End Sub

Private Sub HScroll1_Change()
Out &H378, HScroll1.Value
Label1.Caption = HScroll1.Value / 20
End Sub
```

Software

A very simple control program is all that is needed to get this project working. The simple Visual BASIC program used to test the unit is shown in operation in Fig.4. See also the Listing panel.

The output voltage is controlled via a long horizontal scrollbar, and the selected voltage is displayed via a large digital readout. Three command buttons enable the required limit current to be selected.

Note that this program requires **Inpout32.dll** to be available to the system in order to run. As usual, the Visual BASIC 6.0 source files, the compiled program, and support files are available at the *EPE* web site, Downloads section, in the Interface folder.

The routine for each command button simply outputs the appropriate value to the handshake register at address &H37A. It is assumed here that the printer port is at the usual base address of &H378. The input/output addresses used in the program must be adjusted accordingly if a printer port at a different base address is used.

Command buttons 1 to 3 respectively set limit currents of 20mA, 100mA and 1A. The routine for Form1 sets the unit so that it has an initial limit current of 20mA.

The routine for the scrollbar has two functions, and the first of these is to send the scrollbar's value to the printer port each time a change is made. The scrollbar is set to have maximum and minimum values of 0 and 255. Consequently, there is no need to provide any mathematical manipulation prior to writing the values to the port. Each new value is simply written direct to the port's data lines at address &H378.

This routine is also used to update the digital readout each time the user sets a new output voltage. Label1 is used to display the voltage reading, and Label2 provides the "OUTPUT VOLTAGE" label above the readout. New values from the scrollbar are therefore used as the caption for Label1. However, the raw values from the scrollbar must be divided by 20 in order to give the corresponding output voltage from the power supply unit.

No doubt this basic control program could be improved. A scale along the scrollbar would make it easier to set the required output voltage for example. With computer control it is possible to have the output vary between certain limits, taking a specified time to do so.

This makes it easy to check the effect of a varying supply voltage on the test circuit being powered from the supply unit. There is plenty of scope for expanding the program to suit individual needs.

Constructional Project

Spontaflex 550kHz To 30MHz Radio Receiver

Raymond Haigh

A modern-day update of Sir Douglas Hall's famous Spontaflex reflex circuit

THIS updated version of the Spontaflex receiver is presented with a more powerful single i.c. add-on audio amplifier, extends coverage through the medium wave band, and uses currently available components that are assembled on printed circuit boards. Using just two transistors, the tuner section retains all of the sensitivity of the original design. The set will receive a.m. and s.s.b. signals.

The receiver is assembled on three separate printed circuit boards, comprising a tuner section, a coil pack, and an audio power amplifier. This arrangement has been adopted so that readers can more easily modify the design to suit their own requirements, or to use coils and an amplifier already to hand.

Tuner Section

The combined circuit diagram of the Tuner and Coil Pack stages is shown in Fig.1. With the audio output emerging at the "earthy" end of the radio frequency input attenuator, its functioning is obscure, even by reflex radio standards. Perhaps the best way to unravel it is to follow the signal path.

Regenerative receivers are easily overloaded by strong signals, so an Input Attenuator control is provided by potentiometer VR1. The injection of low frequencies into the audio signal path is inhibited by capacitor C2, with capacitor C4 limiting the effect of aerial loading on the tuning and regeneration controls.

Signals picked up by the aerial are applied, via C4, to the emitter (e) of TR1. This transistor functions as a grounded base amplifier at radio frequencies, and chokes RFC1 and RFC2 act as the collector (c) load. The base (b) is "grounded" by capacitor C6.

The radio frequency output from transistor TR1's collector (c) is applied to the base (b) of TR2 via d.c. blocking capacitor C7. At radio frequencies, transistor TR2 is configured as a common collector (or emitter follower) stage. Its collector is grounded at radio frequencies by capacitor C6, and diode D1 rectifies the output at TR2's emitter in order to recover the audio modulation from the signal. This common collector arrangement results in a comparatively high impedance at TR2's base, and direct connection to the tuned circuit is permissible. (Damping is overcome by *Q multiplication* or *regeneration* – see later).

Audio Frequencies.

The audio signal voltage, developed across diode D1, is injected automatically at the emitter of TR2 which now functions as a grounded base amplifier. The base of this transistor is grounded, at audio frequencies, via the tuning coil (selected by rotary switch S1b) and capacitor C5. The audio signal, developed across TR2's collector load resistor (presets VR2 to VR6, wired as variable resistors), is connected directly to the base of TR1, which operates as a common collector amplifier at audio frequencies.

Audio output at TR1's emitter is developed across load resistor R2, and capacitor C3 shunts unwanted radio frequencies. Blocking resistor R1 prevents the shorting of the radio frequency input by this capacitor.

Deploying transistors in the common collector mode, which gives current amplification but no voltage amplification, and the grounded base mode, which provides voltage amplification but no current amplification, is unusual. However, the high input and low output impedances of common collector stages are matched to the low input and high output impedances which result when the transistors are configured in the grounded base mode, and overall gain is high. This, coupled with the dramatic increase in efficiency afforded by regeneration, gives the receiver its high sensitivity.

Tuning - In

The receiver is tuned to the desired frequency by one of the switched coils L1 to L5 and bandset (Tuning) variable capacitor VC1. Tuning, especially on the higher frequency shortwave bands, is critical, and a low-value bandspread (Fine Tune) variable capacitor, VC2, makes it easier to adjust the receiver. Series capacitor C8 reduces the effective swing of VC2 to make its action even gentler.

Some readers may not want multi-band operation and the complication it brings, or they may wish to experiment with the tuner before embarking on the construction of the full receiver. Details of simpler, single band tuning arrangements are given later.

Regeneration

A technique known as *regeneration* can enhance the sensitivity and selectivity of simple receivers and make them responsive to extremely weak signals. It involves the use of controlled positive feedback to dramatically increase the *Q-factor* of the tuning coil and capacitor combination. Signal magnification is directly related to tuned circuit Q, and the performance of the receiver is enormously improved.

For greatest sensitivity and selectivity, the circuit has to be held close to the onset of oscillation, and control is usually effected by placing a variable capacitor or resistor in the feedback path, or by adjusting the gain of the amplifier providing the feedback. Armstrong and Hartley oscillators form the basis of these regenerative circuits, and a coil with two windings, or a tapped coil, is required for the injection of the feedback.

The regeneration system used in this receiver is based on a Colpits oscillator in which a single winding coil is tapped by a pair of capacitors. One of these is formed by the internal capacitance of transistor TR2; the other is the variable capacitor VC3 connected between TR2's emitter and the 0V rail. Increasing the value of VC3 progressively shifts the capacitance tapping until a point is reached when the stage bursts into oscillation. The simplicity of the single winding coil is the circuit's main advantage.

It will be recalled that TR2 is operating in the "grounded base" mode at audio frequencies, and a high value collector load is required to maximise gain. This transistor also provides the positive feedback for regeneration or Q-multiplication, and a resistor value that allows smooth regeneration at 1MHz completely inhibits it at 30MHz. A compromise has to be struck and preset potentiometers VR2 to VR6, one for each band, enable regeneration to be optimised over the full coverage of the receiver.

Sir Douglas Hall K.C.M.G., M.A.

Sir Douglas Hall died, aged 95, in April 2004. Described as an "inveterate experimenter with wireless, but no mere tinkerer", his involvement with the science spanned eight decades.

When transistors were first introduced in the 1960's, they cost £5 or more at present day money values. Sir Douglas devised many ingenious circuits, using them to amplify twice, first at radio and then at audio frequencies. Known as *reflexing*, the technique was widely adopted in the early days of radio when a valve cost as much as a week's wages.

Clearly, he drew heavily on his early experiences when he began producing designs for simple transistor radios. His understanding of the new devices enabled him to combine them in ingenious ways, extracting the last ounce of performance from a handful of components.

He is, perhaps, best known for his *Spontaflex* circuit (when he introduced it in June 1964 he called it the *Autoflex* without realizing he'd used the trade name of a firm of traffic-light manufacturers). With this arrangement, the clever inter-connection of transistors and a signal diode matches impedances along the signal path and eliminates the need for additional components to return the audio frequencies back through the amplifying stages (hence automatic or spontaneous *reflexing*).

Sir Douglas used the circuit in a variety of receivers, but one of the most popular was a short-wave design first published in 1964 with improved versions appearing in 1968 and 1970. Built by amateurs in large numbers, the dominant characteristic of the set was its sensitivity. One Australian constructor claimed to have received signals from London using a 10 inch (250mm) aerial.

Unfortunately, most of Sir Douglas's circuits incorporated components that are no longer retailed. His designs also pre-dated the widespread use of printed circuit boards by home constructors.

It is hoped that this revival of his *Spontaflex* design will help keep alive the memory of an "inveterate experimenter with radio" whose ingenuity inspired and delighted a generation of electronics enthusiasts.

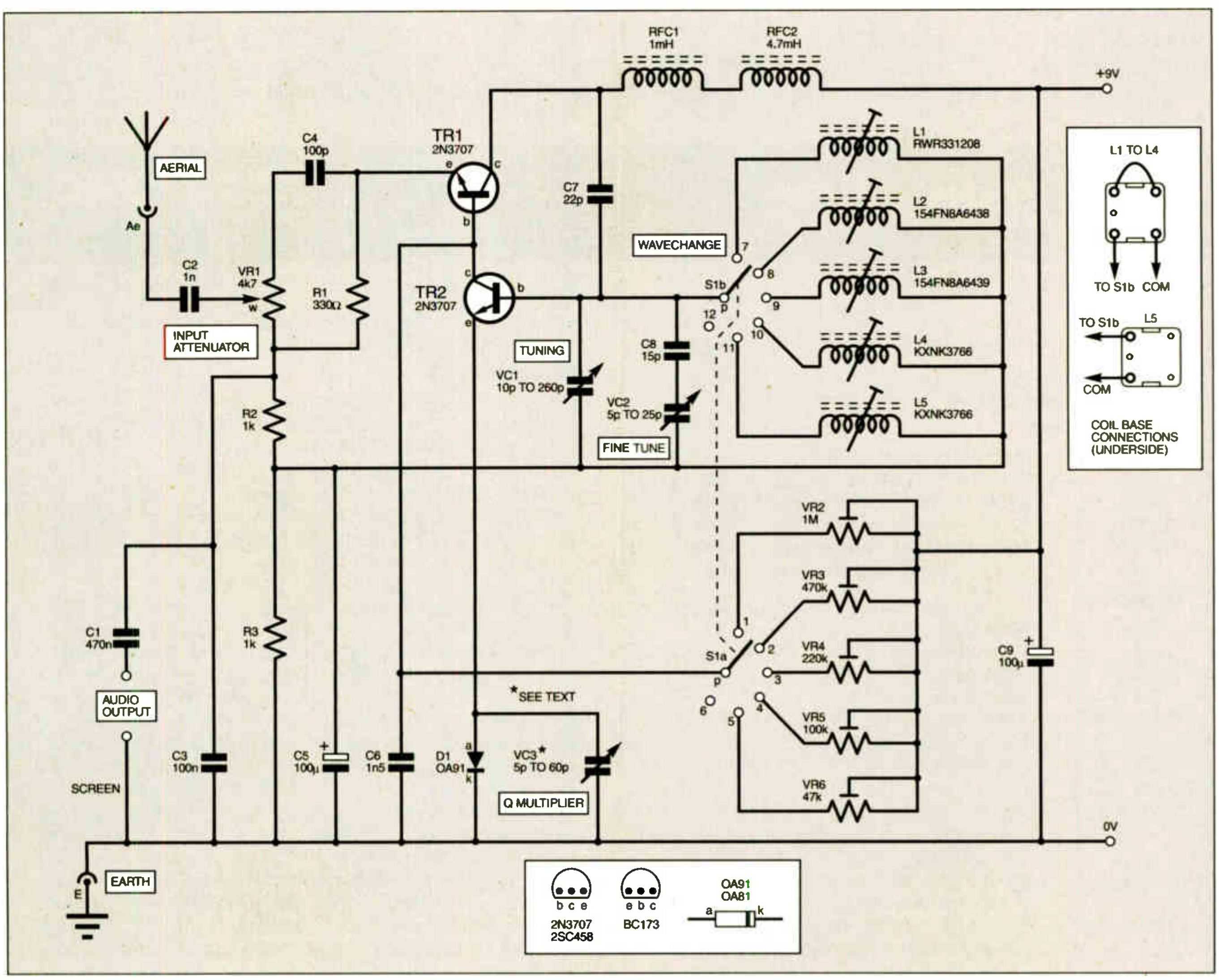
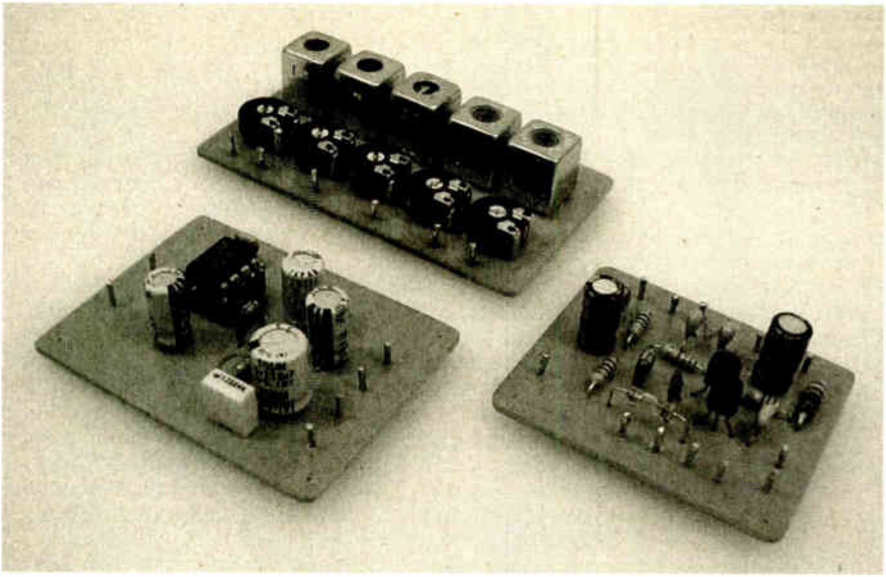


Fig. 1. Circuit diagram for the general coverage (550kHz to 30MHz) "Spontaflex" Tuner



The three main circuit boards that make up the Spontaflex Receiver: Coil Pack (top), Audio Amp (left) and Tuner (right)

Choked-Up

Similarly, two radio frequency (r.f.) chokes, RFC1 and RFC2, are connected in series to ensure consistent performance across the tuning range. The higher inductance 4·7mH choke is required to ensure smooth regeneration at frequencies below 1MHz. Readers who do not wish to use the receiver for medium wave reception can dispense with this component, but remember to insert a wire link in its place on the printed circuit board.

Bypass capacitor C9 prevents instability with ageing batteries when the Tuner is used as a stand-alone unit. If the Tuner is connected to an audio amplifier, and both units are powered by the same battery, connect the tuner to the power supply via a one kilohm (1kΩ) decoupling resistor. Provision is made for this resistor (R3) on the printed circuit board of the amplifier to be described later. Failure to include it will result in erratic regeneration and "motor-boating" (low frequency instability).

Audio Output

The Audio output signal is taken from the emitter of transistor TR1 via d.c. blocking capacitor C1. A small value is quoted for this component in order to attenuate the lower audio frequencies.

The signal voltage developed across resistor R2 will produce a clearly audible output from a crystal earpiece. These units, which rely on the piezoelectric effect, are very sensitive and present a high impedance to the signal source. Walkman type earphones are ***not*** suitable for direct connection to the Tuner.

Components

The transistor used in the TR2 position must be capable of operating at a low collector current. The 2N3707 is the device specified, but a 2SC458, which has the same lead arrangement, has been "set tested" and found to perform equally well. Substituting a BC173 results in a barely perceptible reduction in sensitivity, but it is certainly an acceptable substitute.

Most small signal, high gain, *npn* transistors, e.g., the BC549C, will function acceptably in the TR1 position. Transistors specially manufactured for use at radio frequencies, e.g., the BF494, are ***not*** suitable for use in this circuit.

A diode with a relatively high forward resistance is required. The original circuit used an 0A81 *germanium* diode, but an 0A91 is equally suitable. Although not "set tested", an 0A85 or an AA117 should also work in this circuit. An unsuitable diode will reduce sensitivity and inhibit regeneration above 10MHz.

Tuning Coils

Consisting of a single, untapped winding, the tuning coils couldn't be simpler and almost any inductor of appropriate value should prove suitable.

COMPONENTS

Approx. Cost Guidance Only **£25** *excl. case and batts*

TUNER

See SHOP TALK page

Resistors

R1	330Ω
R2, R3	1k (2 off)

All 0.25W 5% carbon film

Potentiometers

VR1	4k7 rotary carbon, lin
VR2	1M enclosed carbon preset, horiz.
VR3	470k enclosed carbon preset, horiz.
VR4	220k enclosed carbon preset, horiz.
VR5	100k enclosed carbon preset, horiz.
VR6	47k enclosed carbon preset, horiz.

Capacitors

C1	470n ceramic
C2	1n ceramic
C3	100n ceramic
C4	100p ceramic
C5, C9	100µ radial elect. 16V (2 off)
C6	1n5 ceramic or polyester
C7	22p ceramic
C8	15p ceramic
VC1	10p to 260p (two a.m. gangs of a 4-ganged a.m./f.m. polyvaricon connected in parallel)
VC2	5p to 25p (one f.m. gang of a 4-ganged a.m./f.m. polyvaricon)
VC3	5p to 60p or 5p to 140p (one gang of a 2-ganged a.m. only polyvaricon - see text)

Semiconductors

D1	OA91 germanium diode
TR1,TR2	2N3707 *npn* transistor (2 off)

Miscellaneous

L1	RWR331208 Toko coil
L2	154FN8A6438 Toko coil
L3	154FN8A6439 Toko coil
L4,L5	KXNK3766 Toko coil (2off)
RFC1	1mH min. ferrite-cored r.f. choke
RFC2	4m7H min. ferrite-cored r.f. choke (only required for reception below 1MHz – see text)
S1	2-pole 6-way rotary switch

Printed circuit boards available from the *EPE PCB Service*, codes 494(Tuner), 495(Coil) and 406 (Tune Cap – 3 off, see text); metal case, size and type to choice; epicyclic slow-motion drive; one large and four small plastic control knobs; screw terminals (2 off) for Aerial and Earth; white card, rub-down lettering and small piece of 2mm transparent acrylic sheet for front panel dials; stick-on rubber feet connecting wire; p.c.b.-mounting stand-offs; solder pins; nuts, bolts and washers; solder etc.

If the Tuner is to be used as a stand-alone unit you will need a small metal or plastic case, a crystal earpiece and a jack socket to match.

For single-band (6MHz to 16MHz) tuning coil : 6mm (1/4in.) diameter coil former. Use an off-cut from a *plastic* potentiometer spindle. A short length of 32s.w.g. (30a.w.g.) enamelled copper wire for winding the coil (wire gauge is not critical).

A very inexpensive coil, consisting of 30 turns of 32s.w.g. (30a.w.g.) enamelled copper wire, wound side-by-side on a short length of 6mm (1/4in.) plastic potentiometer spindle off-cut, will give coverage from approximately 6MHz to 16MHz. Wire gauge is not critical. This is a busy segment of the shortwave spectrum and one over which the receiver performs well. Details of a simplified tuning arrangement, using this coil, are given in Fig.9.

Unscreened inductors are not suitable for a switched coil pack unless provision is made for shorting out any coils not in use. Tuned by self-capacitance, they resonate within the frequency range of the coil in circuit, and this causes regeneration dead spots. The screening cans of the specified Toko coils avoid this problem. Moreover, their inductance can be varied over fairly wide limits, making it easy to adjust the receiver for continuous coverage.

Audio instability problems were encountered when attempts were made to tune the original receiver over the medium wave band. This was attributed to the greater d.c. resistance of the medium wave coil, and the problem does not arise with the Toko component. The additional 4·7mH radio frequency choke, RFC2, must, however, be fitted, or performance at the low frequency end of the medium wave band will be erratic.

Audio Power Amplifier

Small, inexpensive, and highly efficient audio power amplifier i.c.s, capable of low-distortion and high gain, have become commonplace since Sir Douglas published his reflex designs. His single transistor output stage, intended for earphone listening and the low-level speaker reproduction of strong signals, has been replaced by a TBA820M audio amplifier i.c. The complete circuit diagram for this simple Audio Power Amplifier is given in Fig.2.

Audio signals from the Tuner are applied, via the moving contact (wiper) of Volume control potentiometer VR1, to the input (pin 3) of IC1. Note that the required input d.c. blocking capacitor is located on the Tuner printed circuit board (C1). Readers wishing to use this amplifier with other equipment should inject the signal via a 4·7μF electrolytic capacitor (negative lead to VR1).

Bypass capacitors C1 and C2 ensure stability at audio and radio frequencies. The overall gain of the circuit is fixed, by resistor R1, at 230 times (47dB), and response to higher audio frequencies is curtailed by increasing the value of feedback capacitor C5 to 680pF. This measure makes externally and internally generated electrical noise much less intrusive.

The Zobel network, formed by resistor R2 and capacitor C6, prevents damage being caused to the on-chip output transistors by transient, high-level signals. Blocking capacitor C7 couples the amplifier to the loudspeaker LS1. Headphone listening is obtained via jack socket SK1, which automatically takes the speaker out of circuit as the headphones are plugged in. As with the input blocking capacitor, the value of capacitor C7 has been reduced to limit output at low frequencies and avoid overloading the miniature speaker.

Readers who require a flat response should reduce the value of C5 to 220pF and increase C7 to 1000μF. If the amplifier is to be used only with 32 ohm Walkman type headphones, greater speech clarity can result if the value of C7 is further reduced to 22μF, or even 10μF.

Ripple on the power supply rail is rejected by capacitor C4, and the tuner supply is decoupled by resistor R3. The associated decoupling capacitor (C9) is located on the Tuner board.

A low current l.e.d., (D1) together with dropping resistor R4, gives a visual On indication, and S1 is the On/Off switch.

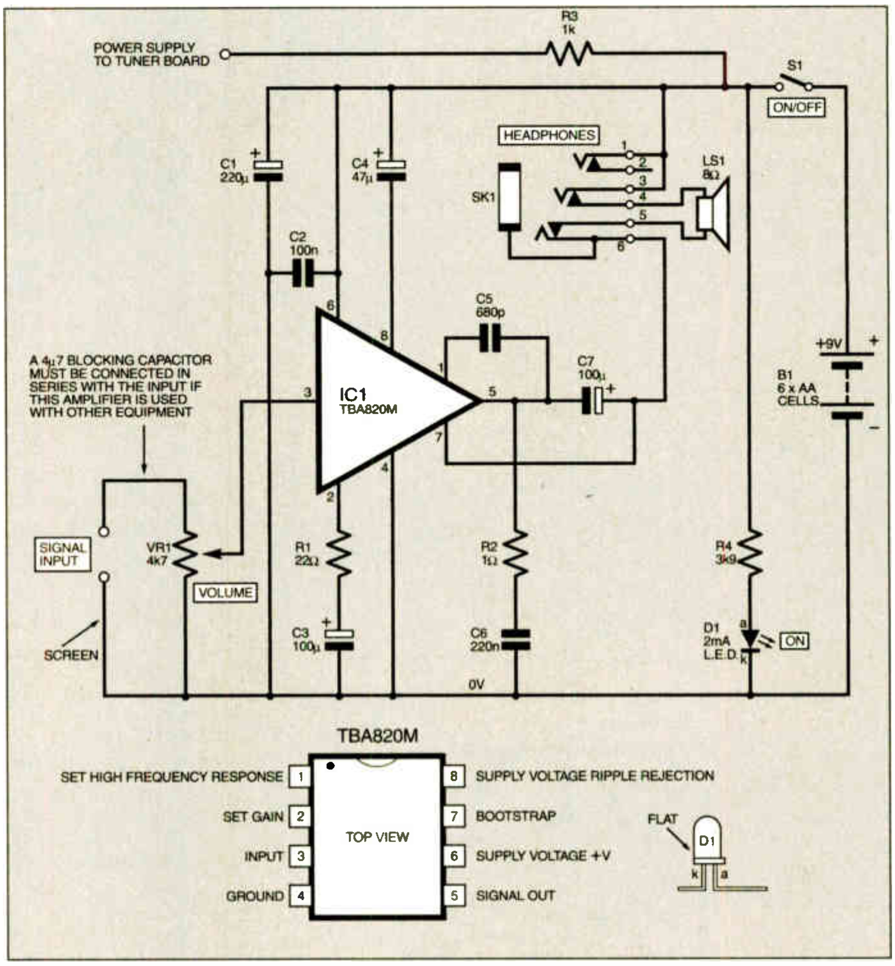


Fig.2. Circuit diagram for the add-on Audio Power Amplifier. The component values for capacitors C5 and C7 have been chosen to restrict the frequency response of the amplifier – see text

COMPONENTS

Approx. Cost Guidance Only **£9** excl. speaker, case and batts

AUDIO AMPLIFIER

See SHOP TALK page

Resistors

R1	22Ω
R2	1Ω
R3	1k
R4	3k9

All 0.25W 5% carbon film

Potentiometer

VR1	4k7 rotary carbon, log.

Capacitors.

C1	220μ radial elect. 16V
C2	100n ceramic
C3, C7	100μ radial elect. 16V (2 off)
C4	47μ radial elect.16V
C5	680p ceramic
C6	220n polyester

Semiconductors

D1	5mm low current (2mA) l.e.d., red
IC1	TBA820M audio power amp

Miscellaneous

LS1	8Ω 65mm (2in.) dia. loudspeaker
S1	s.p.s.t. toggle switch.
SK1	6·35mm (1/4in.) stereo jack socket, with switched contacts

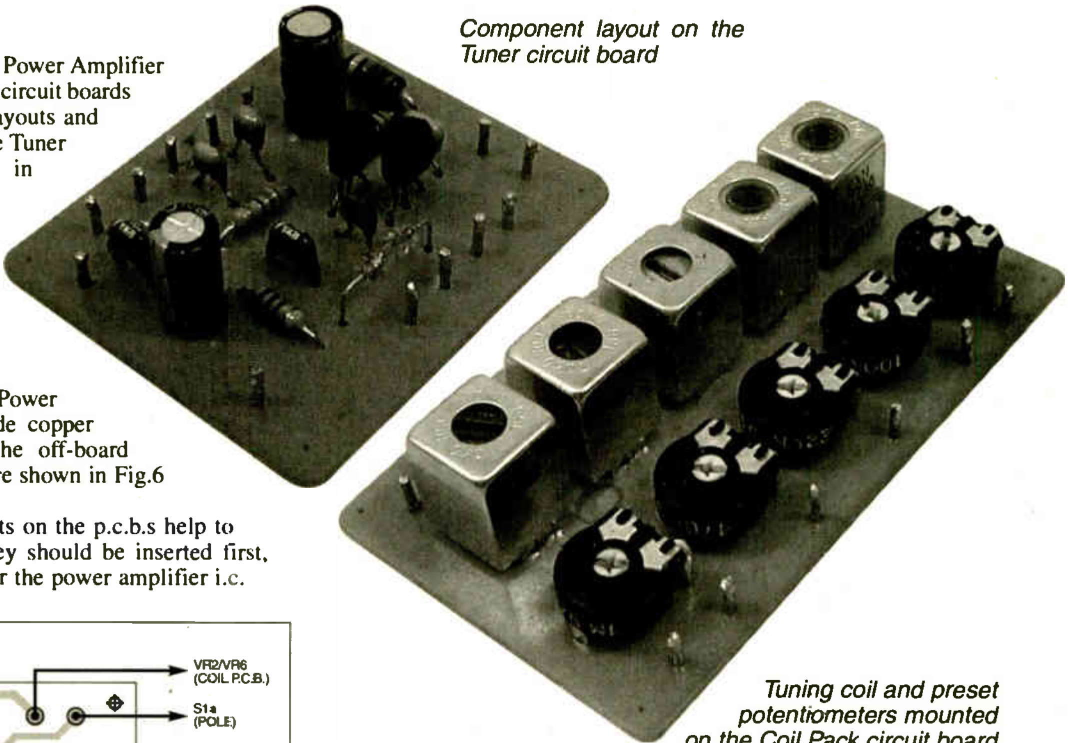
Printed circuit board available from the *EPE PCB Service*, code 496(Amp); 8-pin d.i.l. socket; p.c.b. stand-off pillars; l.e.d. bezel; small plastic knob; battery holder (6 x AA cells); multistrand connecting wire; nuts, bolts and washers; solder pins; solder etc.

Construction

The Tuner, Coil Pack and Audio Power Amplifier are assembled on individual printed circuit boards (p.c.b.s). The topside component layouts and underside copper foil masters of the Tuner and Coil Pack boards are shown in Fig.3 and Fig.4. The wiring to the wavechange switch and variable capacitors, is illustrated in Fig.5. Readers wishing to dispense with the coil pack should refer to Fig.9, which gives details of a simple, single coil arrangement.

The component layout of the Power Amplifier p.c.b., full-size underside copper foil pattern and the wiring to the off-board Volume control and loudspeaker, are shown in Fig.6 and Fig.7.

Solder pins at the lead-out points on the p.c.b.s help to make off-board wiring easier. They should be inserted first, followed by a 8-pin d.i.l. socket for the power amplifier i.c.



Component layout on the Tuner circuit board

Tuning coil and preset potentiometers mounted on the Coil Pack circuit board

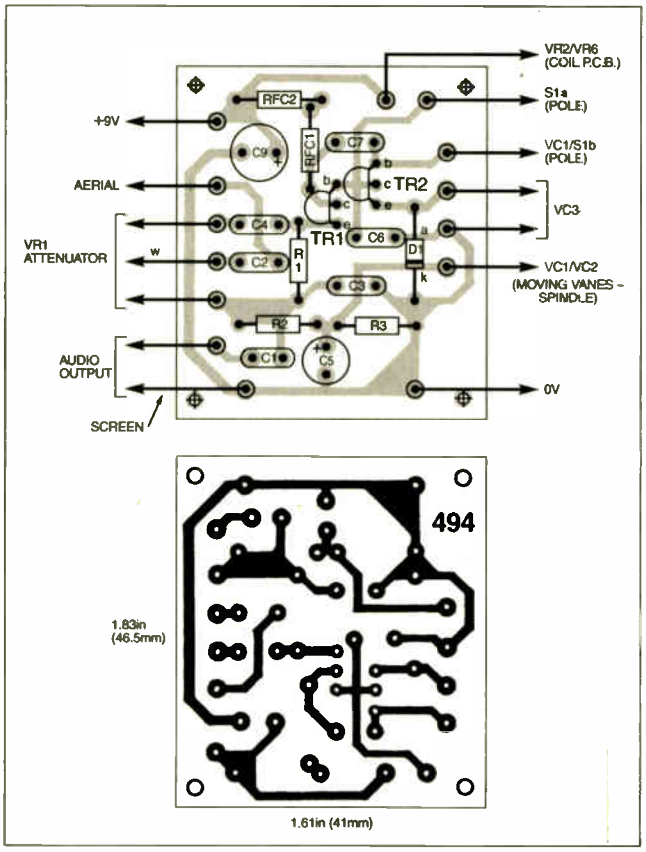


Fig.3. Tuner printed circuit board component layout (excluding coils, presets and wavechange switch), lead-off wires and full-size underside copper foil master. A screened lead must be used for the output lead. Note capacitor C8 is mounted directly between the tuning capacitor p.c.b.s

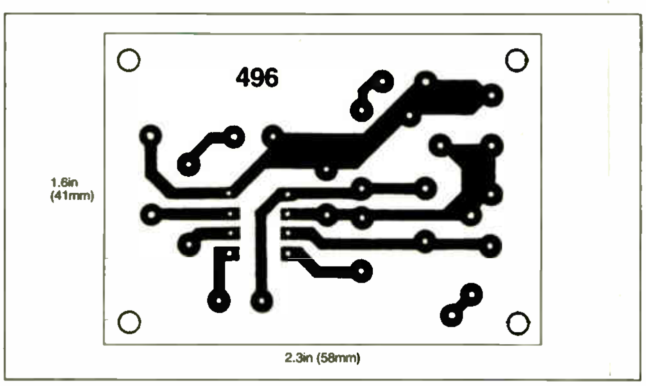


Fig.6. Full-size copper foil master pattern for the simple TBA820 i.c. Audio Power Amplifier

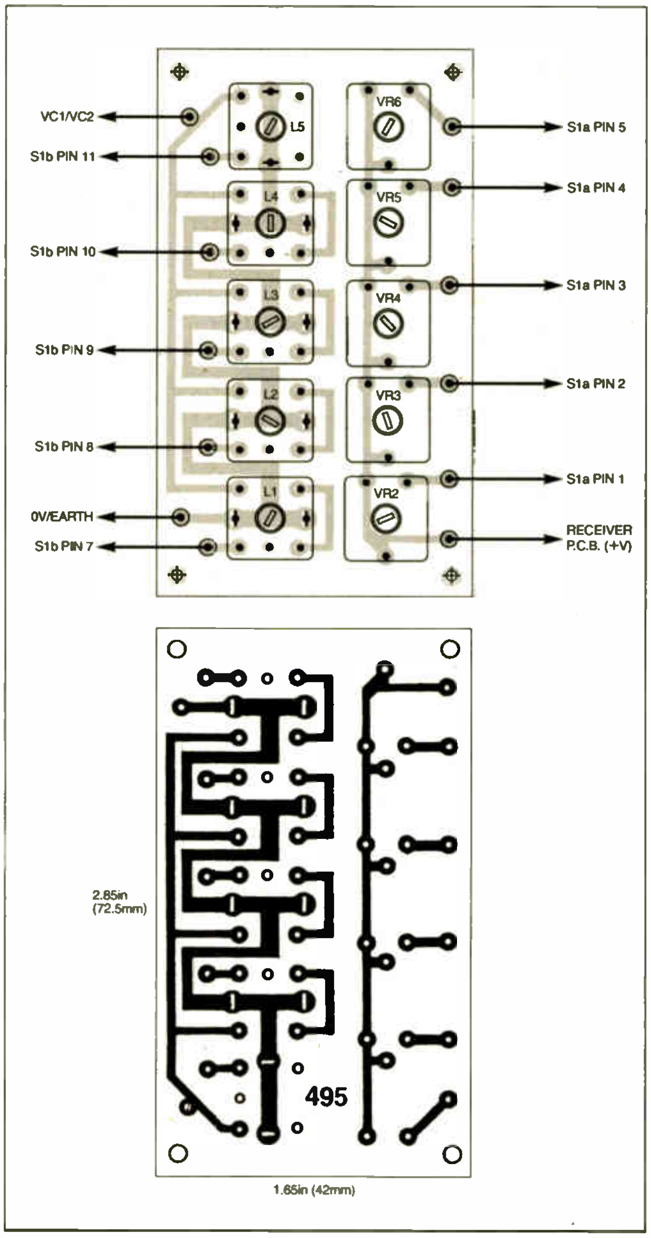


Fig.4. Printed circuit board component layout wiring details and full-sized foil master for the Coil Pack

Follow these items with the resistors and r.f. chokes, then the capacitors, smallest first, and, finally, the transistors and diode. Germanium diodes are vulnerable to damage by excessive heat during soldering. It is good practice to leave a sufficient lead length on these devices to allow a miniature crocodile clip to be attached to act as a heatshunt whilst soldering in position.

Make sure the Toko coils are correctly placed on the coil pack board before soldering them in position: they are difficult to remove. Straining the pins can result in open circuit coils.

Remember to insert a wire link if r.f. choke RFC2 is not fitted, and to provide a decoupling resistor for the Tuner if it is used with a different amplifier and connected to a shared power supply.

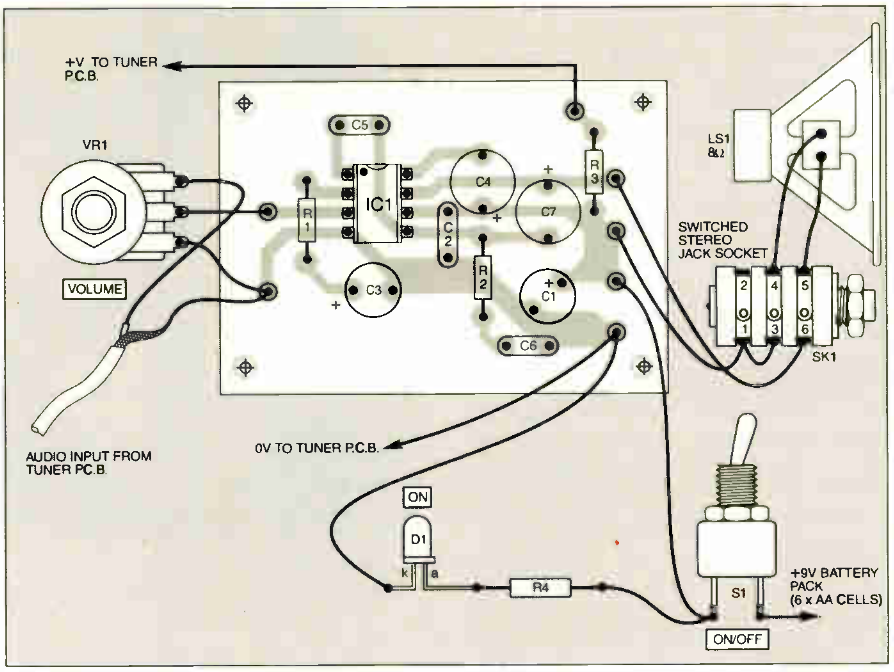
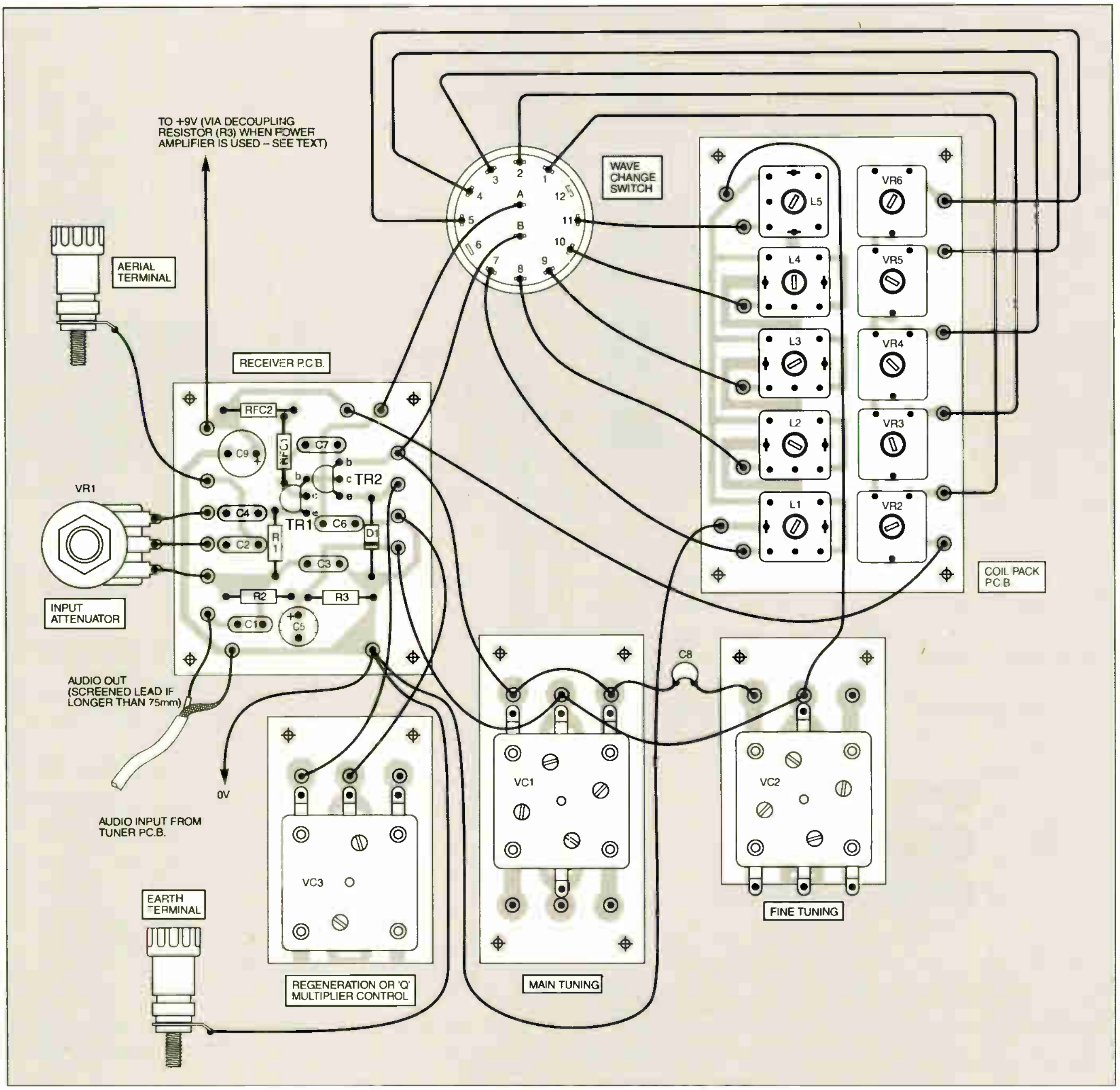


Fig.7(right). Amplifier printed circuit board component layout and wiring to off-board components. Note that a plastic bodied insulated stereo jack socket must be used for the headphones

Fig.5(below). Interwiring to the wavechange switch and variable capacitor p.c.b.s



Variable Capacitors

Miniature polythene dielectric variable capacitors (otherwise known as polyvaricons) are used for tuning and the control of regeneration. Inexpensive and widely available, they can contain up to four gangs (separate capacitors) which can be combined to form different tuning swings.

The capacitors which tune the Receiver have two a.m. and two f.m. gangs. The bandset, or coarse, tuning capacitor VC1 is formed by wiring the two a.m. gangs in parallel to produce a swing of 10pF to 260pF. Some polyvaricons have a.m. gangs with a swing of around 300pF, in which case only one should be connected into circuit. These capacitors have a deeper case: around 20mm (3/4in.) instead of 12mm (1/2in.).

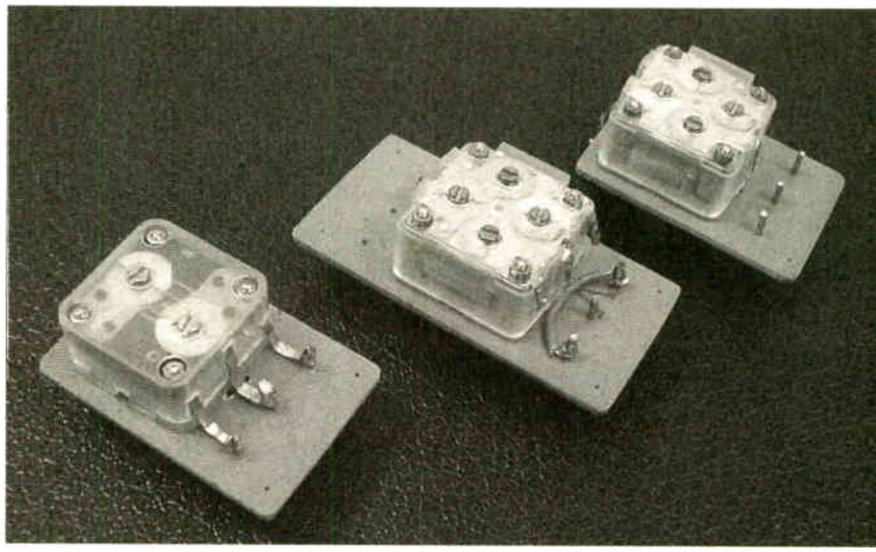
One of the 25pF f.m. gangs is used as the bandspread or Fine tuning capacitor VC2. It is connected across the bandset capacitor via series capacitor C8 (see Fig.5) which reduces its swing to produce a slower tuning rate.

The variable capacitor (VC3) used to control regeneration requires a swing of around 5pF to 100pF. An a.m.-only tuning capacitor is ideal for this purpose. These usually combine a 60pF oscillator stage tuner (marked O) with a 140pF aerial section (marked A on its case). Try the smaller of the two capacitors first, and if this doesn't have a big enough swing to make the set regenerate at all settings of the tuning capacitor, use the 140pF section. Clockwise rotation reduces the value of these capacitors. The Regeneration (Q-Multiplier) control is, therefore, advanced by turning the control knob anti-clockwise.

Moving vanes of variable capacitors are always connected to the "earthy" side of the circuit. Fixed vanes go to the "hot" or signal side. The connections shown in Fig.8 are typical of most components of this kind, but they do vary, and retailers will usually supply details.

The printed circuit board illustrated in Fig.8 will accommodate most screw or solder-tag fixed polyvaricons. It is useful for mounting these components behind the front panel, particularly when a slow-motion drive is provided or when the capacitor spindles have to be insulated. Any fixing screws driven into the variable capacitor's front plate *must be short* or they will protrude into the case and damage the vanes.

Extenders are required for the very stubby spindles of these capacitors. With this design, the tuning capacitor moving vanes (connected to the spindle) are at a small positive potential, and they ***must be insulated from any metal case.*** Insulated spindle extenders are, therefore, to be preferred. As an alternative, a 6mm diameter nylon stand off, secured to the capacitor spindle with a 2mm metric bolt, will also serve if these parts are to hand or can be sourced.



Miniature polythene dielectric (polyvaricon) variable capacitors mounted on p.c.b.s to aid wiring and ease mounting in the case. Note the two cut-down boards

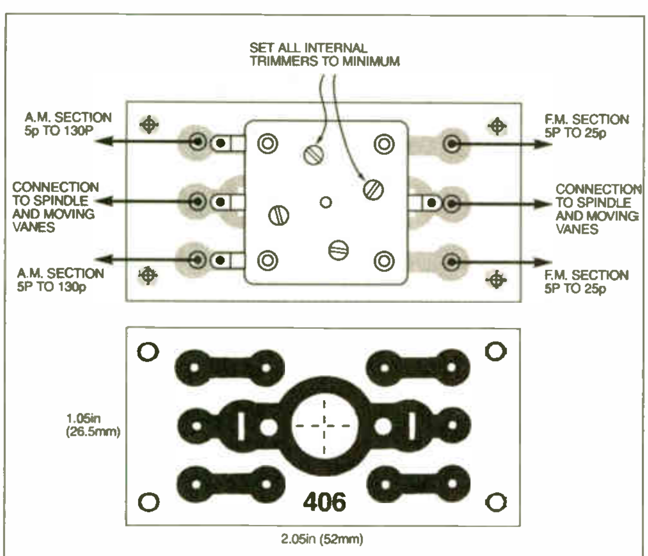


Fig.8. Typical connections and capacitor values for most 4-gang a.m./f.m. polyvaricons. The Fine Tune and Regeneration capacitors p.c.b.s have to be cut down to fit inside the case – see Fig.5. This p.c.b. will accept most screw or solder-tag fixed polyvaricons

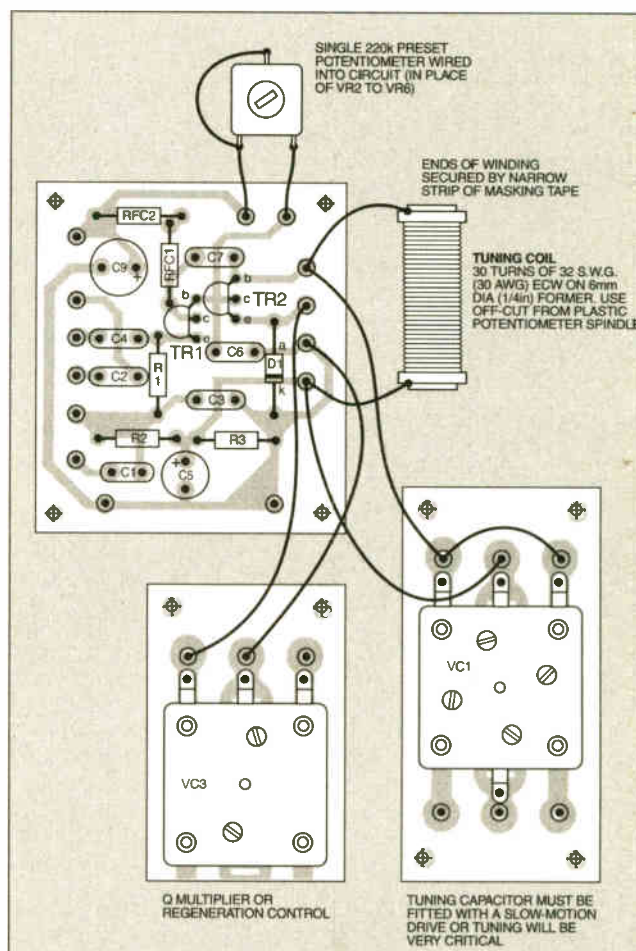
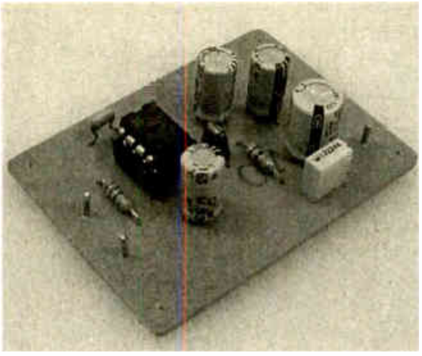


Fig.9. Simplified tuning arrangement using a hand-wound coil. Using this homemade coil will give a coverage of 6MHz to 16MHz



Components mounted on the Audio Amplifier p.c.b.

Layout of components and lettering of components mounted behind the top of the Receiver case. This arrangement allows room for a slow-motion drive for a front panel dial

Headphones.

A headphone socket is an essential feature on any shortwave receiver. It should be of the switched kind to isolate the speaker when the phones are inserted. Most earphones are now of the stereo variety, and a stereo socket should be fitted and connected so that both earpieces are wired in parallel.

Testing

Commence testing by first checking the printed circuit boards for poor soldered joints and bridged tracks, then check the placement of components and the orientation of electrolytic capacitors, diode, transistors and integrated circuit.

It is a good idea to test the Receiver before mounting the various parts in a case, and the p.c.b.s can be temporarily wired up on the bench to facilitate this. Make the connections to the coil pack with crocodile clips on short leads, or adopt the simple single-coil arrangement depicted in Fig.9, for the test. Use short (no longer than 75mm or 3in.) leads to connect potentiometers and capacitors to the boards. You must use a screened lead to connect the Tuner p.c.b. to the Amplifier p.c.b.

Attach two to three metres (six to ten feet) of flex to act as an aerial, and set the r.f. potentiometer VR1 for maximum input. Set the regeneration preset potentiometers, VR2 to VR6, to the mid-way position, and turn the regeneration capacitor, VC3, fully clockwise (to minimum). Set all the variable capacitor's internal trimmers to minimum (vanes unmeshed: they can be viewed through the back of the capacitor's translucent case).

Connect a fresh 9V battery pack. Current drain of the tuner should be approximately 0·6mA (600μA), and the drain of the amplifier around 6mA under no-signal conditions.

Tuning-In

Advance the Regeneration control, VC3, until a faint hiss is heard in the loudspeaker. Rotating the Tuning capacitor, VC1, should now bring in a number of stations. Check all of the ranges on the coil pack, and adjust presets VR2 to VR6 until the regeneration control, VC3, operates smoothly at all settings of the tuning capacitor VC1. Best results will be obtained with the presets (wired as variable resistors) set at as high a resistance as possible (clockwise rotation). Guidance on operating the receiver is given later, and this may prove helpful during the testing process.

Little and Large

Readers will have their own ideas about mounting the receiver in a case, and much will depend on whether a multiband or a single-band version has been constructed.

Single-band operation and the connection of a crystal earpiece to the Tuner board (the volume control can be omitted) opens up the possibility of a very small receiver. With a current drain of around 600μA, a PP3 battery should power the set for many hours,

When small size is not important, considerable advantage can be gained by fitting a larger speaker (at least 100mm or 4in. diameter) to make more efficient use of the power delivered by the Audio Power Amplifier.

Casing Up

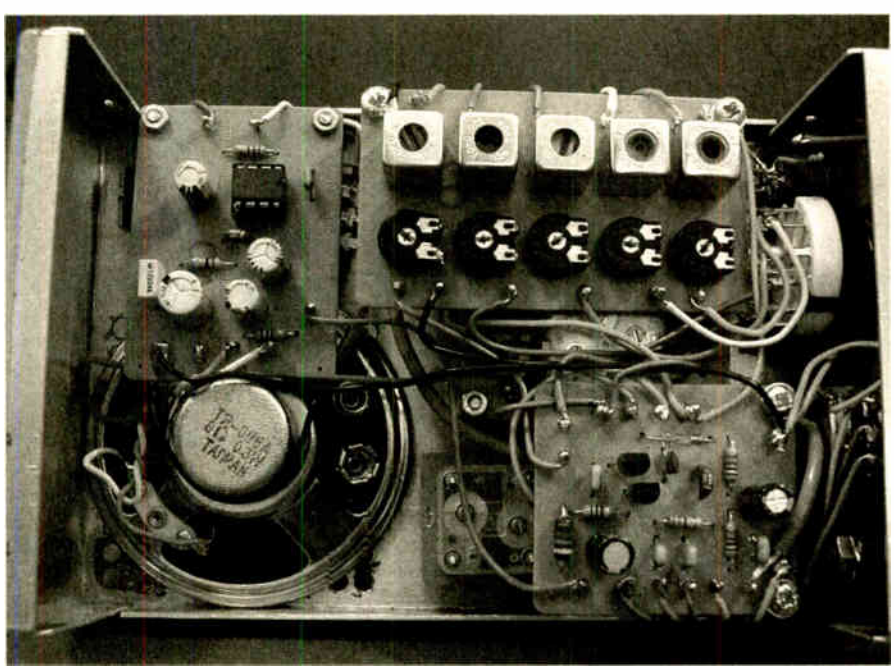
The version of the Spontaflex Receiver described here is housed in a standard aluminium box, measuring 154mm × 104mm × 52mm (6in. × 4in. × 2in.), and the various photographs show the general arrangement of the components.

Stand-offs are used to mount the printed circuit boards and variable capacitors behind the front panel. Remember that the tuning capacitor spindles ***must not*** connect to the 0V rail, and the nylon extenders insulate them from the metal front panel.

In order to make room for a Tuning dial, the Aerial and Earth terminals, R.F. Input Attenuator potentiometer (VR1), Wavechange switch, On/Off switch and On indicator l.e.d. are mounted at the top of the case. An epicyclic slow-motion drive is fitted to the main tuning (bandset) capacitor, VC1.

With a layout as compact as this, it is recommended that colour-coded leads be soldered to the wavechange switch and the other components located at the top of the case before the printed circuit boards are mounted in position.

The loudspeaker, headphone socket, and volume control are located behind the front panel. A pattern of holes, 3mm (1/8in.) diameter, are drilled in the front panel to form a speaker grille, and the speaker glued in position behind them with cyanoacrylate adhesive (Superglue).



General layout of components and printed circuit boards inside the aluminium case. Note that the base of the case becomes the receiver's front panel and one end panel the top

Aluminium primer and car spray paint are used to finish the case, and the dials are marked out on white card and annotated with rub-down lettering. Acrylic sheet, the kind of 2mm thick material used for DIY double glazing, protects the card.

The prototype dials are reproduced, half-size, in Fig.10. Note the anti-clockwise rotation of the Q-multiplier or Regeneration control (VC3). A pointer for the tuning dial is cut from scrap acrylic sheet, and its scribed hairline filled with black ink (see photographs).

Power Supply

A pack of six AA cells represents an economical way of powering the Receiver. They are mounted in holders Superglued to the back and side of the case, and have to be carefully positioned to fit into the available space. The photographs show the general arrangement.

A PP3 battery is completely unsuitable for powering a receiver containing an amplifier of this kind. Its life would be short and its rising internal resistance would cause instability.

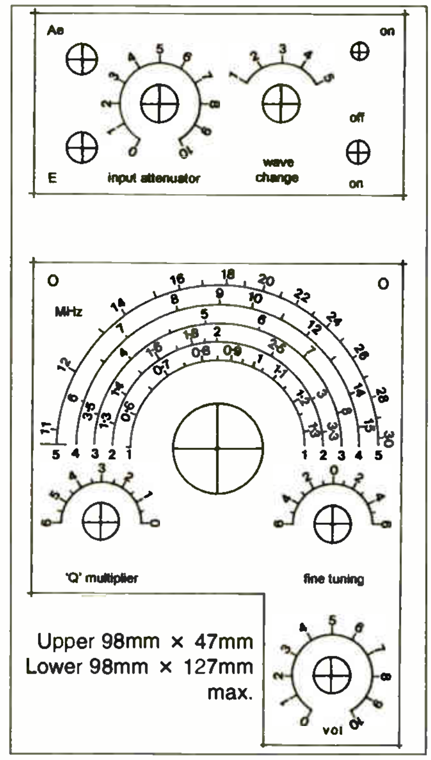
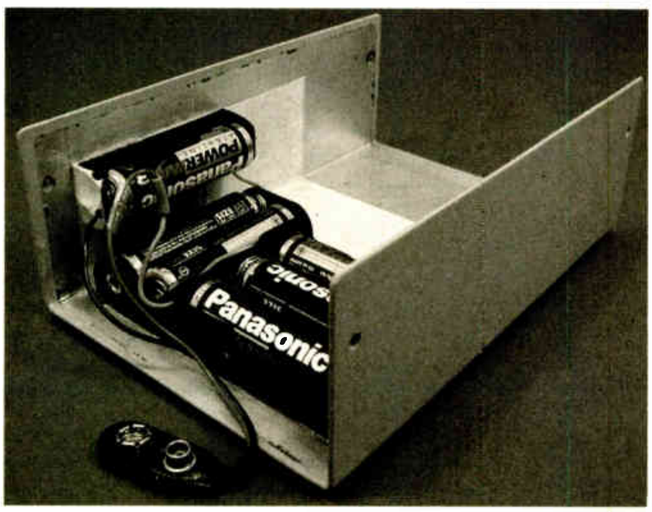
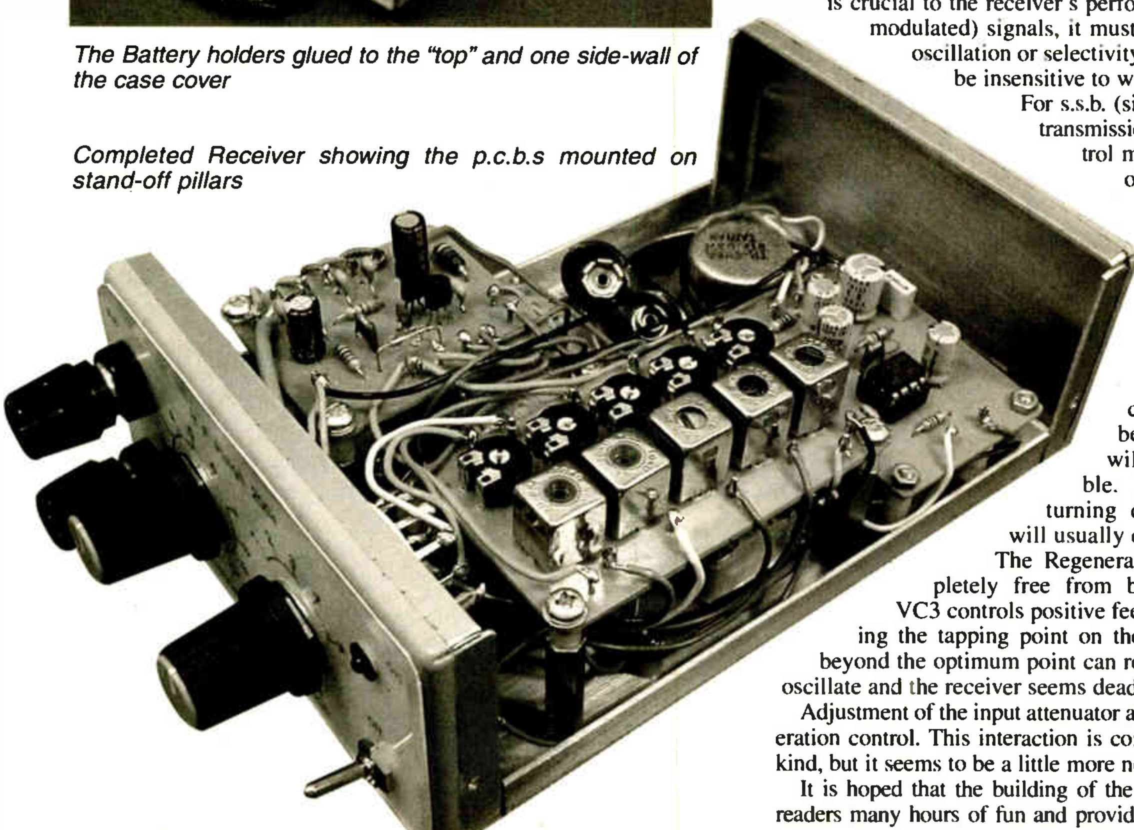


Fig.10 (above right). Top and front panel control dials reproduced half size. The completed Receiver is shown top left



The Battery holders glued to the "top" and one side-wall of the case cover

Completed Receiver showing the p.c.b.s mounted on stand-off pillars



Operations

Short aerials work best with this Receiver, certainly no more than six metres (twenty feet), and a length of wire stretched across the room is usually more than sufficient. An Earth connection will eliminate hand-capacity effects and improve reception on the lower frequencies. A lead clipped to the central heating pipework is likely to be satisfactory.

Turn the Input Attenuator down and use the Volume control to maintain the desired sound output. Even when very short aerials are fitted, strong signals can sometimes overload this receiver.

Regeneration

The correct setting of the Regeneration (Q-Multiplier) control is crucial to the receiver's performance. For a.m. (amplitude modulated) signals, it must be kept on the threshold of oscillation or selectivity will be poor and the set will be insensitive to weak signals.

For s.s.b. (single side band), the mode of transmission used by amateurs, the control must be advanced until the set oscillates. This local, signal frequency, oscillation replaces the carrier suppressed at the transmitter and the diode detector is able to recover the audio modulation in the usual way.

Tuning must be very precise when s.s.b. signals are being received, or the speech will be garbled and unintelligible. If a signal refuses to clarify, turning down the Input Attenuator will usually effect a cure.

The Regeneration control (VC3) is completely free from backlash. Variable capacitor VC3 controls positive feedback by electrically adjusting the tapping point on the tuning coil. Advancing it beyond the optimum point can result in the circuit ceasing to oscillate and the receiver seems dead.

Adjustment of the input attenuator affects the setting of the regeneration control. This interaction is common to all receivers of this kind, but it seems to be a little more noticeable with this circuit.

It is hoped that the building of the *Spontaflex* receiver will give readers many hours of fun and provide just a small insight into the ingenuity and imagination of a true "wireless experimenter". □

New Power Products From B.K.Electronics

A new range of 12V and 24V to 230V Inverters with soft start

NEW

A Complete range of regulated inverters to power 220V and 240V AC equipment via a car, lorry or boat battery. Due to their high performance (>90%) the inverters generate very little heat. The high stability of the output frequency (+/-1%) makes them equally suitable to power sensitive devices.
These inverters generate a modified sine wave, which are considerably superior to the square waves which are produced by most other inverters. Due to this superior feature they are capable of powering electrical equipment such as TV,s, videos, desktop & notepad computers, microwave ovens, electrical lamps, pumps, battery chargers, etc.

★ Soft start (Minimises shutdown when used with inductive loads) ★ Reverse polarity protection ★ Battery low/high shutdown ★ Short Circuit, overload and overtemp protection

150W

£26.48

Part No. 12V	651.620
Part No. 24V	651.623
Continuous Power	150W
Peak Power	450W
Output Voltage	230V AC
AC Frequency	50Hz
Efficiency	90%
Stability	+/-10%
Dimensions	165x91x58mm
Weight	850g

300W

£34.43

Part No. 12V	651.626
Part No. 24V	651.629
Continuous Power	300W
Peak Power	1000W
Output Voltage	230V AC
AC Frequency	50Hz
Efficiency	90%
Stability	+/-10%
Dimensions	190x91x58mm
Weight	1.1kg

600W

£69.09

Part No. 12V	651.632
Continuous Power	600W
Peak Power	1800W
Output Voltage	230V AC
AC Frequency	50Hz
Efficiency	90%
Stability	+/-10%
Dimensions	242x91x58mm
Weight	1.7kg

1000W

£141.47

Part No. 12V	651.638
Continuous Power	1000W
Peak Power	3000W
Output Voltage	230V AC
AC Frequency	50Hz
Efficiency	90%
Stability	+/-10%
Dimensions	393x242x80mm
Weight	3.1kg

300W Pure Sine Wave Inverter

300W

A pure sine wave inverter for supplying 230V AC from a 12V car battery. A pure sine wave is required for example field lab use.

★ Generates pure sine wave
★ Cooling Fan
★ Low Voltage alarm below 10.5V DC
★ Automatic turn off when voltage below 10V
★ Protected against short circuit and overheating

Price £122.06

Part No. 12V	651.650
Continuous Power	600W
Peak Power	1000W
Stability	+/-10%
Efficiency	90%
THD	<4%
Dimensions	80x242x255mm
Weight	2.8kg
Temperature Range	-15 to +50 Deg C

1500W 12 or 24V to 230V Inverter

★ The inverter gives an audible warning signal when the battery voltage is lower than 10.5V (21 for the 24V versions). The inverter automatically shuts off when the battery voltage drops below 10V (20V for the 24V versions)
★ Protection - Input short circuit and over heating (55 Deg C)
★ Modified sine wave
★ Remote lead available

Price £246.75

Part No. 12V	651.602
Part No. 12V	651.605
Continuous Power	600W
Peak Power	1800W
Output Voltage	230V AC
AC Frequency	50Hz
Efficiency	90%
Stability	+/-10%
Dimensions	242x91x58mm
Weight	1.7kg

Regulated PSU Adjustable 0-20V / 2A

Only £24.48

Regulated power supply with a variable output voltage ranging from 0V to 30V at 2 amp max.
★ Housed in a solid case
★ Fixed mains lead
★ Illuminated mains switch
★ Output via red(+) and black(-) 4mm sockets
★ Fitted with 2 panel meters for analogue display of Voltage and current

Power Supply 230V AC 50Hz, Output Voltage 0 to 20VDC, Output Current 2A Max, Dimensions 110x240x150mm, Weight 2.8kg Pt.No.650.673

Regulated PSU Adjustable 0-30V / 10A

Only £157.92

Regulated power supply with a variable output voltage 0 to 30V and current limiting up to 10 Amps
★ Voltage and current limiting provided by "coarse" and "fine" rotary controls
★ The unit has short and "FOLDBACK" overload protection
★ Output via red(+) and black(-) and green(ground) 4mm sockets
★ Output voltage and current are indicated by two clear 3-digit green LED displays

Power Supply 230V AC 50Hz, Output Voltage 0 to 30VDC, Output Current 0 to 10 Amps, Dimensions 160x260x355mm, Weight 12kg Pt. No.650.682

Regulated PSU Adjustable 0-30V / 3A

Only £82.91

Regulated power supply with a variable output voltage 0 to 30V and current limiting up to 3 Amps
★ The unit has short and "FOLDBACK" overload protection
★ Housed in a solid case
★ Power switch fitted
★ Output via red(+) and black(-) 4mm sockets
★ Output voltage and current are indicated by two high precision LED displays

Power Supply 230V AC 50Hz (150W), Output Voltage 0 to 30VDC, Output Current 0 to 3 Amp, Dimensions 155x2133x285mm, Weight 3.7kg Pt.No.650.676

Triple Output Regulated PSU Adjustable 2x30V / 0-3 Amps Plus 5V at 3 Amp Fixed

Only £157.92

Regulated power supply with with dual variable voltages from 0 to 30V DC and a fixed 5V at 3A output
★ The setting of the output voltages can be coupled (master/slave)
★ Series and parallel switchable output
★ The unit has short and "FOLDBACK" overload protection
★ Output via red, black and green terminals
★ Output voltage and current are indicated by two clear 3-digit green LED displays

Power Supply 230V AC 50Hz, Output Voltages 2 x 0 to 30VDC 1 x 5V fixed, Output Current 2 x 0 to 3 Amps 1 x 3A fixed, Dimensions 160x260x355mm, Weight 12kg Pt. No.650.685

Regulated PSU Adjustable 0-50V / 3A

Only £94.75

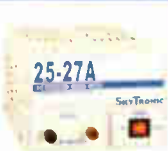
Regulated power supply with a variable output voltage 0 to 50V and current limiting up to 3 Amps
★ The unit has short and "FOLDBACK" overload protection
★ Housed in a solid case
★ Power switch fitted
★ Output via red(+) and black(-) 4mm sockets
★ Output voltage and current are indicated by two high precision LED displays

Power Supply 230V AC 50Hz (175W), Output Voltage 0 to 30VDC, Output Current 0 to 3 Amp, Dimensions 155x2133x285mm, Weight 3.7kg Pt.No. 650.679

13.8V Fixed Voltage PSU's

A complete range of fixed voltage regulated power supplies all short circuit and "FOLDBACK" protected housed in sturdy cases

Model Number	650.652	650.654	650.657	650.660	650.663	650.667
Continuous Current	3A	5A	7A	9A	12A	15A
Maximum Current	5A	7A	10A	15A	20A	25A
Peak Surge Current	7A	9A	12A	17A	22A	27A
Output Voltage	13.8V DC	13.8V DC	13.8V DC	13.8V DC	13.8V DC	13.8V DC
Price	£18.70	£23.96	£32.81	£49.26	£57.46	£67.17



DELIVERY CHARGES:- ALL ABOVE ITEMS CHARGED AT £8.00 PER ORDER. ORDERS FROM SCHOOL, COLLEGES, GOVT., PLCs ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER. CREDIT CARD ORDERS ACCEPTED BY POST PHONE OR FAX. E&OE

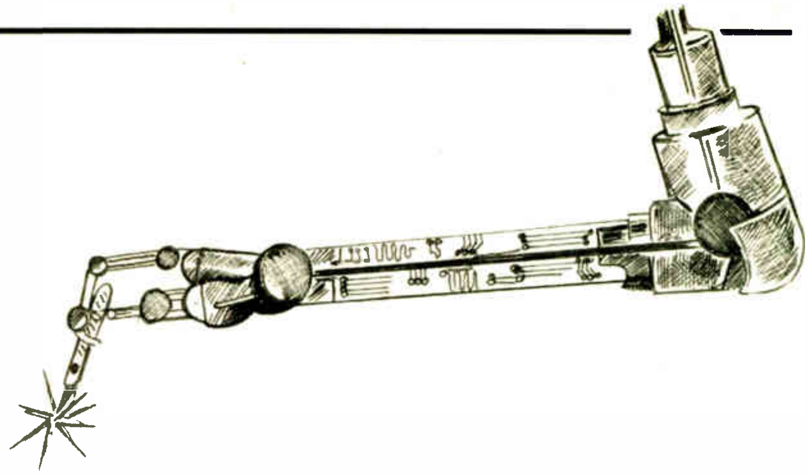
B.K. ELECTRONICS

UNIT 1 COMET WAY, SOUTHEND-ON-SEA, ESSEX. SS2 6TR.
TEL.: 01702-527572 FAX.: 01702-420243
Web:- http://www.bkelec.com E-Mail sales@bkelec.com

Ad-5

Regular Clinic

Circuit Surgery



Alan Winstanley and Ian Bell

EPE's brainy surgeons offer a useful reminder about thermistor theory together with more helpful pointers on the FT232B USB-series chip mentioned in previous issues

USB Update

In previous *Circuit Surgery* columns (Dec. 2004 to Feb. 2005) we introduced the principles behind the Universal Serial Bus (USB). We mentioned the extremely useful FT232BM chip which can provide a USB-serial interface for many devices including PIC microcontrollers. Using suitable software, this will allow you to control PICs via a USB port on your PC. Although the FT232B is a surface mount device, many constructors with reasonable soldering skills will be able to use one successfully on a home-brew p.c.b.

Readers will recall from the December 2004 issue the difference between self-powered (needing an external power source such as a mains adaptor) and bus-powered USB devices, the latter drawing power from e.g. the PCI bus of a computer. We omitted to show the change of connection required on the PWRCTL terminal (pin 14) which is used for configuring self-powered and bus-powered operation. This pin is used to inform the chip which way it is being used so that it will respond appropriately.

When experimenting with USB-based circuits it can be useful to switch between bus-powered and self-powered operation. This can be done simply by constructing a board with jumpers to allow either configuration to be set up. A possible circuit for doing this is shown in Fig. 1. Note that this diagram does not show all the connections to the FT232BM (see Feb. 2005 *Circuit Surgery* for more details), but only those related to power configuration and USB connection

In Fig. 2 we show the jumper settings for bus-powered operation. In this mode the +5V supply comes from the USB connection and the circuit will only be powered up when it is connected to an active USB port. In bus-powered mode an external supply must not be connected!

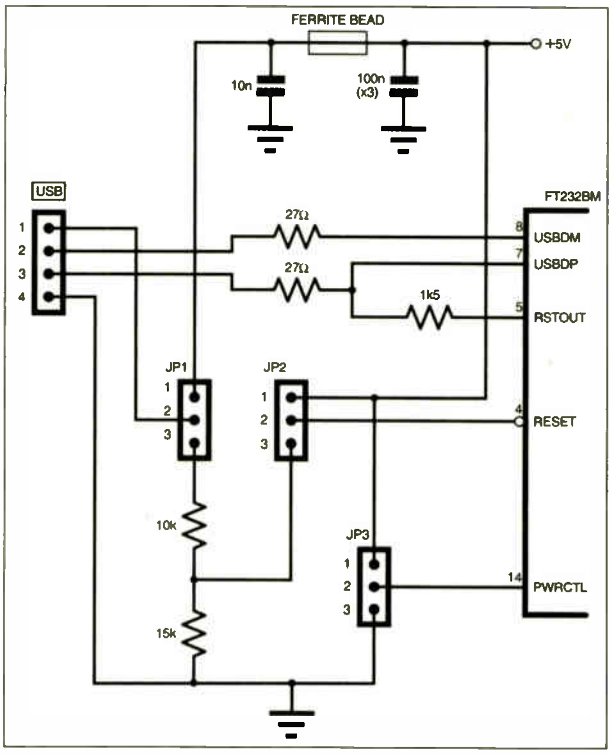


Fig. 1. Experimental FTB232BM circuit which can be configured for bus powered or self powered operation by jumper settings on a circuit board.

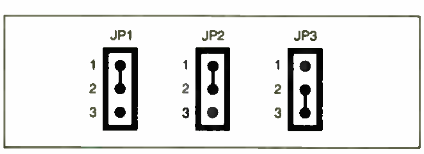


Fig.2. Jumper settings for Bus Powered Operation

For self-powered operation, the jumper settings in Fig. 3 should be used. Here the circuit is isolated from the USB power source and must be provided with a separate regulated +5V supply instead. The circuit will be powered up if this supply is connected, irrespective of whether or not it is connected to a USB port. Connection of the circuit to a USB port without the +5V supply present will not result in a connection being established. More details of the FT232BM USB-serial interface are available from FTDI, see **www.ftdichip.com**. *I.M.B.*

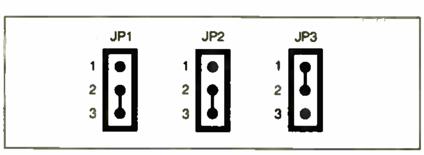


Fig.3. Jumper settings for Self Powered Operation

Thermistors

We continue with a useful reminder of the theory behind thermistors – what they are and how to use them. A thermistor is a thermally-dependent resistor that belongs to the class of components called *transducers* – devices that convert one form of energy or phenomenon into another.

Microphones, loudspeakers, piezo-electric sounders and opto-resistors are basic examples of transducers; ultrasonic sounders convert electrical signals into ultrasound waves that are imperceptible to human hearing. Light-emitting diodes convert electrical energy into visible and non-visible light and can be classed as transducers as well. Thermistors should not be confused with *thermocouples*, that are sensitive transducers that are often intended for use in, say, a rugged environment such as a kiln or oven.

Thermistors act primarily as simple resistors, the ohmic value of which depends on its temperature. Their obvious use is in temperature detection and monitoring, though they also have a more specialist application in stabilizing sensitive oscillators such as precision Wien bridge circuits, and they can also find their way into anti-surge power circuits, to prevent damage to equipment during power-up. Thermistors may be *rod*, *disc* or *bead* types, the first two being basic temperature-dependant devices suitable for general thermal detection. A *glass bead* thermistor is very much more expensive, and is contained in an evacuated glass envelope (vacuum bulb). They have a fast response time and are used for precise temperature measurement.

Looking at some technical and practical aspects of thermistor specifications, the resistance of a negative temperature coefficient (**NTC**) thermistor is inversely proportional to the surrounding temperature: its resistance falls when temperature rises. NTC types are suitable for most temperature measurement and detection circuits. Conversely, the resistance of a positive temperature coefficient (**PTC**) thermistor will rise with temperature. PTC types are used in overload protection circuitry to handle in-rush currents and protect equipment from damage. Schematic symbols for both types are shown in Fig. 4.

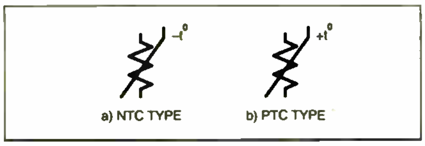
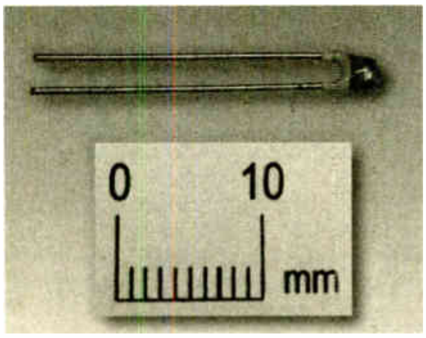


Fig.4. Thermistor schematic symbols. Note the – and + prefixes

The standard resistor colour code may be used to denote the value of a thermistor using coloured bands printed on the body, and it is usual to specify a thermistor's resistance at 25 degrees Celsius. Just like ordinary resistors, they are manufactured in a range of preferred values. The Philips 640 range of thermistors, for example, starts at 2k2 through to 470k @ 25°C. Different families may have closer tolerances on accuracy, from 10% down to 1%.

Hobby catalogues are pretty sparse on useful information, so let's fill in some of the background and describe the technique used to estimate the resistance of a thermistor at a particular temperature.



A typical bead thermistor

Thermistors from A to B

Two important factors are alpha (symbol α), which is the thermistor's temperature co-efficient of resistance (an indication of how much its resistance changes for a given change in temperature), and Beta (symbol β), the material temperature constant which is expressed in Kelvin and is usually given for the detection range of 25° to 85°C.

The temperature coefficient of resistance is given in percent per deg. C. and is related approximately to the temperature constant as follows:

$$\alpha = -\frac{\beta}{T^2} \times 100\ \%\ \text{per}\ °\text{C}$$

where T is an absolute temperature in Kelvin. (The negative sign indicates that the temperature coefficient decreases when the resistance and temperature rise.)

The Beta value is useful in helping us to calculate a resistance at a given temperature. Unfortunately for us, thermistors are non-linear devices. It isn't as though doubling the temperature causes the resistance of an NTC device to fall precisely by half. This makes it more difficult to predict an exact resistance value for a certain temperature. For two resistance values R1 and R2 at two temperatures T1 and T2 (in Kelvin), Beta can be calculated as:

$$\beta = \frac{\ln x \left(\frac{R1}{R2}\right)}{\left(\frac{1}{T1} - \frac{1}{T2}\right)}$$

Beta is quoted in Kelvin (K), not to be confused with the kilo (1,000s) prefix. As can be seen from the formula, Beta is calculated by taking the natural log of the ratio of two resistances R1/R2, and dividing that by the difference between the two temperature reciprocals of T1 and T2, which are also specified in Kelvin.

For those unfamiliar with the Kelvin temperature scale, it has the same interval as the Celsius scale, but is shifted by a value of 273·15. The ice point of water for example (0°C) is 273·15K and the steam point (100°C) is 373·15K. Simply add 273·15 to the Celsius temperature to obtain the Kelvin value.

We can then estimate the resistance of a thermistor if we know the Beta value of a specific device, as follows:

$$R2 = R1 \times e^{\left(\frac{\beta}{T2} - \frac{\beta}{T1}\right)}$$

The value of e is 2·7183. As a worked example: the data sheet of an NTC bead thermistor states a Beta value of 3740(K), and resistance (R1, in ohms) of 15 kilohms @ 25°C (T1). What is the resistance (R2, in ohms) at 75°C (T2)? Remember to shift the temperatures to the Kelvin scale by adding 273·15. Then (scientific calculators at the ready) the answer is R2 = 15,000 × $e^{-1{\cdot}803}$ or about 2475 ohms.

This technique is near enough for hobby use but is based on just two temperature references. Also, the self-heating effects generated by current passing through the thermistor have been ignored. For more accurate results, a method using the Steinhart & Hart Equation would be used. This involves taking actual readings of a thermistor at three different temperatures and calculating the value using three simultaneous equations. For most constructional projects, any inaccuracies can be "trimmed out" using preset resistors, using a multi-turn type if necessary.

A web site worth bookmarking is the US thermistor manufacturer Ametherm (**www.ametherm.com**) where I found a number of well-written and concise definitions. I was also impressed with Ametherm's friendly response to our enquiries. Their sales engineer Garon Martin explains: "a lot of people out there do not know about thermistors. For instance, we are finding that many companies are using $20 circuits to limit inrush currents, when they can be spending pennies on the dollar for a PTC thermistor. Not to mention that limiting inrush is just one use for a thermistor... they can be used to monitor temperature, circuit overload protection etc...etc... The more knowledge that people like you can supply in one way or another, the better our business does and in turn our customers can save money as well. Thank you for the help!"

EPE is happy to oblige! Next month we will explore more basic principles and offer some simple temperature control ideas using NTC thermistors. Also in the pipeline, Ian Bell is doing interesting things with Compact Flash (CF) cards and we hope to bring you a special feature explaining how to use these useful memory modules to store data. *A.R.W.*

TECHNO-TALK MARK NELSON

THE EYES HAVE IT

Catseyes on our roads are being replaced by clever optoelectronics. Mark Nelson sheds some light on the subject.

Two of the greatest advances in road safety come from Yorkshire and both involve cats. But no animals were harmed in the research for the products, nor indeed in the writing of this article. OK, let's get serious.

Clever Cats

One of Britain's gifts to the world is the catseye, the reflective markers that indicate the centre (or side) of the road in the dark. It was the invention of a Yorkshireman, Percy Shaw (1890-1976), and came about from a chance observation of his that on poorly lit roads, the glint of light on tram rails (commonplace in those days) provided a handy marker for the road ahead.

Another version of the story asserts he was driving one dark and foggy night when he spotted a pair of small green lights near the edge of the road. On stopping, he discovered the apparition was the eyes of a cat caught in his headlights.

You can make your own decision as to which tale sounds more likely but the nett result was his notion of twin glass mirrors that reflected vehicle headlamps, a piece of inspiration that made him a rich man after he patented the idea in 1935.

The original version of his masterpiece embraced reflective marbles placed close together in a rubber casing that flexed under the weight of vehicles driving over it, cleaning the marbles in the process. Later versions of the same device used strips of Scotchlite, the retroflective material used on many roadsigns and reflective jackets. This uses microprism technology and millions of minute high-performance glass beads bonded with a special polymer layer.

Even Cleverer Catseyes

The other day I spotted for the first time one of the new "intelligent catseyes", which are electronic and highly ingenious. Used and positioned in the same way as the traditional catseye, the new version detects light from oncoming vehicles and then triggers a timed light output.

The power for the electronics comes from a solar cell on top of the unit charged by daylight. Since l.e.d. power usage is directly proportional to the time the light is on, the light source flashes or twinkles in a rather alarming way (well, quite scary if you haven't seen them before!). According to the experts, you are not supposed to see the flashing head-on but do notice the flickering in your peripheral vision.

Like the original catseye, the new product is a British invention and is made by a firm appropriately called Reflecto. Although the company has a Yorkshire postal address, it's actually based in north Nottinghamshire in the small village of Everton, three miles east of the Great North Road near Bawtry. Everton is of course more famous for mints and football but this is a different Everton!

Life Saver

Famed or not, since the introduction of Reflecto's self-illuminating road studs in 1998, more than 50 county councils and highway authorities throughout the UK have deployed them as a means of accident reduction and prevention. According to the makers, the cost of deploying these Reflectolites is recovered rapidly with the prevention of just one serious injury (and the total cost of deploying ambulance and police teams is pretty horrendous). The prevention of just one fatality pays for over thirty new installations in the first year of operation.

The ultra-bright l.e.d.s are visible for a kilometre or more and the anti-strobing 250Hz frequency used is stated to be flicker-free (but not to my tired old eyes!). Colour options are red, white, amber and green, whilst the low-profile gizmos can withstand compression of 20 tonnes and the effect of a snow plough passing over at 35m.p.h.

A major benefit is their brightness, meaning drivers do not have to use high beam lights to see the road ahead. Anecdotal evidence has it that they work well for three quarters of the year, although their output is said to be dimmer in winter, presumably because there is less daylight to recharge the cells.

The cost means they have been installed mainly on routes having a high incidence of people running on the road at night and already they have had a large impact on reducing the accident rate. However, they make a marvellous trophy for "collectors" (petty thieves) and are fairly easily stolen.

Road Power

Using a small part of the road surface to generate electricity is one thing but what about using all the highway? That's the brainwave of Edward Sargent from the University of Toronto, who notes that one thousandth of the area of the United States is paved with road. "If all of this tarmac could convert the sun's power into electricity, it would provide enough energy to supply all of the US's energy needs", he argues.

But how do you turn tarmac into a power station? By embedding in it tiny semiconductor crystals that generate electricity, specifically from the infra-red component of the sun's rays. According to a document by Sargent and his colleagues reported recently in *The Guardian*, this method will produce much more electricity than conventional solar cells.

"Half of the sun's energy reaching the Earth is in the infra-red spectrum. These new nanocrystals could enable us to harness the sun's power in an efficient and cost-effective way", he says, adding that the new-style nanocrystal solar cells are cheap enough to be produced on a large scale for incorporation into the surface layer of tarmac on roads and pavements. They can also be added to paint or ink and could be painted onto the roofs of houses and offices in sunny areas.

Holy Grail

That's by no means all you can do with nanocrystals, he continues, which can be combined with all manner of silicon electronics, passive optics and RF platforms. By altering their diameter you can tune, through the quantum size effect, the spectrum of their optical emissions as well as create all the various elements needed to switch and route the all-optical networks of the future.

Lasers, modulators, detectors and multiplexers could all be integrated onto a single substrate, producing a photonic microchip that was cheap, robust and convenient. Currently this represents the Holy Grail of the optical communications industry, according to Sargent, and today's researches are "a critical first step in the development of photonic circuits and microchips".

Future networks have got to be optical because light can carry far more information than today's generation of electronic switches and Internet routers are capable of transmitting. With today's technologies light is difficult to control, however, which is why there is still some way to go. Nevertheless, according to Sargent, his team's techniques could point the way to an Internet or information highway that not only operates literally at the speed of light but can also be directed to our desks at the same speed.

Very Interesting!

The entire range of the 2005 Skytronic catalogue available from Cricklewood Electronics

This, Dutch Wholesaler's Catalogue, is now available to UK retail customers via Cricklewood Electronics and includes thousands of electronic items and components at bargain prices. The 432 page catalogue includes:
Plugs, Sockets, Cables, Switches, Speakers, Microphones, Components, Car Audio, Disco & PA & HiFi Equipment, CCTV Cameras & Recorders, Tools, Test Equipment, Inverters, Power Supplies, Electrical, Multimedia, Computer accessories, etc etc

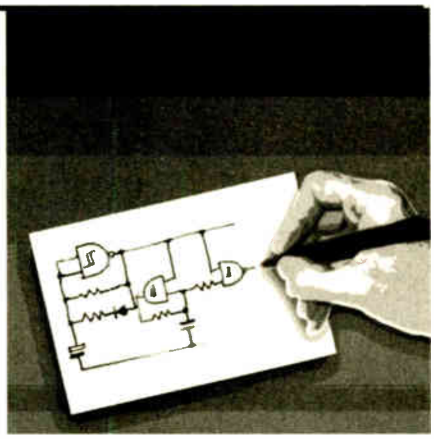
Catalogue & Price List free to shop-callers. To have it posted - please send £2.00 towards postage costs. (UK only).

Cricklewood Electronics Ltd

40-42 Cricklewood Broadway, London NW2 3ET. Tel: 020 8452 452 0161, Fax 020 8208 1441
email: sales@cricklewoodelectronics.com
Visit our website @ www.cricklewoodelectronics.com

Constructional Project

Back to Basics – CMOS Logic Devices



Bart Trepak

Part 1 Introduction and Fridge/Freezer Door Alarm

This short series of articles illustrates how useful circuits can be designed simply using CMOS logic devices as the active components

IT may seem strange, but electronics, like many other fields of human endeavour, is also subject to fashion. As ideas and circuit techniques change, so too do the components available, giving rise to whole series of here today gone tomorrow components.

Every now and then, however, a technique is developed which is so good or has so many advantages that it stands the test of time. The development of the bipolar transistor over 50 years ago was one such example, which effectively spelt the death of the thermionic valve, changing the whole course of electronics design. Bipolar transistors are still widely used today and were the subject of a previous *Back to Basics* series (Feb to Jun '03).

Another much quieter, though perhaps no less important revolution, occurred in the early 1970s with the development of CMOS logic devices without which the so-called digital revolution, and certainly the personal computer, might probably have remained just an interesting theoretical concept.

CMOS, Complimentary Metal Oxide Semiconductor, to give it its full title, made possible the development of a whole range of very complex integrated circuits containing millions of transistors, ultimately leading to the fabrication of the microcontroller, which was a revolution in its own right and which is so evident in today's circuit designs.

As well as being used in large scale integrated circuits, CMOS devices are also available in much simpler circuits such as gates and counters. This short series aims to explain briefly the basic operation of CMOS logic circuits, their advantages in the fabrication of complex integrated circuits, and introduce a number of practical applications using just four of the devices from the extensive range available.

Since their introduction, the range of CMOS devices has increased and apart from the original 4000 series, newer CMOS versions of TTL (Transistor-Transistor-Logic) series devices with similar pin-out arrangements have appeared. These feature high speed operation from lower supply voltages, even down to around 2V.

The 4000 series devices, which will be used throughout this series, can operate from 3V to 15V and are therefore more useful in projects powered by a 9V battery.

MOS Transistors

To understand how CMOS logic devices work and their advantages, it is useful to examine the structure and operation of metal oxide semiconductor transistors which operate in a totally different way to bipolar transistors. The term MOS essentially describes the structure of the transistor device, which consists of a Metal gate, deposited on an Oxide insulator on a Semiconductor substrate, as shown in Fig.1.1.

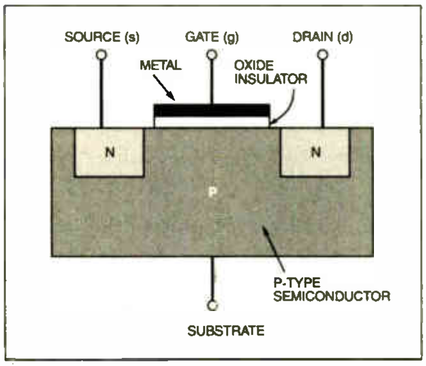


Fig.1.1. Basic structure of a CMOS transistor

Using this basic structure it is possible to make a variety of transistors which work in a number of different ways, but in this case we are interested in what is known as an *enhancement MOS transistor* which has two contacts of opposite polarity semiconductor (*n*-type in this case) made in the substrate (*p*-type), which form the source and drain connections.

A basic logic inverter using a MOS device is shown in Fig.1.2a and consists of a transistor and load resistor. With the supply connected, no current will flow through the circuit because of the reverse biased *pn* junction in the drain (d) connection of the device so that the drain voltage will be the same as the supply voltage, or logic 1 (high).

If a sufficiently high positive voltage (usually about one or two volts) is applied to the gate (g), electrons in the substrate material will be attracted to the region underneath the gate giving a local excess of negative charge carriers, changing the *p*-type substrate into a low resistance *n*-channel.

No current will flow from the gate to the substrate because of the insulating oxide layer, but the device will now conduct between the source (s) and drain causing the drain voltage to fall to a low value, logic 0 (low). Connecting the gate to 0V again will inhibit the channel, switching the device into its high resistance state so that a logic 0 at the gate will result in a logic 1 at the drain and vice versa, giving the logic inversion function.

Note that the conductivity of the channel is proportional to the gate voltage so that linear amplification is also possible, but in logic circuits the transistors are (normally) used as switches and the gate voltage is switched between 0V and the positive supply.

It is interesting to compare the circuit in Fig.1.2a with the bipolar equivalent circuit in Fig.1.2b. The most striking difference is the absence of a resistor in series with the gate, a terminal which can be considered analogous to the base (b) of the transistor. The bipolar transistor needs a base current

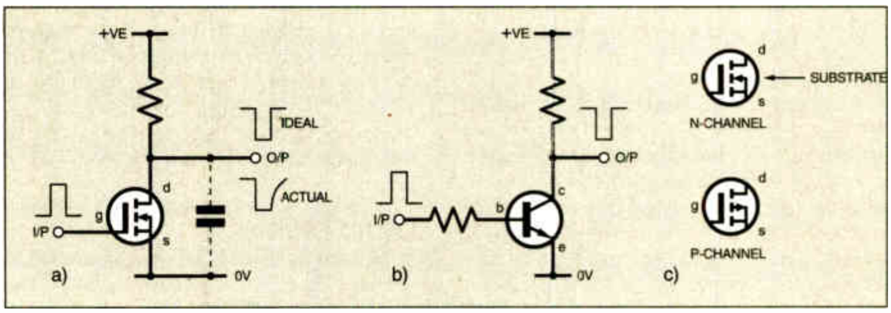


Fig.1.2. (a) CMOS inverter, (b) bipolar inverter, (c) n-channel and p-channel circuit symbols

of a few microamps to switch on, so a resistor is required to prevent too large a current flowing into the base. But since the gate of the MOS transistor is insulated, no current (other than that needed to charge or discharge the gate capacitance) can flow in the gate circuit when it is made positive.

Just as bipolar transistors are available in both *npn* and *pnp* variants, MOS transistors can also be fabricated in *n*-channel and *p*-channel versions. The operation of these is the same, except that the gate, drain and source polarities must be reversed. A *p*-channel device will therefore be operated with a negative drain voltage and the gate will have to be made negative with respect to the substrate to switch it on.

Note that the substrate is normally connected to the negative supply in the case of *n*-channel devices and the positive supply for *p*-channel devices, which in logic circuits is (almost) always the source terminal of the device.

The circuit diagram symbols for *n*-channel and *p*-channel enhancement MOS transistors are shown in Fig.1.2c.

CMOS

A problem with the inverter shown in Figs.1.2a/b, is that when the transistor is on and current is flowing, power is dissipated in the load resistor. This could easily be reduced by simply increasing the value of the resistor, but such circuits do not operate in isolation. The output will always be connected to the inputs of one or more other gates, which can be thought of as a capacitor (shown dotted in Fig.1.2a) and a parallel resistor to represent the input impedance of these gates. (With MOS transistors this resistor will have a very high value and may be ignored so it is not shown).

If the output is to switch between logic levels, the capacitor must be charged or discharged by the circuit before a recognisable logic level is achieved. The high to low logic transition can occur fairly quickly because the low resistance of the transistor when it is switched on will discharge the capacitor quickly. But in switching from logic 0 to 1 the capacitor must charge and this can only happen with the current flowing through the load resistor.

The output waveform will therefore be nearer to that shown as "actual" rather than a steep rise in voltage as the "ideal". With a high value load resistor, as the switching speed is increased, a point will be reached when the output voltage will not have time to rise to a recognisable logic high before the transistor switches on again and discharges the capacitor. The output of the inverter stage will thus appear to be permanently low to successive logic circuits. For high speed operation, therefore, the load resistor value must be kept low, which leads to higher power dissipation.

Dissipation

Dissipation may not be such a problem with an individual device unless it is to be battery powered but, in a complex integrated circuit such as a microcontroller, which may contain hundreds of thousands of such elements, the resulting power dissipation could increase the temperature of the chip beyond safe levels. The use of complementary MOS transistors, however, enables designers to achieve both high speed and low power dissipation.

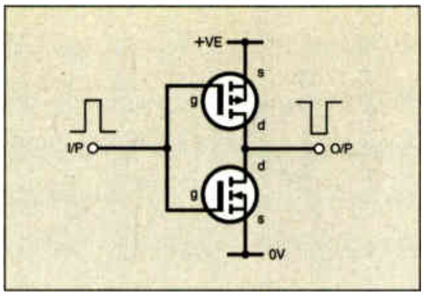


Fig.1.3. CMOS gate inverter

Inversion

If the input signal is inverted by a CMOS gate, comprised of *n*-channel and *p*-channel elements as in Fig.1.3, a load resistor is not required. There is then no significant heat generated during the inversion process (apart from that across the gate's own inherent resistance, which can never be zero). Consequently, the rate at which the signal is actually processed is also increased.

To explain the inverter in Fig.1.3, its two elements are connected in series across the supply with their gates tied together forming the input. If the input is connected to the positive supply, the upper *p*-channel element will be cut off while the lower *n*-channel element will be switched on.

The output, which is taken from the common junction of the two device drains, will therefore be connected to the 0V supply line via the relatively low resistance of the *n*-channel transistor and be at logic 0. With the input connected to the 0V supply, the *n*-channel transistor will be turned off and the *p*-channel turned on, connecting the output to the positive rail, logic 1. The output voltage will therefore be the opposite logic to the input logic, giving the logic inversion required.

Low Power

The important thing to note about this circuit is that only one of the transistors is on at any one time and as there is no continuous path between the supply rails, the circuit will draw virtually no current, resulting in very low power dissipation.

The very high input impedance also means that any similar following stages will draw almost no current from the output, allowing virtually any number of similar inputs to be driven. It is these features which make the circuit ideal for battery operation and for use in complex large scale integrated circuits such as microcontrollers.

Another feature of CMOS circuits is their relative tolerance to variations in the supply voltage. The 4000 series devices, for example, will work quite happily from any supply between 3V and 15V, making them ideal for battery operation at 9V. (Very high speed CMOS circuits which are pin compatible with the old TTL logic are also available, but these have a more restricted supply voltage range and will not be considered here.)

Logic Levels

As with all digital circuits, the operation is based on only two voltage levels – low and high (logic 0 and logic 1) and in any practical circuit voltages between these levels should be avoided as there will be uncertainty about which logic level is intended.

In general, the voltage threshold of CMOS inputs above which logic 1 and below which logic 0 are registered, varies with the supply voltage and usually can be taken to be roughly half of the supply voltage, within a few millivolts (although there are exceptions to this rule).

This threshold should never be aimed for in a logic design. At this level, which is only approximate, any small noise voltage picked up by the high impedance inputs could cause the circuit to switch erratically. In practice, the voltage difference between the two input logic levels should be kept as large as possible.

Ideally, most circuits should be operated with input levels within a few millivolts of the supply rail voltages to give the highest possible noise immunity. This is done by drawing the smallest possible current from any output, especially if that output is also connected to the input of another CMOS device.

Despite this, most logic gates can source or sink a few milliamps. However, the effective channel output resistance of the MOS transistors when they are on depends on the gate voltage. So circuits operating at say 10V will have a lower "on resistance" and can therefore output (sink or source) more current than ones operating at 5V, without the output voltage being significantly reduced.

The lower output impedance at higher supply voltages also means that circuits will switch faster, although this is not normally important in many simple applications.

Buffering

External buffer resistors should always be fitted to the output if there is the possibility of potentially damaging currents or high power dissipation being generated. This should always be done when driving l.e.d.s or bipolar transistors. With l.e.d.s, for best results low current types should be used, indeed standard 4000 series CMOS cannot adequately drive normal l.e.d.s. at a reasonable brightness.

The outputs of CMOS devices should never be connected together directly unless it *can be guaranteed* that they will always be in the same state. This technique is sometimes used when two or more inverters are paralleled to increase the current available from an output.

Although Fig.1.3 shows a simple logic inverter, similar logic gates such as AND and OR can be formed by connecting MOS transistors of both polarities in series or parallel arrangements. These can also be followed by another inverter to form NAND and NOR gate functions. Counters and other more complex functions also have their outputs buffered by similar circuits so that conditions at the output pins cannot upset the internal logic levels.

A final point about CMOS circuits concerns handling. The very high input impedance of the gate circuit allows high static voltages to build up which can cause the very thin gate oxide layer to break down, destroying the device. Such voltages are frequently encountered (e.g. simply walking across a carpeted room can generate a voltage in excess of 20kV). Consequently, CMOS circuits normally have protection diodes and resistors internally connected from the inputs to the supply rails to prevent the voltage at the gate from exceeding the supply voltage.

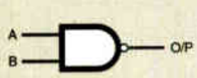
Despite this, it is best to avoid touching the pins when constructing circuits and the use of sockets is highly recommended. For this reason also, any unused inputs should be connected either to used pins or to one or other supply rail (depending on function) to prevent the input from "floating" and picking up stray voltages and so assuming unintended logic states. This does not apply to unused output pins which should always be left unconnected.

The protection diodes can handle a forward current of up to about 10mA so that if the source voltage at an input pin is in danger of rising above V_{dd} (positive rail voltage) or falling below V_{ss} (0V) during circuit operation and a current greater than this could flow, an external resistor should be connected in series with the pin.

Using CMOS

Although the 4000 CMOS logic range contains a large number of devices with many useful functions, this series of articles will use only four of them (4011, 4017, 4040 and 4093) and a fuller explanation of these is given here to avoid repetition later in the series.

The 4011 device is a NAND gate. Its truth table shown in Fig.1.4, from which it will be seen that the output is low (0) only when input A AND input B are both high (1). The output will always be high if either or both inputs are low. It is worth noting that if both inputs are tied together (i.e. input A is always the same as input B) the gate will function as a logic inverter.



INPUT A	INPUT B	OUTPUT
0	0	1
1	0	1
0	1	1
1	1	0

Fig.1.4. NAND gate truth table

As well as performing their stated logic functions, NAND gates can be interconnected to form bistable, monostable and astable circuits. Fig.1.5 shows a bistable circuit formed from two NAND gates. This has two stable states, with either output A or output B being high, but both outputs can never have the same logic level at the same time. Use the truth table to work out for yourself how output logic states change in response to various input level changes.

A monostable circuit built around two NAND gates is shown in Fig.1.6. A monostable has only one stable state in which the output B is high and output A is low.

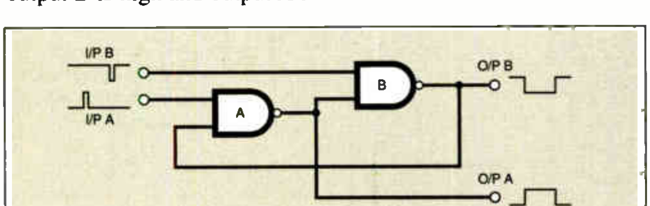


Fig.1.5. Bistable formed from two NAND gates

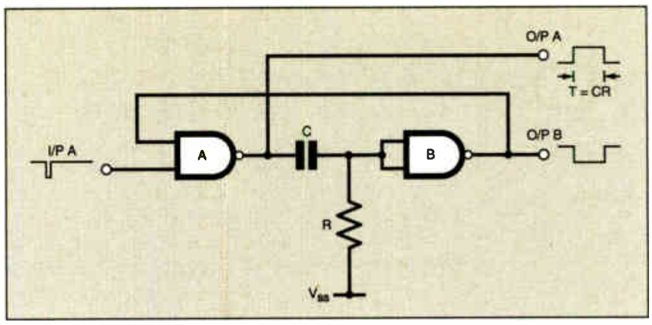


Fig.1.6. Monostable formed from two NAND gates

The combined inputs of gate B are held low by resistor R and since the output of gate A is also normally low, capacitor C will be discharged. On receipt of a low-going trigger pulse at gate A, a positive-going pulse will be developed across the capacitor, triggering output B to go low. As this output is also fed back to gate A, that input will also go low, preventing the gate from responding to any more input trigger pulses.

This condition will remain until capacitor C discharges through resistor R, after which the circuit reverts to its previous state. The low output pulse period is determined by the values of C and R.

Astable

The circuit for an astable is shown in Fig.1.7. In this circuit, neither output state is stable and the circuit continues to switch between the two (output high and output low) with capacitor C constantly charging and discharging via resistor R. These components therefore determine the frequency of the oscillation.

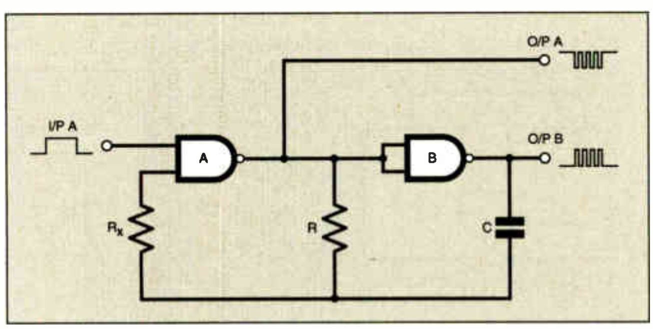


Fig.1.7. Astable formed from two NAND gates

The high input impedance of CMOS circuits enables a wide range of values to be used for these components so that a wide frequency range can easily be obtained. Very large values of R (say above 1MΩ) should be avoided otherwise frequency instability can result. Also note that, as the voltage across the capacitor repeatedly changes polarity, normal electrolytic capacitors are unsuitable for this circuit.

Resistor Rx makes the circuit less sensitive to supply voltage and gate threshold variations, its value should be roughly 10 times that used for resistor R.

In this circuit, both gates operate as inverters and by using only one of the inputs of the first gate as shown, a gated astable oscillator can be produced which can be stopped and started under control of the other input. Taking the input high allows oscillation, while taking it low forces the output of the first gate high and prevents oscillation.

Schmitt Trigger

One problem with the basic inverter circuit shown in Fig.1.3 is that the signal level is changing slowly. A situation is reached around the threshold level where both transistors are conducting. This not only increases the supply current and power dissipation, but it is also undesirable in a logic circuit as the device then operates as a linear high gain amplifier. This can result in the output oscillating randomly as the input voltage slowly switches between logic levels.

To avoid this problem when input levels are changing slowly, a Schmitt Trigger circuit can provide the solution.

As the input voltage to such a circuit is increased, the output does not change until an upper threshold level is reached when it suddenly switches to its other (low) state. If the input is now reduced slightly, the output will remain in this new state and the input must be reduced substantially to below a lower threshold before the output switches back to its original (high) state.

This difference in the switching thresholds is called *hysteresis* and is an important feature in the operation of Schmitt trigger circuits. It is an action which not only finds good use for "cleaning up" input signals, but also allows a simple gated oscillator to be formed around a Schmitt gate, as shown in Fig.1.8.

The oscillating output waveform is a square wave with a frequency depending on the values of C and R, and the threshold values of the gate, which may vary between different devices. Note that the first cycle will be slightly longer than the remainder, the capacitor will initially be fully discharged.

An advantage of this circuit over the gated oscillator shown earlier is that as the voltage across the capacitor does not reverse, an electrolytic component can be used. This enables much lower frequencies to be achieved without resorting to bulky capacitors or very high value resistors. Be aware, though that electrolytics can "leak" current and so there is a practical upper limit to the value of the resistor.

By connecting a diode and resistor in series across R, the mark-space ratio may be changed as the time constant for either

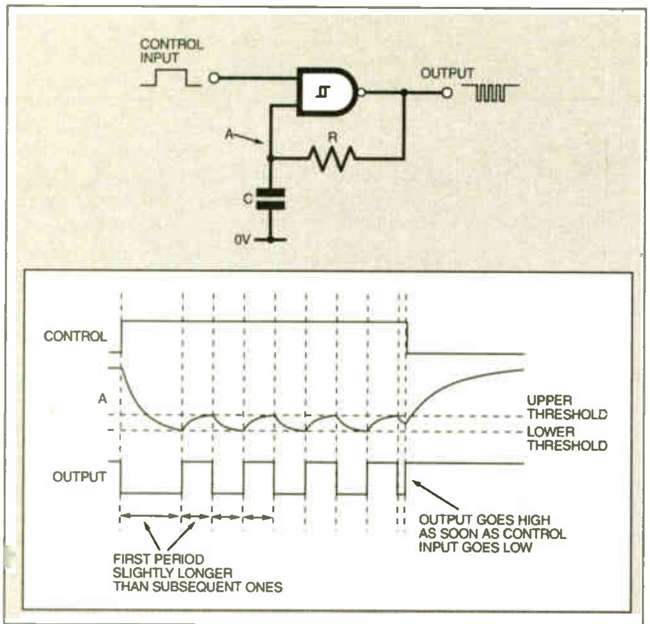


Fig.1.8. Gated oscillator formed around a Schmitt Trigger NAND gate, plus associated waveforms

charging or discharging C will be reduced (depending on the orientation of the diode) from the value due to R alone to that of R in parallel with the new resistor. Note also that the output goes high immediately the control input is taken low irrespective of the voltage at point A.

Although the actual values of the high and low threshold voltages vary from device to device, with supply voltage and even if both inputs are tied together or used individually, as a rough approximation they can be assumed to be 2/3 and 1/3 of the supply voltage respectively.

Note that only a Schmitt gate can be used in this circuit. A suitable device is the 4093 quad Schmitt NAND gate.

Counters

Many copies of the bistable in Fig.1.5 can be chained together, with the output at each stage being at half the rate of the preceding stage. In this configuration the circuit becomes a rudimentary counter. An example is shown in Fig.1.9 where three bistables are coupled in series, with an 8-stage counting cycle. The waveforms and truth table show the circuit's behaviour. The counting can be halted and reset to zero by taking the common Reset line low. More bistables can be added to increase the count cycle.

Each extra stage will increase the maximum count by a factor of two, thus four stages provide counts of up to 16, and five stages counts up to 32, and so on. As each output switches at half of the frequency of the preceding stage, if the input clock frequency is 10kHz, say, the output of Q1 will be 5kHz, Q2 2·5kHz and so on down the chain.

Dividing by other values, such as three or five (or even by 5371 if the counter is large enough) is possible by counting up to this number and then resetting the counter. This can be done by using a multiple input AND gate to decode the required state of the counter and connecting the output to the counter's reset pin.

Thus to divide by three, the AND gate would detect when Q1 and Q2 were high (which is the condition of the counter after three clock pulses) while a divide by five would use Q1 and Q3. In the first case the output of the AND gate would go high after every three clock pulses and this would be used to reset the counter, as well as providing the output.

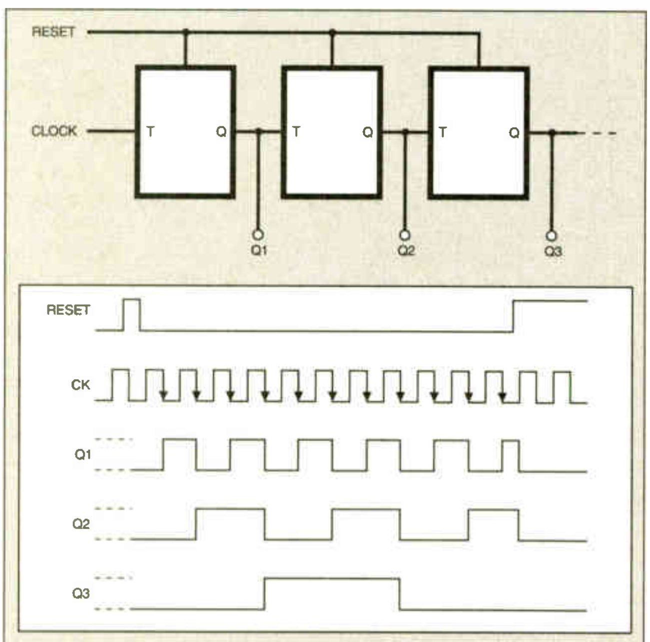
Note that the output would not be a square wave (i.e. equal mark-space ratio) as in the case of a divide by two circuit, but would consist of short pulses. This will be explored in some of the projects later in this series.

Ripple

It is clear that each output can only change after the previous stage has switched and this can lead to problems in some cases. Take for example the output state 011. The next clock pulse should cause the counter to change to 100 but before the second digit can change the first digit must change state so that for a very brief moment the outputs of the counter will be 010, then 000 before finally settling on 100.

For long counters the output state changes will thus "ripple" through the counter as it is advanced and if the decoder is fast enough, this can lead to unwanted pulses appearing at the wrong time, causing problems with the logic unless precautions are taken.

This kind of counter is known as a Binary Ripple Counter (to distinguish it from Synchronous Counters where the outputs are made to change in time with the clock input) and is available in a number of variants. The type which we will use in this series is a 4040 which consists of 12 stages, Q1 to Q12, giving a maximum count of up to 4096.



CK PULSE	Q3	Q2	Q1
	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1
8	0	0	0

Fig.1.9. Simple bistable counter circuit, plus waveforms and truth table

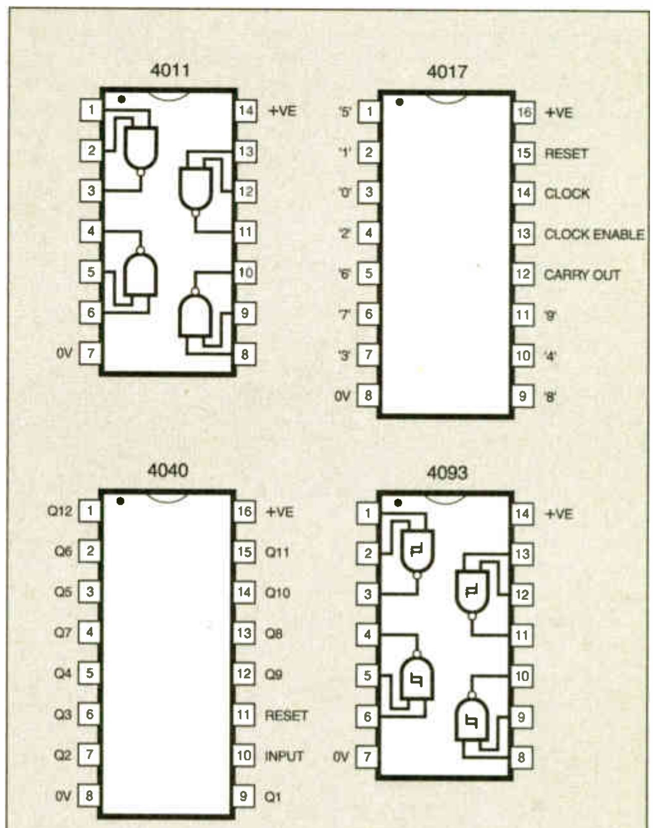


Fig.1.10. Pinouts for 4011, 4017, 4040 and 4093 devices

As well as a clock input the device also has a reset pin which, when connected to logic 1, resets the counter (all outputs at logic 0) and inhibits counting. When the reset pin is taken to logic 0 the counter advances on each negative transition of the clock input.

Decade Counter

Another useful counter chip is the 4017 decade counter. This has ten decoded outputs which are triggered in sequence, but only one can be high at any stage of the count.

The count is triggered each time the input goes high (i.e. on the positive edge of the input pulse), provided the Inhibit and Reset pins are held low. If Inhibit is high, counting cannot occur. If Reset is low, the count is reset to zero and held there until the pin is taken high again. The Carry Out pin allows several counters to be cascaded in sequence, to extend the count.

It is also a simple matter to realise counts of less than nine which may be required in some applications. For instance, if you want to divide the count by six, this can be done by connecting output Q7 to the Reset pin so that as soon as the seventh input pulse is received, Q7 will go high and reset the counter causing output Q1 to go high instead.

General Information

Pin connections for the 4011, 4093, 4040 and 4017 devices are shown in Fig.1.10. Power to these devices in the rest of the series is intended to be from a 9V battery.

Remember that to obtain correct device operation all unused inputs to gates and counters should be connected to one or other supply rail. Unused outputs should be left unconnected.

This completes our brief look at CMOS devices. During this short series a range of simple projects based on these four logic devices will be described. We start off with a Freezer Door Alarm.

Fridge/Freezer Door Alarm

THE short term consequences of leaving the fridge or freezer door open are a larger than normal electricity bill, while in the longer term, it may result in an early retirement of your freezer due to an overworked motor, not to mention the possibility of your food going off and having to be thrown out. This little gadget should help prevent such disasters by sounding an alarm if the door is left open for a prolonged period.

Most fridge and freezer doors do not lend themselves to fixing magnets and reed switches, which are the conventional way of detecting if a door is closed. Nor are they suited to the monitoring of the internal light (if one is fitted) as this has the drawback that wires will need to be passed from inside – and drilling holes in the appliance is not to be recommended!

Basic Operation

The circuit presented here is designed to sense the cold air which "spills out" from under the door when it is opened. The drop in temperature is detected by a thermistor connected to a simple circuit which can be mounted in a small box and placed on the floor below the door.

A thermistor is a specially designed resistor which exhibits a relatively large change in its resistance with temperature. The most common types have a negative temperature coefficient, which means that the resistance increases as the temperature falls. With the type specified, this varies from about 30kΩ at 25°C to around 80kΩ at 0°C. The variation is not linear over large ranges, but since we are not measuring the *actual* temperature in this application this is of no consequence.

The change in resistance is converted to a change in voltage by connecting the thermistor as one arm of a potential divider. This is used to turn on an oscillator which drives a piezo sounder. Although the thermistor responds fairly slowly to a sudden change in air temperature, a further (electronic) delay is introduced between the sensing and alarm circuits to ensure that the alarm does not go off during normal use, but only if the door is left open for a prolonged period.

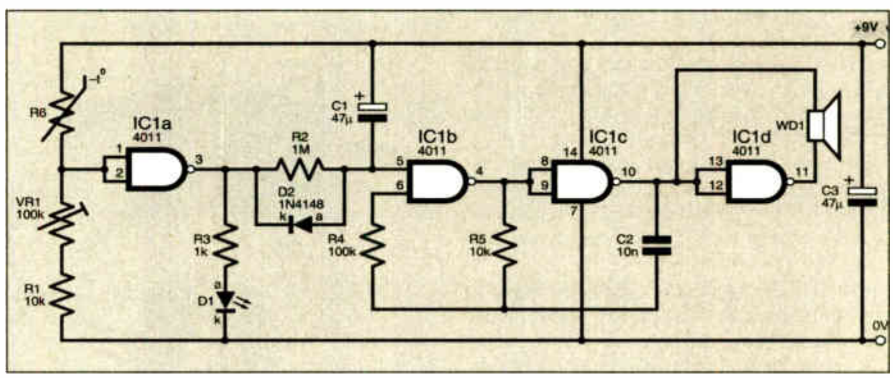


Fig.1.11. Circuit diagram for the Freezer Door Alarm

Alarm Circuit

The complete circuit diagram for the Fridge/Freezer Door Alarm is shown in Fig.1.11. It is based around a type 4011 quad NAND gate. The first point of interest is the potential divider formed by thermistor R6, preset VR1 and resistor R1. This is connected to the input of the first NAND gate, IC1a.

Although CMOS logic gate i.c.s are basically designed for use as *logic* level detectors, they are also ideal for sensing the voltage across the potential divider when it is roughly in the region of the gate's mid-way trigger threshold voltage. This is due to the gate's high input impedance and steep voltage transfer characteristics.

This means that the output switches from one logic state to the other over a relatively small range of input voltage. Further, the threshold voltage, although it varies from device to device, remains relatively constant with supply voltage variations and can be taken to be roughly 50% of the supply voltage.

As the temperature falls, the thermistor resistance increases, causing the input voltage to the gate to fall below half supply voltage level. At this point the output of the gate goes high, and in this case causes l.e.d. D1 to turn on, buffered by resistor R3. The voltage (and hence the temperature) at which this occurs can be adjusted by means of VR1, which also allows thermistors with a higher or lower initial resistance to be accommodated.

With the value of VR1 specified, almost any thermistor with a resistance of up to 100kΩ at the lowest ambient temperature should work so that many other types could be used. High values are preferable as this will result in an even lower stand-by current (the rest of the circuit draws virtually no current). If necessary, the value of R1 or VR1 could be increased to enable a higher resistance thermistor to be used. Thermistor resistance is almost always specified at 25°C.

Next comes the delay circuit, formed around resistor R2, diode D2 and capacitor C1. When the output of IC1a is low, C1 is charged quickly via D2, causing a logic low level to appear at the input of IC1b. This prevents the "gated oscillator" formed by IC1b and IC1c from operating.

When the output of IC1a goes high, C1 will discharge slowly via R2 until eventually a logic high level is recognised on the input of IC1b. This will cause the circuit to oscillate at a frequency determined by C2 and R5, with a square wave appearing at the output of IC1c.

Gate IC1d is wired as a logic inverter and buffer, so that the piezo transducer WD1 is effectively driven by anti-phase signals, resulting in a much louder sound than would be obtained by simply connecting the other end of WD1 to one of the supply rails.

Construction

The circuit is built on the printed circuit board using the layout shown in Fig.1.12. This board is available from the *EPE PCB Service*, code 498.

Care should be taken to ensure that components D1, D2, C1, C3 and IC1 are mounted the correct way round, as shown. The thermistor, R6, is not polarised and may be connected either way around, as can the piezo transducer (despite the fact that many of these have black and red leads). Ensure, incidentally, that the device is just the piezo element and does not contain an internal oscillator circuit (these are often housed in similar, albeit larger, round plastic cases).

The use of a socket for IC1 is strongly recommended as, being a CMOS device it could be damaged by static electricity. It should therefore only be connected to the circuit when all soldering has been completed, taking care to avoid touching the pins. It is also necessary to discharge yourself by touching an earthed surface before handling the device.

The choice of case for this unit is up to you, but a plastic one is recommended.

Testing

In common with all of the other projects in this series, this circuit can be powered by a 9V PP3 type battery. The current drain is very low in the stand-by state, at about 300μA.

With the thermistor at the lowest expected room temperature, preset VR1 should be adjusted so that the l.e.d. just remains off. Any further drop in temperature will then cause the circuit to switch and the l.e.d. to turn on. The alarm should sound about 30 seconds later and should switch off immediately the l.e.d. turns off when the thermistor is warmed up, the door now having been closed.

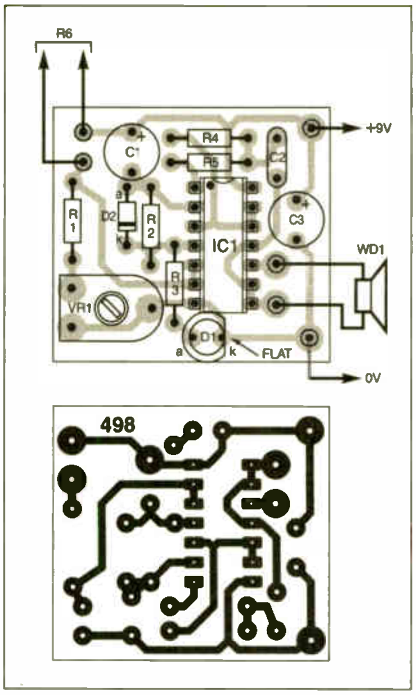
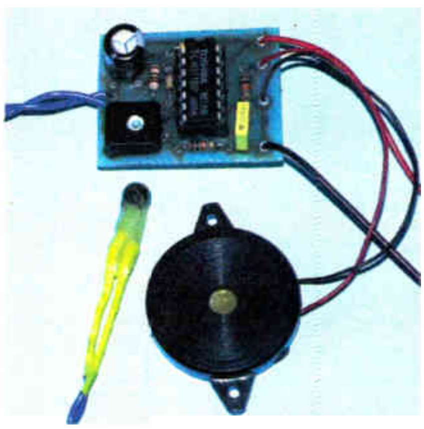


Fig.1.12. Printed circuit board component and track layout details



Prototype Fridge/Freezer Door Alarm. Differs slightly from the final version

COMPONENTS

Resistors — See SHOP TALK page

R1, R5	10k (2 off)
R2	1M
R3	1k
R4	100k
R6	thermistor, 30k at 25°C

Potentiometer

VR1	100k preset, horiz. skeleton

Capacitors

C1, C3	47μradial elect, 16V (2 off)
C2	10n ceramic disc, 5mm pitch

Semiconductors

D1	red l.e.d.
D2	1N4148 signal diode
IC1	4011 quad NAND gate

Miscellaneous

WD1	passive piezo sounder

Printed circuit board, available from the *EPE PCB Service*, code 498; d.i.l. socket; PP3 battery connector; connecting wire; solder, etc.

Approx. Cost Guidance Only **£9** *excl. speaker, case and batts*

Next Month

In Part Two next month we present a *Water Level Detector* and a simple *Burglar Alarm.* □

DrDAQ Data Logger

External sensors: Humidity
Temperature
O2 In Air
Reed Switch

- Low cost - under £80 (+VAT)
- Built in sensors for light, temperature and sound (level and waveforms)
- Use DrDAQ to capture fast signals
- Outputs for control experiments
- Supplied with both PicoScope (oscilloscope) and PicoLog (data logging) software

For more information on DrDAQ, please visit:

www.picotech.com/drdaq117

PC Oscilloscopes

- Scope and spectrum analyser functions
- A fraction of the cost of benchtop scope
- Save multiple setups, for ease of use
- Save, print and e-mail your traces
- FREE technical support for life
- FREE software and upgrades
- Automated measurements

For more information on our scopes, please visit:

www.picotech.com/scope257

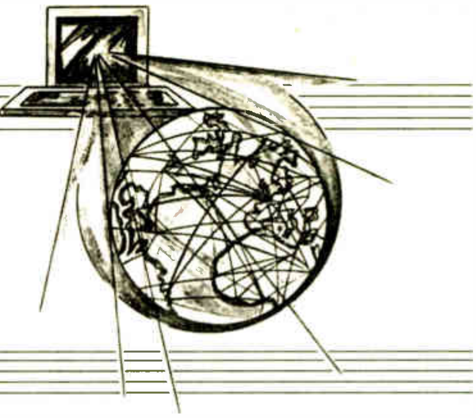
pico Technology Limited

Tel: 01480 396395 Fax: 01480 396296 E-mail: sales@picotech.com

SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY



Oh What a Tangled Web We Weave…

WELCOME to *Net Work*, our column specially written to offer timely and practical advice for Internet users (which is most readers!). In recent months we have highlighted some of the latest Internet-based fraudulent ploys including the phenomenon of "Cashback Fraud". This money-laundering fraud involves "over-paying" innocent individuals for a transaction (e.g. an eBay item) by using stolen money orders or cheques, and then inviting "surplus" funds (the cashback amount) to be sent via Western Union to a "shipping agent" or similar. Then the original payment bounces weeks or months later and the innocent victim loses everything. No compensation is available to victims of this type of fraud.

Only hours after *Net Work* March 2005 hit the streets, the writer's email started to fill up with readers' horror stories, including more reports related to eBay and PayPal transactions that have turned sour. As mentioned before, most deals on eBay are fulfilled without problems but occasionally things can go wrong: buyers as well as sellers can default on a deal. Depending on the sums involved, some people write off their losses to experience, but others are quite prepared to go the course in order to get settlement of their claim. One reader recommends that "if things go wrong, complain endlessly many times a day until they [eBay] wake up!".

What to do when things go wrong? The flip side of having an entire business model founded on Internet trading is that it is made impossible for users to drill down to eBay's bricks and mortar presence. Even eBay's invoices arrive out of the ether by email, showing a Swiss address. The closest you get is when mailing a direct debit mandate to a P.O. Box number. It is only more recently that a chink has opened in the autonomous eBay organisation that allows UK law and Customs authorities a foot in the door. Incidentally, the shopping comparison web site **kelkoo.co.uk** – now owned by Yahoo! – quotes eBay's UK office address as P. O. Box 659, Richmond Upon Thames, Surrey, TW9 1TX.

With thousands of deals going through at any one time, it stands to reason that an automated system is necessary to get any sort of response out of eBay at all. The main point of contact is by a convoluted email form, so you spend time trying to pigeon-hole your query into one of eBay's pre-formatted FAQ headings.

…When We Practice to Deceive

An eBay transaction can go awry in a number of ways, including identity theft and "second offer" fraud, forged or stolen goods being traded or "fenced", stealing user IDs and logins, fraudulent escrow services, and verification and funding via stolen bank accounts. Technology is available that provides a safe and robust system that is resilient against online fraud and identity theft. Whether eBay's perfunctory bank account check is adequate protection against criminals that use stolen account details, for example, is very questionable.

eBay goes to some lengths to assure its customers that transactions are safe and secure. Their Standard Purchase Protection plan warrants up to £120.00 with £15 deducted for costs, so if a deal turns sour then eBay will offer no more than £105.00 per claim. PayPal's Buyer Protection up to £500 is offered by sellers using PayPal who meet a number of strict criteria (98%+ rating for over 50 items, Verified user status, Premier or Business account holders). Unlike its parent company eBay, PayPal has a customer contact telephone number in the UK (08707 307 191 – see web Contacts page).

The problem is, of course, that more rigorous security checks (e.g. issuing a secure digital certificate) just slows the process down, which goes against the grain of quick and easy sign-up and the immediacy of the Internet. Other ways of stealing logins are constantly being developed, only to be defeated later on.

A Phishing Expedition

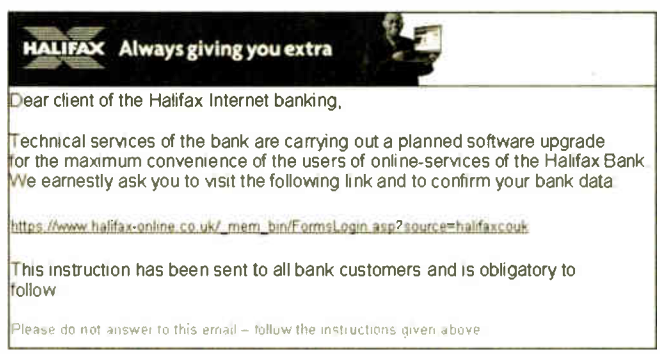
eBay, PayPal and most major UK banks and building societies have become targets of the electronic scam known as "phishing". This much publicised sting involves tricking innocent people into revealing PIN numbers and log-in details for their online banking, by replying to authentic-looking emails requesting sensitive information. No reputable organisation will ever email you asking for your personal login details.

The audacity of phishers is astonishing. Emails often contain a **.gif** or **.jpeg** which look like a text mail when viewed in an HTML email reader, but it clicks through to a fraudulent web site (e.g. in Russia) that captures login details or drops spyware onto your PC. Only the keenest eye would notice a click-through passing via a Russian domain (**.ru**) before arriving at, say, the web site of Barclays Bank.

eBay has tried to eliminate these phishing mails by introducing its own messaging system integrated into the eBay portal. Additionally, a new eBay toolbar can be downloaded which integrates into Internet Explorer to help overcome fraud.

A new weapon to help defeat phishing comes in the form of the Netcraft Anti-Phishing Toolbar, which I have been testing successfully for several weeks. Download it free from **www.netcraft.com.** This flags up an alert if you accidentally click through to a known phishing site, and you can also submit phishing URLs yourself to enhance the database.

To conclude this month's Net Work, two samples of actual phishing emails are shown along with the Netcraft toolbar. You can email me at **alan@epemag.demon.co.uk**


HALIFAX Always giving you extra

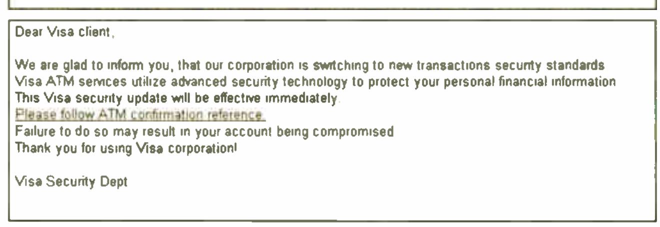
Dear client of the Halifax Internet banking,

Technical services of the bank are carrying out a planned software upgrade for the maximum convenience of the users of online-services of the Halifax Bank. We earnestly ask you to visit the following link and to confirm your bank data

https://www.halifax-online.co.uk/_mem_bin/FormsLogin.asp?source=halifaxcouk

This instruction has been sent to all bank customers and is obligatory to follow

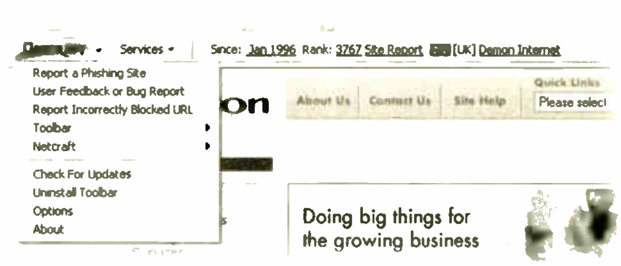
Please do not answer to this email – follow the instructions given above


Dear Visa client,

We are glad to inform you, that our corporation is switching to new transactions security standards
Visa ATM services utilize advanced security technology to protect your personal financial information
This Visa security update will be effective immediately.
Please follow ATM confirmation reference.
Failure to do so may result in your account being compromised
Thank you for using Visa corporation!

Visa Security Dept

Above: Two examples of phishing emails. Below: Netcraft Anti-Phishing Toolbar



PIC N' MIX

ANDREW JARVIS

Our periodic column for your PIC programming enlightenment

Mixing C and Assembler with Hi-Tech PICC Lite

LAST month we briefly mentioned the relative merits of losing assembler for a while and exploring hobby PIC development using the C programming language. It was found that the Hi-Tech PICC Lite compiler supports many of the devices commonly used in *EPE* projects and therefore represents a fine place to start.

There are, though, lots of other C compilers that you could use, including the free student edition of Microchip's C18 compiler, interesting because the only limitations are with optimisation and the extended instruction set, not devices or memory limits as is usual.

Standard Issue

The reason for doing all this is to see how much easier it becomes to write larger, more complex programs for the latest PICs. Best of all, you can more easily take the code with you on your journey up the PIC hierarchy (though just how easy depends on your C compiler, and the amount of assembler or other code you have written that extends the ANSI standard).

It is interesting to see how porting can be further eased if we can express our input and output needs in terms of the standard library – because the functions that comprise this library, while not strictly part of the C language itself, should exist on most C platforms. Projects that use a keypad and l.c.d. display would lend themselves well to implementing the simple model of formatted text input and output that the standard library offers, using functions like **printf()** and **getch()**, which pass text to or from **stdout** (usually the screen), and **stdin** (usually the keyboard) respectively.

Opportunity Knocks

While thinking about how best to demonstrate this, *EPE* published John Becker's *PIC to PS/2 Mouse and Keyboard Interfacing* (Aug '04) – a perfect opportunity to show the C code in mind without needing to duplicate any of the tricky groundwork! Using the same circuit, which can easily be assembled using *Toolkit TK3*, and some of the same core routines – we can re-architect this keyboard interface using a mixture of C and assembler.

The PICC Lite installation contains a very useful samples directory, including an l.c.d. interfacing example with code that shows how to interface to the standard l.c.d. controller in 4-bit mode. This in turn uses some delay functions, also installed into the samples directory. We'll benefit from both of these, which supply all the code needed (and more besides) to make the 2 × 16 l.c.d. our very own **stdout**.

There are a couple of points to note using this Hi-Tech example code. The delay functions (found in the two source files **samples\delay\delay.c** and **samples\delay\delay.h**) use a predefined symbol XTAL_FREQ to set the crystal frequency. Make sure you set this to the correct value (of the actual crystal used in your circuit) either by editing **delay.h** or, better still, by adding it as a macro definition in the PICC compiler tab of the build options for your MPLAB project. The value used in John's circuit is 4MHz, which coincidentally is also the default value for XTAL_FREQ.

The l.c.d. functions (found in the two source code files **samples\lcd\lcd.c** and **samples\lcd\lcd.h**) use PORTA<2> and PORTA<3> for "register select" and "enable" functions of the l.c.d. controller respectively. To make this code compatible with the layout for the l.c.d. connector of the *TK3* board, you should change them to PORTB<4> and PORTB<5>. Edit **lcd.c** and swap in these two lines for the existing equivalents:

```
static bit LCD_RS@    ((unsigned)&
PORTB*8+4);// RS

static bit LCD_EN@    ((unsigned)&
PORTB*8+5);// Enable
```

The connections for the data bits are already compatible with *TK3* and do not need to be changed. If you are not a *TK3* user then check out the comments in **lcd.c** for further detail of how the module is connected.

It's a Wrap

The complete section of assembler that receives and processes a key press from the PS/2 keyboard into two scan codes is taken from **kbd151.asm**, which accompanies the original article. That's the whole section, pretty much unchanged, from the labels **RECEIVE:** to **RX4:** where the return is made, and including a couple of the helper subroutines along the way.

I've also taken most of the code from the main loop (starting **MAIN**), which monitors PORTA waiting for a key to be pressed. In essence, this is most of the code that comprised Listing 1 in the original article, though it has been changed slightly to remove some code that attempts to write to the l.c.d.

All of this has been wrapped up as a new, external C function called **receive**, which has no arguments and returns a structure that contains two scan codes, declared as:

```
extern struct scancodes receive(void);
```

This wrapped-up assembler is placed separately in its own source file (but still processed by PICC Lite), and includes a few techniques that facilitate the mixture of C and assembler. Have a look at the source code (download access via **www.epemag.co.uk** and in the *PIC n' Mix* folder within the link) and the PICC Lite documentation for the detail of how this is done.

Briefly, there are three issues to resolve: matching signatures, temporary variables and returning structures. Assembly functions must include a signature that is compatible with the C prototype used to invoke it. For example, in the source code file **receive.as**, the following **SIGNAT** directive appears that associates a unique value with the **receive** function label:

```
SIGNAT _receive,90
```

The value 90 is derived from the combination of return types and arguments, and it must be correct or you will get link errors. The easiest way to get hold of the value is to make PICC Lite do the work for you. Create a dummy C file and place into it a function with the same signature, like the example code used shown in Listing 1. Then compile from the command line with **picl -16F627 -s file.c**. Using the **-s** switch ensures that you compile to assembler code only, and you can grab the correct **SIGNAT** directive for your function from the code generated in **file.as**.

Directives aside, about the only difference in the assembler from John's original is the way space is allocated for the variables used in Bank 0 RAM. The original code EQUated variables to specific locations, but

Listing 1

```
struct scancodes
{
    char code1;
    char code2;
} scan;

struct scancodes receive(void)
{
    return scan;
}
```

it's better in this example not to second-guess where the linker will want to place things, so we just give it a useful hint with a **ds** (reserve storage) instruction.

Returning an 8-bit value from external assembler functions is easy, simply make sure the value you want to return is in the **W** register (just like **retlw**). Returning a structure containing two such values, like the one for the scan codes, is slightly more complex – they have to be returned in a special area of memory reserved for temporary data. Look for use of **btemp**, which is the start label for this memory.

Party Time

The main C function is the code that pulls all of this together with printing to the l.c.d. – and thinking that I really should bring something to this party, I've attempted to add a little value here by implementing the shift key behaviour, which John left out of the original article. The best part is that we can do it all in C, because it has nothing to do with actually retrieving the scan codes. The file can be downloaded as **main.c.**

The function **getch()** calls **receive**, which waits until a key is pressed then returns the scan codes. A lookup is then done using one of two arrays depending on the state of the shift key, to convert the scan code into a printable ASCII value. The array is traversed in the **table_lookup()** function until the scan code is found or the end is reached. If no code is found a default ASCII character is returned.

To make **printf** work you have to implement the **putch()** function, and we simply pass everything through to **lcd_putch()** which is given to us by the l.c.d. sample code.

Example Use

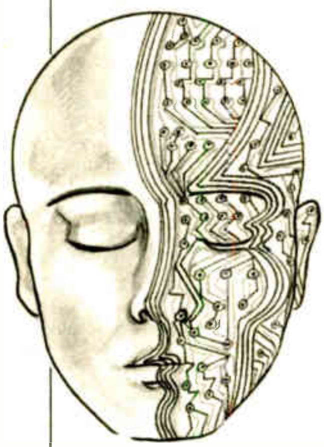
To use this example (assuming the circuit from *EPE* Aug '04 is already built!), take the downloaded C and assembler source files and add the PICC Lite example code files described earlier (four files in total from the l.c.d. and delay directories), remembering to change them for *TK3* and crystal compatibility if necessary. Start the MPLAB IDE, choose **Project->Project Wizard**, then 16F627 for the device.

This is different from the 16F628 used in the original article, but we have to tell the compiler that we're using the alternative because the 16F628 is not actually listed as a supported device. If you try to build the project using this PIC you'll get an error: *Unknown flag -16F628.*

In fact, it doesn't really matter which of the two you use in the circuit – for the purpose of this example they are interchangeable and the code generated should work with either. The two devices are pin compatible, the only major difference is the increased flash program memory size of the '628 which has 2K program words rather than 1K.

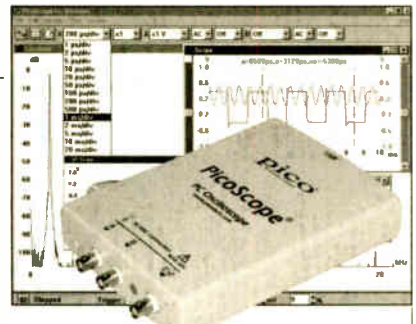
Compiling for the lower limit offered by the '627 doesn't give a lot of room for the scan code arrays we require. Remember that constant data is stored in program ROM as well as the program code. For this reason the arrays of scan codes have been massively reduced so that they will fit. So much so in fact, that all that remains is the shifted and unshifted first 16 letters of the alphabet, but I hope it is still enough to illustrate the principal, and you can always port it to a device with more memory. The objective here was to keep it in the '62x family so that the circuit could be reused.

Back in Project Wizard, choose the Hi-Tech PICC Toolsuite. Name the project, path it to where you placed the source files and add them in (there should be six files to add). That's it; you can now build the project, take the hex file produced in your project directory and send it to the PIC using *TK3* or your own programmer (make sure you have the correct PIC type selected). You don't need to use MPLAB if you don't want to, but I'll leave you to figure the command line alternative. □



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 published or 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 component values. **Please draw all circuit schematics as clearly as possible.**
Send your circuit ideas to: *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!**



WIN A PICO PC BASED OSCILLOSCOPE WORTH £599

- 5GS/s Dual Channel Storage Oscilloscope
- 50MHz Spectrum Analyser
- Multimeter
- Frequency Meter
- USB Interface

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.
Every 12 months, Pico Technology will be awarding a PicoScope 3205 digital storage oscilloscope for the best IU submission. In addition, a DrDAQ Data Logger/Scope worth £59 will be presented to the runner up.

Breadboard Project Protector – Power Cut

THE Breadboard Project Protector circuit diagram shown in Fig.1, is a simple cutout device that should be particularly useful for the experimenter who regularly builds circuits on breadboards but who does not have the luxury of a power supply with built-in current limiting. The device is used as an add-on and wired between a "home-made" power supply, i.e. a simple transformer-rectifier-smoothing capacitor arrangement, and the breadboard.

The "Protector" will cut power to a circuit that is trying to draw too much current. This can, of course, occur quite regularly when building on a breadboard due to the very nature of the process. Even when great care is being taken, component leads tend to come into contact unintentionally. And who has never accidentally connected the positive supply to zero volts?

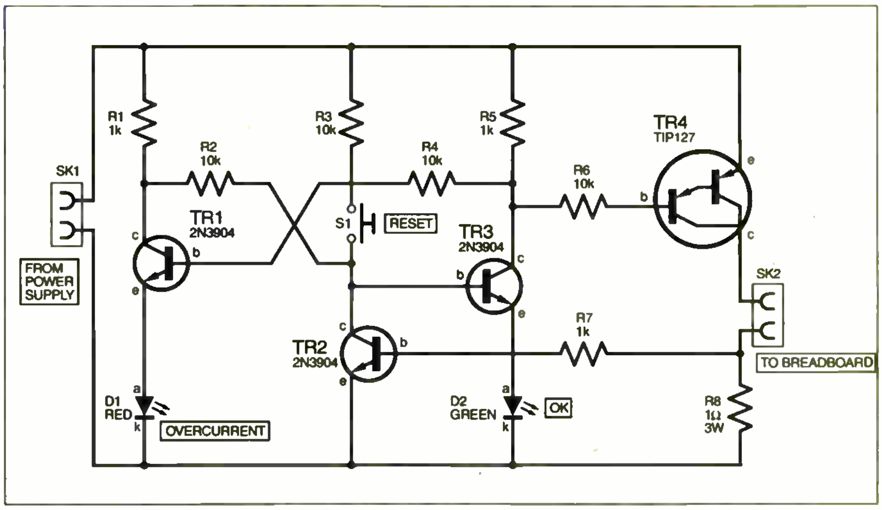


Fig.1. Circuit diagram for the Breadboard Project Protector

Cutout Current

The value of current at which the cutout trips is determined by a single resistor that can be chosen to suit the particular requirement. With the design shown, the cutout current value is around 700mA. A green l.e.d. (D1) lights when all is well. Once the cutout has operated, the device latches in its cutout state, and a red l.e.d. (D2) lights to indicate that the cut-out has operated. The "Protector" is reset via pushbutton switch S1.

The use of this device thus protects both the power supply (or prevents large numbers of fuses being wasted if it is properly fused) and also the components on the breadboard. At its heart is a bistable multivibrator based on transistors TR1 and TR3. The l.e.d.s in the emitter paths of the transistors indicates which of the two states the bistable is in, one corresponding to an OK state, and one corresponding to the situation where Overcurrent has been detected.

In the OK state, transistor TR3 is turned on so allowing current to flow from the positive supply line, through the *pnp* Darlington transistor TR4 and to the breadboard circuit under test. It also flows through resistor R8.

The bistable is triggered into indicating the overcurrent state when transistor TR2 is switched on. This occurs when the voltage across resistor R8 exceeds around 1·4V. The voltage across R8 is, of course, proportional to the current passing through R8, which is the same current passing through the breadboard circuit. When triggered into the over-current state, transistor TR3 is turned off, and with it, so too is TR4, removing power from the breadboard.

The value of R8 can be varied to provide different values of current that will trigger the cut-off state. However, it must have a sufficiently high power rating to match the conditions under which it is used – the usual 12 × *R* rule can be applied here. Once the bistable is in its overcurrent state, it will remain so until Reset switch S1 is pressed, at which point the bistable latches into the OK state. (This assumes that the cause of the excessive current consumption has been removed in the meantime.)

Note that a heatsink may be needed for the Darlington transistor TR4 if the current being drawn by the breadboard being protected (under normal conditions) is significant for other than short periods. The TIP127 transistor used for TR4 is rated at maximum 5A, but breadboard contacts are not normally rated at more than 1A.

Apart from R8, all other resistors are 0·25W carbon film; Reset switch S1 only passes a few milliamps; TR1 to TR3 are general-purpose *npn* types and the l.e.d.s are similarly standard.

David Clark, Sheffield

INGENUITY UNLIMITED
BE INTERACTIVE

IU is your forum where you can offer other readers the benefit of your Ingenuity. Share those ideas, earn some cash and possibly a prize.

Theremin Doorbell – Calling The Tune

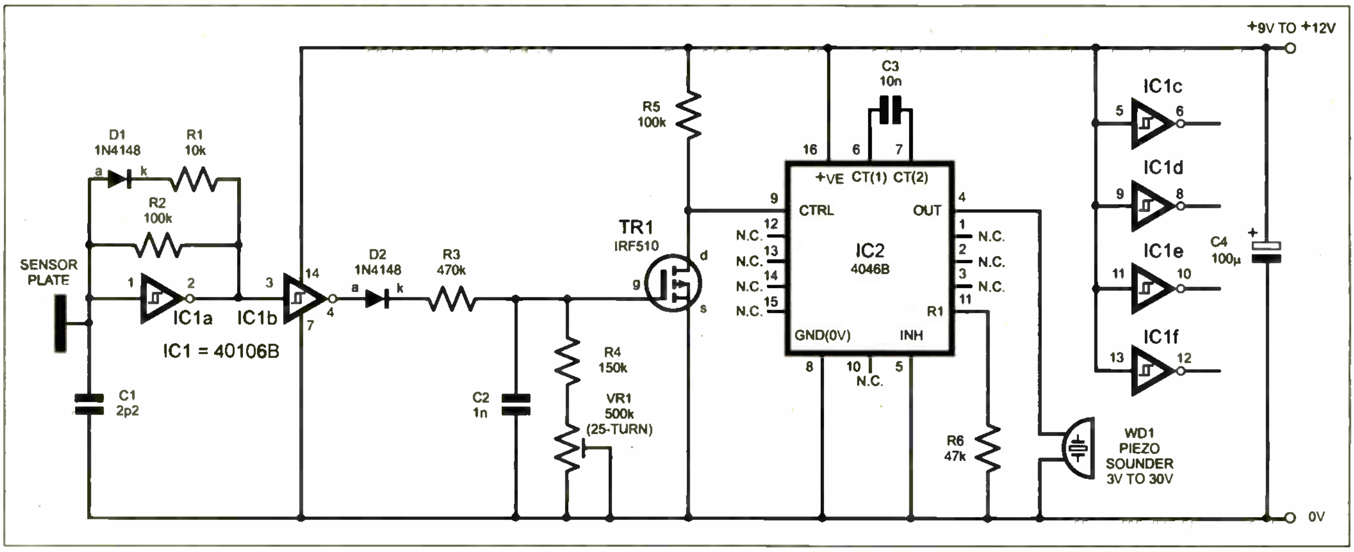


Fig.2. Circuit diagram for a Theremin Doorbell

INSTALL a doorbell with a difference. The Theremin Doorbell circuit diagram shown in Fig.2. uses a metal sensor plate for the "doorbell", playing a Theremin as a hand approaches it. Therefore, a slight tremolo effect might indicate the presence of Aunt Agatha, while a more authoritative swoop in pitch might indicate the presence of Brother Joe.

Not only this, but the sensor plate may be placed at the foot of a doorway instead, to report people walking in and out. This would make an interesting alternative to the more usual broken beam detector.

The range of the Doorbell is up to 20cm. That is, a hand will induce a shift in frequency of one tone at a maximum 20cm. For everyday use, however, this lies more realistically around 8cm. This is still sufficient to play e.g. "Happy Birthday" with careful control of one's hand/fingertips.

Relaxation oscillator IC1a employs a very small value for capacitor C1, so that the presence of a human body at the sensor plate increases its effective capacitance. This in turn decreases the frequency of oscillator IC1a. As the number of pulses generated at IC1b output pin 4 decreases, so the charge on capacitor C2 also falls.

If the rate of discharge of capacitor C2 is critically adjusted through preset VR1, a small variation of the voltage across C2 causes a large variation of potential at power MOSFET TR1's drain. This is used in turn to control the frequency of a voltage controlled oscillator (v.c.o.) IC2. Transistor TR1 may be virtually any *n*-channel MOSFET.

The v.c.o. selected for this task is surely the simplest and most versatile available. Strictly speaking, it is a phase-locked loop i.c., of which only the oscillator section is put to use. It has the great advantage of becoming completely inactive as the voltage at control pin 9 falls to about 1V, as well as having an easily adjustable top frequency limit, which is determined by resistor R6. Thus, the Theremin Doorbell is silent until a hand approaches, and will not exceed a specified frequency even when a hand touches the sensor plate directly.

The Doorbell draws just over 3mA current on standby. A regulated power supply is recommended for stability. Initially try a metal plate or sheet of tin foil measuring about 20cm by 20cm for the sensor, connected firmly to the circuit.

To set up the Doorbell, turn preset potentiometer VR1 across its range until the critical point is reached where frequency varies vastly over a few turns. Then adjust for silence, so that a hand at about 8cm begins to cause a crackle in piezo sounder WD1.

Thomas Scarborough,
Cape Town, South Africa.

Reverse Battery Protection – Backwards Compatable

OFTEN there is the danger that a battery can be connected around the wrong way, thus harming a circuit. One common practice is to put a diode in the positive lead that becomes reverse-biased when the above calamity occurs. But in normal operation the diode drops about 0·8V off the supply voltage, which may matter. A transistor connected as a diode is marginally better at about 0·6V. I have even seen diodes positioned across the supply, but then wrong connection may cook the battery, which then leaks all over the circuit-board!

The method shown in Fig.3 drops about 10mV across the saturated transistor, dependant on its gain and the value of R1, which is determined by the current drawn by load. For a modest load, let's throw some components at it: R1 = 100kΩ, TR1 = BC337, C1 = 100pF.

Current lost to R1 is about 9V/100k = 90µA. Now a reversed battery of 9V means the base/emitter junction might avalanche, with less than a volt appearing across the circuit. If it matters then two in series stop even that, as shown in Fig.4. This can also protect against higher voltages.

Now let's put this obese circuit on a diet (fewer components = less to go wrong)! The circuit shown in Fig.5 provides symmetrical protection of both power lines. Transistor TR1 can be a BC327, TR2 a BC337, R1 100kΩ. etc., Capacitor C1 is required for smoothing, and its value will depend on the load current being drawn.

Leanne Wallace-Hyland,
Rochester, Kent

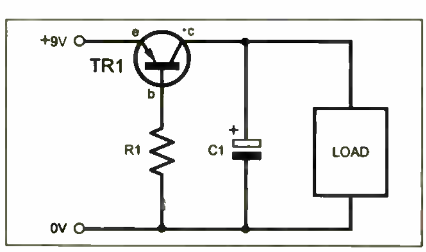


Fig.3. Basic protection circuit

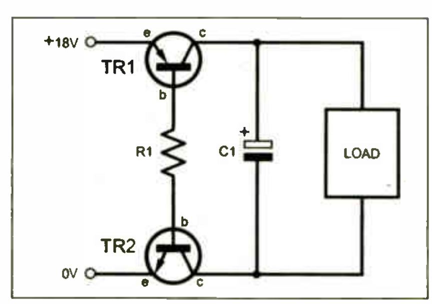


Fig.5. Final protection circuit

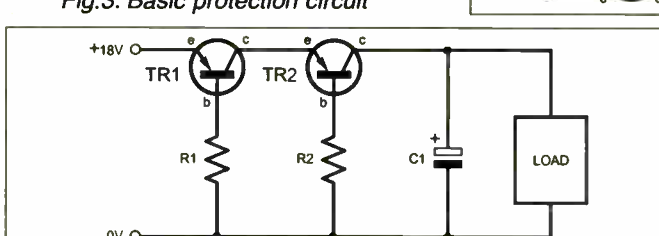


Fig.4. Improved protection circuit

Tri-State Controller – Trigger Happy

THE usual way to control a heater is On/Off, or phase control, or burst fire. The circuit in Fig.6 has tri-state control: Off/Half On/Fully On.

If the heater is such that the temperature can be maintained with half its power, then the element spends most of its time at half power, resulting in a very long life. It is ideal in applications which do not need accurate temperature control, e.g. water heaters, space heaters, fish tanks.

In the circuit, the two power op.amps in IC1 are wired as Schmitt triggers, both controlled by preset VR1. IC1a is more sensitive than IC1b. When the temperature drops and the resistance of thermistor R15 rises, IC1a switches state first, its output pin 1 going low. This triggers optotriac IC2 which, through diode D4, turns on the main triac, SCR1, but only during the positive half cycles of the mains waveform.

Should the temperature fall a further 2°C, then IC1b is triggered, which switches on optotriac IC3, fully powering triac SCR1. As the temperature rises, IC1b switches off first, then IC1a. Once the working temperature has been reached, the circuit cycles on/off at half power through IC1a.

Load

The circuit as shown can control a load up to 1kW. Changing the triac to one with a higher rating, it can control up to 4kW. But note that domestic wiring may cause flicker if the load exceeds 3kW. Regulator IC4 and SCR1 should be mounted on heat sinks.

The circuit uses the high power twin op.amp package L272M. Do not use FET or CMOS i.c.s as they are prone to temperature drift. The thermistor as specified is a 15kΩ device at 20°C. This has to be balanced at the operating temperature by resistor R1, select its value on test. A close match between thermistor R15 and R1 will result in tight temperature control. The 2°C operational difference is set by R5, another select on test value.

Temperature Compensation

Diodes D1 or D2 (not both) are ambient temperature compensation devices. Only trial and error will determine if your circuit will need compensation and in which leg. Replace the unwanted one with a link wire.

The triac and its drivers are at mains voltage and this circuit should only be constructed by those who are suitably qualified or supervised.

J. Vella, Carlisle

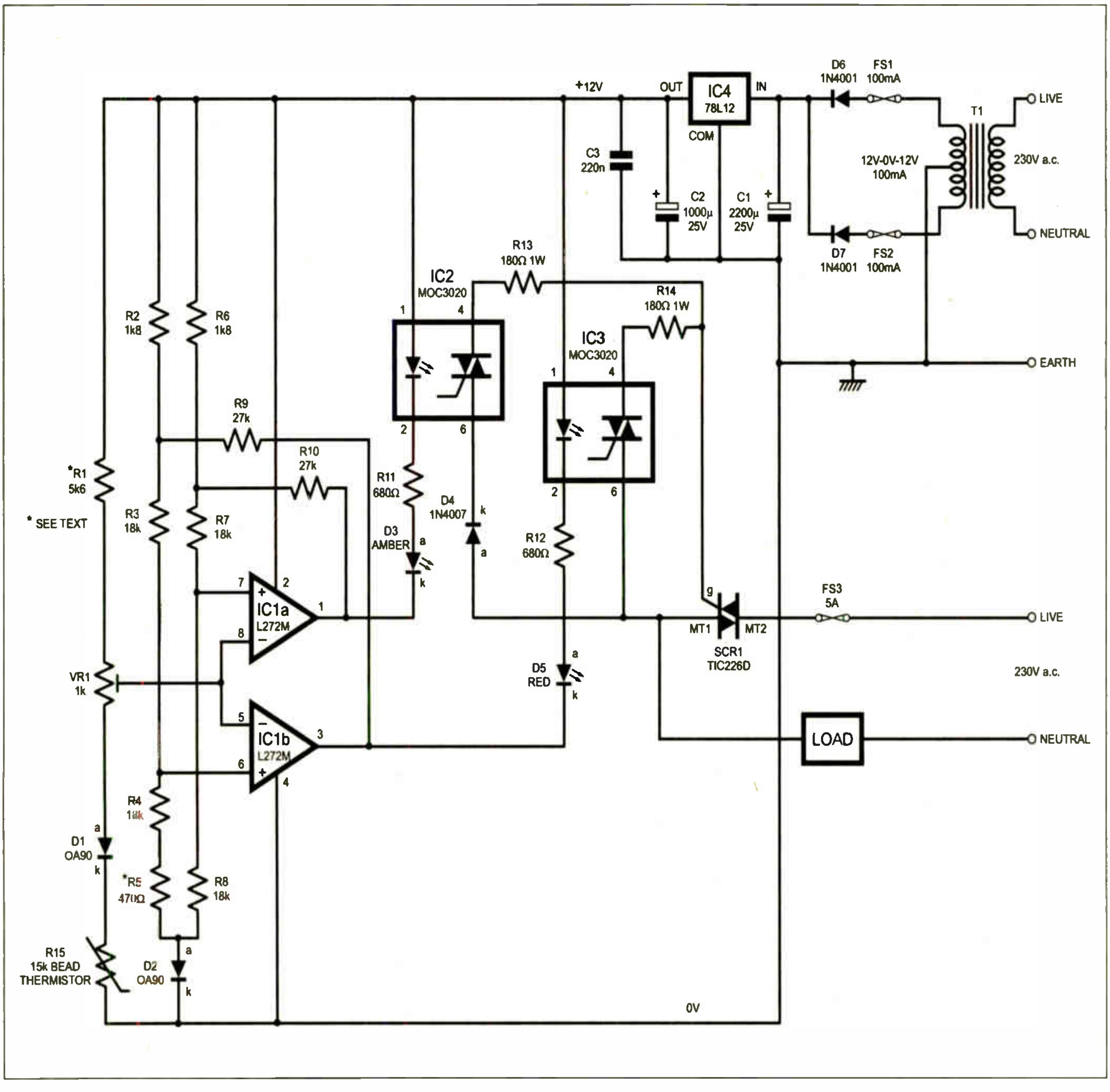
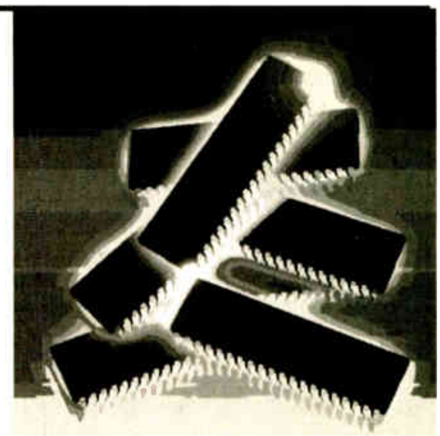


Fig.6. Circuit diagram for the Tri-State Controller. Either of the temperature compensation diodes, D1 or D2, should be replaced with a wire link – see text. Values of R1 and R5 are selected on test

Special Feature

PIC 18F Microcontroller Family Introduction

Malcolm Wiles



The recently introduced PIC18Fxx2 devices have many benefits compared to the PIC16F87x family

THIS article is an introduction to Microchip's new PIC18F series of high-end microcontrollers, with special reference to the PIC18Fxx2 family. At present this comprises the four devices summarised in Table 1, below.

Device	On-Chip Program Memory		On-Chip RAM (bytes)	Data EEPROM (bytes)
	FLASH (bytes)	Single Word Instructions		
PIC18F242	16K	8192	768	256
PIC18F252	32K	16384	1536	256
PIC18F442	16K	8192	768	256
PIC18F452	32K	16384	1536	256

The PIC18F4x2 devices have 40-pin d.i.p. packages, and are pin compatible with the PIC16F877. The PIC18F2x2s have 28 pins, and are pin compatible with the PIC16F876.

In many ways these 18F devices are similar to, and backwards compatible with, their 16F counterparts. They have been enhanced in quite a number of ways which we'll look at, but the good news is that, for readers familiar with the 16F series, there isn't a steep learning curve before you can start using them.

Programs written for a 16F can usually be ported to run on a similar 18F with only a modest amount of work – it's not a rewrite job, although there are a few nasty pitfalls to avoid that we'll note later. You can learn about a number of the new features gradually, and only when you need them.

Intention

This article is not an in-depth tutorial on this new PIC family. The intention is rather to give an overview of the available features, concentrating on those areas where the 18Fs differ most from the 16Fs. It no doubt also has a programming bias reflecting the author's background as a software engineer. Readers may refer to the documentation described next for more details. General familiarity with the PIC16F microprocessor family is assumed.

Most development tool references are to Microchip's assembler MPASM, because *TK3* support for 18F was still in development when this article was written. MPASM is part of the MPLAB IDE, free from **www.microchip.com** (see *Pic n' Mix* Aug '04), but the assembler can be run stand-alone by double-clicking on the file **mpasmwin.exe** in the MPLAB directory. *TK3* with its 18F facilities was placed on the *EPE* downloads site (access via **www.epemag.co.uk**) in early January '05.

Documentation

The two main Microchip documents that describe the PIC18Fxx2 family are the datasheet (DS39564B) and the programming specification (DS39576B), available via **www.microchip.com**. These documents both cover all four devices. The datasheet is referred to as "the spec" from now on.

The spec is a 330-odd page epic. Datasheets for 16F devices like the 16F84 and 16F877 are light reading by comparison, and in the author's experience they are good quality documents containing few errors. It would be nice to report that the spec is of similar high quality, but sadly this does not seem to be so.

The author is aware of many errors, obscurities, omissions and contradictions. Some of these will be mentioned in what follows, but there are others which are not. The reader is advised to approach the spec and related documentation with due care; it cannot be said always to be the reliable guide that we may have come to expect.

Peripherals

The peripherals of the 18Fxx2 family are very similar to those of the 16F877. Readers familiar with this latter device will find few surprises. There are (depending on the device):

- 3 or 5 I/O ports, PORTA to PORTE
- 4 timers (Timer0 to Timer3)
- 2 CCP modules – MSSP – USART
- 5 or 8 10-bit A/D channels
- PSP (40-pin devices only)
- watchdog timer
- power on reset
- brown out detection
- 17 or 18 interrupt sources

Timer0 can be used in either 8-bit (as on 16Fs), or 16-bit mode. For Timer0 in 16-bit mode and Timer1 (which is always a 16-bit counter), when the low byte of the counter is read, the high byte is automatically latched by the hardware so that subsequently reading it is guaranteed to give a consistent result. Similarly, writes to the counter high byte are latched and only take effect when the low byte is written.

The messy code needed on 16Fs to allow for the possibility of a counter/timer wrap between reads or writes of the low and high bytes of the counter is unnecessary.

In PORTA to PORTE the output latch register (present but invisible in 16F devices) is visible as an SFR. Port outputs can be driven either by writing directly to PORTx, or to LATx (x = A to E). The difference is that reads of LATx return the last values written by software, whereas reads of PORTx return the actual state of the device pins.

Brown out detection has four configurable threshold voltages.

The more recently announced PIC18F2455/2550/4455/4550 family includes a USB 2.0 peripheral. Beyond the scope of this article, these devices are nevertheless the main reason why the author is interested in the 18F family! It is expected that USB interfacing projects using some of these devices will feature in *EPE* before too long.

Clocking

The 18F family can be clocked at up to 40MHz (10Mips). The usual range of LP, XT, HS, RC and external clock options is available. In RC mode, CLKOUT can be disabled, which saves power and releases the pin to become another I/O pin (RA6). In HS mode, an internal PLL can be used to quadruple the external clock speed (primarily intended for use where high external clock speeds might cause excessive electromagnetic interference).

Memory Organisation

It is in memory organisation and the more under-the-bonnet stuff like the instruction set where the real changes are. Let's look at program memory first.

The big difference here is that program memory has grown from being 14 bits wide to 16 bits wide. With a few exceptions discussed later, 18F instructions occupy 16 bits. However, program memory on 18F is 8-bit byte addressed. So the PC increments by two for each instruction.

All instructions must start on an even program memory address. Be warned: MPASM will let you ORG to an odd address (a perfectly legitimate thing to do on the word addressed 16Fs) and start assembling code from this address. But such a program will not execute correctly.

Program memory on 16Fs is quoted in bytes. So 18Fs may appear to have twice the program memory of their 16F counterparts, but only because the units have changed. The 8K (word) 16F877 and the 16K (byte) 18F442 both have the capacity for 8192 instructions.

Program memory is readable and writable at run time (not just at programming time). More on this in the Tables section later.

Data Memory

Data memory is banked, as it is on 16Fs, but banks are 256 bytes long rather than 128 bytes. To allow for the possibility of up to 16 banks, there are four bank select bits and they have moved out of the STATUS register into their own Bank Select Register (BSR). The data memory bank accessed is dependent on the BSR; no surprises there.

However, there's a new Access Mode. The (up to 128) SFRs (which are mapped into Bank 15) and the first 128 of the GPRs in Bank 0 are mapped into a virtual Access Bank which is permanently visible, whatever BSR is set to. Access Bank is selected by means of a new "A" bit present in all instructions using file memory. If A=0 the Access Bank is selected and this overrides the BSR setting; A=1 means use BSR.

To accommodate this new "A" bit, file register manipulating instructions have grown a new argument. So, for example, the 16F ADDWF F,D command becomes ADDWF F,D,A in 18F assembler (the notation being used is the same as in section 20 of the spec).

The "A" suffix is an optional argument. For some instructions (e.g. ADDWF, BSF etc) the spec does not say whether A=0 or A=1 is the default. For most instructions (e.g. ANDWF, BCF etc) it states that A=1 is the default. Despite this, the author has found that in both MPASM versions 3.20 and 3.80 (at the time of writing the current version), **the default is always A=0** (Access mode).

Access mode is nonetheless a very useful innovation. All the SFRs are permanently visible in Access mode, removing the need to fiddle with the bank select bits to get at some of the more obscure ones, which is always a pain in 16F programming. 128 GPRs are also permanently visible, independent of BSR, for working set variables etc. So if BSR is initialised to (say) Bank 1 then a total of 384 bytes of general purpose data memory (sufficient for most programs?) is visible without ever needing to change BSR at all.

Data EEPROM

Data EEPROM is accessed in almost exactly the same way as on 16Fs.

There is a very confusing discussion in the spec (section 6.8) which appears to be trying to say that data EEPROM needs refreshing at intervals if it is not rewritten. This text is followed by a Note which appears to state the exact opposite. The author would be interested to hear from any reader who can explain what section 6.8 is really trying to say!

Addressing

The program counter (PC) is 21 bits wide – sufficient to address h1FFFFF (2,097,152 decimal) program memory bytes – scope for a certain amount of future expansion! 18F CALL, GOTO and RETURN instructions can address the whole of this range (how they do it in 16 bits we'll see in the instruction set section later).

So program memory is "flat", not paged, the LCALL and LGOTO pseudo instructions are unnecessary, and there's generally no need to do messy manipulation of PCLATH bits in order to jump across 2K boundaries. This is all much nicer than on 16Fs.

Just for the record, we'll note that the 21-bit program counter (PC) is physically implemented in three 8-bit SFRs: PCL (bits 0 to 7), PCLATH (bits 8 to 15) and PCLATU (for upper) (bits 16 to 20).

Indirect addressing

Indirect addressing is similar in principle to 16Fs, but has undergone a welcome tidy up and enhancement. When an INDF register is used, the location pointed to by the corresponding FSR is accessed. The FSR registers are 12 bits wide, which is sufficient to address the whole of the maximum of 16 banks of 256 bytes each. So the dreadful IRP bit has gone, and the author is sure nobody will mourn its passing.

There are three separate INDF and three corresponding FSR registers, so it is possible to have indirect pointers set up to three separate areas of data memory at the same time. It is much easier to move or copy areas of data memory around than on 16Fs. Handling buffers of data is almost easy!

To store the 12 bits of the indirect address, two 8-bit registers are physically required: FSRnL and FSRnH (n = 0 to 2). A new instruction, LFSR, facilitates loading both parts of any FSRn at once.

Another enhancement is in the provision of modes which allow the indirect address pointer to be incremented or decremented automatically. The author finds the assembler syntax to do this a little odd: for example to add one to the address in FSRn and then clear the addressed location, the following is written:

```
CLRF PREINCn
```

To clear the location and then decrement the pointer, one would write:

```
CLRF POSTDECn
```

and so on. (PREINCn, POSTDECn etc are mapped into SFR space, but are not physically implemented registers.) It's possible to post-decrement, post-increment, and pre-increment, but not pre-decrement. There's also a mode in which W is used as an offset to FSRn. For further details, readers are referred to the spec section 4.12.

Tables

A significant innovation is the provision of a proper method to create and access data tables in program memory. This is implemented by new table read and table write instructions.

Associated with these instructions is the table pointer register. This is 22 bits wide, so is physically three registers (low, high and upper as with the PC described above). The lower 21 bits are used to address program memory. The 22nd bit provides access to the device ID and configuration bits, which are mapped to the top of program memory space. Yes, it's possible (but probably not advisable!) to change configuration settings by software.

Reading program memory is easy. The required address is loaded into the upper, high, and lower parts of the table pointer, and a table read instruction is executed. The data byte is loaded into the table latch register and is available at the next instruction cycle.

As with indirect addressing, pre- and post-increment, and post-decrement of the table pointer are possible. The assembler syntax is cryptic and different from that for indirect addressing, e.g.:

```
TBLRD*   ; table pointer not modified
TBLRD*+  ; increment pointer after read
TBLRD*-  ; decrement pointer after read
TBLRD+*  ; increment pointer before read
```

Writing program memory is rather more complicated. The sequence is similar to writing data EEPROM, except that the address is held in the table pointer not in EEADR, and some control bits in the EECON1 register have to be set differently. Data have to be written eight bytes at a time, aligned on an 8-byte boundary in memory.

Erazure First

Additionally, program memory has to be erased before it can be written. The erase sequence is again similar to writing data EEPROM. Program memory is erased in blocks of 64 bytes, which must be 64-byte aligned. It goes without saying that the memory being erased should not be in use to store current program instructions, especially those for the erase sequence itself, otherwise unpredictable effects may occur...

It's not possible for the PIC to be writing program memory and reading instructions from it at the same time, so the processor halts completely for about 2ms for each erase and write operation, according to the spec. (The author has done some tests with a 18F442, and found that this quoted time is a bit pessimistic, but even so erasing then writing 64 bytes of program memory in eight writes of eight bytes each is going to take of the order of 10 to 18ms.)

It isn't possible to get an interrupt on completion of the write, as with writing data EEPROM, to allow the processor to do other things. This is a substantial holdup, which would probably not be tolerable in real time applications.

However, for accessing static data tables, the table read mechanism is a vast improvement on the hated "computed goto" sometimes inevitable on the 16F series. Readers familiar with the author's previous rant on this subject (*PIC Macros and Computed GOTOs*, Jan '03) will know his views.

Table read, as well as being much simpler, safer and easier to use, is more efficient, allowing data bytes to be held straightforwardly and contiguously in memory, rather than encoded one byte per 16-bit word in RETLW instructions. Properly implemented, table read can be used to access a table located anywhere in memory, from anywhere in memory, without any PCLATH complications.

The MPASM "DB" and "DATA" statements can be used to set up arrays of data bytes in program memory. An MPASM "feature" (not mentioned in the spec) is that each DB statement starts a new word in the .HEX file, any unspecified bytes being zero padded. So if you want data bytes packed two to a 16-bit word, as usually you will, it's necessary to define data in multiples of two bytes for each DB statement, e.g.:

DB '0', '1' ; defines ASCII 0 and 1 in two contiguous bytes, but..
DB '0' ; generates two bytes containing 0x30 and 0x00

A demo program **test18f.asm** is available on the *EPE* website (see below). This contains example code for (amongst several other things) program memory read and write, and illustrates how to implement data tables on 18F.

The computed goto construct is still possible on 18Fs, but any programmer who uses it still has to grapple with all the complexities of PCLATH and additionally PCLATU – the only place in 18F programming where this would now appear to be necessary. Recidivists who persist with the computed goto on 18Fs have only themselves to blame, and can expect no help from the present author.

Interrupts

Another useful addition to the 18F architecture is the provision of automatic context saving by hardware on interrupt. When an interrupt is taken, the STATUS, BSR and W registers are always saved in a non-accessible memory area.

On exit from an ISR, it is possible optionally to specify that the automatically saved context is reloaded by the hardware from its save area. For most programs this is the only context information that needs preserving, and so it eliminates the chore of saving and restoring context in software in the ISR, and can usefully speed up interrupt response times.

By default interrupts look just as they do on the 16F series, where all interrupt sources vector through one address and are handled by the same ISR. However, the 18F architecture also supports a high and low priority interrupt scheme with two vector locations and potentially two ISRs.

Apart from the Timer0, which for some reason must always be a high priority interrupt, all other interrupt sources are software programmable to be high or low priority. This is done by means of a third array of bits for each interrupt. As well as the interrupt flag bit and interrupt enable bit, there is an interrupt priority bit.

Enabling of the high and low priority interrupt system is under software control at run time. High and low priority interrupts can be separately enabled and disabled as a group.

High priority interrupts pre-empt low priority ISR processing. This means that low priority ISRs cannot safely use the hardware's context saving mechanism described above, since the save area can be overwritten by a high priority interrupt. Low priority ISRs must do context saving and restoring by software as on 16Fs.

It also means that high and low priority ISRs must not access the same locations, or else the low priority ISR must disable high priority interrupts before doing so (which probably rather defeats the point of high priority interrupts).

In some of its example code for writing program and data memory, the spec (section 5) shows only high priority interrupts being disabled around the special write unlock sequences. The author is sure that this is an error, and that if priority interrupts are in use then both priority levels must be disabled. In any event this is the safer option.

The author has played with priority interrupts, and finds them great fun. However, he admits that they are likely to be of very little application to the majority of *EPE* projects, and so has reluctantly resisted the temptation to discuss them further here. Readers requiring more information on interrupts generally may refer to his previous articles (*Programming PIC Interrupts*, Mar/Apr '02).

Stack

The return address stack is 31 entries deep, and allows any combination of calls and interrupts to occur. It stores the full 21-bit return address value.

The stack is visible, unlike the 16F stack. There is a stack pointer which is readable and writable. There are PUSH and POP instructions, but somewhat curiously PUSH takes no arguments; only the PC can be written to the stack with PUSH. Likewise POP does not return the top of stack value; it effectively discards it by decrementing the stack pointer. The top of the stack location is visible, and can be accessed and changed via the TOSU, TOSH, and TOSL registers.

Stack underflow and overflow cause status bits to be set. A configuration bit can be set to cause a device reset if underflow or overflow occurs.

Most of these features are probably intended for real time operating system designers, and the author doesn't think that any of them is of much use to the average programmer. They could even be quite harmful. Messing about with the stack pointer and the return address stack are both excellent methods to make a program go wrong in spectacular and very hard to debug ways. The clunky nature of the PUSH and POP instructions, and the odd width (21 bits) of the stack make it unsuitable for passing procedure operands in the style of a high level language compiler.

Well-designed programs should not be in any danger of blowing a 31-deep stack. During development and testing it may be useful to enable reset on stack overflow or underflow. Code can be placed at the reset vector to detect such an occurrence, and halt the program while preserving as much diagnostic information as possible in order to find and fix the fault. Once a project has gone "live", it is unlikely in most cases that any sensible recovery could be made, and a program restart is probably the only option.

If reset is disabled in the configuration, only an extremely paranoid programmer is going to bother to poll the status bits to check for possible stack errors. In most cases it's unlikely that, if a stack error has occurred, the program will still be functioning well enough to detect it anyway.

Configuration

There are 11 bytes holding various device configuration bits, and two holding device ID information, which are generally unremarkable. Quite a number of these bits are to do with memory protection; it is possible selectively to prevent read and/or write access to 4K blocks of program memory from other 4K blocks. This would allow the implementation of a rudimentary protected mode operating system with fixed 4K partitions. There is also a boot block comprising the first 512 bytes of memory, which can be separately protected, and which is intended to hold the bootstrap code for a downloaded application.

The configuration memory can be read and written by software using the table mechanism; writing incurs the same 2ms processor halt overhead as writing program memory. It can be written a byte at a time. The spec doesn't say explicitly anywhere, but from experiment it seems to be unnecessary to erase configuration memory before writing it.

Programming

Programming 18F devices will not be covered here, as it's something that few readers will want or need to do for themselves. It is just noted that while the same programming hardware as for 16Fs can be used, the software procedures and algorithms are completely different (they are in fact based on the table read and write operations covered earlier.) Both low and high voltage programming modes are supported.

Instruction Set

There are 76 instructions on the 18F processor, compared with 35 on the 16F series. It can hardly be described as a RISC any more! With three exceptions, noted below, all the 16F instructions are present on the 18F. We've met some of the new instructions along the way. This section is not going to attempt to describe all of the remaining ones, but just give a flavour of what's new.

Most instructions are 16 bits or two bytes long. However, a few are double length, or four bytes long. These include the CALL and GOTO instructions, which is how these instructions manage to encode the full 21 bits of program memory address.

The second word of double length instructions always starts with binary "1111", which is interpreted by the processor as a NOP instruction. So these instructions can be safely used with skip instructions, for example:

```
BTFSC STATUS,Z,A  ; skip if Z is clear
GOTO  ZEROSET
...

ZEROSET:
...
```

If Z is clear, the skip will actually occur into the second half of the GOTO instruction. This will execute as a NOP, and then go on to execute the next "proper" instruction. Thus the program will function as intended.

In addition there is a set of branch instructions. Branches are addressed relative to the current instruction, and are single length, so their range is limited. With the conditional branches it is possible to branch backwards 128 bytes or forwards 126 bytes from the current instruction; the unconditional branch (BRA) can go backwards 1024 bytes or forwards 1022 bytes. So if ZEROSET were within range in the example above, it could have been written:

```
BTFSC STATUS,Z,A
BRA  ZEROSET   ; unconditional branch
...
```

which would generate less code. But even better, since there are conditional branch instructions to test all the STATUS bits directly, we could simply have written:

```
BZ    ZEROSET        ; branch if Z is set
```

In passing it is noted that there are two new flags, N and OV, in the STATUS register, which may be helpful in two's complement arithmetic operations. N (negative) is set by some instructions when the most significant bit of a result is "1", and OV (overflow) is set when it changes.

Hardware multiply is supported by two instructions MULWF and MULLW, which execute in a single instruction cycle. These instructions take two 8-bit operands and generate a 16-bit result. There are code examples in the spec showing how to construct 16-bit signed and unsigned multiply routines using them.

There is a MOVFF instruction to copy a file memory location directly to another without having to go through W.

Three 16F instructions have disappeared. CLRW is unnecessary because W is an addressable SFR on the 18F series (mnemonic WREG), so it is possible to write the equivalent CLRF WREG,A instead.

Rotation Changes

RLF and RRF have been replaced by RLCF and RRCF respectively. The latter are almost semantically identical to RLF and RRF on a 16F, but they have the additional effect of setting Z. 18Fs also support RLNCF and RRNCF which are rotates that do not go through Carry.

The DECF and INCF instructions have also changed compared with their 16F equivalents in that they additionally set C and DC on the 18F. It's not clear why Microchip have been inconsistent and changed the RLF and RRF mnemonics but not INCF and DECF.

These differences can be critical when porting 16F code to 18F. For example, Peter Hemsley's *High Speed Binary to Decimal* routine (Sep '04) does not work when reassembled and run on an 18F, because its logic relies on C being preserved across DECF instructions.

The spec is most unhelpful: it does state that Z, C and DC (also N and OV) are "affected" by DECF and INCF, but gives no further information of exactly how, when and in what circumstances any of these flags is changed. It is not obvious to the author how a DECF instruction should affect C and DC (if at all).

These changes in the way flags are affected are perhaps the least satisfactory aspect of Microchip's "enhancements". They offer little of any practical use to the programmer, and for the most part will only cause problems. The bottom line is that special attention may need to be given when porting 16F code using RLF, RCF, INCF or DECF instructions, to make sure that the program logic does not require the preservation of Z, C or DC.

No Shorthand

MPASM in 18F mode does not support some of the shortcut pseudo-instructions like SKPC. Presumably the reasoning is that the conditional branch instructions provide a better alternative. While this is true for new code, the control flow is not the same, and when porting code from 16F it would have been useful to have retained these mnemonics for backwards compatibility. However, they are easy enough to replace automatically with their longhand equivalents using macros.

The author would be interested if any reader could devise a mnemonic that will help him remember the differences between the SUBFWB, SUBWFB, and SUBWF instructions!

Development Tools

In compensation for their poor documentation, it would have been nice to conclude that Microchip's MPASM/MPLAB development tools, when applied to 18F program development, were of high quality. But sadly again, that's not possible either. Consider the following (the notation being used is the same as in section 20 of the spec).

MPASM has built into it F and W (also f and w) as mnemonics for the "d" argument. It doesn't need any equates or include files for (e.g.) ADDWF FRED,W or ADDWF FRED,F statements to assemble correctly. Even if F and W are redefined, e.g.:

```
W EQU  1
ADDWF  FRED,W
```

the "correct" code (result in W in this case) is still assembled.

TK3, on the other hand, requires equates to be defined for F and W. If they are defined wrongly, the wrong assembly results will be obtained.

But inconsistently, MPASM does *not* have equates for "A" (or "a") argument mnemonics built-in. If ADDWF FRED,F,A is assembled for an 18F without any include files, an error is obtained. The 18Fxxx.inc files include the definitions "A equ 0" and "BANKED equ 1". So using the appropriate one of these include files one can indeed write ADDWF FRED,F,A, and it will assemble correctly.

(As a short digression, the author prefers to write ADDWF FRED,F,B instead of ADDWF FRED,F,BANKED, and so proposes a convention: that for 18F code in *EPE* the symbol B is reserved for this use, and is always equated to 1. It is suggested that this is not done by modifying the 18Fxxx.inc files, which should be the unmodified Microchip versions, but as a separate statement that all our .ASM files contain.)

For 16F assembly, if ADDWF FRED is assembled then MPASM assembles its default ADDWF FRED,F, and generates a warning message. *TK3* requires explicit specification of F or W, and generates an error. The author thinks either behaviour is acceptable.

But for 18F assembly with MPASM this warning message has disappeared. ADDWF FRED just assembles as ADDWF FRED,F,A using the defaults for "d" and "a" with *no* warning message given. The author finds this very disappointing, as leaving off the "d" argument is a slip he makes regularly, and he has come to rely on the warning message to find occurrences for him.

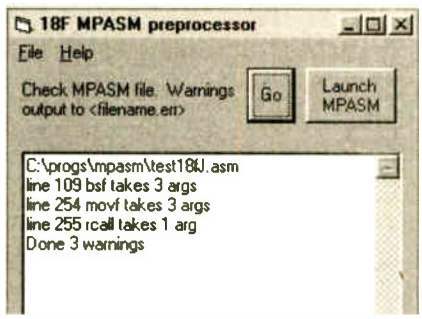
Of course, more errors are possible with three arguments when defaults are permitted. In spite of F and W being built-in, MPASM can't seem to tell which argument has been omitted (probably because the symbols have all been pre-processed and reduced to 0s and 1s by the time it checks).

In MPASM, ADDWF FRED,A assembles as ADDWF FRED,W,A, which is possibly what was intended, but ADDWF FRED,BANKED assembles as ADDWF FRED,F,A, which is almost certainly not what was meant. (In these examples, A and BANKED are being taken as the "d" argument, and the "a" argument defaults.) In neither case is any warning message given.

In 18F assembly code, instructions can take anything from zero to three arguments, and the number is mostly different from their 16F equivalents. When converting from 16F to 18F, or perhaps when working concurrently on 16F and 18F projects, it is all too easy to make mistakes.

Prempasm

The author is so concerned at the possible coding errors that can go undetected by MPASM in this way that he has written a pre-processor (called **prempasm**) which supplies the missing checks. **Prempasm** will highlight any lines where potentially the wrong number of arguments has been specified, and so where a possibly inappropriate default might be supplied by the assembler.



The idea is to run .ASM files through **prempasm** periodically, and check out any warning messages that are generated. In some cases these won't actually be errors – the defaults supplied may be correct. When this has been done, MPASM can be launched directly from **prempasm** to do the assembly proper.

The first time the program is run, it will ask you to specify the path to your **mpasmwin.exe**. You can refuse, but it will keep nagging you each time you run it until you do, and the Launch MPASM button will be greyed out and inoperative. After this, select file/open, and browse to a .ASM file.

When you click the Open button, the preprocessor runs straight away on the selected file. This file is remembered next time you run the program, so thereafter you can simply click the Go button to repeat a scan of the same .ASM file. Scan results are displayed in the text window, and also written to a file with the same path and name as the .ASM file but with the extension ".ERR".

Prempasm does not perform all the other checks that MPASM does, so no warnings from **prempasm** does not necessarily mean that your file will assemble without errors! It only has a simple parser, so there may occasionally be false warnings if it misunderstands something – for example it assumes that all labels start in column 1, anything that does not being treated as an instruction mnemonic, and it won't understand any macros you define.

Prempasm is available from the *EPE* downloads site (via **www.epemag.co.uk**), in the *TK3* folder.

It is suggested that, as good coding practice, all instruction arguments are always specified in the source, even when the correct defaults would apply.

TK3 Support for 18F

TK3 now supports 18Fxx2s! You can assemble code for them, program them and even simulate them using version 3.00 or later. *TK3* assembler is actually better at error checking than MPASM. If you omit the "d" argument where it is needed, *TK3* will generate an error. If you omit the "a" argument, *TK3* assumes a=0 by default, but generates a warning message that it has done it. (*TK3*'s handling of 18F devices was discussed last month. Ed.)

If you assemble ADDWF FRED,BANKED with *TK3*, the beta version at the time of writing will actually assemble ADDWF FRED,F,A as MPASM does, but you will at least get the (slightly misleading!) warning message that you have omitted the access bit.

Demo Program

A demo program *TEST18F.ASM* containing examples of how to use some of the new instructions and features of the 18F series is also available from the *EPE* website, again in the *TK3* folder.

Conclusion

Microchip have done a good job in improving the 16F core processor. They have removed almost all the awkward programming features of the 16F, and in the main provided useful and worthwhile enhancements while retaining a high degree of backwards compatibility.

It is a great shame that their programming tools and documentation are not of a commensurate standard at present, and let the product down rather badly. Hopefully Microchip will improve these areas before too long. □

SHOP TALK

with David Barrington

Safety Interface

The microprocessor compatible H11L1 Schmitt trigger opto-isolator used in the *Safety Interface* project is currently listed by **Squires** *(☎ 01243 842424* or ***www.squirestools.com***, code 622-655. The other opto-solators, MOC3041 zero crossing triac driver and the MOC3021 random phase, non-zero, triac driver, are both listed by **Cricklewood** ***(☎ 0208 452 0161*** or ***www.cricklewoodelectronics.com)***, quote type numbers.

The high frequency 4mH 250W 0·9Ω, open toroidal, suppression choke came from **Farnell** ***(☎ 0870 1200 100*** or ***www.farnellinone.co.uk)*** code 581-240. They also supplied the high voltage (500V) 270kΩ 2W metal film resistors, code 896-299. Note they are supplied in quantities of ten.

A ready programmed PIC16F84 for the PIC Controller circuit can be purchased directly from the author for the sum of £7 (add £1 for overseas). Orders *(mail only)* should be sent to *David Clark, 97 Thirlwell Road, Sheffield, South Yorkshire, S8 9TF*. Payment should be make out to *David Clark*.

The software is available on a 3·5in PC-compatible disk (Disk 8) from the *EPE Editorial Office* for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 301). The software is also available for Free download via the Downloads link on our UK website at **www.epemag.co.uk**.

The printed circuit board can be obtained from the *EPE PCB Service*, code 497.

Spontaflex Radio Receiver

As with previous radio projects, one or two components for the *Spontaflex 550kHz to 30MHz Radio Receiver* may not be available through the usual local supply channel. This applies particularly to the coils.

We understand that all the specified Toko coils are available from **JAB Electronic Components** ***(☎ 0121 682 7045*** or ***www.jabdog.com) mail order*** by quoting the type number listed in the components list and on the circuit diagrams. The above company also supply small quantities of enamelled copper wire for the single coil version.

All the transistors mentioned in the article are listed by **Cricklewood Electronics** ***(☎ 0208 452 0161*** or ***www.cricklewood-electronics.com)***, order by type number. The preferred transistor is the 2N3707. Any point-contact germanium diode, such as OA81, OA85, OA90 and OA91, should work as the detector diode. However, it must be a *germanium* type.

The polyvaricon (polythene dielectric) variable capacitor will normally be found listed as a "transistor radio" type and consists of an antenna and oscillator section, plus trimmers. They are currently stocked by **ESR Components** ***(☎ 0191 251 4363*** or ***www.esr.co.uk)***, code 896-110 and **Sherwood Electronics** (see page 304), code CT9. The tuning and regeneration capacitors used in the model came from Maplin ***(☎ 0870 264 6000*** or ***www.maplin.co.uk)***, codes AB11M a.m./f.m. (two used) and a FT78K a.m. only.

The printed circuit boards are available from the *EPE PCB Service*, code 494 (Tuner), 495 (Coil Pack), 406 (Tune Cap – 3 off needed) and 496 (Amp) – see page 301.

Back to Logic Basics – 1 Fridge/Freezer Door Alarm

The collection of CMOS logic i.c.s that make up the ever popular 4000 series is vast and enables an extensive range of possible functions and applications to be undertaken. However, for this new short series of practical articles, and to make things easier for the less experienced constructor, the author has chosen just four i.c.s: the 4011 quad 2-input NANDgate; the 4017 decade counter; the 4040 12-stage binary ripple counter; and finally, the 4093 quad Schmitt NAND gate.

The first of the *Back to Logic Basics* projects is a simple *Fridge/Freezer Door Alarm* and readers should have no difficulties in obtaining parts for this project. Nearly all our components advertisers carry good stocks of the 4000 series of CMOS i.c.s and should be able to supply the 4011 quad 2-input NAND gate.

It is most likely that component suppliers will offer a choice of negative temperature coefficient bead thermistors ranging from about 20kΩ up to 47k at 25°C. However, as we are not measuring actual temperature, only changes, any device within this range, or even higher, should be sufficient for this circuit.

When ordering the piezoelectric sounder make sure you specify that you want one that only contains the element. Do not accept one with an internal oscillator drive circuit.

The small printed circuit board is available from the *EPE PCB Service*, code 498 (see page 301).

Smart Karts – 7

Only the Top Deck needs a complete re-build to produce our "all-singing, all-dancing" *Smart Kart SK-4* mobile buggy, the last constructional project in this novel series of adaptable robots – the software will be described next month. The lower and middle decks remain almost untouched, requiring only minor alterations such as lead disconnection/connection. You will also need to make a deeper box for the upper deck to make room for the lid-mounted speaker and microphone insert.

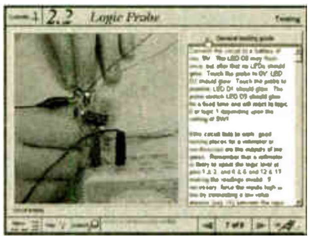
You will probably find that you need to purchase a larger piece of stripboard and cut it down to size for the Audio/Optical circuit board. Take care when mounting the crystal and associated components on the board not to short any leads together and to double-check that the crystal casing does not make contact with surrounding components/wires.

Apart from the two, differently programmed PIC16F84 microcontrollers, all other semiconductor devices are standard "off-the-shelf" items. For those readers unable to program their own PICs, ready-programmed PIC16F84 microcontrollers for Smart Kart SK-4 can be purchased from **Magenta Electronics** ***(☎ 02083 565435*** or ***www.magenta2000.co.uk)*** for the inclusive price of £5.90 each (overseas add £1 p&p). Please quote version SK-4 when ordering and ensure you order them as the matched pair needed. The software is available on a 3·5in. PC-compatible disk (Disk 8) from the *EPE Editorial Office* for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 301). The software is also available for *Free* download via the Downloads link on our UK website at **www.epemag.co.uk**.

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

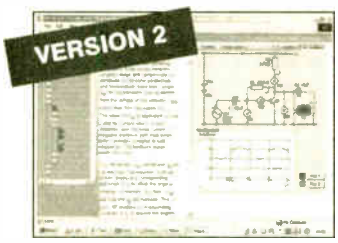
ELECTRONICS PROJECTS



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.

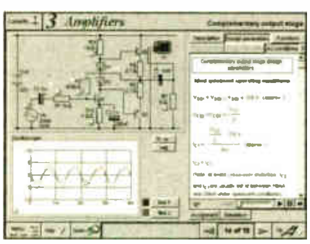
ELECTRONIC CIRCUITS & COMPONENTS V2.0



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.

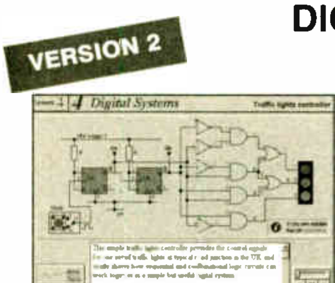
ANALOGUE ELECTRONICS



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.

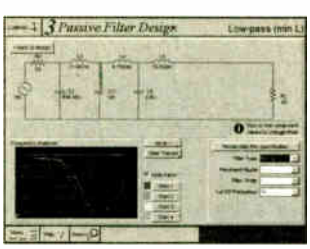
DIGITAL ELECTRONICS V2.0



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.

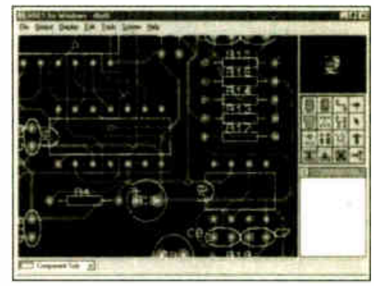
ANALOGUE FILTERS



Filter synthesis

Analogue 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

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)	£249 *plus* VAT
Site Licence	£499 *plus* VAT

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

PICmicro TUTORIALS AND PROGRAMMING

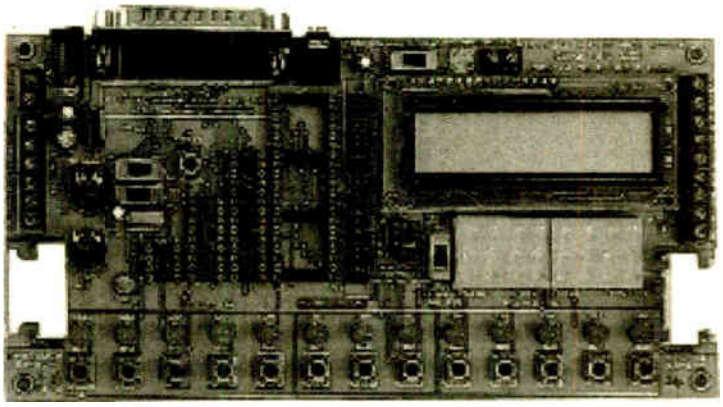
HARDWARE

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.

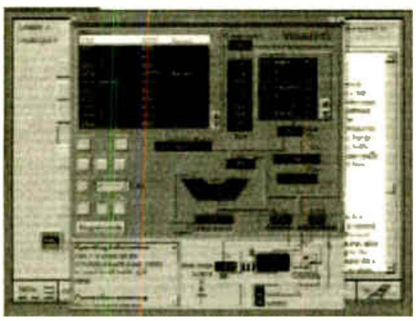
NEW V3

ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (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 45 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.



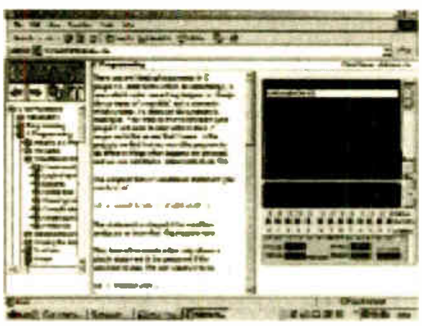
Virtual PICmicro

'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.

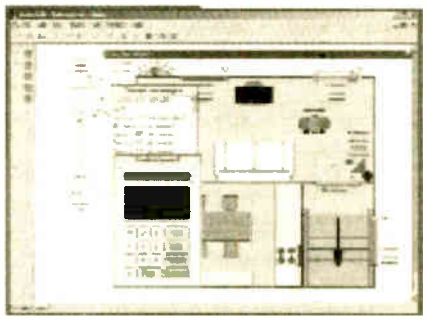
FLOWCODE FOR PICmicro V2

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 18, 28 and 40-pin devices ● Professional versions include virtual systems (burglar alarm, buggy and maze, plus RS232, IrDa etc.).



Burglar Alarm Simulation

PRICES

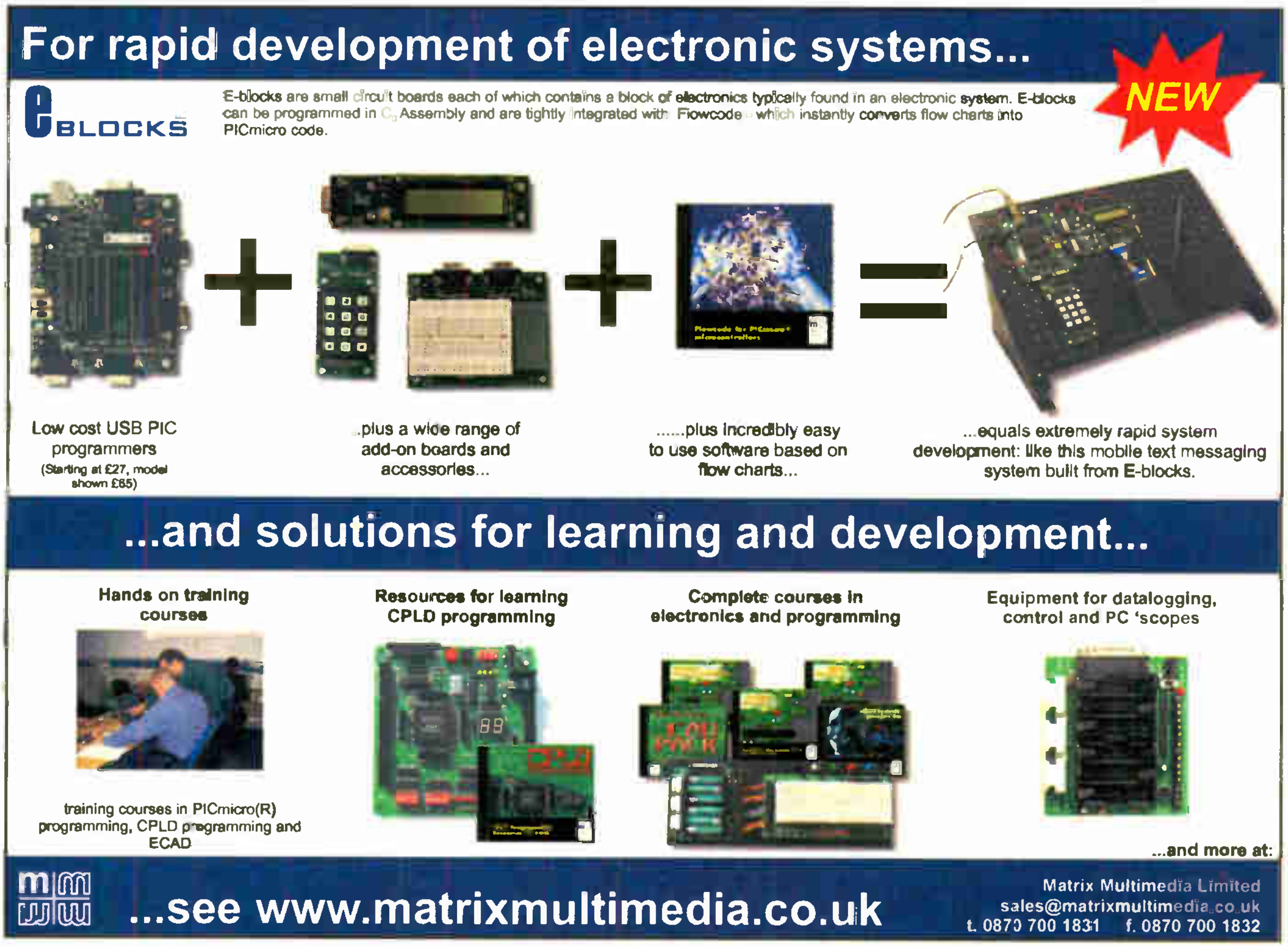
Prices for each of the CD-ROMs above are:

(Order form on next page)

Hobbyist/Student	£45 inc VAT
Flowcode V2 Hobbyist/Student	£57 inc VAT
Institutional (Schools/HE/FE/Industry)	£99 *plus* VAT
Flowcode Professional	£99 *plus* VAT
Institutional/Professional 10 user (Network Licence)	£300 *plus* VAT
Site Licence	£599 *plus* VAT

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


JabsPlace
Jabsplace.co.uk
Solder Stations
Power Supplies
Leads & Cables
Circuit Boards
Components
BUILT BY SPECIALISTS...
...PARTS FROM
JABSPLACE
Web: http://www.jabsplace.co.uk
eMail: sales@jabsplace.co.uk


For rapid development of electronic systems...
NEW
E-BLOCKS
E-blocks are small circuit boards each of which contains a block of electronics typically found in an electronic system. E-blocks can be programmed in C, Assembly and are tightly integrated with Flowcode, which instantly converts flow charts into PICmicro code.
Low cost USB PIC programmers
(Starting at £27, model shown £85)
...plus a wide range of add-on boards and accessories...
......plus incredibly easy to use software based on flow charts...
...equals extremely rapid system development: like this mobile text messaging system built from E-blocks.
...and solutions for learning and development...
Hands on training courses
training courses in PICmicro(R) programming, CPLD programming and ECAD
Resources for learning CPLD programming
Complete courses in electronics and programming
Equipment for datalogging, control and PC 'scopes
...and more at:
...see www.matrixmultimedia.co.uk
Matrix Multimedia Limited
sales@matrixmultimedia.co.uk
t. 0870 700 1831 f. 0870 700 1832

READOUT

Email: john.becker@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 AN ATLAS LCR ANALYSER WORTH £79

An Atlas LCR Passive Component Analyser, kindly donated by Peak Electronic Design Ltd., will be awarded to the author of the *Letter Of The Month* each month.

The Atlas LCR automatically measures inductance from $1\mu H$ to 10H, capacitance from 1pF to $10{,}000\mu F$ and resistance from 1Ω to $2M\Omega$ with a basic accuracy of 1%.

★ LETTER OF THE MONTH ★

Anniversary Reminiscences

Dear EPE,

I have just read with interest your *Practical Electronics 40th Anniversary* tribute in the Nov '04 issue. In 1964 I was 15 and bought something to read on a train trip at the station newsagent. It was the first edition of *PE*, as you illustrated. Returning to Australia I became a glued-on reader for many years even though I had to make a special trip into Melbourne city to a technical bookshop to get it.

After a very satisfying and varied career in industrial electronics service, design and manufacture I am in semi-retirement on the NSW north coast hinterland and can once again indulge my electronic whims.

One of those whims has always been lightning, curious since childhood. So when I was on a rare trip to Taree and found my favourite mags weren't in, I took a look at *PE* (or *EPE* as it is now) and there was an article on a lightning detector, so I grabbed it for the files.

When I got home you can imagine my surprise to discover the coincidence that this, the first copy I had bought in many years, was the 40th anniversary issue.

It's interesting to see that many of the ideas laid down with *PE* continue, as well as the standard of contributions. Magazines such as *PE/EPE* have an important role in electronics education, perhaps even vital as a front-end introduction.

Apart from lightning and high-power audio, I've always been a CRO fanatic (I have more than a dozen). In fact the next thing I built after a crystal set TRF was the CRO from the 1949 *ARRL*. The interest was started by a booklet, E.N. Bradley's *Build Your Own Oscilloscope*, and a fairly fancy one it was too. This and other booklets of the time are a forgotten stepping stone between the magazines like *PE* and the expensive tomes of engineering.

It's also interesting to recall that, in the early days, p.c.b. layouts were a bit blobby because, before suitable marking pens, we painted the resist using Mom's nail varnish and acetone remover ("Oh no! Not the Helena Rubenstein!"). Ooops.

Happy Anniversary guys - well done!

Trevor (Roly) Wilson,
NSW, Australia,
via email

That was a really nice long letter from which I've extracted the above, Roly, thank you. My history goes back that far too. Yes, fond memories, but still lots of excitement from what is happening around us now!

Bit of a Character

Dear EPE,

I have been having a play with John Becker's *Graphics LCD* tutorial of Feb '01, using a 240 by 64 display and most of what I try is going well, thanks John. The only thing I have not been able to solve is writing a byte starting at a specific pixel address. Is this possible or have I missed something ?

If I want to start at the third pixel down and the tenth pixel from the left, I calculate this as (3 x 240) + 10 = 730 = \$2DA. Add to that my graphic offset of \$1000 = \$12DA, but if I use this value to set the address the byte is printed at the cell on row 3 and 10 from the left.

Trevor Wilson, via email

Tony, I regret that you won't write a byte to a specific pixel address unless that pixel happens to be the first pixel where the byte is placed by the GLCD's internal system. Pixel address setting only affects that particular bit of an existing 8-bit byte. User-generated bytes have specific addresses to which they are written and which are not directly pixel related.

Free PSU Safety

Dear EPE,

Harry Hall is right to take safety of surplus computer PSUs seriously (*Readout* Dec '04). Here's my test regime:

None of those acquired have been old enough for dried-out electrolytics to be a concern. Before powering up, a proper IEC mains lead is connected and, if a mains switch is fitted, the supply is thereby switched on. A 500V insulation test is carried out with a suitable instrument ("Megger" brand in my case, or else a portable appliance tester should do the same thing).

At the mains plug, there will be a brief tiny "kick" from earth to both phase and neutral as the suppressor capacitors charge, thereafter infinity. The test probes are removed while the test button is still held down. Then the button is released, turning the device into a 250V meter and, when the probes are re-applied, there is again the same tiny "kick" as the capacitors discharge into the meter.

Line-to-load isolation is also checked with the 500V tester, phase plug pin to one wire of each output voltage and also to 0V. The capacitor "kick" must be followed by infinity ohms. Then the earth integrity is checked, first from the plug earth pin to the PSU case on low-ohms (the "Megger" shows no more than a fraction of an ohm) or using the *Low Range Ohmmeter Adaptor* (*EPE* July '03 P464).

A high-current mains pulse earth loop impedance (Zs) check comes next, again using a dedicated tester. The PSU is plugged in to the mains but the socket remains switched off, the tester's probe is applied to the PSU's case. The reading should be compared with the Zs directly at the mains socket used for the test and should be little more. I get about a third of an ohm here on the mains supply.

As my ring main sockets are protected by earth leakage (residual current) circuit breakers, I have provided a dedicated, ***un***protected, socket near the consumer unit for these tests. It is usually covered to prevent inadvertent use for any other purpose.

If all's well, the PSU is connected to a dummy load where a 12V 5W car bulb and a 6·5V 0·3A MES bulb, in suitable holders, are respectively wired to the 12V and 5V terminals of a computer-type power plug, ready to connect to any PSU. Only now can the device be switched on and the output voltages measured, if both bulbs light up. So, yes, I'm fussy (but, to quote James Bond, "I find I live a little longer that way").

Godfrey Manning,
G4GLM, Edgware, Middx,
via email.

An admirable technique, Godfrey, thank you. Long may you emulate Bondage!

Speed Camera Query

Dear EPE,

I have successfully built many of your projects over many years but remain a "monkey see, monkey do" hobbyist! I am keen to have a go at Mike Hibbett's *Speed Camera Watch* (Jan '05). The use of an EEPROM is new to me and thinking ahead raises some questions. I will list them but not all will be relevant I believe.

I have already downloaded the Gatso list and created a database program to strip it down to the recommended size keeping those areas relevant for me. My query concerns the future. What if I download a new file that has been updated with new sites?

1. Using the PC interface, if I send in a few new data positions would that simply overwrite the first positions on the unit's EEPROM?

2. If I send in a complete new file does that overwrite the existing file? And, if the

existing file had 920 locations and the new file had 880, would that leave the last 40 in situ? This may leave duplicate entries.

3. Is it necessary to wipe the EEPROM before putting in any new data? If so, can this be done through the PC interface as per the project?

4. Is it possible to read back the file from the EEPROM? If you have added any locations of your own by pressing the "Record" button the only way to obtain the Lat/Long would be by reading that file. You may wish to make a note of these (found by file comparison or just lack of a name), for addition to a new file that may not include them. I imagine that this would require more connections from the MAX232 along with a fully connected null modem lead?

It does not seem adequate to just load the current Gatso file and settle for that because these things are blossoming as fast as dandelions and to get the best from this project it would need to be updated from time to time.

Frank Butler,
Metheringham, Lincoln,
via email

Mike Hibbett replied to Frank:

Q1/Q2. When you download data from a file to the *Camera Watch*, any data already in the EEPROM will be erased. So if you download just two locations, but there were 800 there before, you will have just the two. The reason for this is that the file download is really intended as an "initial startup". In fact I had originally not even planned the download feature, which is why there is not a separate RS232 interface.

Q3. No, you do not need to do any special programming or erasing of the EEPROM.

Q4. The simple answer is "not really". In reality, though, there is a debugging command available over the RS232 interface that will dump the contents of the EEPROM, but I really only intended this for development.

If you hook up the RS232 interface to the board, and run Windows Hyperterminal at 4800 Baud n-8-1, then type in the string "$GP!" (without the quotes), the board will dump all 8192 bytes from the EEPROM. You could in theory write your own code to read this data and merge it with the external file. A bit slow, but possible.

Mike Hibbett,
via email

SN74AUC1G14 SOURCE

Dear EPE,

With reference to Anthony H. Smith's ultra-low voltage circuit featured in Fig.11 of *Light Emitting Diodes* Part 3 (Nov '04), I have been unable to find a supplier for the SN74AUC1G14 Schmitt inverter as a "normal" pinned device. I can only find it as an SMD (Surface Mount Device).

David R. Smith,
via email

Tony Smith replied:

Unfortunately, Texas Instruments only supply the SN74AUC1G14 as an SMD device, either in the SOT-23 or SC-70 packages, or the even smaller NanoStar package.

During development of the Fig.11 circuit, I used a SOT-23 sample of the device – not very easy to breadboard, but manageable with a little dexterity and patience!

In this age of miniaturisation, it seems to be the trend among manufacturers to provide new devices mainly in SMD packages only. I'm not aware of any single-gate logic devices that are available as conventional, through-hole parts.

Tony Smith,
via email

Elaborating the Flow

Dear EPE,

Just a quick note to say that I have picked up the Feb '05 issue, after a break of many years, and enjoyed it immensely. Nice to see that someone is still publishing component level designs and practical construction plans.

A suggestion – I did need to do some digging to work out how the *PIC Electric Mk2* is supposed to work, and even what it will do (e.g. does it measure Watts or VA or both). It would have helped me if there had been some introduction, such as a.c. energy measurement methods, a block diagram for the hardware and a flow diagram for the software, and a full description of the Hall Effect Transducer (what does the 1000 turn secondary winding do exactly?). Maybe I will be satisfied by the second part of the article in the next issue.

David Bowers,
via email

Hopefully, David, having now had a chance to read Part 2 you will be feeling somewhat more enlightened. But some aspects that you query are not really suited to elaborating on in a constructional article. Such things as a.c. measurement principles, the functioning of Hall Effect devices and so forth, are more suited to coverage in "tutorial-type" columns like Circuit Surgery *etc.*

The PIC Electric *software is highly complex and certainly not suited to flow charts, which would take up far too much magazine space. And to readers not interested in the specifics, they would be meaningless and tedious. My own views on flow charts are previously well documented in my* PIC Tutorials.

Whilst some may find them useful in getting their thinking "into gear" (and may be mandatory for commercial software writers), my flow charts are purely in my head – I can "see" what I'm doing and aiming at without the laborious action of drawing them, which would consume great chunks of time that I would sooner spend designing something else.

The fact that we publish flow charts for our Smart Karts *is an expression of Owen Bishop's desire that they should be an aid to readers who wish to modify his software to make the buggies do other things. Designs like* PIC Electric *are not suited to ready modification, as the Karts are, being tailored to meet a specific need within a given specification. There is no need for users to make system changes – if changes that are needed come to light, I will make those changes myself for general distribution.*

We appreciate that some readers may wish to extract some routines from other software designs for use in their own applications, and they are welcome to do so. Many of the routines, though, are simply variants of others which have been discussed at greater length in earlier issues of EPE.

Many of those I used in PIC Electric *and other designs were discussed in my* PIC Tutorials; *the maths routines are Peter Hemsley's, the most recent edition of which was discussed in Jan '05; the RS232 serial routines are Joe Farr's, discussed in Oct '03; the EEPROM access routines are adaptations of Microchip's published software.*

The main routines are simply "glued" into a design as modified library routines – something which anyone familiar with PIC program writing should be capable of doing for themselves, and without additional documentation. And we certainly could not re-publish such documentation each time a fresh design uses the routines.

It is interesting to note that a fair number of designs offered to us for publication do indeed have some of those routines embedded in them. Personally, I feel very gratified to see that a bit of code I have previously developed, possibly with great effort, is finding wider use!

Candid Camera Watch

Thinking of Speed Cameras (Jan '05 issue), the latest in the speed camera world was tested in the Manchester area and is now being rolled out down the M1. Each gantry has a camera for each lane and it takes a photo of the car. The next gantry does the same and compares the photo. When it gets a match it checks the time interval and you are nicked.

The system is infallible – like when it took a photo of a Merc at 50mph in a densely built-up area when the road was unusually clear. Car registration was a fake and belonged to a 1923 combine harvester that resided in Wiltshire and had never gone faster than 4mph in its life. I fully expect the market for fake car number plates to go through the roof, together with the market arrival of fakes of the ID cards that are impossible to clone!

George Chatley,
via email

Cynics might say that this is the price of Nanny's progress, George!

Atlas Prized

Dear EPE,

It certainly was a very pleasant surprise to see my letter as *Letter of the Month* in the Feb '05 issue. I have received my Atlas LCR Component Tester and it is great – I don't know how I did without one for so long. The bag labelled "What are these?" is now empty.

It is very generous of Peak Electronics to present this prize – not that I ever regard *Readout* as a competition. I can only say again that I am delighted, and give a sincere "thank you" to you and to Peak.

Harry Weston,
via email

Thanks Harry – I've played with one and agree that they are good units.

TK3 Sim Feedback

Dear EPE

Firstly, many thanks John for yet another great addition to the *TK3* software. I am referring to the simulation you have set up.

I ran it before the issue covering it came out, and was able to use it quite easily, even without instruction. That said, I have now read your article closely and have picked up pointers that will help me further. I have already been able to partly debug a program I have been working on, and look forward to completing the rest in due course.

There is one question that I do want to raise, though: I see that at present, the Sim will not work with (among other things), access to data EEPROM. This being the case, what happens when the Sim reaches this point? From initial observations, if an EEPROM value is read and a bit test performed on the value obtained, it seems to treat the result as zero, regardless of what is contained in the value. Would that be correct?

If within the program being simulated, a value is written or read to the EEPROM, could the simulator create a virtual EEPROM, based on the addresses the EEPROM is being written to and read from?

Also, with interrupts, especially port change interrupts, could these be included and activated by clicking the required input, as currently achieved with the inputs so far.

Anyway, as said, even as is, this is a great help, but you did ask for feedback!

Bob Syers, via email

Nice to know you find TK3's *Sim easy use Bob. I haven't actually tested it for what happens if EEPROM access is attempted. I suspect it might tell you in some circumstances that too high an address is being called.*

I'll look into the possibility of actually implementing EEPROM and interrupts as you suggest. Time, though, is a factor – not enough of it. The V3.00 upgrade was started back last August and continued until the day of release this Jan, so I've a few other things to catch up on before going back to TK3.

TK3 at Warp Speed

Dear EPE,

Further to my chat with John about running *TK3* with an 18F PIC on an overclocked XP machine, I found some spare time and looked in depth at the problems I was having and have now got a fully working system.

It looks as if my system is just too fast for the code – some of the delays did not work correctly. I have an XP Service Pack 2 running an AMD XP2600 (overclocked to run at 2209Mhz). To be more precise, the **t=Timer** delay in sub routines **SendBytes18F()** and **PICconfig18F()** was the problem. Having now inserted additional delays of 1ms following each occurrence of **t=Timer**, by adding the command line **Call Delay1ms**, all now works.

I have not determined the optimum settings – I have just inserted these 1ms delays. I did try an unmodified version of the code on a slow old laptop running Win98SE and it worked correctly (I did expect that it would but wanted to be absolutely sure that I did not have any sort of obscure hardware fault).

I no longer have any real interest in this "problem" as I have modified the source and re-compiled, but I guess it might be of some interest to you as it is very possible that others might encounter the same problem.

Is it your intention to accommodate other 18F series PICs in the future? Is it intended to make those features that currently don't work with the 18F PICs work with these chips (e.g. debug)?

John Hudson,
via email

Thanks John, I'll embed the changes into a future version. I guess it's a problem that had to arise sooner or later, with PCs working nearer the speed of light now!

At present I have no further plans for 18F coverage via TK3, *but maybe one day ...*

More on Electrical Installations

Dear EPE,

Following on from the letters in the March '05 edition concerning how the new regulations affect DIYers doing their own domestic electrical work, the NICEIC website on **www.niceic.org.uk** does include in its Part P section an easy-to-read table containing a fairly comprehensive breakdown of all the electrical jobs one could expect to encounter in the home, detailing whether or not they require certification on completion.

There is in fact a wide range of jobs, from simple replacement of broken socket/switch/light fittings on a new-for-old basis up to adding extra spurs, etc, that can still be done legally by a DIYer without informing anyone.

I noticed in one of Alan Winstanley's responses the statement: "It would be a very sad day if it should be deemed illegal for a hobbyist to solder up a transformer and plug it into the mains". Well I'm sorry Alan, but I have a horrible feeling that if the exponents of the so-called "politically-correct nanny state" had their way we'd be hard-pressed to solder up anything after they have taken our soldering irons off us (lest we burn our fingers) along with our hammers (lest we strike our thumbs) and our saws (oh dear, we might cut ourselves).

Who knows, one day I may just achieve the pinnacle of politically-incorrect success by getting myself chucked in jail after being stopped by the Police for running over a fox in my 4 × 4 while going on a fishing trip, and asking for illegal possession of a mains transformer to be taken into consideration before sentencing!

Chris Swinnerton,
via email.

I dare'st not comment Chris for fear of being thought to collude in your crimes!

Congratulations

Dear EPE,

I am a 46 years old electronics technician from Belgium. For me, it all started as a hobby when I was 13 or 14 and since then I can say I have read hundreds of magazines in various languages (French, English, Dutch, German).

In my opinion your magazine stands out "in keeping up the spirit". By this, I mean the style that I find in the 50s, 60s and 70s mags that I have collected): giving enthusiasts *tools* and not simply *recipes*, making them think, exciting their imagination and creativity by presenting the information in a clear, concise, ready to use form and always with the practical goal in mind. And, very importantly, in an entertaining manner with a kind of "family" or "brotherhood" spirit which makes me always impatient for the next issue.

Learning is not only by studying, it is also by making. Your magazine superbly blends theory and construction articles. Your readership is broad, ranging from the novice to the more advanced. I think I can consider myself as quite experienced but still, even in the articles geared towards the beginners among our colleagues, there is always something new for me to learn: an unusual approach, an explanation from a different angle or some very original "horizon broadening" subject which would not find its place in so-called "serious" or "professional" (and as far as I am concerned: dry and unappealing) journals.

Congratulations and many thanks.

José Rousseau,
Soignies, Belgium,
via email

Many thanks for those kind words José. On "family", my own feelings are that this has become the reality in many ways since we not only started our Chat Zone *(via **www.epemag.co.uk**), but also introduced email, both of which have enabled quick informal correspondence to develop. I suspect that even* Readout *has made a similar contribution.*

Blood Pressure Sensing

Dear EPE

How do you calibrate these electric blood pressure meters you buy from say Argos or Boots? I have had several of them in my time from the pump it up yourself to the automatic pump and record systems. Most of them did not agree with the mercury column unit some of the quacks (especially mine) still use.

It's a huge problem because if, for example, I take three readings on myself, they can vary a considerable amount. A chemist said that it's £35 to have the thing sent back and re-calibrated, which is precisely the price paid for it new. Perhaps you could ask in the mag for ideas?

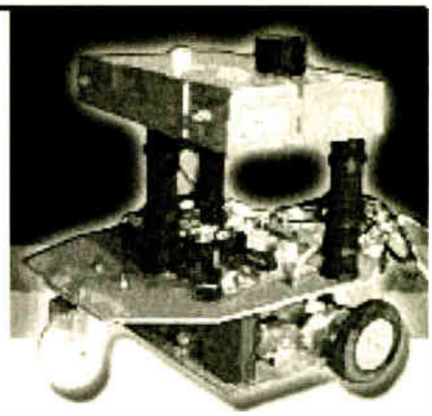
My present unit is the most scorned type where it just clips over your wrist and you clasp your armpit while sitting up, and cleverly the numbers and the start button are on the inside! It has a beeper to tell you the state of play but being deaf that's totally useless to me! The unit is said by some to be dead useless, but it does closely mimic the quack's numbers.

George Chatley,
via email

Well readers, how's your electronics knowledge on this one? Mine's non-existent. But I have thought in the past that designing such a device might have general benefit. Tell George and us some more please!

Constructional Project

Smart Karts



Owen Bishop

Part 7 – *Son et Lumière,* all singing, all dancing (nearly)!

THE final version of our Smart Kart we have named SK-4, presenting it as a musical (?) robot with which to entertain your friends. Smart Kart SK-4 has two modes of operation. In Mode 1 it is a dancer, swirling around the room in time to its own music. In Mode 2 is talks to itself and your task is to work out what it is saying.

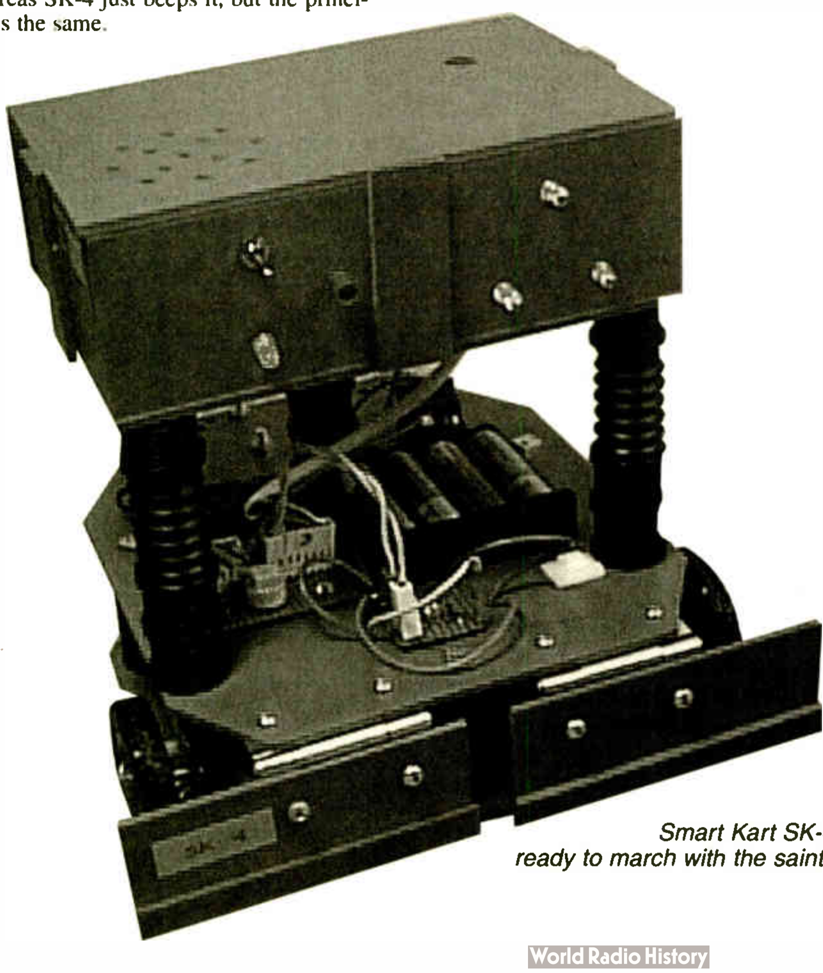
Talking by using musical tones is by no means new. A report in the *Daily Telegraph* on 3 January 2005 suggested that the practice might be as much as 2500 years old. According to the report, such a language, *Silbo*, was used by inhabitants of La Gomera, one of the Canary Islands, and is still being taught there today.

Silbo is said to be an effective means of communicating complex statements over distances too far for the human voice to carry. The islanders whistle their language, whereas SK-4 just beeps it, but the principle is the same.

Musical Chat-Up

While engaged in its dancing and talking, SK-4 uses its bumpers and a light sensor to help it navigate. These sensors come from Smart Kart SK-2 (Dec '04/Jan '05). The Audio-Optical (or AO) board is entirely new. It includes a very sensitive audio amplifier used to detect sounds, and the circuits for switching an array of l.e.d.s.

The most interesting thing about the AO board is that it has its own PIC for generating music and the robot's language, as well as responding to the sounds detected by the microphone. Having two PICs to control the robot is an example of distributed processing. The original PIC on the middle deck (we shall call this PIC1 from now on) still has the job of controlling the drive motors and in the dancer program takes its orders from the PIC on the AO board (which we shall call PIC2 from now on).



Smart Kart SK-4 ready to march with the saints

Microcontroller PIC2 processes anything to do with detecting and making sound, and also switches the light display. In the talker program PIC1 is in charge, while PIC2 provides a commentary in the tonal language. The two PICs communicate with each other through Port B (RB3 to RB6), using handshaking protocols. More about this later.

Back to Basics

The first task in constructing SK-4 is to remove unwanted parts of previous robot systems. What you need to remove depends on whether you are starting with SK-1, SK-2 or SK-3 but, at the end of it, your basic stripped-down SK-4 should comprise the following parts:

Lower Deck: As usual, this is complete with power board, motors, gearboxes wheels and castor. SK-3 had a lead running from the positive terminal of the power board terminal block to a second power board on the upper deck (for the jaws/winch motor). Remove this lead.

Middle Deck: This carries the Processor board and the battery for the Processor board and the upper deck. SK-2 and SK-3 had a lead running from pin 3 of the Processor to the ultrasonic transmitter (in SK-2) or the multiplexer (in SK-3). This carried the output signal from PIC pin RA4, which is not used in SK-4. Unplug this lead from its terminal pin at G8 on the Processor board.

Upper Deck: There is a new upper deck.

Audio Sensor

The circuit diagram for the audio sensor is shown in Fig.7.1. Sound is picked up by an electret microphone (MIC1). This is powered via resistor R8 and when activated produces a small rapidly changing voltage across capacitor C4. The signal is fed to op.amp IC2a, which is wired as an inverting amplifier with a gain of 330. The output from IC2a pin 7 goes to a diode pump formed by diodes D5 and D6, capacitor C5 and resistor R13.

The pump's action is to increase the voltage across C5 when the output voltage of the op.amp swings positive, but to prevent

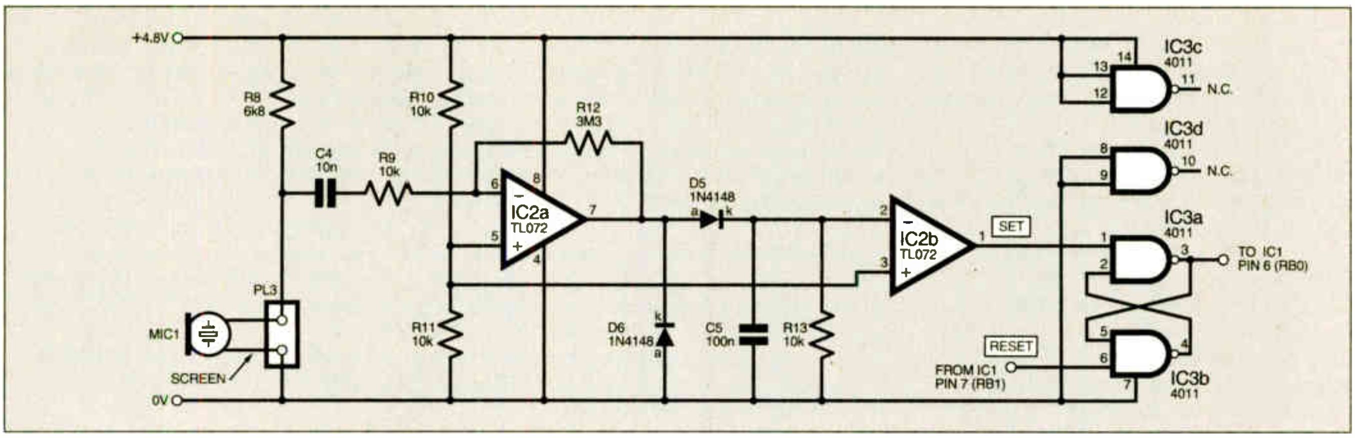


Fig.7.1. Schematic diagram of the audio amplifier of the AO (Audio/Optical) board, with output flip-flop

the voltage at C5 from falling on negative output swings. Consequently a burst of sound results in C5 becoming positively charged.

The second op.amp of the pair, IC2b, is wired as a comparator, comparing the voltage at its inverting input, pin 2, with the constant voltage (equal to half the supply voltage) at its non-inverting input, pin 3. A rise in the voltage across C5 causes the output of IC2b, pin 1, to swing low. When the sound ceases, C5 is gradually discharged through resistor R13 and the op.amp output rises close to the supply voltage.

This signal from IC2b goes to a Set-Reset flip-flop built from two NAND gates, IC3a and IC3b. Normally its input pins 1 and 6 are held high and the output from the flip-flop, pin 3, is low. The output goes high when input pin 1 (Set) goes low – that is, when sound is detected. The output stays high, even after the sound has ceased, until a low level (Reset) is sent to input pin 6.

Sound and Light Output

The circuit diagram in Fig.7.2 is for the PIC-controlled Sound and Light output functions, which are triggered in response to signals generated via the Audio Sensor. The PIC (PIC2) is shown as IC1 and is run at 4MHz, as set by crystal X1.

The output from IC3 pin 3 goes to PIC pin RB0, which is configured as an input. The Reset input of the flip-flop is controlled by RB1, configured as an output.

The logic level on RB0 can be read by the program at any time, to determine whether or not a sound has been detected. Once a high level has been read, the program produces a short low pulse at RB1, resetting the flip-flop in preparation for detecting the next burst of sound.

Port A pins RA0 to RA3 are devoted to outputting signals to the speaker (LS1) and to the group of three l.e.d.s (D1 to D3, red, green and blue respectively). The outputs are buffered, using conventional common-emitter switches based on *npn* transistors TR1 to TR4. Pin RA4 is not used.

When the program select switch (S1) is open, pin RB2 (configured as an input) is held low by resistor R1 and the robot performs its music and dance routine. When the switch is closed, RB2 is made high and the robot starts to "talk".

The logic level at RB2 is also fed through the 6-way cable (PL1) to RB0 of PIC1 on the middle deck. In this way, both processors will be in the same program mode.

Bits RB3 to RB6 communicate through the 6-way cable to the corresponding pins of PIC1. The way these are used is described next month when we discuss SK-4's software. Bit RB7 of PIC2 is not used.

On connector PL1, the pin marked "RB7" is connected to the corresponding pin of PL2 on the Processor board (Fig.5

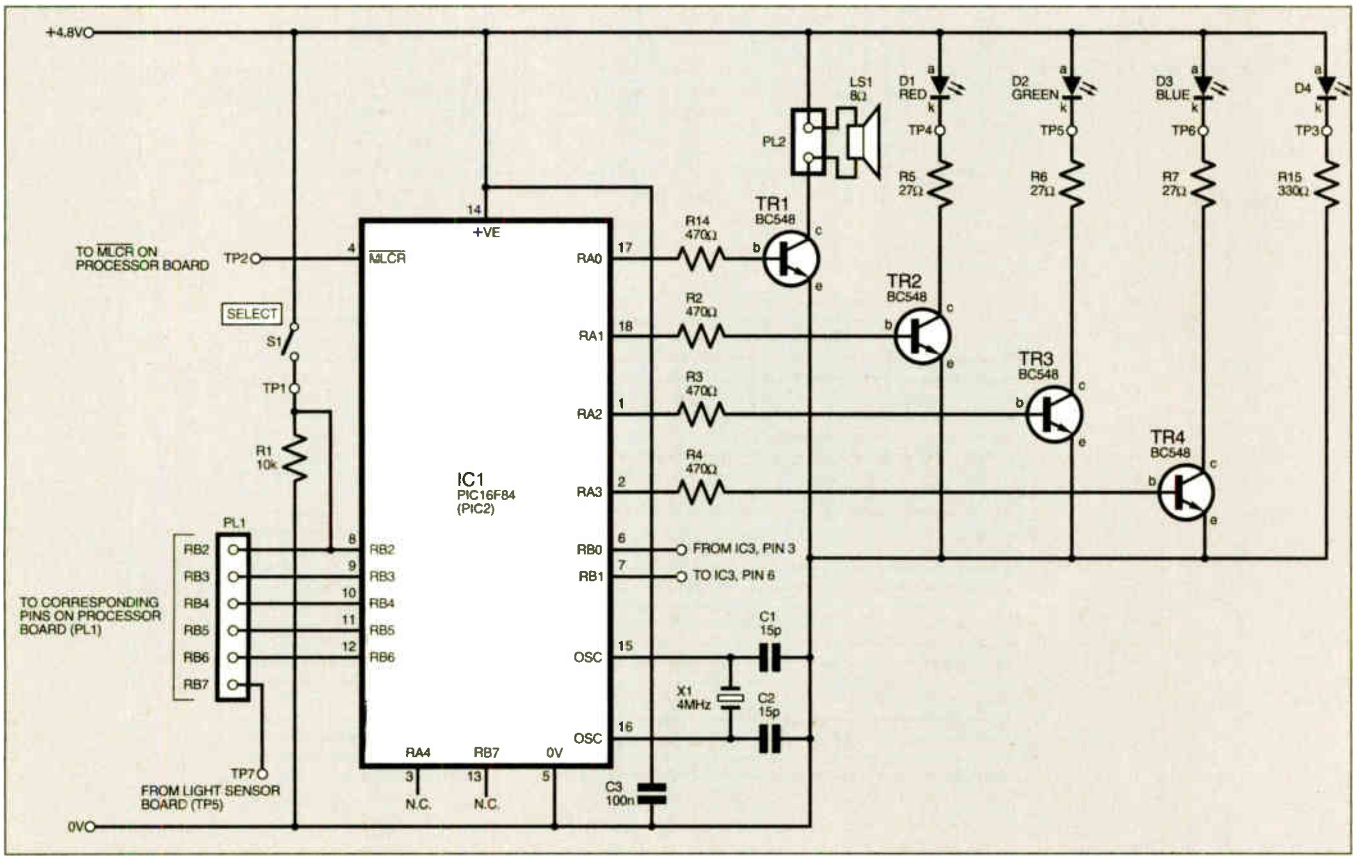


Fig.7.2. Sound and Light circuit diagram of the remainder of the AO (Audio/Optical) board, including PIC2

Oct '04). This line carries the output signal from the Light Sensor (on the upper deck) to IC2b on the Processor board (on the middle deck), and then connecting to that board's PIC pin RB7.

There is a connection from PIC2's $\overline{MCLR}$ pin (pin 4) to the reset circuit around pin 4 of PIC1 on the Processor board. This ensures that both processors are reset when the Reset switch (S5) on the Processor board is pressed.

Pilot l.e.d. D4 indicates when the power to the board is on. The Processor and AO boards are wired in parallel to the power supply, so the same on/off switch (S4 in Fig.5 Oct '04) controls the power supply to both boards.

Construction

The component layout and track cutting details of the stripboard assembly for Smart Kart SK-4 are shown in Fig.7.3. Note that the copper strip is *not* cut between pins 7 and 8 of IC3.

The oscillator circuit (X1, C1 and C2) is laid out compactly to minimise stray capacitances. As a result there is the possibility that the rim of the metal case of crystal X1 may touch against the wire lead of resistor R2, the wire link from stripboard points *K15* to *L15*, or the wire leads of one or both of C1 and C2. This would produce one or more short circuits, preventing PIC2 from operating correctly.

To eliminate this risk, solder in the crystal last, after all other leads are in place. When soldering, do not push the crystal down until it rests flat on the board, but solder it with the base of its case about 2mm above the board. Finally, inspect the crystal carefully to make certain that the case is not making contact with any of the leads that surround it.

Ensure that all polarity-sensitive components are orientated correctly. Do not insert the d.i.l. (dual-in-line) devices into their sockets yet.

Testing the AO Board

Before applying power to the board, thoroughly check it for poor solder joints and tracks cuts. Begin testing *without* the three i.c.s in their sockets and with no power applied. Check for continuity between:

- The 0V terminal of TB1 and all terminals and other points in the circuit that are supposed to be at 0V.
- The positive terminal of TB1 and all terminals and other points in the circuit that are supposed to receive the positive supply.
- The PIC2 socket and the pins of PL1, TP1 and TP4, C1 and C2.
- The RB0 line from pin 6 of the PIC2 socket to pin 5 of IC3.
- The RB1 line from pin 7 of the PIC2 socket to pin 6 of IC3.
- The line between IC3 pin 1 and IC2 pin 1.

To test the audio amplifier, put IC2 and IC3 in their sockets, plug the microphone

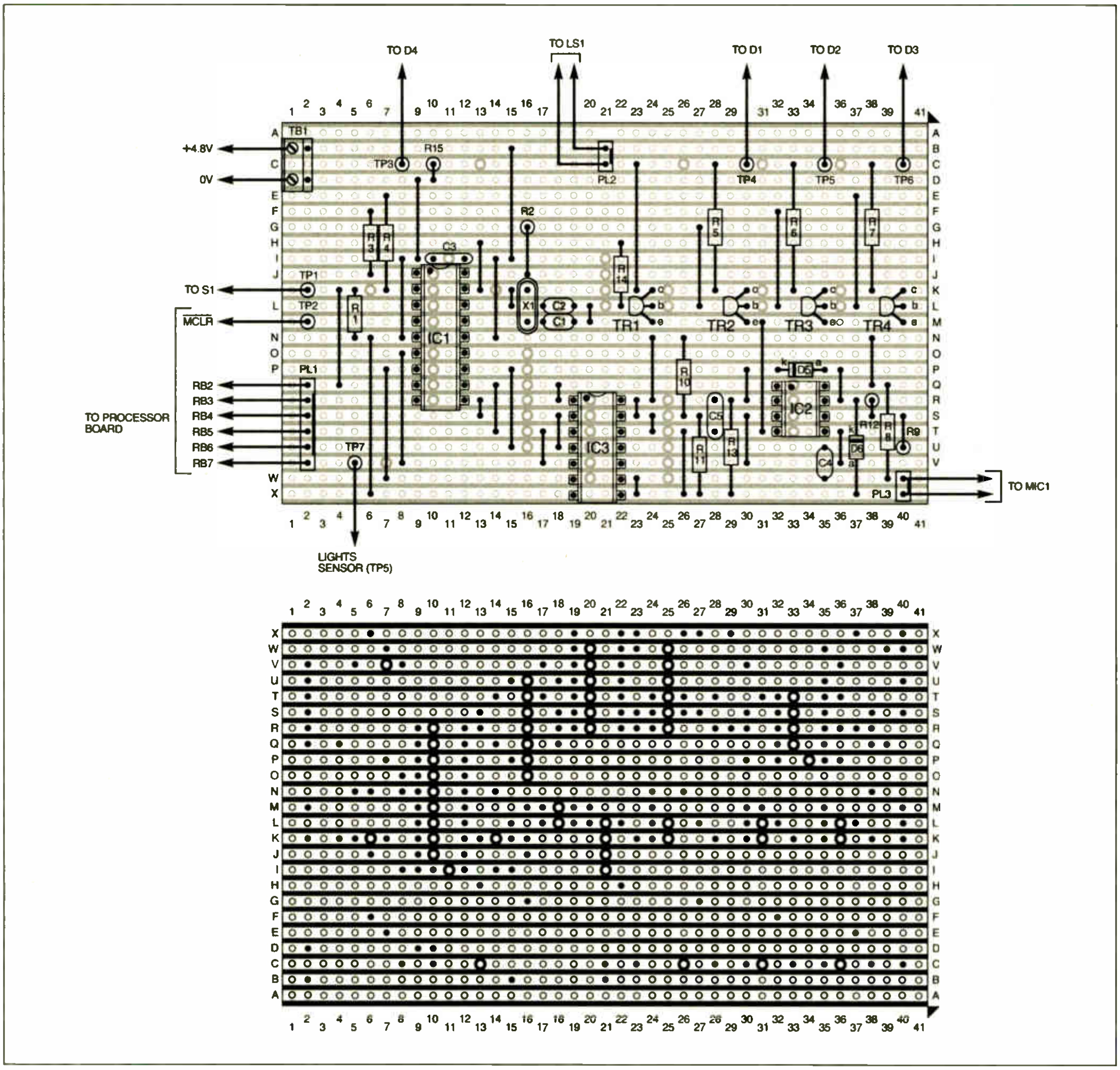


Fig.7.3. Stripboard component layout, wiring and details of underside copper strip break for the AO circuit board

COMPONENTS

Approx. Cost Guidance Only **£9** excl. speaker, case and batts

Resistors

R1, R9 to R11, R13	10k (5 off)
R2 to R4, R14	470Ω (4 off)
R5 to R7	27Ω (3 off)
R8	6k8
R12	3M3
R15	330Ω

All 0·25W, 5% or better

See SHOP TALK page

Capacitors

C1, C2	15p ceramic disc, 5mm pitch (2 off)
C3, C5	100n polyester, 5mm pitch (2 off)
C4	10n polyester, 5mm pitch

Semiconductors

D1	5mm, high brightness l.e.d., red
D2	5mm, high brightness l.e.d., green
D3	5mm, high brightness l.e.d., blue
D4	5mm, l.e.d., yellow
D5, D6	1N4148 signal diode (2 off)
IC1	PIC16F84 preprogrammed (see text)
IC2	TL072, dual low-noise j.f.e.t. op.amp
IC3	4011 quad NAND gate
TR1 to TR4	BC548 *npn* transistor (4 off

Miscellaneous

X1	4MHz crystal
LS1	minature 8Ω loudspeaker
MIC1	electret microphone insert
S1	min. s.p.s.t. toggle switch
TB1	2-way screw-terminal block, p.c.b. mounting
TP1 to TP7	pin header and socket (7 off)
PL1	6-way header socket
PL2, PL3	2-way header plug and socket (2 off)

Stripboard, size 24 strips x 41 holes; connecting wire (single-core and multi-core); single-core screened cable (10cm); 8-pin d.i.l. socket; 14-pin d.i.l. socket; 18-pin d.i.l. socket; p.v.c. board for new upper deck (see Table 7.1); glue for upper deck panels, Blu-Tack or similar; solder, etc.

into PL3 and switch on the power (4·8V as before). Check the voltages at IC2 pin 8 (+4·8V), and pins 3 and 5 (2·4V). The voltage at pin 1 should be close to +4·8V but will dip instantaneously if the microphone is tapped. You are unlikely to detect a sharp downward spike with a meter, though you should be able to if you use an oscilloscope.

For the final test of the sound sensor circuit, temporarily connect pin 6 of IC3 to the positive supply through a 10 kilohms pull-up resistor. Temporarily wire a push-switch between pin 6 and the 0V line. Monitor the output from pin 5 (or you could monitor it at pin 6 of the PIC2 socket). Briefly press the switch to reset the flip-flop, setting the output low.

Make a sound (clap, whistle, voice) and the output should go high, and stay high until the switch is again pressed. You should find that this circuit is extremely sensitive – even a near-by whisper can be sufficient to trigger it. So you need a quiet environment for operating the robot. If this is not easy to obtain and the sensor is being triggered falsely, try the effect of muffling the microphone. For a permanent solution, try reducing resistor R12 to 1MΩ or less.

The interfaces to the l.e.d.s are tested by temporarily wiring an l.e.d. with its anode (a) (longer wire) to the positive supply and its cathode (k) to TP3. Use a flying lead to connect the positive supply to pin 18 of the PIC2 socket; the l.e.d. should light. Repeat this test with the l.e.d. connected to TP4, then to TP5; the l.e.d. should light when the flying lead is connected to pins 1 and 2 respectively of the PIC2 socket.

The speaker interface is tested by plugging the speaker into PL2, then taking PIC2 socket pin 17 high with the flying lead. The speaker crackles loudly as contact is made and broken.

System Assembly

To assemble the SK-4 system, first build the new upper deck, then replace the bumpers and light sensor used with SK-2. There is a small addition to the Processor board, as discussed shortly. To complete the robot, assemble and install the audio-optical board on the new upper deck.

This consists of a shallow box, similar to that in SK-1 and SK-2 (see photo below). You could adapt the upper deck of one of these versions, but the box described here for SK-4 is deeper than those to give increased clearance. The three display l.e.d.s. (D1 to D3), the pilot l.e.d. (D4), the l.d.r. sensor (from SK-3), and the single select switch (S1) are mounted on the front panel of the box. It has a drop-on lid which carries the speaker and the microphone; this is why adequate clearance is important. As before, the deck is built from 3mm expanded p.v.c. sheet, or equivalent. A cutting and drilling guide is given in Table 7.1.

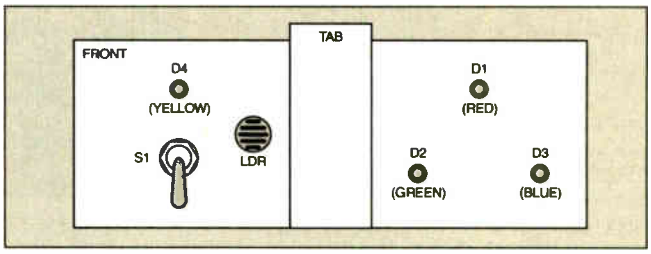
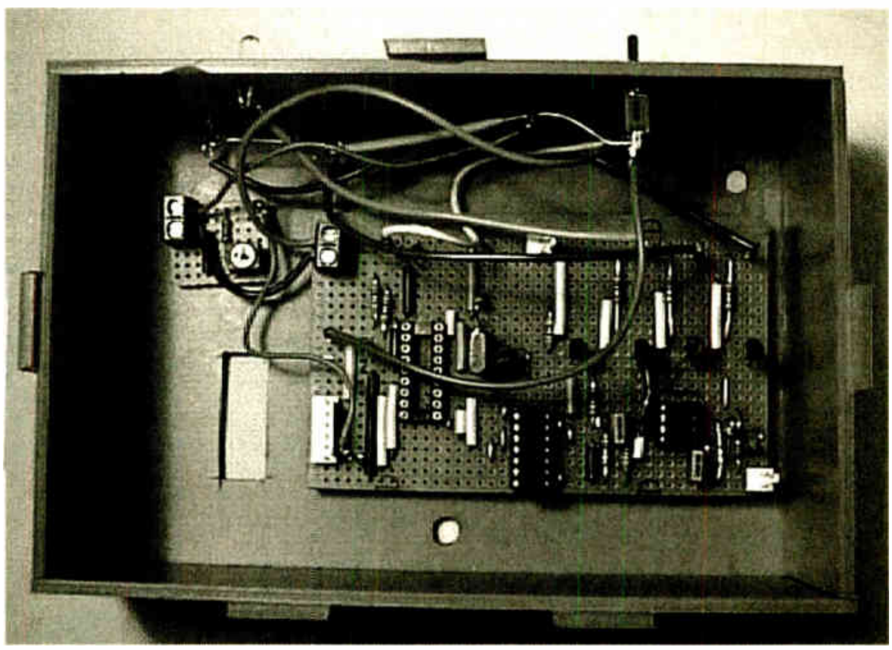


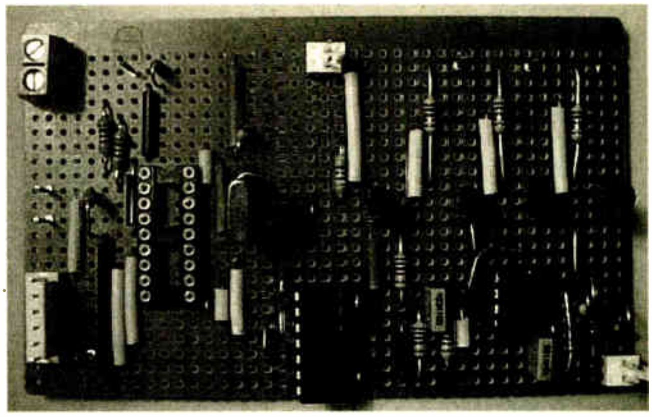
Fig.7.4. The layout of the front panel of the Upper Deck



The audio-optical (AO) board and light sensor board (Dec '04 – Fig.3.5) mounted in the Upper Deck, with connections to the l.e.d.s and the l.d.r.

Table 7.1: Cutting and drilling guide for the Upper Deck.

Piece	*Dimensions (mm)*	*Holes Required*
Bottom	165 x 110	separators (3), slot for cable
Top	165 x 110	speaker, microphone
Front	165 x 50	l.e.d.s (4), l.d.r., switch S1 (see Fig.7.1)
Rear	165 x 50	-
Sides	104 x 50 (2 off	-
Tabs	55 x 20 (5 off)	-



The completed AO board ready for testing (PIC socket empty). The audio amplifier circuit with flip-flop occupies the bottom right quarter of the board

The deck is assembled in the same manner as that of SK-1 (Oct '04). In the lid, drill an array of holes (each, say, 5mm diameter) where the speaker is to be mounted, to allow sound to escape. The speaker may be glued by its rim to the underside of the lid. Alternatively, it may be held in place by clips bolted to the lid.

Solder tags make quite good clips, the rim of the speaker being gripped between the "tag" part and the lid. In this case, drill holes for the bolts. Usually three clips are sufficient.

Electret microphone inserts are usually in a cylindrical metal case, 10mm in diameter. Possibly fixed by a little glue, the microphone is a reasonably tight fit in a 10mm hole drilled in the lid.

Processor Board

Both PICs are reset simultaneously when the Reset switch on the Processor board (S5, Fig.5 Oct '04) is pressed. To connect the switch with the $\overline{MCLR}$ input at pin 4 of PIC2, solder a terminal pin at *H8* on the Processor board (Fig.6 Oct '04). Prepare a lead about 30cm long, with a single header socket at both ends, to connect the pin at *H8* with the pin at *M2* (Fig.7.3, TP4) on the AO board.

With the power on, check that the voltages at pin 4 of the PIC1 socket and pin 4 of the PIC2 socket are normally +4·8V, but drop to 0V for as long as Reset switch S5 is pressed.

Bumpers

The Bumpers were described in Part 3 (Dec '04). The bumper board for SK-4 is the same as before, the only difference being that the signals from this board go to PIC1 inputs at RB0 and RB1 through connector PL1. In Part 3 Fig.3.2 (circuit diagram) and Fig.3.3 (board layout), read "RB0" for "RB4" and read "RB1" for "RB5".

Use a connecting lead with a 2-way header socket at each end to connect the bumper board to the Processor board. This plugs on to pins PL2/0 and PL2/1 (Fig.5 Oct '04), sharing this 8-way plug with a 6-way socket of the 6-way cable that runs between the Processor board and the AO board.

Light Sensor

The Light Sensor was also described in Part 3 (Dec '04, Fig.3.4 and Fig.3.5). It is mounted in the upper deck and the l.d.r. (R3) is glued at the centre on the outside of the front of the deck. It can be glued in place. Its leads pass to the interior through a pair of 1mm holes. It is surrounded by an open tube of black card to make it respond most strongly to a source of light that is ahead of the robot.

Connections to the board are as set out in Part 3 Fig.3.4 and Fig.3.5, except that the output now goes to the AO board pin TP7, instead of pin 5 on the Distribution board (this pin is not used in SK-4).

The lid of the Upper Deck seen from below showing the mounted speaker (LS1) and microphone insert (MIC1)

Off-Board Wiring

As the upper deck is enclosed, it is safe to use double-sided adhesive pads or Blu-Tack to fix the AO and Light Sensor boards in place. One terminal of S1 and of the l.d.r., and the anode wires of the four l.e.d.s, are joined by a wire that goes to the positive terminal of TB1. This provides the positive supply to all these components.

Solder short wires (about 10cm long, but check that they will reach) to the other terminals of these components and terminate those from the switch and l.e.d.s in pin header sockets. Push these on to terminal pins TP3 to TP6 of the AO board. Connect the other terminal of the LDR to TB2 on the Light Sensor board (Fig.3.5, Part 3). Prepare a lead with a header socket at both ends and use this to connect TP3 on the Light Sensor board to TP7 on the AO board. This is the $\overline{MCLR}$ line.

As well as the $\overline{MCLR}$ line, the AO board is connected to the Processor board by a 6-way cable with a header socket at both ends. You can use the cable that was used in SK-2 for connecting the Distribution board to the Processor board. Slice off one of the polarising strips of one of the sockets (the strip nearer the RB1 connection), so that it can be plugged on to the 8-way plug PL2 on the Processor board, alongside the 2-way socket from the Bumper board.

Solder a pair of wires, each about 10cm long, to the terminals of speaker LS1. Solder a 2-way header socket to the other ends of the wires and plug this on to PL2. It is better to use light-duty single-core screened cable for the microphone lead. You need a piece about 10cm long. At one end solder the core to the signal terminal of the microphone and the screen to the case-connected terminal. At the other end, fit a 2-way header socket, observing the polarity shown in Fig.7.2.

Run the 0V line from the terminal block TB6 on the Processor board, up through the slot to TB1 of the AO board and TB2 of the Light Sensor board. Run the positive supply line from the terminal block TB6 on the Processor board, up through the slot to TB1 of the AO board but not to the Light Sensor board.

Testing the System

Without the PICs in their sockets and with power switched off check the continuity of the positive line at the terminal blocks on the Processor and AO boards, and the positive terminals of off-board components in the upper deck. Check the continuity of the 0V line at the terminal blocks on the Processor, Light Sensor and AO boards. Check the continuity between the following pins of PIC1 and the same-numbered pins of PIC2: $\overline{MCLR}$ (pin 4), RB2 (pin 8), RB3 (pin 9), RB4 (pin 10), RB5 (pin 11).

When testing is complete, insert the two PICs in their sockets. If they are already programmed, your next step is to investigate the action of the software, as described next month.

Resources

Software, including source code files, for the Smart Kart Part 7 is available on 3.5-inch disk from the Editorial office (a small handling charge applies – see the *EPE PCB Service* page). It can also be downloaded *free* from the *EPE* Downloads page, accessible via the home page at **www.epemag.co.uk**. It is held in the PICs folder, under SmartKart. Download all the files within that folder.

In the final Smart Kart article next month, Part 8, we discuss the software that controls Smart Kart SK-4. □

EVERYDAY PRACTICAL ELECTRONICS

BACK ISSUES

We can supply back issues of *EPE* by post, most issues from the past three years are available. An *EPE* index for the last five years is also available at **www.epemag.wimborne.co.uk** or see order form below. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photocopy of any *one article* (or *one part* of a series) can be purchased for the same price. Issues from Nov. 98 are available on CD-ROM – see next page – and issues from the last six months are also available to download from **www.epemag.com**. Please make sure all components are still available before commencing any project from a back-dated issue.

DID YOU MISS THESE?

DEC '03

PROJECTS • PIC Nim Machine • Practical Radio Circuits–7 (Superhet Tuner) • PIC Virus Zapper Mk2 • Christmas Cheeks.
FEATURES • Teach-In 2004 – Part 2 • Electrotherapy • Circuit Surgery • Ingenuity Unlimited • Techno Talk • High-Speed Decimal To Binary For PICs • Interface • Network – The Internet.

JAN '04

PROJECTS • Car Computer • Practical Radio Circuits–8 (Dual-Conversion SW Receiver) • Bedside Nightlight • PIC Watering Timer.
FEATURES • GPS to PIC and PC Interface • Practically Speaking • Teach-In 2004 – Part 3 • Ingenuity Unlimited • Techno Talk • Circuit Surgery • New Technology Update • Net Work – The Internet Page.

FEB '04

PROJECTS • PIC LCF Meter • Sonic Ice Warning • Jazzy Necklace • PIC Tug-of-War.
FEATURES • Surface Mount Devices • Circuit Surgery • Teach-In 2004 – Part 4 • Interface • Ingenuity Unlimited • Techno Talk • Net Work – The Internet Page.

MAR '04

PROJECTS • Bat-Band Convertor • Emergency Stand-by Light • MIDI Health Check • PIC Mixer for RC Planes.
FEATURES • Teach-In 2004 – Part 5 • New Scientist CD-Rom Review • Circuit Surgery • Techno Talk • Ingenuity Unlimited • Practically Speaking • Net Work – The Internet Page.

APRIL '04

PROJECTS • EPE Experimental Seismograph Logger 1 • Infra-Guard Monitor • Loft Light Alarm • PIC Moon Clock.
FEATURES • USB To PIC Interface • Ingenuity Unlimited • Teach-In 2004 Part 6 • Interface • Techno Talk • Circuit Surgery • New Technology Update • Net Work – The Internet Page • Pull-Out – Semiconductor Classification Data.

MAY '04

PROJECTS • Beat Balance Metal Detector • In-Car Laptop PSU • Low-Frequency Wien Oscillator • EPE Experimental Seismograph Logger–2.
FEATURES • Coping With Lead-Free Solder • Teach-In 2004 – Part 7 • Ingenuity Unlimited • Techno Talk • Circuit Surgery • Practically Speaking • Pic-N'-Mix • Net Work – The Internet Page.

JUNE '04

PROJECTS • PIC Quickstep • Crafty Cooling • MIDI Synchronome • Body Detector Mk2.
FEATURES • Clinical Electrotherapy • Ingenuity Unlimited • Teach-In 2004 – Part 8 • Interface • Circuit Surgery • Techno Talk • PIC-N'-Mix • Net Work – The Internet Page.

JULY '04

PROJECTS • Portable Mini Alarm • Bongo Box • Hard Drive Warbler • EPE PIC Magnetometry Logger–1.
FEATURES • Making Front Panel Overlays • Practically Speaking • Teach-In 2004 – Part 9 • Ingenuity Unlimited • Circuit Surgery • Techno Talk • PIC-N'-Mix • Net Work – The Internet Page.

AUG '04

PROJECTS • EPE Scorer • Keyring L.E.D. Torch • Simple F.M. Radio • EPE PIC Magnetometry Logger – 2.
FEATURES • PIC To PS/2 Mouse and Keyboard Interfacing • Techno Talk • Circuit Surgery • Teach-In 2004 – Part 10 • Interface • Ingenuity Unlimited • PIC-N'-Mix • Net Work – The Internet Page.

SEPT '04

PROJECTS • EPE Wart Zapper • Radio Control Failsafe • Rainbow Lighting Control • Alphamouse Game.
FEATURES • Light Emitting Diodes – Part 1 • High Speed Binary-To-Decimal For PICs • Practically Speaking • Ingenuity Unlimited • Techno-Talk • Circuit Surgery • PIC-N'-Mix • Network – The Internet Page

OCT '04

PROJECTS • EPE Theremin • Smart Karts – Part 1 • Volts Checker • Moon and Tide Clock Calendar.
FEATURES • Light Emitting Diodes – 2 • Circuit Surgery • Interface • Ingenuity Unlimited • Techno Talk • PIC-N'-Mix • Network – The Internet Page • ROBOTS – Special Supplement

NOV '04

PROJECTS • Thunderstorm Monitor • M.W. Amplitude Modulator • Logic Probe • Smart Karts - 2.
FEATURES • Light Emitting Diodes-3 • Floating Point Maths for PICs • Ingenuity Unlimited • PE 40th Anniversary • Circuit Surgery • Techno Talk • PIC-N'-Mix • Net Work – The Internet Page.

DEC '04

PROJECTS • Super Vibration Switch • Versatile PIC Flasher • Wind Direction Indicator • Smart Karts - 3.
FEATURES • Light Emitting Diodes-4 • Ingenuity Unlimited • Circuit Surgery • Interface • PIC 'N' Mix • Techno Talk • Net Work – The Internet Page • INDEX Vol. 33.

JAN '05

PROJECTS • Speed Camera Watch • Gate Alarm • Light Detector • Smart Karts - 4.
FEATURES • Practially Speaking • 32-Bit Signed Integer Maths for PICs • Ingenuity Unlimited • Circuit Surgery • Techo Talk • PIC 'N' Mix • Picoscope 3205 Review • Net Work – The Internet Page

FEB '05

PROJECTS • PIC Electric MK2 Pt1 • Sneaky • Sound Card Mixer • Smart Karts - 5.
FEATURES • Interface • Circuit Surgery • Ingenuity Unlimited • Techno Talk • PIC 'N' Mix • E-Blocks and Flowcode V2.0 Reviews • Net Work – The Internet Page

MAR '05

PROJECTS • Cat Flap • Stereo Headphone Monitor • PIC Electric Mk2 Pt2 • Smart Karts - 6 • Bingo Box.
FEATURES • TK3 Simulator and PIC18F Upgrade • Circuit Surgery • Ingenuity Unlimited • Techno Talk • PIC 'N' Mix • Practically Speaking • Net Work – The Internet Page

BACK ISSUES ONLY £3.50 each inc. UK p&p.
Overseas prices £4 each surface mail, £5.50 each airmail.

We can also supply issues from earlier years: 1999 (**except** Feb., May, Aug., Sept., Dec.), 2000 (**except** Feb., Mar., July, Oct.), 2001 (**except** May, Aug. to Nov.), 2002 (**except** Feb., June, Aug. to Nov.), 2003 (except June) Where we do not have an issue a photocopy of any ***one article*** or ***one part*** of a series can be provided at the same price.

ORDER FORM – BACK ISSUES – PHOTOCOPIES– INDEXES

☐ Send back issues dated ....

☐ Send photocopies of (article title and issue date) ....

☐ Send copies of last five years indexes (£3.50 for five inc. p&p – Overseas £4 surface, £5.50 airmail)

Name ....

Address ....

.... Tel: ....

☐ I enclose cheque/P.O./bank draft to the value of £ ....

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch £ .... Switch Issue No. ....

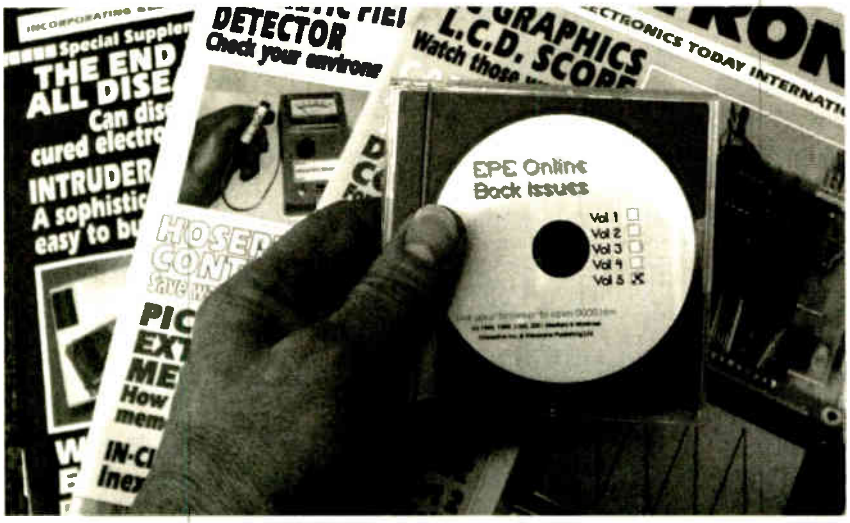
Card No. ....

Valid From .... Card Expiry Date .... Card Security Code ....
(The last 3 digits on or just under the signature strip)

SEND TO: **Everyday Practical Electronics, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND.**
Tel: 01202 873872. Fax: 01202 874562.
E-mail: orders@epemag.wimborne.co.uk **On-line Shop:** www.epemag.wimborne.co.uk/shopdoor.htm
Payments must be in £ sterling – cheque or bank draft drawn on a UK bank. Normally supplied within seven days of receipt of order.
Send a copy of this form, or order by letter if you do not wish to cut your issue.

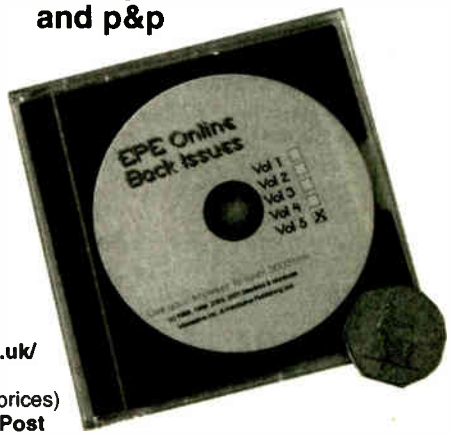
M03/05

STORE YOUR BACK ISSUES ON MINI CD-ROMS



VOL 11 NOW AVAILABLE

ONLY
£14.45 each
including VAT
and p&p



A great way to buy *EPE* Back Issues – our mini CD-ROMs contain back issues from our *EPE Online* website plus bonus articles, all the relevant PIC software and web links. Note: no free gifts are included. All this for just £14.45 each including postage and packing.

VOL 1: BACK ISSUES – January 1999 to June 1999
Plus some bonus material from Nov and Dec 1998

VOL 2: BACK ISSUES – July 1999 to December 1999

VOL 3: BACK ISSUES – January 2000 to June 2000

VOL 4: BACK ISSUES – July 2000 to December 2000

VOL 5: BACK ISSUES – January 2001 to June 2001

VOL 6: BACK ISSUES – July 2001 to December 2001

VOL 7: BACK ISSUES – January 2002 to June 2002

VOL 8: BACK ISSUES – July 2002 to December 2002

VOL 9: BACK ISSUES – January 2003 to June 2003

VOL 10: BACK ISSUES – July 2003 to December 2003

VOL 11: BACK ISSUES – January 2004 to June 2004

NOTE: These mini CD-ROMs are suitable for use on any PC with a CD-ROM drive. They require Adobe Acrobat Reader (available free from the Internet – **www.adobe.com/acrobat**)

WHAT IS INCLUDED

All volumes include the *EPE Online* editorial content of every listed issue, plus all the available **PIC Project Codes** for the PIC projects published in those issues.

Note: Some supplements etc. can be downloaded free from the Library on the *EPE Online* website at **www.epemag.com**.
No advertisements are included in Volumes 1 and 2; from Volume 5 onwards the available relevant software for *Interface* articles is also included.

EXTRA ARTICLES – ON ALL VOLUMES

BASIC SOLDERING GUIDE – Alan Winstanley's internationally acclaimed fully illustrated guide. **UNDERSTANDING PASSIVE COMPONENTS** – Introduction to the basic principles of passive components. **HOW TO USE INTELLIGENT L.C.Ds**, by Julyan Ilett – An utterly practical guide to interfacing and programming intelligent liquid crystal display modules. **PhyzzyB COMPUTERS BONUS ARTICLE 1** – Signed and Unsigned Binary Numbers. By Clive "Max" Maxfield and Alvin Brown. **PhyzzyB COMPUTERS BONUS ARTICLE 2** – Creating an Event Counter. By Clive "Max" Maxfield and Alvin Brown. **INTERGRAPH COMPUTER SYSTEMS 3D GRAPHICS** – A chapter from Intergraph's book that explains computer graphics technology. **FROM RUSSIA WITH LOVE**, by Barry Fox – Russian rockets launching American Satellites. **PC ENGINES**, by Ernest Flint – The evolution of Intel's microprocessors. **THE END TO ALL DISEASE**, by Aubrey Scoon – The original work of Rife. **COLLECTING AND RESTORING VINTAGE RADIOS**, by Paul Stenning. **THE LIFE & WORKS OF KONRAD ZUSE** – a brilliant pioneer in the evolution of computers. A bonus article on his life and work written by his eldest son, including many previously unpublished photographs.

Note: Some of the **EXTRA ARTICLES** require WinZip to unzip them.

Order on-line from
www.epemag.wimborne.co.uk/shopdoor.htm
or **www.epemag.com** (USA $ prices)
or by phone, Fax, E-mail or Post

BACK ISSUES MINI CD-ROM ORDER FORM

Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 1**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 2**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 3**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 4**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 5**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 6**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 7**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 8**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 9**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 10**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 11**
Price £14.45 each – includes postage to anywhere in the world.

Name ....

Address ....

.... Post Code ....

☐ I enclose cheque/P.O./bank draft to the value of £ ....

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Maestro

£ ....

Card No. ....

Card Security Code .... (The last 3 digits on or just under the signature strip)

Valid From .... Expiry Date ....

Maestro Issue No. ....

SEND TO: **Everyday Practical Electronics, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND.**
Tel: 01202 873872. Fax: 01202 874562.
E-mail: orders@epemag.wimborne.co.uk
Payments must be by card or in £ Sterling – cheque or bank draft drawn on a UK bank.
Normally supplied within seven days of receipt of order.

FREE *Electronics Hobbyist Compendium* book with Teach-In 2000 CD-ROM

EPE TEACH-IN 2000 CD-ROM

The whole of the 12-part *Teach-In 2000* series by John Becker (published in *EPE* Nov '99 to Oct 2000) is now available on CD-ROM. Plus the *Teach-In 2000* interactive software (Win 95, 98, ME and above) covering all aspects of the series and Alan Winstanley's *Basic Soldering Guide* (including illustrations and Desoldering).

Teach-In 2000 covers all the basic principles of electronics from Ohm's Law to Displays, including Op.Amps, Logic Gates etc. Each part has its own section on the interactive software where you can also change component values in the various on-screen demonstration circuits.

The series gives a hands-on approach to electronics with numerous breadboard circuits to try out, plus a simple computer interface (Win 95, 98, ME only) which allows a PC to be used as a basic oscilloscope

ONLY **£12.45** including VAT and p&p

Order code Teach-In CD-ROM

DIRECT BOOK SERVICE

NOTE: ALL PRICES INCLUDE UK POSTAGE

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order to your door. Full ordering details are given on the last book page.

For a further selection of books see the next two issues of *EPE*.

Robotics

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. Then explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Details building and programming instructions provided, including numerous step-by-step photographs.

288 pages – large format Order code BP901 £14.99

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision Command System

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using Lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

298 pages Order code BP902 £14.99

ANDROIDS, ROBOTS AND ANIMATRONS – Second Edition – John Iovine

Build your own working robot or android using both off-the-shelf and workshop constructed materials and devices. Computer control gives these robots and androids two types of artificial intelligence (an expert system and a neural network). A lifelike android hand can be built and programmed to function doing repetitive tasks. A fully animated robot or android can also be built and programmed to perform a wide variety of functions.

The contents include an Overview of State-of-the-Art Robots; Robotic Locomotion; Motors and Power Controllers; All Types of Sensors; Tilt; Bump; Road and Wall Detection; Light; Speech and Sound Recognition; Robotic Intelligence (Expert Type) Using a Single-Board Computer Programmed in BASIC; Robotic Intelligence (Neutral Type) Using Simple Neural Networks (Insect Intelligence); Making a Lifelike Android Hand; A Computer-Controlled Robotic Insect Programmed in BASIC; Telepresence Robots With Actual Arcade and Virtual Reality Applications; A Computer-Controlled Robotic Arm; Animated Robots and Androids; Real-World Robotic Applications.

224 pages Order code MGH1 £16.99

Radio

BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages Order code NE30 £18.99

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.

92 pages Order code BP304 £4.45

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages Order code BP257 £5.49

Computers and Computing

THE INTERNET FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s. Uses only clear and easy-to-understand language. Larger type size for easy reading. Provides basic knowledge to give you confidence to join the local computer class.

This book explains how to use your PC on the Internet and covers amongst other things: Choosing and setting up your computer for the Internet. Getting connected to the Internet. Sending and receiving emails, photographs, etc., so that you can keep in touch with family and friends all over the world. Searching for and saving information on any subject. On-line shopping and home banking. Setting up your own simple web site.

228 pages Order code BP600 £8.99

HOW TO BUILD YOUR OWN PC – Third Edition
Morris Rosenthal

More and more people are building their own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a state-of-the-art computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. For non-specialists, there's even a graphical glossary that clearly illustrates technical terms. The author goes "under the hood" and shows step-by-step how to create a socket 7 (Pentium and non-intel chipsets) and a Slot 1 (Pentium II) computer, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows 98. The few existing books on this subject, although badly outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

224 pages – large format Order code MGH2 £20.99

PIC YOUR PERSONAL INTRODUCTORY COURSE SECOND EDITION John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PIC's capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised second edition covers the popular reprogrammable EEPROM PICs: P16C84/16F84 as well as the P54 and P71 families.

270 pages Order code NE36 £15.99

eBAY FOR BEGINNERS NEW
Cherry Nixon

There are two kinds of people, those who are trading on eBay and the rest who are missing out. Though eBay has been embraced by entrepreneurs all over the world, it remains the peoples' site and offers the largest market for the smallest fee.

eBay presents an opportunity for everyone, the trick is to master it. This book shows you how to start trading on eBay UK. It also offers advice on getting organised and tips to put you ahead.

The book has been developed from Cherry's popular hands-on course "Buying and Selling on eBay for Technological Simpletons". In addition to fully explaining eBay and how to trade on it there are sections on Paypal, producing pictures of your sale items, fees and accounts, safety and security including what to do when things go wrong and what protection is provided.

178 pages Order code BP551 £8.99

UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold (Revised Edition)

PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.

This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!

128 pages Order code BP282 £5.45

Theory and Reference

BEBOP TO THE BOOLEAN BOOGIE
Second Edition
Clive (Max) Maxfield

BOOK PLUS CD-ROM

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. Comes with a free CD-ROM which contains an eBook version with full text search plus bonus chapter – An Illustrated History of Electronics and Computing.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

500 pages **Order code BEB1** **£27.50**

BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

CD-ROM

This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!

Over 800 pages in Adobe Acrobat format

CD-ROM **Order code BEB2 CD-ROM** **£21.95**

ELECTRONICS MADE SIMPLE
Ian Sinclair

Assuming no prior knowledge, *Electronics Made Simple* presents an outline of modern electronics with an emphasis on understanding how systems work rather than on details of circuit diagrams and calculations. It is ideal for students on a range of courses in electronics, including GCSE, C&G and GNVQ, and for students of other subjects who will be using electronic instruments and methods.

Contents: waves and pulses, passive components, active components and ICs, linear circuits, block and circuit diagrams, how radio works, disc and tape recording, elements of TV and radar, digital signals, gating and logic circuits, counting and correcting, microprocessors, calculators and computers, miscellaneous systems.

199 pages **Order code NE23** **£13.99**

SCROGGIE'S FOUNDATIONS OF WIRELESS AND ELECTRONICS – ELEVENTH EDITION
S. W. Amos and Roger Amos

Scroggie's Foundations is a classic text for anyone working with electronics, who needs to know the art and craft of the subject. It covers both the theory and practical aspects of a huge range of topics from valve and tube technology, and the application of cathode ray tubes to radar, to digital tape systems and optical recording techniques.

Since *Foundations of Wireless* was first published over 60 years ago, it has helped many thousands of readers to become familiar with the principles of radio and electronics. The original author Sowerby was succeeded by Scroggie in the 1940s, whose name became synonymous with this classic primer for practitioners and students alike. Stan Amos, one of the fathers of modern electronics and the author of many well-known books in the area, took over the revision of this book in the 1980s and it is he, with his son, who have produced this latest version.

400 pages **Temporarily out of print**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**

THE AMATEUR SCIENTIST CD-ROM

CD-ROM

The complete collection of The Amateur Scientist articles from *Scientific American* magazine. Over 1,000 classic science projects from a renowned source of winning projects. All projects are rated for cost, difficulty and possible hazards.

Plus over 1,000 pages of helpful science techniques that never appeared in *Scientific American*.

Exciting science projects in: Astronomy; Earth Science; Biology; Physics; Chemistry; Weather . . . and much more! The most complete resource ever assembled for hobbyists, and professionals looking for novel solutions to research problems.

Includes extensive Science Software Library with even more science tools.

Suitable for Mac, Windows, Linux or UNIX. 32MB RAM minimum, Netscape 4.0 or higher or Internet Explorer 4.0 or higher.

Over 1,000 projects

CD-ROM **Order code AS1 CD-ROM** **£19.95**

Music, Audio and Video

QUICK GUIDE TO ANALOGUE SYNTHESIS
Ian Waugh

Even though music production has moved into the digital domain, modern synthesisers invariably use analogue synthesis techniques. The reason is simple – analogue synthesis is flexible and versatile, and it's relatively easy for us to understand. The basics are the same for all analogue synths, and you'll quickly be able to adapt the principles to any instrument, to edit existing sounds and create exciting new ones. This book describes: How analogue synthesis works; The essential modules every synthesiser has; The three steps to synthesis; How to create phat bass sounds; How to generate filter sweeps; Advanced synth modules; How to create simple and complex synth patches; Where to find soft synths on the Web.

If you want to take your synthesiser – of the hardware or software variety – past the presets, and program your own sounds and effects, this practical and well-illustrated book tells you what you need to know.

60 pages **Order code PC118** **£7.45**

QUICK GUIDE TO MP3 AND DIGITAL MUSIC
Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

How to play MP3s on your computer; How to use MP3s with handheld MP3 players; Where to find MP3s on the Web; How MP3s work; How to tune into Internet radio stations; How to create your own MP3s; How to record your own CDs from MP3 files; Other digital audio music formats.

Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

60 pages **Order code PC119** **£7.45**

ELECTRONIC MUSIC AND MIDI PROJECTS
R. A. Penfold

Whether you wish to save money, boldly go where no musician has gone before, rekindle the pioneering spirit, or simply have fun building some electronic music gadgets, the designs featured in this book should suit your needs. The projects are all easy to build, and some are so simple that even complete beginners at electronic project construction can tackle them with ease. Stripboard layouts are provided for every project, together with a wiring diagram. The mechanical side of construction has largely been left to individual constructors to sort out, simply because the vast majority of project builders prefer to do their own thing in this respect.

None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.

124 pages **Order code PC116** ~~£10.95~~ **£5.45**

THE INVENTOR OF STEREO – THE LIFE AND WORKS OF ALAN DOWER BLUMLEIN
Robert Charles Alexander

This book is the definitive study of the life and works of one of Britain's most important inventors who, due to a cruel set of circumstances, has all but been overlooked by history.

Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first elecronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

420 pages **Order code NE32** **£17.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** ~~£10.95~~ **£5.45**

PC MUSIC – THE EASY GUIDE
Robin Vincent

How do I make music on my PC? Can I record music onto my PC? What's a sequencer? How can I get my PC to print a music score? What sort of a soundcard do I need? What hardware and software do I need? How do I connect a keyboard to my PC?:

Just a few of the questions you've probably asked. Well, you'll find the answers to all these questions, and many more, in this book. It will show you what can be done, what it all means, and what you will need to start creating your own music on your PC. It's an easy read, it's fully illustrated and it will help you understand how a computer can be used as a creative music tool.

It covers soundcards, sequencers, hard disk digital audio recording and editing, plug-ins, printing scores with notation software, using your PC as a synthesiser, getting music onto and off the Internet, using Windows, sample PC music setups, FAQs, a glossary, advice on hardware and software, and a list of industry contacts.

116 pages **Order code PC117** **£11.95**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold

Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages **Temporarily out of print**

Circuits, Data and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop

This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

88 pages — **Order code BP299** — £5.49

DIGITAL ELECTRONICS – A PRACTICAL APPROACH
With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality)
FREE SOFTWARE
Richard Monk

Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer aided design including the FREE software.

There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

250 pages (large format) — **Order code NE28** — £21.99

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages — **Order code BP332** — £5.45

DOMESTIC SECURITY SYSTEMS
A. L. Brown

This book shows you how, with common sense and basic do-it-yourself skills, you can protect your home. It also gives tips and ideas which will help you to maintain and improve your home security, even if you already have an alarm. Every circuit in this book is clearly described and illustrated, and contains components that are easy to source. Advice and guidance are based on the real experience of the author who is an alarm installer, and the designs themselves have been rigorously put to use on some of the most crime-ridden streets in the world.

The designs include all elements, including sensors, detectors, alarms, controls, lights, video and door entry systems. Chapters cover installation, testing, maintenance and upgrading.

192 pages — **Order code NE25** — £20.99

MICROCONTROLLER COOKBOOK
Mike James

The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages — **Order code NE26** — £23.99

For a further selection of books see the next two issues of *EPE*

Project Building & Testing

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages — **Order code BP371** — £5.45

FAULT-FINDING ELECTRONIC PROJECTS
R. A. Penfold

Starting with mechanical faults such as dry joints, short-circuits etc, coverage includes linear circuits, using a meter to make voltage checks, signal tracing techniques and fault finding on logic circuits. The final chapter covers ways of testing a wide range of electronic components, such as resistors, capacitors, operational amplifiers, diodes, transistors, SCRs and triacs, with the aid of only a limited amount of test equipment.

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

136 pages — **Temporarily out of print**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages — **Order code BP374** — £5.45

RADIO BYGONES

We also carry a selection of books aimed at readers of *EPE*'s sister magazine on vintage radio *Radio Bygones*. These books include the *Comprehensive Radio Valve Guides* (five books with a Free copy of the Master Index) for just £15. Also Jonathan Hill's excellent *Radio Radio*, a comprehensive book with hundreds of photos depicting the development of the British wireless set up to the late 1960s.

The three volumes of our own *Wireless For the Warrior* by Louis Meulstee are also available. These are a technical history of radio communication equipment in the British Army from pre-war through to the 1960s.

For details see the shop on our UK web site at **www.epemag.wimborne.co.uk** or contact us for a list of *Radio Bygones* books.

BOOK ORDERING DETAILS

All prices include UK postage. For postage to Europe (air) and the rest of the world (surface) please add £2 per book. For the rest of the world airmail add £3 per book. CD-ROM prices include VAT and/or postage to anywhere in the world. Send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or card details, Visa, Mastercard, Amex, Diners Club or Maestro to:

DIRECT BOOK SERVICE, WIMBORNE PUBLISHING LTD.,
408 WIMBORNE ROAD EAST, FERNDOWN, DORSET BH22 9ND.

Orders are normally sent out within seven days of receipt, but please allow 28 days for delivery – more for overseas orders. *Please check price and availability (see latest issue of* Everyday Practical Electronics*) before ordering from old lists.*

For a further selection of books and CD-ROMs see the next two issues of *EPE*.

Tel 01202 873872 Fax 01202 874562. Email: dbs@epemag.wimborne.co.uk

Order from our online shop at: www.epemag.wimborne.co.uk/shopdoor.htm

BOOK/CD-ROM ORDER FORM

Full name: ....

Address: ....

....

....

.... Post code: .... Telephone No: ....

Signature: ....

☐ I enclose cheque/PO payable to DIRECT BOOK SERVICE for £ ....

☐ Please charge my card £ .... Card expiry date....................

Card Number .... Maestro Issue No....................

Card Security Code .... (The last 3 digits on or just below the signature strip)

Please send book/CD-ROM order codes: ....

....

Please continue on separate sheet of paper if necessary
If you do not wish to cut your magazine, send a letter or copy of this form

PCB SERVICE

Printed circuit boards for most recent *EPE* constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for *airmail* outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872; Fax 01202 874562; Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag. wimborne.co.uk/shopdoor.htm.** Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

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

Please check price and availability in the latest issue.

A large number of older boards are listed on our website.

Boards can only be supplied on a payment with order basis.

PROJECT TITLE		Order Code	Cost
Spooky Bug (Top Tenner)	OCT '03	409	£5.07
Radio Circuits–5 Crystal Marker		415	£4.44
Super Regen. Receiver		419	£5.07
Buffer Amplifier		420	£4.44
★★Serial Interface for PICs and VB6		416	£5.23
★PIC Breakpoint – **Software only**		–	–
Anyone At Home – Logic Board	NOV '03	421	Pair £6.35
– Relay Board		422	
Radio Circuits–6 Direct Conversion SW Receiver		423	£6.02
★PIC Random L.E.D. Flasher		424	£4.60
★PIC Virus Zapper Mk2	DEC '03	425	£5.72
Radio Circuits–7 SW Superhet Tuner/Mixer		426	£5.70
Christmas Cheeks (double-sided)		427	£4.44
★PIC Nim Machine – **Software only**		–	–
Bedside Nightlight (Top Tenner)	JAN '04		
Sound Trigger		417	£4.44
Timing/Lamp		418	£4.60
Radio Circuits–6 Dual Conversion SW Rec. – I.F. Amp		428	£5.71
– Signal-Strength Meter		429	£4.45
– B.F.O./Prod. Detector		430	£4.75
★Car Computer (double-sided)		431	£7.61
★PIC Watering Timer – **Software only**		–	–
★GPS to PIC and PC Interface – **Software only**		–	–
Jazzy Necklace	FEB '04	432 pair	£5.40
Sonic Ice Warning		433	£5.39
★LCF Meter		434	£5.00
★PIC Tug-of-War		435	£5.00
Bat-Band Convertor	MAR '04	436	£4.76
★MIDI Health Check – Transmitter/Receiver		437 pair	£7.61
Emergency Stand-by Light		438	£5.55
★PIC Mixer for RC Planes – **Software only**		–	–
★Teach-In '04 Part 5 – **Software only**		–	–
Infra-Guard	APR '04	439	£5.07
★Moon Clock		442	£5.71
★Teach-In '04 Part 6 – **Software only**		–	–
★EPE Seismograph Logger			
Control Board		440	pair £6.50
Sensor Amp. Board		441	
In-Car Lap-Top PSU	MAY '04	443	£4.60
Beat Balance Metal Detector		444	£4.60
Teach-In '04 Part 7 – Transmitter		445	£4.91
Receiver		446	£4.75
Moisture		447	£4.44
★PIC Quickstep	JUNE '04	448	£5.71
Body Detector MkII		449	£4.91
★Teach-In '04 Part 8 – **Software only**		–	–
★MIDI Synchronome – **Software only**		–	–
Hard Drive Warbler	JULY '04	450	£4.60
★Bongo Box		451	£6.02
Portable Mini Alarm – Sensor		452	£5.23
– Counter		453	£5.07
★Teach-In '04 Part 9			
PIC Combination Lock Alarm Monitor		454	£5.07
★EPE Magnetometry Logger		455	£5.71
Keyring L.E.D. Torch	AUG '04	456	£4.12
★Teach-In '04 Part 10 – PIC Curtain or Blind Winder		457	£5.39
Simple F.M. Radio – F.M. Tuner		458	£5.07
– Tone Control		459	£4.75
– Audio Power Amp (TDA2003)		347	£4.60
– Power Supply		460	£5.39
★EPE Scorer – Control Board		461	£6.66
– Display Board		462	£7.93
– Slave Board		463	£5.55
★PIC to Mouse/Keyboard – **Software only**		–	–
EPE Wart Zapper	SEPT '04	464	£4.60
★Radio Control Failsafe		465	£4.76
★AlphaMouse Game		466	£4.60
★Rainbow Lighting Controller – **Software only**		–	–
★Moon and Tide Clock Calendar	OCT '04	467	£5.55
Volts Checker		468	£4.20
★Smart Karts – **Software only**		–	

PROJECT TITLE		Order Code	Cost
Logic Probe	NOV '04	469	£4.76
Thunderstorm Monitor		470	£5.39
MW Amplitude Modulator			
– V.F.O./Buffer		471	£4.76
– Modulator/PA		472	£5.07
– Power Supply		473	£4.76
Super Vibration Switch	DEC '04	474	£4.75
Wind Direction Indicator		475	£6.18
★PIC Flasher Mk2			
– Control Board		476	£4.75
– Transmitter		477	£4.44
– Multipurpose Board		478	£4.75
– Simple Cycler		479	£4.44
– Luxeon V Controller		480	£4.44
– Power Supply		473	£4.76
Light Detector	JAN '05	481	£4.44
★Camera Watch		482	£6.03
Gate Alarm – Oscillator		483	£4.92
– Delay/Timer		484	£4.92
★Sneaky – Transmitter	FEB '05	485	£4.60
– Receiver		486	£4.91
★PIC Electric Mk2 – Control		487	£5.87
– Sensor		488	£5.71
Sound Card Mixer		489	£7.29
Headphone Monitor	MAR '05	490	£5.71
EPE Cat Flap		491	£6.02
★Bingo Box – Main		492	£9.04
– Big Digit Display		493	£10.31
Spontaflex Radio – Tuner	APR '05	494	£5.55
– Coil Pack		495	£5.71
– Audio Amplifier		496	£5.55
– Tuning Capacitor Board		406	£4.28
★Safety Interface		497	£6.18
Back-To-Basics 1 – Fridge/Freezer Door Alarm		498	£5.39

EPE SOFTWARE

Software programs for *EPE* projects marked with a single asterisk ★ are available on 3·5 inch PC-compatible disks or *free* from our Internet site. The following disks are available: **PIC Tutorial V2** (Apr-June '03); ***EPE* Disk 3** (2000); ***EPE* Disk 4** (2001 – excl. PIC Toolkit TK3); ***EPE* Disk 5** (2002); ***EPE* Disk 6** (2003 – excl. Earth Resistivity and Met Office); ***EPE* Disk 7 (2004)**; **EPE Disk 8** (Jan 2005 to current cover date); ***EPE* Earth Resistivity Logger** (Apr-May '03); ***EPE* PIC Met Office** (Aug-Sept '03); ***EPE* Seismograph** (Apr-May '04); ***EPE* Magnetometry Logger** (July-Aug '04); ***EPE* Teach-In 2000**; ***EPE* Spectrum**; ***EPE* Interface Disk 1** (October '00 issue to current cover date). **EPE Toolkit TK3** software is available on the *EPE* PIC Resources CD-ROM, £14.45. Its p.c.b. is order code 319, £8.24. ★★The software for these projects is on its own CD-ROM. The 3·5 inch disks are £3.00 each (UK), the CD-ROMs are £6.95 (UK). Add 50p each for overseas surface mail, and £1 each for airmail. All are available from the *EPE PCB Service*. All files can be downloaded *free* from our Internet FTP site, accessible via our home page at: **www.epemag.co.uk**.

EPE PRINTED CIRCUIT BOARD SERVICE

Order Code   Project   Quantity   Price

....

Name ....

Address ....

....

Tel. No. ....

I enclose payment of £................ (cheque/PO in **£ sterling only**) to:

Everyday Practical Electronics

MasterCard, Amex, Diners Club, Visa or Switch/Maestro

Card No. ....

Valid From .... Expiry Date ....

Card Security Code .... Switch/Maestro Issue No ....
(The last 3 digits on or just under the signature strip)

Signature ....

NOTE: You can also order p.c.b.s by phone, Fax, Email or via our Internet site on a secure server:

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

EVERYDAY PRACTICAL ELECTRONICS CLASSIFIED

Everyday Practical Electronics reaches twice as many UK readers as any other UK monthly hobby electronics magazine, our sales figures prove it. We have been the leading monthly magazine in this market for the last twenty years.

If you want your advertisements to be seen by the largest readership at the most economical price our classified and semi-display pages offer the best value. The prepaid rate for semi-display space is £10 (+VAT) per single column centimetre (minimum 2·5cm). The prepaid rate for classified adverts is 40p (+VAT) per word (minimum 12 words).

All cheques, postal orders, etc., to be made payable to Everyday Practical Electronics. **VAT must be added.** Advertisements, together with remittance, should be sent to Everyday Practical Electronics Advertisements, Mill Lodge, Mill Lane, Thorpe-le-Soken, Essex CO16 0ED. Phone/Fax (01255) 861161.

For rates and information on display and classified advertising please contact our Advertisement Manager, Peter Mew as above.

BOWOOD ELECTRONICS LTD
Suppliers of Electronic Components
Place a secure order on our website or call our sales line
All major credit cards accepted
Web: www.bowood-electronics.co.uk
Unit 1, McGregor's Way, Turnoaks Business Park, Chesterfield, S40 2WB. Sales: 01246 200222
Send 60p stamp for catalogue

The Versatile, Programmable On Screen Display System
www.STV5730A.co.uk

- Fully programmable
- PIC 16F628 microcontroller
- Demo software code available
- OSD IC 28 by 11 screen
- I/O lines free to connect sensors or buttons
- Serial or PC keyboard interface versions

X-10® Home Automation
We put *you* in control™

Why tolerate when you can automate?
An extensive range of 230V X-10 products and starter kits available. Uses proven Power Line Carrier technology, no wires required.
Products Catalogue available Online.
Worldwide delivery.
Laser Business Systems Ltd.
E-Mail: info@laser.com
http://www.laser.com
Tel: (020) 8441 9788
Fax: (020) 8449 0430

VVT TRANSFORMERS
Transformers and Chokes for all types of circuits including specialist valve units
Custom design or standard range
High and low voltage
Variable Voltage Technology Ltd
Unit 3, Sheat Manor Farm, Chillerton, Newport, Isle of Wight, PO30 3HP
Tel: 0870 243 0414 Fax: 01983 721572
email: sales@vvt-cowes.freeserve.co.uk
www.vvttransformers.co.uk

TOTALROBOTS
ROBOTICS, CONTROL & ELECTRONICS TECHNOLOGY
High quality robot kits and components
UK distributor of the OOPic microcontroller
Secure on-line ordering
Rapid delivery
Highly competitive prices
Visit **www.totalrobots.com**
Tel: 0208 823 9220

Component Kits!

Mail order P&P: £2.50 (Free P&P orders over £20)
www.fastcomponents.co.uk
Tel: 0870 750 4468 Fax: 0870 137 6005
Winchester House, Winchester Rd, Walton-on-Thames, Surrey. KT12 2RH

TRANSFORMERS
- Custom Wound
- 1 Phase to 50kVA
- 3 Phase to 100kVA
- A.C. and D.C. Chokes
- H.T. up to 5kV
- Transformer Kits
- Coils up to 1m Dia.
- Transformer Rectifiers
- Toroidals
- Motor Generators

Visit www.jemelec.com for details or request our free leaflet
Jemelec, Unit 16, Vanguard Trading Estate, Storforth Lane, Chesterfield, S40 2TZ
Tel: 0870 787 1769

BTEC ELECTRONICS TECHNICIAN TRAINING
VCE ADVANCED ENGINEERING
ELECTRONICS AND ICT
HNC AND HND ELECTRONICS
NVQ ENGINEERING AND IT
PLEASE APPLY TO COLLEGE FOR NEXT COURSE DATE
FULL PROSPECTUS FROM
LONDON ELECTRONICS COLLEGE (Dept EPE) 20 PENYWERN ROAD EARLS COURT, LONDON SW5 9SU
TEL: (020) 7373 8721

READY TO PAY FOR DESIGNING...
/technical know how, prototype of continuous monitoring / portable gas detector system with digital display (ppm reading) alarm system using Figaro (Japan) gas sensor (semiconductor type) or Citicel-UK (electrochemical type). Basic circuitry may be supplied by us. You will have to issue an attorney licence. Expert electronic engineers may contact on:
Telephone No - 91-22-26361469
EMAIL abhitron@bom5.vsni.net.in

Miscellaneous

MICRO CHIP DEVICES for home and business. Projects and Products on Microchip and 1-wire technologies. Visit our WEB site at: **www.microchipdevices.com**

MODULE ASSORTMENT £15.00! Jumbo displays + regulated power supplies, stereo amplifiers + controls – K.I A. 1 Regent Road, ILKLEY LS29

NARROW BANDWIDTH TELEVISION ASSOCIATION, now thirty years old! Fascinating hobby! Ring 0115-9282896 for leaflet.

VALVES AND ALLIED COMPONENTS IN STOCK. Phone for free list. Valves, books and magazines wanted. Geoff Davies (Radio), tel. 01788 574774.

KITS, TOOLS, COMPONENTS. S.a.e. catalogue: Sir-Kit Electronics, 52 Severn Road, Clacton, CO15 3RB. **www. geocities.com/sirkituk**.

EPE MAGAZINES for sale 1994 10 2004 Phone 01992 448535 after 8:00 p.m.

Computer Software

FREE DOWNLOADABLE SOFTWARE: Electronics, Electrical and Computing V8.2. Computer Science V8.2 and GCSE Maths V8.2. Still selling at £120 each on CDROM is now available to download and fully install to your hard drive COMPLETELY FREE OF CHARGE. Latest update includes the new Web Links feature. Visit **www.eptsoft.com** for details.

TO ADVERTISE IN EPE
contact
Peter Mew
01255 861161

ADVERTISERS INDEX

ADVERTISEMENT MANAGER: PETER J. MEW
ADVERTISEMENT OFFICES:
EVERYDAY PRACTICAL ELECTRONICS, ADVERTISEMENTS, MILL LODGE, MILL LANE, THORPE-LE-SOKEN, ESSEX CO16 0ED. Phone/Fax: (01255) 861161

For Editorial address and phone numbers see page 235

EPE SUBSCRIPTIONS

SAVE 51p AN ISSUE OVER UK NEWSTAND PRICES ON A UK ONE YEAR SUBSCRIPTION

Subscriptions for delivery direct to any address in the UK: 6 months £16.50, 12 months £31, two years £57; Overseas: 6 months £19.50 standard air service or £28.50 express airmail, 12 months £37 standard air service or £55 express airmail, 24 months £69 standard air service or £105 express airmail.

Cheques or bank drafts (in **£ sterling only**) payable to *Everyday Practical Electronics* and sent to *EPE* Subs. Dept., Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872. Fax: 01202 874562. **Email**: subs@epemag.wimborne.co.uk. Also via the **Web** at **http://www.epemag.wimborne.co.uk**. Subscriptions start with the next available issue. We accept MasterCard, Amex, Diners Club, Switch or Visa. (For past issues see the Back Issues page.)

ONLINE SUBSCRIPTIONS

Online subscriptions, for downloading the magazine via the Internet, $10.99US (approx. £7) for one year available from **www.epemag.com**.

USA/CANADA SUBSCRIPTIONS

To subscribe to *EPE* from the USA or Canada please telephone Express Mag toll free on 1877 363-1310 and have your credit card details ready. Or fax (514) 355 3332 or write to Express Mag, PO Box 2769, Plattsburgh, NY 12901-0239 or Express Mag, 8155 Larrey Street, Anjou, Quebec, H1J 2L5.

Email address: expsmag@expressmag.com.

Web site: **www.expressmag.com.**

USA price $60(US) per annum, Canada price $97(Can) per annum – 12 issues per year.

Everyday Practical Electronics, periodicals pending, ISSN 0262 3617 is published twelve times a year by Wimborne Publishing Ltd., USA agent USACAN at 1320 Route 9, Champlain, NY 12919. Subscription price in US $60(US) per annum. Periodicals postage paid at Champlain NY and at additional mailing offices. POSTMASTER: Send USA and Canada address changes to Everyday Practical Electronics, c/o Express Mag., PO Box 2769, Plattsburgh, NY, USA 12901-0239.

Published on approximately the second Thursday of each month by Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Printed in England by Apple Web Offset Ltd., Warrington, WA1 4RW. Distributed by COMAG Magazine Marketing, Tavistock Rd., West Drayton, UB7 7QE. **Subscriptions** INLAND: £16.50 (6 months); £31 (12 months); £57 (2 years). OVERSEAS: Standard air service, £19.50 (6 months); £37 (12 months); £69 (2 years). Express airmail, £28.50 (6 months); £55 (12 months); £105 (2 years). Payments payable to "Everyday Practical Electronics", Subs Dept, Wimborne Publishing Ltd. **Email:** subs@epemag.wimborne.co.uk. EVERYDAY PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.