

THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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Pain relief without drugs



DEAD SIMPLE USB BREAKOUT BOX

Check you are not overloading the USB port



FLEXITIMER

**Easy-to-programme
multi-purpose timer**

PLUS V2 PC SCOPE – PART 2

\$6.95 US \$8.99 CAN
SEPT 2007 PRINTED IN THE UK



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HB7 Stirling Engine

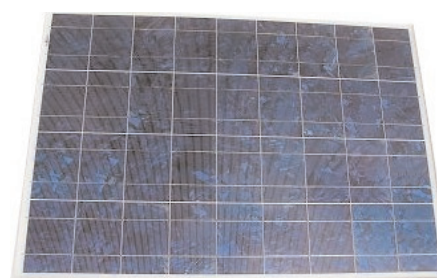
Base measurements: 128 mm x 108 mm x 170 mm, 1 kg
 Base plate: beech - Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
 Bearing application: 10 high-class ball-bearings
 Material: screw, side parts all stainless steel
 Cylinder brass, Rest aluminium and stainless steel.
 Available as a kit £80.75 or built £84.99
www.mamodspares.co.uk



STEAM ENGINE KIT

Everything in the kit enables you to build a fully functional model steam engine. The main material is brass and the finished machine demonstrates the principle of oscillation. The boiler, uses solid fuel tablets, and is quite safe. All critical parts (boiler, end caps, safety vent etc.) are ready finished to ensure success. The very detailed instruction booklet (25 pages) makes completion of this project possible in a step by step manner. Among the techniques experienced are silver soldering, folding, drilling, fitting and testing. £29.70 ref STEAMKIT Silver solder/flux pack £3.50 ref SSK

www.mamodspares.co.uk



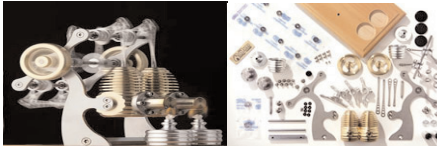
Solar Panels

We stock a range of solar photovoltaic panels. These are polycrystalline panels made from wafers of silicon laminated between an impact-resistant transparent cover and an EVA rear mounting plate. They are constructed with a lightweight anodised aluminium frame which is predrilled for linking to other frames/roof mounting structure, and contain waterproof electrical terminal box on the rear. 5 watt panel £29 ref 5wnav 20 watt panel £99 ref 20wnav 60 watt panel £249 ref 60wnav. Suitable regulator for up to 60 watt panel £20 ref REGNAV



HB9 Stirling engine

Base measurements: 156 mm x 108 mm x 130 mm, 0,6 Kg
 Base plate: beech Working rpm: approx. 2,000 min
 Bearing application: 6 high-class ball-bearings
 Material of the engine: brass, aluminium, stainless steel
 running time: 30-45 min.
 Available as a kit £97.75 or built £101.99
www.mamodspares.co.uk



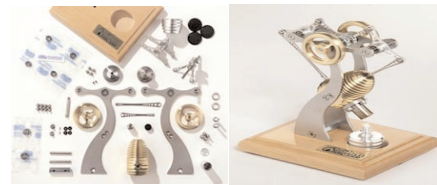
HB14 Stirling Engine

Base measurements: 156 mm x 108 mm x 150 mm, 1 kg
 Base plate: beech Working rpm: 2000 - 2500 rpm/min, .
 Incl. drive-pulley for external drives Bearing application: 10 high-class ball-bearings
 Material: screw, side parts total stainless steel
 Cylinder brass Rest aluminium, stainless steel
 Available as a kit £140.25 or built £144.50
www.mamodspares.co.uk



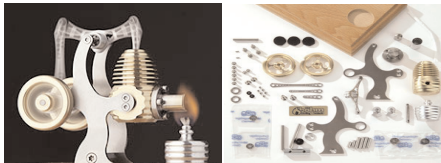
HB10 Stirling Engine

Base measurements: 156 mm x 108 mm x 130 mm, 0,6 Kg
 Base plate: beech Working rpm: approx. 2,000 rpm
 Bearing application: 6 high-class ball-bearings
 Material of the engine: brass, aluminium, stainless steel
 running time: 30-45 min
 Available as a kit £97.75 or built £101.99
www.mamodspares.co.uk



HB15 Stirling Engine

Base measurements: 128 mm x 108 mm x 170 mm, 0,75 kg
 Base plate: beech Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
 Bearing application: 6 high-class ball-bearings
 Material: screw, side parts total stainless steel
 Cylinder brass Rest aluminium, stainless steel
 Available as a kit £97.75 or built £102
www.mamodspares.co.uk



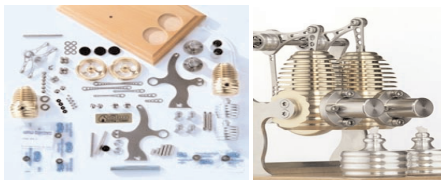
HB11 Stirling Engine

Base measurements: 156 mm x 108 mm x 130 mm, 0,7 Kg
 Base plate: beech
 Working rpm: 2000 - 2500 rpm/min,run Bearing application: 4 high-class ball-bearings
 Material: screw, side parts total stainless steel
 Cylinder brass Rest aluminium, stainless steel.
 Available as a kit £97.75 or built £101.99
www.mamodspares.co.uk



HB16 Stirling Engine

Base measurements: 128 mm x 108 mm x 170 mm, 1 kg
 Base plate: beech Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
 Bearing application: 10 high-class ball-bearings
 Material: screw, side parts total stainless steel
 Cylinder brass Rest aluminium, stainless steel.
 Available as a kit £140.25 or built £144.50



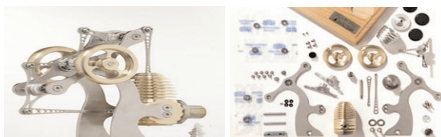
HB12 Stirling Engine

Base measurements: 156 mm x 108 mm x 130 mm, 1 Kg
 Base plate: beech Working rpm: 2000 - 2500 rpm/min,
 Bearing application: 6 high-class ball-bearings
 Material: screw, side parts total stainless steel
 Cylinder brass Rest aluminium, stainless steel.
 Available as a kit £136 or built £140.25
www.mamodspares.co.uk



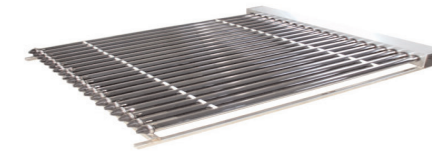
2kW WIND TURBINE KIT

The 2kW wind turbine is supplied as the following kit: turbine generator 48v three taper/ twisted fibreglass blades & hub 8m tower (four x 2m sections) guylines / anchors / tensioners / clamps foundation steel rectifier 2kW inverter heavy-duty pivot tower. £1,499



HB13 Stirling Engine

Base measurements: 156 mm x 108 mm x 150 mm, 0,75 Kg
 Base plate: beech Working rpm: 2000 - 2500 rpm/min,
 Bearing application: 6 high-class ball-bearings
 Material: screw, side parts total stainless steel
 Cylinder brass Rest aluminium, stainless steel.
 Available as a kit £97.75 or built £101.99

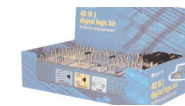


Solar evacuated tube panels

(20 tube shown) These top-of-the-range solar panel heat collectors are suitable for heating domestic hot water, swimming pools etc - even in the winter! One unit is adequate for an average household (3-4 people), and it is modular, so you can add more if required. A single panel is sufficient for a 200 litre cylinder, but you can fit 2 or more for high water usage, or for heating swimming pools or underfloor heating. Some types of renewable energy are only available in certain locations, however free solar heating is potentially available to almost every house in the UK! Every house should have one -really! And with an overall efficiency of almost 80%, they are much more efficient than electric photovoltaic solar panels (efficiency of 7-15%). Available in 10, 20 and 30 tube versions. 10 tube £199, 20 tube £369, 30 tube £549. Roof mounting kits (10/20 tubes) £12.50, 30 tube mounting kit £15



BENCH PSU 0-15V 0-2a Output and voltage are both smooth and can be regulated according to work, Input 230V, 21/2-number LCD display for voltage and current, Robust PC-grey housing Size 13x15x21cm, Weight 3,2kg £48 REF trans2



NEW ELECTRONIC CONSTRUCTION KITS

This 30 in 1 electronic kit includes an introduction to electrical and electronic technology. It provides components that can be used to make a variety of experiments including Timers and Burglar Alarms. Requires: 3 x AA batteries. £15.00 ref BET1803

AM/FM Radio This kit enables you to learn about electronics and also put this knowledge into practice so you can see and hear the effects. Includes manual with explanations about the components and the electronic principles. Req's: 3 x AA batts. £13 ref BET1801

This 40 in 1 electronic kit includes an introduction to electrical and electronic technology. It provides components that can be used in making basic digital logic circuits, then progresses to using Integrated circuits to make and test a variety of digital circuits, including Flip Flops and Counters. Req's: 4 x AA batteries. £17 ref BET1804

The 75 in 1 electronic kit includes an nintroduction to electrical and electronic technology. It provides components that can be used to make and test a wide variety of experiments including Water Sensors, Logic Circuits and Oscillators. The kit then progresses to the use of an integrated circuit to produce digital voice and sound recording experiments such as Morning Call and Burglar Alarm. Requires: 3 x AA batteries. £20 ref BET1806
www.slips.co.uk

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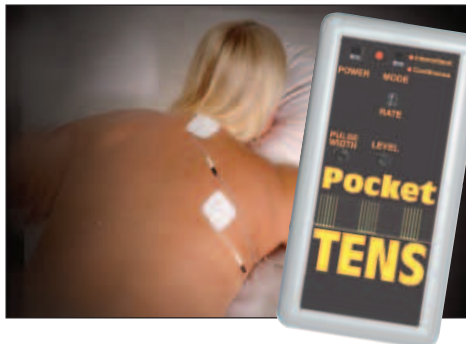
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VOL. 36. No. 9 SEPTEMBER 2007

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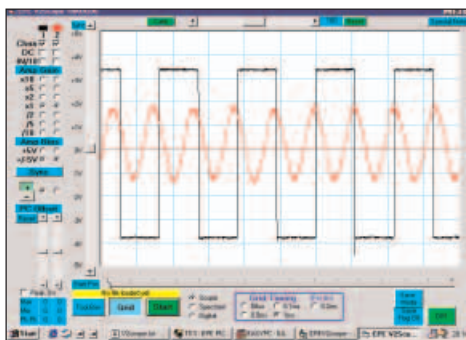
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Our October 2007 issue will be published on Thursday, 13 September 2007, see page 80 for details.

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PIC & ATMEL Programmers

We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

Programmer Accessories:

40-pin Wide ZIF socket (ZIF40W) £14.95
18Vdc Power supply (PSU010) £18.95
Leads: Parallel (LDC136) £3.95 / Serial (LDC441) £3.95 / USB (LDC644) £2.95

NEW! USB & Serial Port PIC Programmer

USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.

Kit Order Code: 3149KT - **£39.95**

Assembled Order Code: AS3149 - **£49.95**

NEW! USB 'All-Flash' PIC Programmer

USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows XP Software. ZIF Socket and USB lead not incl.

Assembled Order Code: AS3128 - **£44.95**

Assembled with ZIF socket Order Code: AS3128ZIF - **£59.95**

'PICALL' ISP PIC Programmer

Will program virtually all 8 to 40 pin serial-mode AND parallel-mode (PIC15C family) PIC microcontrollers. Free Windows software. Blank chip auto detect for super fast bulk programming. Optional ZIF socket.

Assembled Order Code: AS3117 - **£24.95**

Assembled with ZIF socket Order Code: AS3117ZIF - **£39.95**

ATMEL 89xxxx Programmer

Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16Vdc.

Kit Order Code: 3123KT - **£24.95**

Assembled Order Code: AS3123 - **£34.95**

Introduction to PIC Programming

Go from complete beginner to burning a PIC and writing code in no time! Includes 49 page step-by-step PDF Tutorial Manual, Programming Hardware (with LED test section), Win 3.11—XP Programming Software (Program, Read, Verify & Erase), and 1rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). PC parallel port.

Kit Order Code: 3081KT - **£16.95**

Assembled Order Code: AS3081 - **£24.95**

ABC Maxi AVR Development Board

The ABC Maxi is ideal for developing new designs. Open architecture built around an ATMEL AVR AT90S8535 microcontroller. All circuits are embedded within the package and additional add-on expansion modules are available to assist you with project development.



Features

8 Kb of In-System Programmable Flash (1000 write/erase cycles) • 512 bytes internal SRAM • 512 bytes EEPROM • 8 analogue inputs (range 0-5V) • 4 Opto-isolated Inputs (I/Os are bi-directional with internal pull-up resistors) • Output buffers can sink 20mA current (direct LED drive) • 4 x 12A open drain MOSFET outputs • RS485 network connector • 2-16 LCD Connector • 3.5mm Speaker Phone Jack • Supply: 9-12Vdc

The ABC Maxi STARTER PACK includes one assembled Maxi Board, parallel and serial cables, and Windows software CD-ROM featuring an Assembler, BASIC compiler and in-system programmer.

Order Code ABCMAXISP - **£89.95**

The ABC Maxi boards only can also be purchased separately at £69.95 each.

Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. 12Vdc PSU for all units: Order Code PSU445 £8.95

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two & Ten Channel versions also available. Kit Order Code: 3180KT - **£44.95**

Assembled Order Code: AS3180 - **£54.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 45x45mm. Powered by PC. Includes one DS1820 sensor. Kit Order Code: 3145KT - **£17.95**

Assembled Order Code: AS3145 - **£24.95**

Additional DS1820 Sensors - **£3.95 each**



4-Ch DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.

Kit Order Code: 3140KT - **£54.95**

Assembled Order Code: AS3140 - **£69.95**



8-Ch Serial Port Isolated I/O Relay Module

Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA.

Kit Order Code: 3108KT - **£54.95**

Assembled Order Code: AS3108 - **£64.95**



Infrared RC 12-Channel Relay Board

Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12Vdc/0.5A

Kit Order Code: 3142KT - **£47.95**

Assembled Order Code: AS3142 - **£59.95**



Audio DTMF Decoder and Display

Detect DTMF tones from tape recorders, receivers, two-way radios, etc using the built-in mic or direct from the phone line. Characters are displayed on a 16 character display as they are received and up to 32 numbers can be displayed by scrolling the display. All data written to the LCD is also sent to a serial output for connection to a computer. Supply: 9-12V DC (Order Code PSU445). Main PCB: 55x95mm.

Kit Order Code: 3153KT - **£24.95**

Assembled Order Code: AS3153 - **£34.95**



Telephone Call Logger

Stores over 2,500 x 11 digit DTMF numbers with time and date. Records all buttons pressed during a call. No need for any connection to computer during operation but logged data can be downloaded into a PC via a serial port and saved to disk. Includes a plastic case 130x100x30mm. Supply: 9-12V DC (Order Code PSU445).

Kit Order Code: 3164KT - **£54.95**

Assembled Order Code: AS3164 - **£69.95**



Most items are available in kit form (KT suffix) or pre-assembled and ready for use (AS prefix).

Hot New Products!

Here are a few of the most recent products added to our range. See website or join our email Newsletter for all the latest news.

Embedded Engineer's Development Tool (Atmel 89S & AVR)

At last the development tool kit for Atmel 89S & AVR devices that engineers have dreamed of has arrived. The kit includes a Built-in ISP Programmer, Target Section, Interfacing Board, Cables, eBook with codes, e-Learning Software with explanation and CD all in one neat package. Devices covered include 89S51, 89S52, 89S8253, mega8515, mega8535, mega8, mega16 & mega32.

Features

Designed for working professionals, students and product development companies You can connect any device like LCD, 7-Segment, Sensors, Switches to any desired port of the microcontroller No dedicated connections between microcontroller and the interfacing sections. You can connect anything, anywhere e-Learning Tutorial and Book are included Once you start using the kit, you will should never feel the need to attend any trainings because it is simple to use and all concepts are explained in simple language using the tutorial and book Includes 89S51, 89S52, ATmega8, ATmega16, ATmega32 In-circuit Programmer - no need to buy a separate programmer! No ZIF Sockets. No hassle inserting and removing microcontroller to program In-circuit programming reduces development time as you do not need to move microcontroller

Contents

- In circuit programmer for 89S and AVR series (supports up to Atmega128)
- 89S51/52 target section
- ATmega8 Target section
- ATmega16/32 Target section
- Switches
- Relays
- LEDs
- 7 Segment Displays
- 16 X 2 LCD
- ADC
- Motor Driver
- RS232
- EEPROM
- Cables
- Connectors
- Serial Port Lead
- e-Learning Software
- e-Datasheets
- HandyProg Programming software
- IDEs for code writing
- Application source code

Assembled Order Code: EEDT - **£89.95**

Most items are available in kit form (KT suffix) or assembled and ready for use (AS prefix).

Motor Speed Controllers

Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

DC Motor Speed Controller (100V/7.5A)



Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H. Kit Order Code: 3067KT - **£13.95** Assembled Order Code: AS3067 - **£21.95**

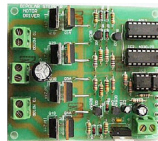
PC / Standalone Unipolar Stepper Motor Driver

Drives any 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps max. Provides speed and direction control. Operates in stand-alone or PC-controlled mode. Up to six 3179 driver boards can be connected to a single parallel port. Supply: 9Vdc. PCB: 80x50mm. Kit Order Code: 3179KT - **£12.95** Assembled Order Code: AS3179 - **£19.95**

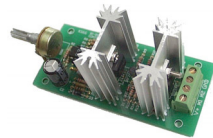


Bi-Polar Stepper Motor Driver

Drive any bi-polar stepper motor using externally supplied 5V levels for stepping and direction control. These usually come from software running on a computer. Supply: 8-30Vdc. PCB: 75x85mm. Kit Order Code: 3158KT - **£17.95** Assembled Order Code: AS3158 - **£27.95**



Bidirectional DC Motor Controller



Controls the speed of most common DC motors (rated up to 32Vdc/10A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections. Kit Order Code: 3166v2KT - **£17.95** Assembled Order Code: AS3166v2 - **£27.95**

AC Motor Speed Controller (700W)

Reliable and simple to install project that allows you to adjust the speed of an electric drill or single phase 230V AC motor rated up to 700 Watts. Simply turn the potentiometer to adjust the motors RPM. PCB: 48x65mm. Not suitable for use with brushless AC motors. Kit Order Code: 1074KT - **£12.95** Assembled Order Code: AS1074 - **£18.95** Box Order Code 2074BX - **£5.95**



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Tools & Test Equipment

We stock an extensive range of soldering tools, test equipment, power supplies, inverters & much more - please visit website to see our full range of products.

Professional Digital Multitester (9 Function inc Temperature)

High quality DMM offering 31 ranges and 9 functions (see table below for full details) and adjustable LCD screen for easy viewing. Supplied with shrouded test leads, K type temperature probe, shock-proof rubber holster, built-in probe holder & stand.



Large 36mm digit adjustable LCD display • Auto power OFF • Data hold • Automatic polarity indication • Low battery indication • Audible continuity test • Transistor hFE and diode test

Technical Specifications

DC voltage: 200mV-1000V • AC voltage: 2V-750V • DC current: 20mA-10A • AC current: 20mA-10A • Resistance: 200Ω-200MΩ • Capacitance: 2nF-20uF • Temperature: 0 - 1000°C • Max display: 1999

Order Code: DMM225 - Was **£31.95**

Now on sale at just £21.95!

See website for more super deals!

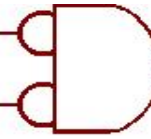


www.QuasarElectronics.com

Secure Online Ordering Facilities • Full Product Listing, Descriptions & Photos • Kit Documentation & Software Downloads

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Compact Control Design



Compact Control Design has a range of off the shelf products designed to meet your control, monitoring and acquisition needs. All products use the latest technology to provide top performance in a small size and at a low cost. We also provide a full hardware and software design service.

P0701 USB PIC

USB 2.0 interface. Can be bus powered or self powered.
Powerful PIC18F4580 Microcontroller running at 40MHz. Up to 10MIPS performance.
All microcontroller I/O pins available except RA6, RA7 (oscillator) and RC6, RC7 (serial port).
Bootloader pre-programmed and download software included, enabling quick and easy programming of applications.
No need for a separate programming device.
Many example applications and firmware available, see Compact Control Design download page.
Connector has standard 40 pin 0.1" pitch 0.6" wide footprint.
High quality tuned pin connectors suitable for most IC sockets and prototyping boards.



Compatible with Microchip's MPLab 'free of charge' programming environment. Libraries and linker scripts included to support assembler programs (MPLab) and popular compilers.

PRICE:£26.00
+ VAT

P0704 Developer Board

The P0704 developer board is an ideal way to get started with our USB-PIC module and motor driver modules. All of the USB-PIC module I/O signals are available through screw terminals making connections to sensors, switches, lamps, relays etc. easy. Ports B & E (11 I/O signals) can also be configured with pull-ups and input filtering suitable for connection to limit switches, home position sensors etc. The board supports up to 4 motor driver modules, each module position accepts either a Stepper motor module or a DC motor module. The board allows bus-powered or self powered operation of the USB-PIC module & includes a P0615 mini regulator so only a single power supply is required for the motor driver modules.

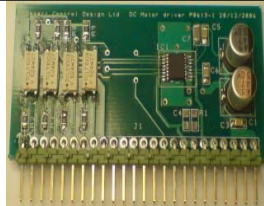


All options are configured using jumpers, and stepper motor driver current can be easily adjusted for each module by variable resistors. All connections are made by high quality screw terminals. The board has been designed to accommodate other driver modules as they become available.

PRICE:£55.00
+ VAT

P0613 DC Motor

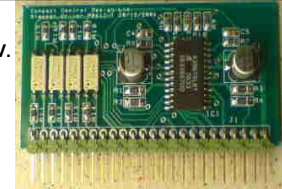
Pulse width modulation control for DC motors, electro-magnets etc.
It has a motor supply voltage of 8 to 36V.
The maximum drive current is 2.5 Amp.
There are pulse and direction inputs.
The PWM control is up to 100KHz.
Mode input for controlling motor braking and sleep input for power saving.
There is built in short circuit and over temperature protection, a fault output pin activates if either of these is detected.
No heat sink is required.
The board has dimensions of 66x30mm and is 12mm high.
There is an adapter available providing easy to use screw terminals for all connections.
All the control inputs are opto-isolated.



PRICE:£14.00
+ VAT

P0612 Stepper Motor Driver

The unit has a motor supply voltage of 5 to 30V.
The maximum drive current per phase is 750mA.
It has current mode control.
The drive current is controlled with a resistor.
It has a selectable step size of full, half, 1/4 + 1/8.
There is a step frequency of 0 to 200KHz and reset and sleep inputs for initialization and power saving.
It is a compact size with dimensions of 66x32mm by 12mm high.
The P0612 does not require a heat sink.
There is an adapter available which provides easy to use screw terminals for all connections.
All the control inputs are opto-isolated.

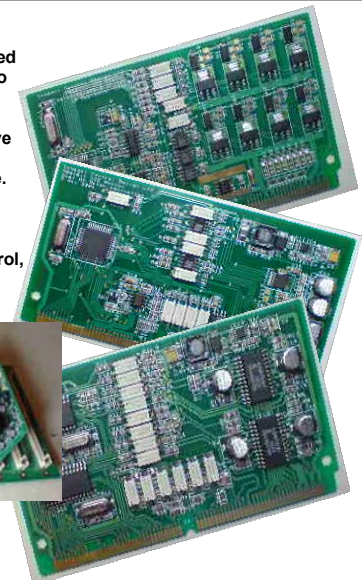
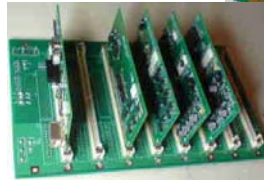


PRICE:£15.00
+ VAT

MonCon

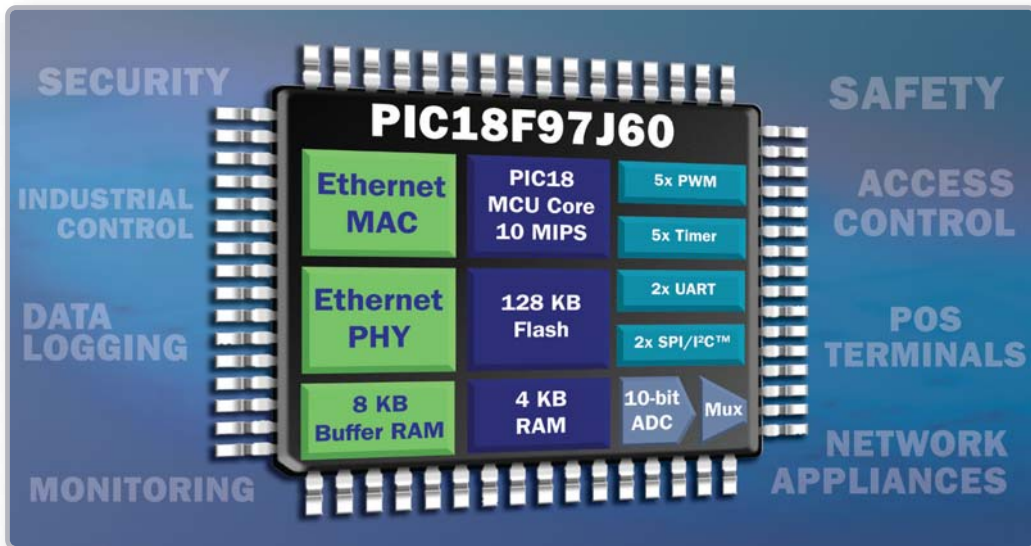
MonCon is a product range intended to form the intelligence at the heart of any equipment from bench-top scientific instruments, production equipment, ATE etc. up to large process control systems.
The MonCon range takes a new approach to monitoring and control by using modules that encapsulate a complete task, such as the stepper motor controller module that includes all inputs and outputs necessary to form a complete stepper motor controller/driver including encoder feedback.
The general purpose modules, such as the Analogue input board are designed to be customized at minimum cost. We can supply such modules to your requirements at little or no additional cost.
The MonCon range is based on a collection of modules, each performing specific and well defined tasks. All modules plug into a back plane which provides power distribution, intercommunication and incorporates the necessary connectors linking the MonCon system to the rest of the equipment.
The modules and backplane connectors have been designed to simplify the interconnection requirements within your equipment.

Most devices, such as stepper motors, sensors etc. are wired to the MonCon backplane directly with no splices or links so the wiring loom is simplified, cheaper to manufacture and more reliable.
We understand that many manufacturers would want to have full control over critical parts of their products, so we are happy to allow our customers to manufacture under license. The product range currently consists of the following - standard back planes with 4, 6 or 8 slots, controller modules for stepper and DC motors, controller modules for valves and solenoids, pressure control, flow control etc.
a USB interface to allow connection to a PC etc.
various I/O modules, Parallel I/O, relay output and Analogue I/O modules.
The MonCon range has been designed with flexibility in mind. Backplanes and modules to meet your requirements can generally be designed & supplied within 6 weeks of receiving a full specification.



Compact Control Design Limited, 77 Woolston Avenue, Congleton, Cheshire. CW12 3ED, UK
Tel : (+44) 01260 281694, Fax : (+44) 01260 501196, E-mail : sales@compactcontrol.co.uk

Embedded Ethernet Solutions



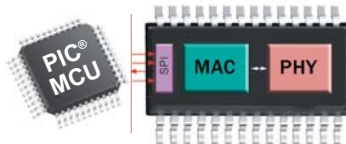
Monitor, control or re-program your application remotely using the integrated Ethernet PIC18F97J60 Microcontroller family and **FREE** TCP/IP software.

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Our TCP/IP stack is available in source code for flexible and optimized code size.
- 3. Check out our low-cost Ethernet tools**
Evaluate the PIC18F97J60 family with the **PICDEM.net™ 2 Demonstration Board** (DM163024) at www.microchipDIRECT.com.

| Device | Pins | Flash (KB) | Features |
|-------------|------|------------|---|
| PIC18F97J60 | 100 | 128 | 10-BaseT Ethernet |
| PIC18F87J60 | 80 | 128 | 12 KB RAM |
| PIC18F67J60 | 64 | 128 | (8 KB dedicated Ethernet) |
| PIC18F96J65 | 100 | 96 | 5x 16-bit timers |
| PIC18F86J65 | 80 | 96 | 10-bit ADC, 16 channels analog comparators |
| PIC18F66J65 | 64 | 96 | 2 UART with LIN protocol |
| PIC18F96J60 | 100 | 64 | 2 SPI, 2 I ² C™ |
| PIC18F86J60 | 80 | 64 | Industrial Temperature -40° to +85°C |
| PIC18F66J60 | 64 | 64 | |
| ENC28J60 | 28 | 8K RAM | MAC, PHY, SPI Interface |

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PCB Production - Development

0.1" Copper Stripboard

| Size | Tracks/Holes | Price |
|-------------------------|--------------|-------|
| 25 x 64mm | 9T / 25H | £0.24 |
| 64 x 95mm | 24T / 37H | £0.87 |
| 95 x 127mm | 36T / 50H | £1.41 |
| 95 x 432mm | 36T / 170H | £4.39 |
| 100 x 100mm | 39T / 38H | £1.40 |
| 100 x 500mm | 39T / 199H | £6.20 |
| 119 x 455mm | 46T / 179H | £5.40 |
| Stripboard track cutter | | £1.99 |

Solderless Breadboard

| Tie Points & Size | Power Rails | Price |
|-------------------|-------------|-------|
| 390 81 x 60mm 2 | | £2.75 |
| 840 175 x 67mm 2 | | £4.86 |
| 740 175 x 55mm 2 | | £4.03 |
| 100 175 x 42mm 0 | | £6.20 |

Many other sizes available, also jump wires & matrix board.

PCB Production - Drafting Materials

Artwork Film (per 10 sheets)

| | |
|---------------------|-------|
| Clear Manual Film | £1.20 |
| Clear Laser Film | £1.75 |
| White HQ Laser Film | £4.62 |

Etch Resist Pens

| | |
|----------------------|-------|
| "Dolo" Pen | £3.36 |
| "Stagedite" Fine Pen | £0.96 |

Etch Resist Transfers

| | |
|---------------------|-------|
| Seno mixed DIL pads | £2.24 |
| Seno mixed Rnd pads | £2.24 |
| Alfoc mixed pad | £1.25 |
| Transfer Spatular | £1.25 |

We carry the full range of Seno & Alfoc PCB transfers, see our catalogue for full details.

Soldering Irons

We carry in stock a wide range of soldering iron and soldering accessories. Irons from 12 to 100 Watts.

| | |
|------------------|-------|
| 20W 240V Basic | £3.74 |
| 25W 240V Ceramic | £1.14 |
| 30W 240V Basic | £4.68 |

Desolder Pumps

| | |
|------------------|--------|
| Basic 165 x 16mm | £2.85 |
| Antistatic 195mm | £3.92 |
| Antex Mini 198mm | £6.02 |
| Antex Pro 210mm | £10.26 |

Soldering Station

A 48W adjustable temperature soldering station with a rotary dial, LED Temperature metering, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 420°C. Low voltage iron with Silicone cable. Supply: 240V, Iron: 24V 48W

Model 167-540 £41.66

Soldering Station

A 45W adjustable temperature soldering station with a rotary dial, Digital Temperature Indication, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 480°C. Low voltage iron with Silicone cable. Supply: 240V, Iron: 24V 48W

Model 167-570 £55.61

Digital Multimeter

Model: 121-120
Price: £11.47

A highly featured digital multimeter for professional use. Offers 30 ranges and 8 functions including temperature, capacitance, diode, continuity and hFE measurement. Large 3.5 digit LCD display with automatic polarity indicator. Supplied with shrouded test leads, K type temperature probe and shock proof rubber holster.

Technical Specifications

| | |
|--------------|-----------------------------|
| DC voltage | 200mV - 1000V (±0.5%) |
| AC volts | 2V - 700V (±0.8%) |
| DC current | 2mA - 20A (±1.2%) |
| AC current | 200mA - 20A (±1.8%) |
| Resistance | 200 Ohms - 20M Ohms (±0.8%) |
| Capacitance | 2000pF - 20µF (±2.5%) |
| Temperature | 0°C - 1000°C (±1.5%) |
| Frequency | 20kHz (±1%) |
| Max display | 1999 |
| Power supply | 9V (PP3 battery) |
| Dimensions | 88 x 173 x 40 mm |

PCB Production - Processing Equipment

We carry a large range of the photographic & chemical processing equipment for PCB production, a full list with full technical specifications is available in our catalogue or visit our web site.

UV Exposure units

| | |
|-----------------------------|-----------------------|
| 2 x 8W Tubes, 6 min timer | |
| 229 x 159mm working area | Model 332-002 £98.75 |
| 4 x 15W Tubes, 7½ min timer | |
| 330 x 260mm working area | Model 332-004 £209.48 |

Chemical Processing

Low cost plastic tray £2.30

Process tanks feature electrically operated pumps and/or heaters with thermostat control, suitable for boards upto 320 x 260mm. Universal Tank with heater. Model 333-007 £169.58

Bubble etch Tank with heater & bubble pump. Model 333-004 £208.48 *Any of these items, carriage £5.50*

PCB Production - Tools

Drill Bits

HSS parallel shank bits available in sizes from 0.3mm to 2.0mm

| | | |
|----------------------------|---------|----------|
| 0.3-0.95mm in 0.05mm steps | £0.60ea | £4.00/10 |
| 1.0-2.0mm in 0.1mm steps | £0.40ea | £3.60/10 |

HSS Reduced Shank (2.35mm) bit available in sizes from 0.6mm to 1.7mm in 0.1mm steps £0.84ea £7.60/10

Reground Tungsten carbide reduced shank available in sizes from 0.6 to 1.6mm in 0.1mm steps £1.90

Drilling Machines

Expo Reliant 12V drill, 3.8mm capacity, 8400rpm £12.78

Expo Zircon 12V drill, 3.8mm capacity, 11900rpm £14.20

Minicraft MX1 230V, 8000 - 21000rpm with chuck & collet. Model EPE270-390

Normal price £48.51

SPECIAL PRICE

£31.02

Servisol Products

| | |
|---------------------------|-------|
| 200ml Switch Cleaner | £2.30 |
| 200ml Freezer | £4.39 |
| 400ml Foam Cleanser | £2.13 |
| 400ml Cleaner / Lubricant | £2.79 |
| 75ml Vide Head Cleaner | £1.94 |
| 200ml Aero Klene | £3.33 |
| 200ml Aero Duster | £5.13 |
| 250ml Cold Clean | £3.14 |
| 200ml Label remover | £3.52 |
| 400ml Isopropyl alcohol | £3.42 |

Tubes

| | |
|-----------------------|-------|
| 10g Heatsink Compound | £1.66 |
| 25g Heatsink Compound | £2.60 |
| 50g Silicone grease | £3.16 |

Bench Power Supplies

A range of single output regulated bench power supplies with variable voltage & current limiting. Features: Short circuit and "foldback" overload protection. Metal case with on/off switch, outputs via Red, Black & Green (Earth) 4mm shrouded sockets.

| | | |
|-----------------------|--------------------|----------------|
| Model: 461-550 | 0-30V0-3A | £70.88 |
| Model: 461-552 | 0-50V 0-3A | £81.00 |
| Model: 461-554 | 0-30V 0-10A | £135.00 |

Panel Meters

High quality analogue panel meters, class 2, zero point correction, mirror scale and "foldback" overload protection. Metal case with on/off switch, outputs via Red, Black & Green (Earth) 4mm shrouded sockets.

Range: Ind Ω

| | |
|---------|------|
| 0-50µA | 6K5 |
| 0-100µA | 1K0 |
| 0-500µA | 430Ω |
| 0-1mA | 200Ω |
| 0-10mA | 20Ω |
| 0-50mA | 1Ω |
| 0-100mA | 0Ω65 |
| 0-1A | 60mΩ |
| 0-3A | 20mΩ |
| 0-5A | 12mΩ |
| 0-15A | 4mΩ |
| 0-10V | 10k |
| 0-15V | 15k |
| 0-30V | 30k |
| ±50µA | 1k9 |

All meters £5.89 each
6V Lamps £1.23 / pair

Magnifying Desk Lamp

A high quality scratch resistant magnifying glass fitted to a balanced swivel arm and desk mount. An integral fluorescent tube provides illumination. Magnification: 3x Lens: 120mm Ø Tube: 22W Daylight simulation.

Model: 028-205 £28.80

PCB Production - Laminates

Copper clad - paper

Single sided low cost paper composite board

| | |
|-------------------|-------|
| 100 x 160mm Board | £0.54 |
| 100 x 220mm Board | £0.62 |
| 160 x 233mm Board | £1.02 |
| 220 x 233mm Board | £1.40 |
| 8" x 12" Board | £1.96 |

Copper clad - glass fibre

Single & Double 1.6mm 30g/m²

| | |
|--------------------|-------|
| 100 x 160mm Single | £1.06 |
| 100 x 220mm Single | £1.49 |
| 160 x 233mm Single | £2.29 |
| 220 x 233mm Single | £2.88 |
| 8" x 12" Single | £3.98 |
| 100 x 160mm Double | £1.09 |
| 100 x 220mm Double | £1.25 |
| 160 x 233mm Double | £2.30 |
| 220 x 233mm Double | £2.90 |
| 8" x 12" Double | £4.05 |

Photoresist Coated

1.6mm 35 micron Pre-coated with a high quality photoresist layer. Available in low cost paper composite or Glass fibre, Single & Double sided. Other sizes also available.

| Size | Paper | | Glass Fibre | |
|-------------|--------|--------|-------------|--------|
| | Single | Double | Single | Double |
| 4 x 6" | £1.47 | £1.82 | £1.89 | £2.17 |
| 6 x 12" | £4.20 | £5.04 | £5.60 | £6.23 |
| 9 x 12" | £6.30 | £7.70 | £8.40 | £9.38 |
| 11 x 12" | £8.19 | £10.01 | £10.78 | £11.83 |
| 12 x 12" | £8.26 | £10.08 | £10.99 | £12.25 |
| 100 x 160mm | | | £2.38 | £2.66 |
| 203 x 114mm | | | £3.01 | £3.43 |
| 220 x 100mm | | | £3.08 | £3.71 |
| 233 x 160mm | | | £4.03 | £5.32 |
| 233 x 220mm | | | £6.83 | £7.70 |

PCB Production - Chemicals

| | |
|---|--------|
| 100ml Aerosol Photoresist spray, covers 2m ² | £4.62 |
| 50g Powder developer, makes 1l | £1.09 |
| 50g Powder developer, makes 10l | £7.08 |
| 250g Ferric Chloride Pellets, makes 500ml | £1.68 |
| 50g Ferric Chloride Pellets, makes 1lt | £3.04 |
| 2.5kg Ferric Chloride Pellets, makes 5lt | £9.84 |
| 11kg Clear Fine etch crystals, makes 5lt | £17.58 |
| 90g Tin Plating Powder, makes 1lt | £11.58 |
| 200ml Aerosol Flux spray | £3.41 |
| 110ml Aerosol PCB Laquer spray | £3.54 |

Tools - Cutters & Strippers

We carry a wide range of specialist tools for the electronics industry including:

Side Cutters

| | |
|-------------------|-------|
| 130mm Low cost | £1.99 |
| 115mm Draper | £2.38 |
| 115mm Box Jointed | £4.26 |
| 145mm Long reach | £3.40 |
| Wire Strippers | |
| 130mm Low cost | £2.30 |
| 150mm Draper 5mmØ | £5.86 |

Tools - Ratchet Crimping Pliers

High quality ratchet crimping pliers for various terminals including Automotive, Data, Audio and Data connections.

| | |
|-----------------------|--------|
| Red / Blue / Yellow | £15.80 |
| BNC /TNC RF series | £15.08 |
| RJ11/RJ25 Data Series | £22.32 |
| RJ45 Data Series | £20.43 |
| RJ11/RJ45 Series | £11.83 |

CK® Tools Crimp Pliers

| | |
|--------------------------------|--------|
| Green/Red/Blue | £24.38 |
| Red/Blue/Yellow | £22.88 |
| 0.24-2.5mm ² crimps | £26.01 |
| 0.2-4.0mm ² crimps | £26.01 |
| Non insulated crimps | £24.38 |

Cable - Ribbon

7/0.127mm Grey ribbon cable on a 0.05" 1.27mm pitch with a red identifying stripe. Supplied by 305mm (1ft) or on full 30.5m (100ft) reels.

| Size | per 305mm | per Reel |
|----------------|-----------|----------|
| 10 Way | £0.10 | £5.80 |
| 14 Way | £0.14 | £7.50 |
| 16 Way | £0.16 | £8.58 |
| 20 Way | £0.20 | £10.72 |
| 26 Way | £0.26 | £13.94 |
| 34 Way | £0.34 | £18.22 |
| 40 Way | £0.40 | £21.44 |
| 50 Way | £0.50 | £26.80 |
| 60 Way | £0.64 | £33.92 |
| IDC Crimp tool | | £10.60 |

CAT5e Networking

UTP Cable

Conforms to CAT5E
100MHz standard,
ETA verified TIA/EIA 568-B.2

| | |
|---------------|--------|
| 305m Box | £45.31 |
| 100m Reel | £22.28 |
| exc carriage. | |

RJ45 Outlet Kit

Backing Box
2 Gang Plate
RJ45 Module
Blank Module
Coloured id inserts.
£2.99ea £2.42 (10+)

Tools

Plastic punch down tool & cable stripper £1.40

Professional punch down IDC & trim tool £7.38

Outlets

| | |
|-----------------------|-------|
| CAT5e Outlet Module | £1.70 |
| 2 Gang Plate (2 Mods) | £0.50 |
| 2 Gang Plate (4 Mods) | £0.75 |
| 1/2 Module Blank | £0.25 |
| 1 Module Blank | £0.35 |
| 2 Module Blank | £0.45 |

Other keystone outlets, switches & accessories available. Patch & Cross-over leads from £0.50

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Blown away!

Never before have I seen an encapsulated module on a PC board blown apart with the plastic melted. The photo below shows the result of a minor explosion on the network card in one of our office computers; the computer and network card are a few years old. One fairly quiet morning in the office the peace was rudely interrupted by a loud 'pop' and smoke rising from the computer, which was still working!

It appears that a tiny encapsulated electrolytic capacitor inside the module had exploded for no apparent reason, blowing the module apart. Once the board was replaced everything was back to normal. I've seen distorted and leaking electrolytic capacitors before, but to see so much damage from such a small component is worrying. Just imagine the mess if it had been a large smoothing capacitor in the PSU!



AVAILABILITY

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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**. We are not able to answer technical queries on the phone.

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 that 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.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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Is Copy Protection Dying?

Copy protection may be on its way out with so many ways to defeat it. Barry Fox reports.

The music industry likes to sell online because if customers download instead of buying CDs, the record companies save the cost of pressing, packaging and shipping CDs. The success of online selling, largely due to Apple's iTunes, is already putting some record shops out of business.

Two music companies, Linn and EMI, have now abandoned the use of Digital Rights Management and copy protection on the tracks and albums which they sell electronically. Steve Jobs has said he would like to see DRM scrapped on all music sold through iTunes. DRM gets in the way of legitimate enjoyment, makes safety backing-up difficult, and does nothing to stop anyone copying music if they really want to – if necessary by the simple trick of taking the analogue output of a music player and re-recording it digitally.

Increased broadband speeds and the more powerful compression offered by MPEG-4 could let Hollywood offer online sales as an alternative to DVD. But the studios do not yet have a clear policy on how to attract customers and whether to use DRM and copy protection.

Services so far trialled have been flakey and stopped short of offering the key incentive – movies to buy online as soon as they are released for rental or purchase on

DVD. LoveFilm worked with AOL on a low key trial which has since sunk without trace. When tested, it refused to sell a movie to a UK AOL subscriber, on a UK phone line, claiming the purchaser was not in the UK!

At the *Driving Digital Content* conference, held in London recently by Understanding and Solutions, Marc Gareton of Warner Bros announced that Warner is getting more serious about Electronic Sell Through. Warner will trial a 'Day and Date' service in Scandinavia and Belgium this August. Movies will be put on line on the same day that they are released on DVD and Pay TV. People who pay to download the movie can burn it to a blank DVD.

"The rental window has collapsed" said Gareton. "Consumers want movies on line". John Newman, Head of Sonic Solutions/Roxio in Europe, described the QFlix system which home PCs will use to burn copy-protected downloads: "CSS is very important for the download business: it's essential for future revenue". Wayne Borg, of Universal, called Download to Burn, or Electronic Sell Through "an alternative to piracy".

Unfortunately, the CSS copy protection system used for DVDs has been hacked to

shreds and DeCSS software, which lets people copy DVDs digitally, is freely available on the web. Howard Kiedaisch of Arts Alliance (the company behind LoveFilm) told how he also sells copy-protected movie files which can be used on portable players like the Archos. "The Archos is a cool device" he enthused.

Unfortunately, devices like the Archos – and from US company Neuros – are now designed to take the analogue output from an ordinary DVD player and make a digital copy to hard disc or memory card for portable viewing. So no special download file need be purchased. Likewise, there is nothing to stop someone taking the analogue monitor feed from a PC while it's playing a DRM-protected download, and copying it to digital disc. There is no Macrovision copy-protection on the monitor signal.

When asked whether they were aware of all this, the panel of experts at the conference looked surprised. After going into a huddle they agreed a comment that: "We need copy protection and DRM for damage limitation". From the audience, David Tarrington of Universal's Technical Origination added: "Your argument is correct but you are looking at it the wrong way". He did not explain what the correct way of looking was, though.

Microchip Lighting Centre

Microchip has announced an online Lighting Applications Design Centre at www.microchip.com/lighting. This comprehensive website provides a wide range of technical tools and resources that designers can use to add intelligence to lighting designs – including information relating to Microchip's PIC microcontrollers, dsPIC Digital Signal Controllers (DSCs), analogue and memory products, as well as development tools.

New lighting technologies, such as LEDs, dimmable fluorescent ballasts and High Intensity Discharge (HID) lamp ballasts, demand increased performance with greater energy efficiency. The flexibility of Microchip's low-cost digital, analogue and memory products enables designers to easily add intelligence to lighting applications. Benefits include energy savings, prolonged product life, improved safety and light quality, reduced component counts, remote control and diagnostic capabilities, and the ability to easily adapt existing lighting designs.

For more information, visit Microchip's website at www.microchip.com/lighting.

Picoscope Programming Interface

Pico Technology have just launched an Application Programming Interface for the PicoScope 5000 series scopes to allow you to write your own software for the devices. This series forms Pico's top-performing scopes, with the world's fastest real-time sampling rate for a USB PC scope of 1Gs/s. This, together with a probe-tip bandwidth of 250MHz, makes

them ideal for use with high-speed analogue and digital signals. The scope's huge memory buffer – either 32M or 128M samples depending on the version – ensures that the high sampling rate can be used on a wide range of time-bases without losing detail.

Browse www.picotech.com or phone +44 (0) 1480 396 395 for more details.



PIC Toothpick

RF Solutions has announced the availability of its Toothpick 2.0 transceiver, a module combining a PIC and LinkMatik (Bluetooth 2.0) radio which is preloaded with Toothpick Services firmware, providing FlexiPanel user interface server, wireless field programming and Toothpick Slave for optional external host control.

Pre-tested firmware solutions available for the Toothpick transceiver enable immediate standalone operation, providing a low-cost and simplified solution. The range of firmware solutions includes DARC-ITM data acquisition and remote control managed via Bluetooth, DARC-IITM data acquisition and remote control with FlexiPanel user interface; Toothpick Slave where Toothpick is controlled by a host processor via a serial link; and Standalone Toothpick programmable in C for low-cost, customized standalone operation.

More information on potential applications is available on the RF Solutions website at www.rfsolutions.co.uk.



USB Device for Embedded Micros

Computer Solutions are now supplying the Micro Digital range of USB drivers – smxUSBD USB Device stack, smxUSBH USB Host stack and smxOTG On the Go stack for dual role devices – all of which will help embedded systems developers by providing easy interfacing between embedded systems and USB.

The smxUSBD USB device stack is designed for situations which require the embedded application to plug into, and exchange data with, a PC. The smxUSBH USB host stack is used in situations where an embedded application needs to act like a PC and control a USB network. This allows the embedded device to use a USB keyboard or mouse, to collect data from an array of USB sensors or to allow a memory stick (Thumb Drive) to be read or written by the embedded application.

For more general information, browse the main web site at www.computersolutions.co.uk. Also, if you are still grappling with USB terminology you may find the tutorial USB for Embedded Engineers of use, visit:

www.computer-solutions.co.uk/info/Embedded_tutorials/usb_tutorial.htm

Churchill Fellowships 2008

Often believing you can change your community is not enough. The difference between an ideal and a worthwhile idea is the possibility to make it happen in reality. Travelling to another country and gaining a better understanding of different cultures is an enriching experience, but with a Winston Churchill Travelling Fellowship, it gives you the 'chance of a lifetime'.

The Winston Churchill Memorial Trust offers British citizens the possibility to undertake projects overseas related to their trade, craft or profession. Any British citizen is eligible to apply, no matter their age, background or educational qualification. Applicants are required to demonstrate that their ideas will add value to the community in the UK on their return.

Anything you can do to make this opportunity more widely known will help more people to turn their ambition into reality. Whether it's a project that relates to your occupation or something of personal interest that can help your community – the Winston Churchill Memorial Trust can give you the funding to embark on the journey of a lifetime.

Some of the 2008 categories are: Science and Technology; Adventure; Exploration and Leaders of Expeditions; Young People (applicants must be under 25 on 31st December 2008); Animal Welfare; Recruitment and Use of Volunteers in the Community; Training and Retention of Teachers; Making a Living in the Countryside; Craft Workers and Teachers involved in the Built Environment; One award in the field of History.

Applications close on 16th October 2007. To find out more, visit www.wcmt.org.uk or call 020 7584 9315.

Peak Electronic Moves

Peak Electronic Design Limited, makers of the Atlas range of test instruments, have moved. They are now located in the centre of Buxton, in the heart of the Peak District and within easy reach of many key northern cities. Their new offices are situated in a technology-centred building, with plenty of space for even more innovative design and manufacture.

Widening their services to their customers, Peak would like to formally announce their expanded in-house design service. Peak's Managing Director, Jeremy Siddons, adds: "This move will really enhance our company and the services it offers. In addition to exciting new product developments, we are now offering our proven expertise to a wider audience. We've always offered a comprehensive design service, providing a high quality and innovative electronic design service to companies and individuals, but now we are delighted that the move will enable us to offer our expertise to a larger client base."

Email, web, telephone and fax details remain unchanged. The postal address has

changed, although any mail to the old address will be automatically routed to the new premises. New contact details: Peak Electronic Design Ltd., West Road House, Dept EPE, West Road, Buxton, Derbyshire SK17 6HF.

Tel: 01298 70012. Fax: 01298 70046. Email: sales@peakelec.co.uk. Web: www.peakelec.co.uk.

Quasar UK Hybrid Transmitter and Receiver

Quasar UK (a subsidiary of RF Solutions and not Quasar Electronics Ltd. of Bishops Stortford) has launched new FM hybrid transmitter and FM-RX1 receiver modules. The new devices are ideal for applications ranging from car security systems to remote sensing and data capture.

The transmitter module provides a complete RF transmitter which can be used to transmit data at up to 4.8Kbps from any standard CMOS/TTL source. The TX module is simple to operate and offers low current consumption (15mA typ). The RX module provides a complete radio receiver which can be used to receive un-decoded data from the FM transmitter modules. It incorporates a PLL that helps ensure precise local oscillator generation. It also offers low power consumption, resulting in extended battery life.

All Quasar UK transmitters and receivers are compatible with one another and provide a complete wireless solution. The modules produce a CMOS/TTL output, and only require connections for power and to an antenna. Data can be fed directly into a microprocessor or decoding device, keeping the component count down and ensuring a low hardware cost.

In addition to its new FM transmitter and receiver modules, Quasar UK also offers a range of compact AM transmitter and receiver modules. A choice of other general purpose radio remote control systems and USB powered GPS receivers are also available.

Further information from RF Solutions, Unit 21, Cliffe Industrial Estate, South Street Lewes, East Sussex BN8 6JL. Tel: 01273 898000. Fax: 01273 480661. Web: www.rfsolutions.co.uk. Email: sales@rfsolutions.co.uk

Two Cheers For Eco-Lamps

Low-energy light bulbs are a key weapon in the battle for saving money, power and fossil fuels. So it's mighty unfortunate that they employ the wrong technology, even worse that the right technology is currently too dear to use. But this may change before long, as Mark Nelson explains.

ECOLOGISTS urge us constantly to change all our traditional lamp bulbs to the (fairly) new low-energy variety. The message is reinforced by government propaganda and bolstered by special offers by power companies. And now the supermarkets have dropped the retail price of these bulbs to a couple of pounds apiece.

The arguments are overwhelming, resistance is futile. And to bayonet cap it all (or screw you completely if you live in countries where the Edison-type fitting reigns supreme), the European Commission is proposing to phase out incandescent bulbs by 2009.

You may well wonder what the fuss is about. Energy-saving bulbs consume far less electricity and last much longer than conventional ones. Their now only slightly higher purchase price is soon offset by the lower running cost, so why on earth should anyone balk against genuine progress?

Ecological nightmare

As so often happens, the facts are not as simple as they are presented and the progress is of the two steps forward, one step backwards kind. Today's version of low-energy lighting, using compact fluorescent lights (CFLs), uses the wrong technology. CFL products may be cheap to buy but their low purchase price obscures some severe ecological problems. They have a number of practical disadvantages too. They are simply the wrong solution and sadly the right solution is just too expensive. What a conundrum!

Let's examine the facts in greater detail. The traditional electric lamp bulb has been a practical proposition since British inventor Joseph Swan patented a workable design in 1878. A year later, the American Edison obtained a patent for a design that he had developed independently and they later merged their intellectual property interests. Incandescent bulbs are relatively simple and cheap to make, especially as by volume the main ingredient is nothing (if a vacuum bulb) or nitrogen (for gas-filled bulbs). The life of these bulbs tends to be short but long-life ones are made. They do, to be fair, consume five times the power of CFL bulbs.

CFL bulbs have been around for 25 years or so, the early ones being substantially bulkier, heavier and slower to reach full brightness than those of today. They have a typical life span of between 6,000 and 15,000 hours, against the 750 to 1,000 hours of incandescent lamps. That said, the energy used in manufacturing CFL bulbs is significantly higher than for incandescent lamps, meaning that their lifetime energy cost (from manufacture to disposal) may actually be higher.

Hazardous waste

The manufacturing process is more complex; the (small) mercury content of CFL bulbs makes them technically hazardous waste and thus banned from standard domestic waste disposal systems. There is concern that this mercury will lead to air and water pollution when disposed with other household waste in landfill sites or incinerator plants. Responsible manufacturers are now limiting the amount of mercury used.

The technical disadvantages of CFL lamps are not so great as to rule out their use but are worth noting. Their light output generally drops during long-term use; the effect is gradual. Many CFL bulbs take between 30 seconds and four minutes to reach full brightness, which could be a disadvantage for safety lighting. At low temperatures they are slow to start or may even fail to operate (light output drops at low temperatures). Lamp life is reduced when CFLs are switched on and off frequently.

Standard CFL bulbs do not work with existing dimmer switches and they will not fit all styles of luminaire (that's the posh word for light fitting!). They need good air flow around them and will suffer a rapid and painful death if they are allowed to overheat in shades profiled like a bluebell or tulip flower. In reflective mirror fittings they cannot provide the attractive 'twinkly' effect that clear bulbs do and then there's the awful pallid light they produce in that weird pinkish or peach colour. The reason for this is because CFLs produce light in a narrow frequency range, whereas normal bulbs put out the full spectrum of light colours, albeit not in equal amounts of all of them. No wonder some people dislike low-energy bulbs with uncharacteristic vehemence.

Even German Chancellor Angela Merkel, who chaired the summit that announced the EU's initiative in March, admitted to misgivings. "Most of the light bulbs in my flat are energy-saving bulbs. They're not yet quite bright enough. When I'm looking for something I've dropped on the carpet, I have a bit of a problem", she said.

Interim technology

It's little wonder that the more enlightened technologists recognise CFLs as no more than an interim solution. Just as oranges are not the only fruit, CFLs are not the only low-energy lamp. So is there more eco-friendly light at the end of the tunnel? There is, but it may be a longer tunnel than we might like.

The future is SSL – solid-state lighting. The potential rewards are high: LED-based

lights are stated to use only half the power that CFLs require or between 8 to 10 per cent of the figure that filament bulbs guzzle. They could (rather than can) be made to last 15 years, producing a broad-spectrum light comparable to natural sunlight. Other advantages include reduced heat generation as well as greater resistance to shock, vibration and wear. All of these increase the lifespan of solid-state lighting significantly.

So are producers interested? Too right they are! Companies all over the world are investigating means of making SSL cost-effective and attractive for domestic use. Even in Britain, the government has demonstrated commitment and in June awarded a three-year contract worth £3 million from the UK government to a consortium of Filtronic, Forge Europa, QinetiQ, Thomas Swan and Cambridge University for developing a route to low cost LEDs for solid-state lighting. In the same month Europe's biggest LED lighting test establishment opened in the UK. Titled the 'Solid State Lighting Research Centre', it opened for business at the Aston Science Park in Birmingham. As well as offering its LED test lab to industrial customers, it is also taking on funded research.

Truly competitive

The Centre's head of business development, Dr Geoff Archenhold, recently told a conference: "If all domestic 60W light bulbs were replaced with LED-based light sources, the amount of electricity used in residential lighting today could be reduced by up to 80 per cent – the equivalent of eliminating the need for approximately two nuclear power stations.

Energy production for all types of illumination around the world creates over 900 million tons of CO₂ gas and represents 19 per cent of all electrical energy used worldwide. We estimate that this figure could be reduced by 300 million tons if LEDs were used for all general lighting purposes."

For this to happen the cost of LEDs will, of course, have to fall significantly to become truly competitive against existing light sources, but it happened with CFLs. How long will it take with LEDs?

Further Facts:

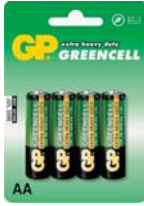
<http://ban-the-bulb.blogspot.com/>

http://en.wikipedia.org/wiki/Incandescent_lamp

http://en.wikipedia.org/wiki/Compact_fluorescent_light_bulb

http://en.wikipedia.org/wiki/Solid-state_lighting

Batteries



Zinc Chloride, Alkaline, NiMH, NiCD & Sealed Lead Acid batteries. We carry battery packs for racing & radio control. We also manufacture the NiCD Bot-Pack+, a high performance custom made pack with forced cooling options for the most demanding applications.

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The 'PICAXE' range of programmable microcontrollers. Write in BASIC or Flowchart and download straight into the microcontroller, so no expensive programmers are required. The 8 pin version provides 5 i/o pins (1 analogue input). The 18 pin version provides 8 outputs and 5 inputs (3 of the inputs have analogue capabilities). The 28-pin version provides 9-17 outputs, 0-12 inputs and 0-4 separate analogue inputs.

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- 8 pin starter kit including software, lead, battery holder, PCB & components for £9.94
- 28 pin version pictured above £21.74

Robot Kits

We carry a wide range of robot kits from BEAM to full combat and includes the very popular Robonova biped walker. Kits range in price from £16.95 to £689.05 built by enthusiasts & school pupils from all over the UK. Many are programmable via a PC, RC or autonomous. Full details of these and lots more can be found on our website.



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- Add a fast charger for an additional £11.46

Electrical

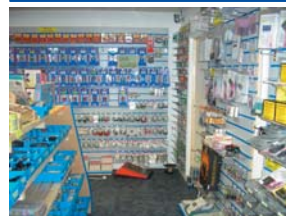


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Pocket TENS

By John Clarke

TENS – Transcutaneous Electrical Nerve Stimulation – is pain relief without drugs. Attach electrodes near to the painful area and start up the TENS unit for a tingling sensation that can help to reduce pain. This pocket-sized TENS unit has adjustable controls that tailor the level to suit each patient's requirement and is battery powered.

- Features**
- Battery powered
 - Adjustable voltage level
 - Adjustable pulse rate
 - Adjustable pulse width
 - Intermittent or continuous output

LIVING IN CONSTANT PAIN is a reality for many people and how well they cope with it depends on the degree of pain and the character of the person.

While pain relief can be managed in the short term using analgesics, their long-term use can be detrimental to the user's health. Side effects of prolonged analgesics use include liver and kidney damage and in some cases irritation to the lining of the stomach. Thankfully, in many cases there is an alternative: TENS or Transcutaneous Electrical Nerve Stimulation.

In many cases where pain is constant, a medical practitioner or physiotherapist may recommend the use of a TENS unit.

These are not a gimmick or a new-age form of treatment. Tests have shown that TENS is an effective and safe way to manage chronic and acute pain with virtually no side effects. Chronic pain conditions that can be alleviated with TENS include, arthritis, lumbago, neck and back pain, post herpetic neuralgia and sciatica. Acute pain conditions such as fractures, muscular pains, post-operative pain and tennis elbow can also be managed with a TENS unit.

Warning!

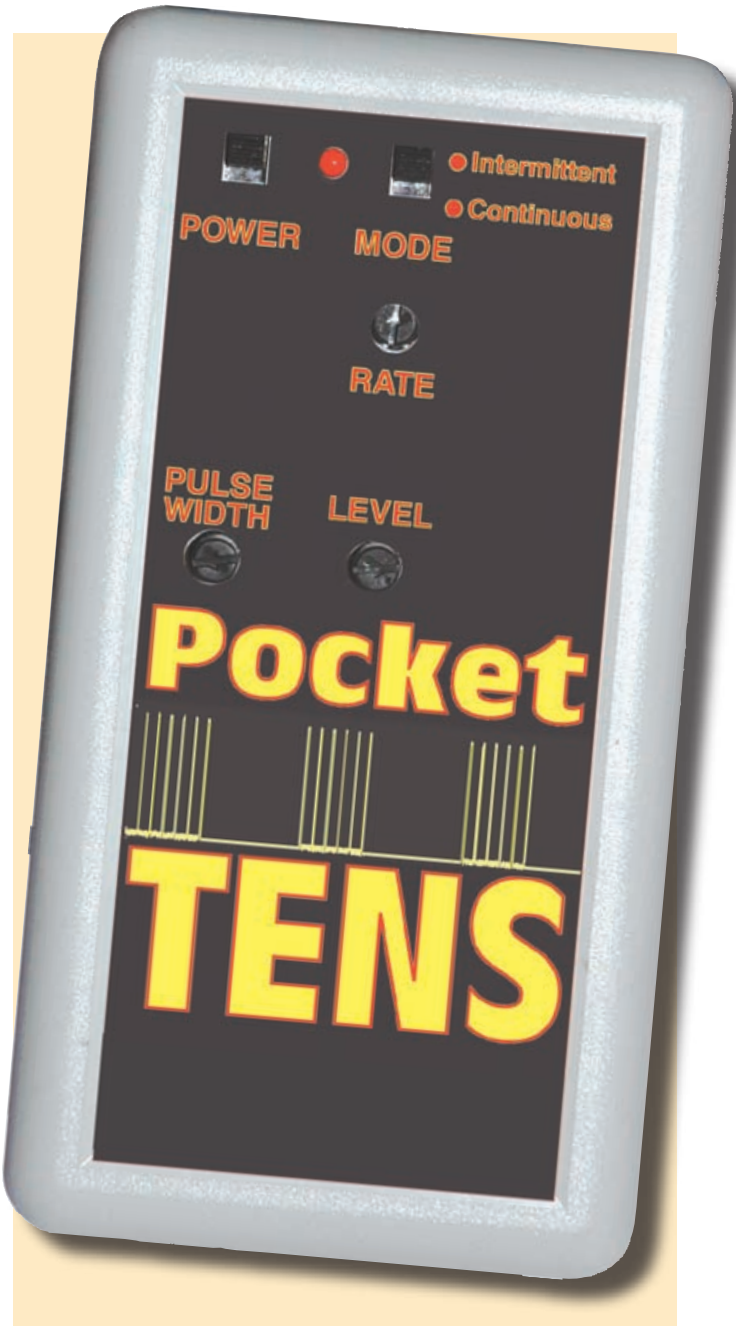
This TENS unit (or any other similar device) must not be used on a person who has a Heart Pacemaker.

Do not connect the electrodes to the body so that there can be a flow of current through the heart.

Electrodes must not be placed on the neck, since this can stimulate nerves which control breathing and blood pressure.

Do not use the TENS unit for headaches or attach the electrodes to the head.

Do not be tempted to run the TENS unit from a mains adaptor, plugpack or power supply. This could be dangerous if a breakdown occurs in the isolating transformer. If you want to reduce the cost of battery replacement, we suggest using a 9V NiMH rechargeable battery.



A TENS unit provides electrical stimulation of the painful area using electrodes attached to the skin. It can cause a tingling sensation in the area where the pads are attached. How the TENS reduces pain is unknown. Some suggest that the nerves are stopped from sending signals to the brain and thus the pain is removed. Alternatively, the stimulation could induce the body to produce natural pain relieving substances called endorphins.

Whatever the reason, a TENS unit can give pain relief for many people, with minimal side effects. It does not provide a cure for the underlying cause of the pain but has the major benefit that the amount of pain killing drugs can be substantially reduced.

Nor is it addictive. Sometimes there can be skin irritation surrounding the electrodes and this can be reduced or alleviated by changing the type of electrode.

Note that a TENS unit must not be used if you have a heart pacemaker. Also, a TENS unit should not be used if the cause of the pain has not been established or if you are pregnant. When using the TENS unit do not attach the electrodes anywhere around the front of the neck, and be sure the TENS unit is kept out of reach of children. It should be treated like any other medicine, by storing it in a childproof cabinet.

Features

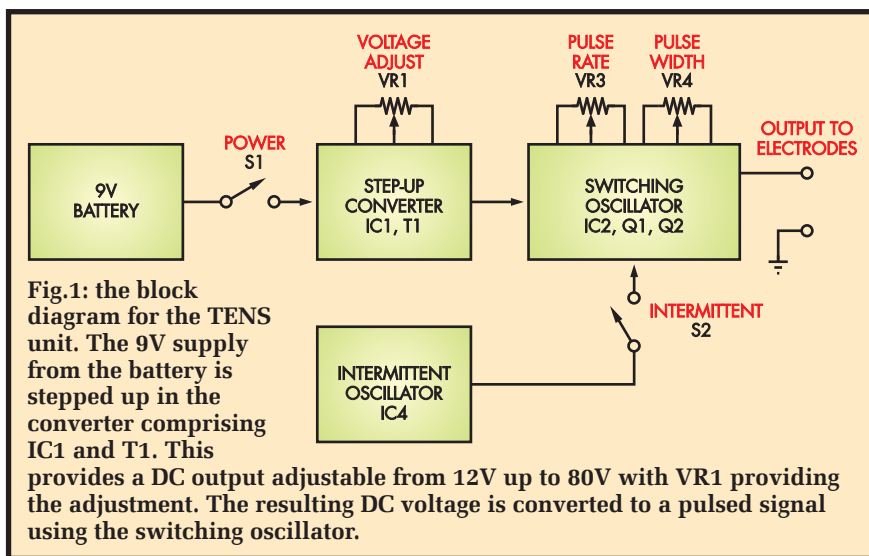
EPE previously featured a TENS unit in the March 1997 issue. This new version uses a different circuit. Three small knobs allow adjustment of the overall output voltage, the width of the voltage pulses and the pulse rate. A continuous/intermittent switch selects whether the pulses are provided as a continuous stream or in short bursts. To the left of that is a power switch and an LED to indicate when the unit is on. Two electrodes connect to the TENS unit via a lead that plugs into a socket at the top end of the box. The electrodes are attached to the skin adjacent to the painful area and the controls are adjusted until the tingling effect becomes just a little uncomfortable. The tingling sensation will tend to decrease over the period of treatment and so the controls will need to be further increased as time goes by. The typical treatment period is about 20 minutes.

Generally, the continuous setting is selected but for long treatment periods, the intermittent mode can be used. This mode helps to overcome the effect where the patient becomes accustomed to the stimulation. The intermittent mode allows a higher voltage and a faster rate to be selected compared to the continuous mode.

Thus, the stimulation is greater in short bursts and because there is a break between pulses, the patient does not adapt too readily to the higher levels.

Block diagram

The block diagram for the TENS unit is shown in Fig.1. The 9V battery supply is stepped up by the converter comprising IC1 and T1. This provides a DC output from 12V to 80V, with VR1 providing the adjustment. The resulting DC voltage is converted to a pulsed signal using switching



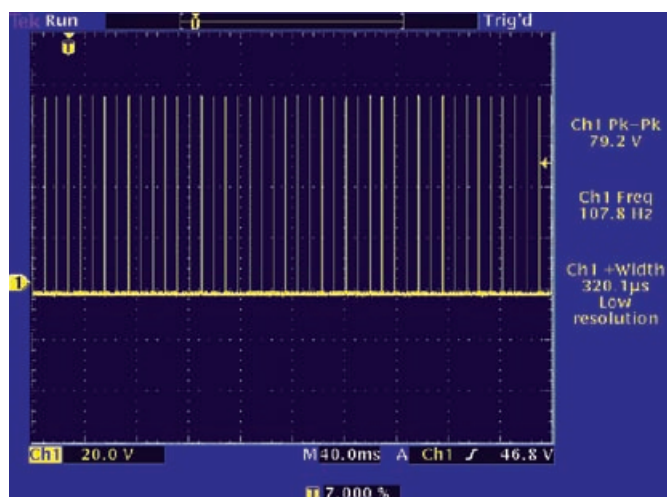
oscillator IC2. Oscillator IC4 is switched into circuit via S2 to gate the switching oscillator, giving short bursts of pulsed signal.

Fig.2 shows how the basic step-up converter circuit operates. It comprises inductor L1 which is energised from the V+ supply through transistor Q1. The energising current is shown as I1. When the transistor is switched off, the stored energy in L1 is dumped via diode D1 into capacitor C1.

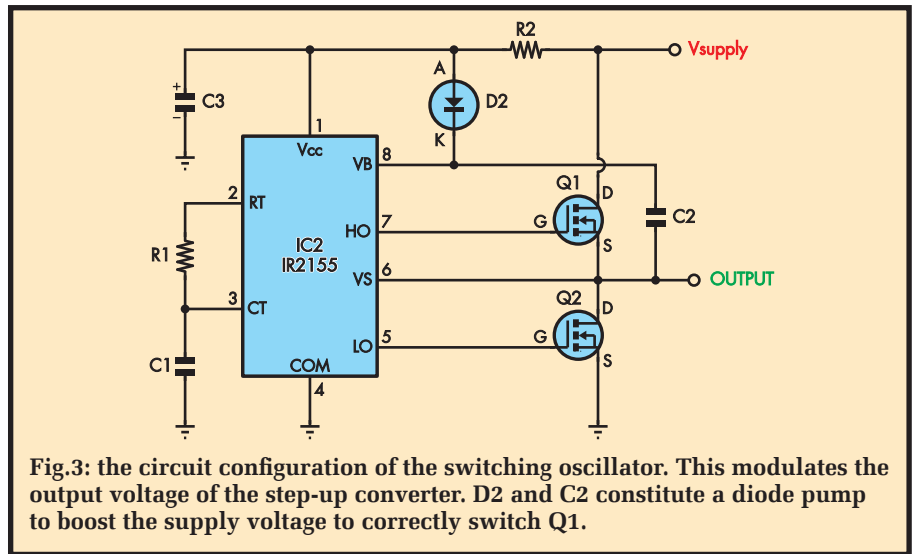
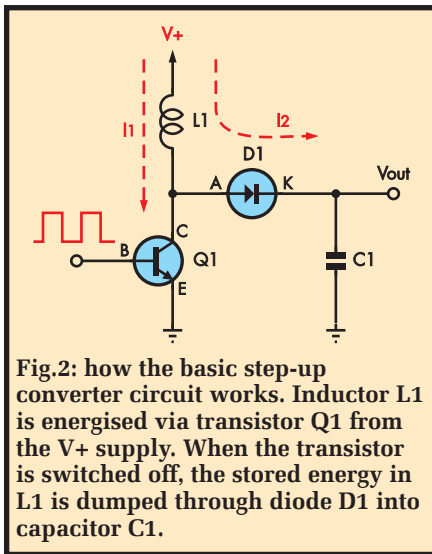
The actual voltage across C1 depends on the amount of energy in L1 and the load current between V_{OUT} and the ground supply. We can maintain a constant V_{OUT} for a variety of loads by controlling the amount of time Q1 is switched on.

Fig.3 shows the circuit of the switching oscillator, comprising IC2, Q1 and Q2. This modulates the output voltage of the step-up converter and is based on an IR2155 made by International Rectifier Corporation. It is described as a high-side self-oscillating power MOSFET gate driver.

Resistor R1 and capacitor C1 at pins 2 and 3 of IC2 set the rate at which MOSFETs Q1 and Q2 are alternately turned on and off. There is a dead time of 1.2µs between each device switching off and the other switching on. This prevents the supply from being short circuited at the switchover period when one MOSFET turns off and the other turns on.



This shows the pulse train signal at the electrodes. Here the voltage is set at 80V and the frequency at 108Hz.



Diode pump

Note that the supply voltage for IC2 is around 10V, while the voltage to be switched can be up to 80V. The gate voltage for Q1 must be raised above its drain by several volts in order for it to be able to switch the 80V supply. This extra voltage is derived using a diode pump consisting of diode D2 and capacitor C2.

Initially, the supply to pin 1 of IC2 is set at about 10V by an external Zener diode. When MOSFET Q2 is switched on, capacitor C2 charges to the 10V supply via D2. When Q2 is turned off, pin 7 is connected internally to pin 8 to switch on Q1. Q1 then pulls pin 6 up to V_{supply} and pin 8 is level-shifted to V_{supply} plus the voltage across C2. So in a few switching cycles, the circuit automatically shifts pin 8 and thereby the gate voltage to MOSFET Q1, to whatever the driving voltage needs to be.

Circuit details

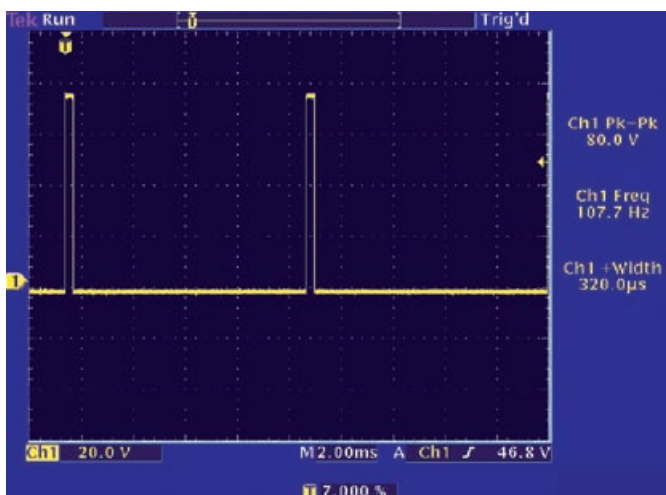
The full circuit diagram for the TENS unit is shown in Fig.4. Power from the 9V battery comes via switch S1 and diode D6. D6 is included for reverse polarity protection but because we are running from batteries, we have specified a Schottky diode to minimise voltage losses.

IC1 is the switchmode controller. It has a switching transistor at pin 1 and a feedback input at pin 5. Its frequency of oscillation is set by the 2.2nF capacitor at pin 3. The peak current through the primary winding of T1 is limited by the 0.22Ω resistor between pins 6 and 7 of IC1. In operation, the current through the primary winding of T1 is switched off when the voltage drop across the 0.22Ω resistor exceeds about 300mV.

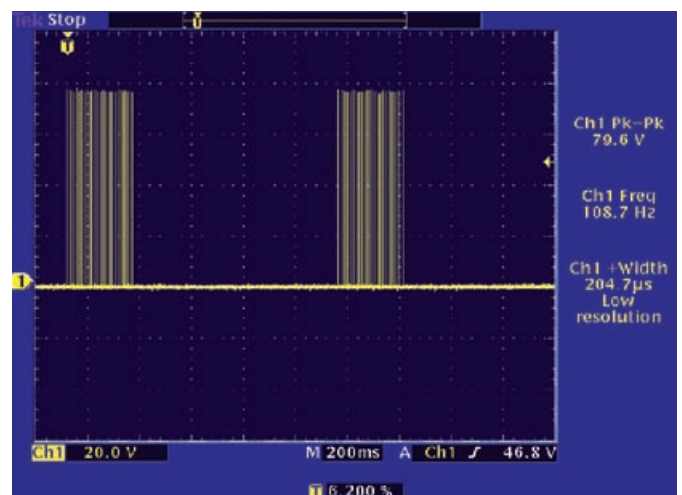
Switching off the current through T1 causes a voltage to be induced into T1's secondary when the primary field collapses. This charges two 470nF capacitors via diode D1. Voltage feedback from the 150kΩ resistor, VR1 and VR2 into pin 5 maintains the voltage at the desired setting up to 80V.

The circuit uses a transformer instead of a step-up inductor, as depicted in Fig.2. This is included to prevent high voltages occurring at pin 1 of IC1, where the maximum allowable voltage is 40V. Since we want up to 80V, the 2.59:1 step-up ratio between primary and secondary of T1 will ensure that the pin 1 voltage will be less than 40V. The primary winding can be used to provide a 10V supply for IC2 and IC4.

This supply is derived in two steps. First, diode D3 charges the associated 4.7μF capacitor. The voltage across



Here are the pulses shown with a faster timebase. It shows the width of each pulse at about 320μs.



Finally, this is the intermittent pulse output showing the bursts of pulses at about 1.2Hz.

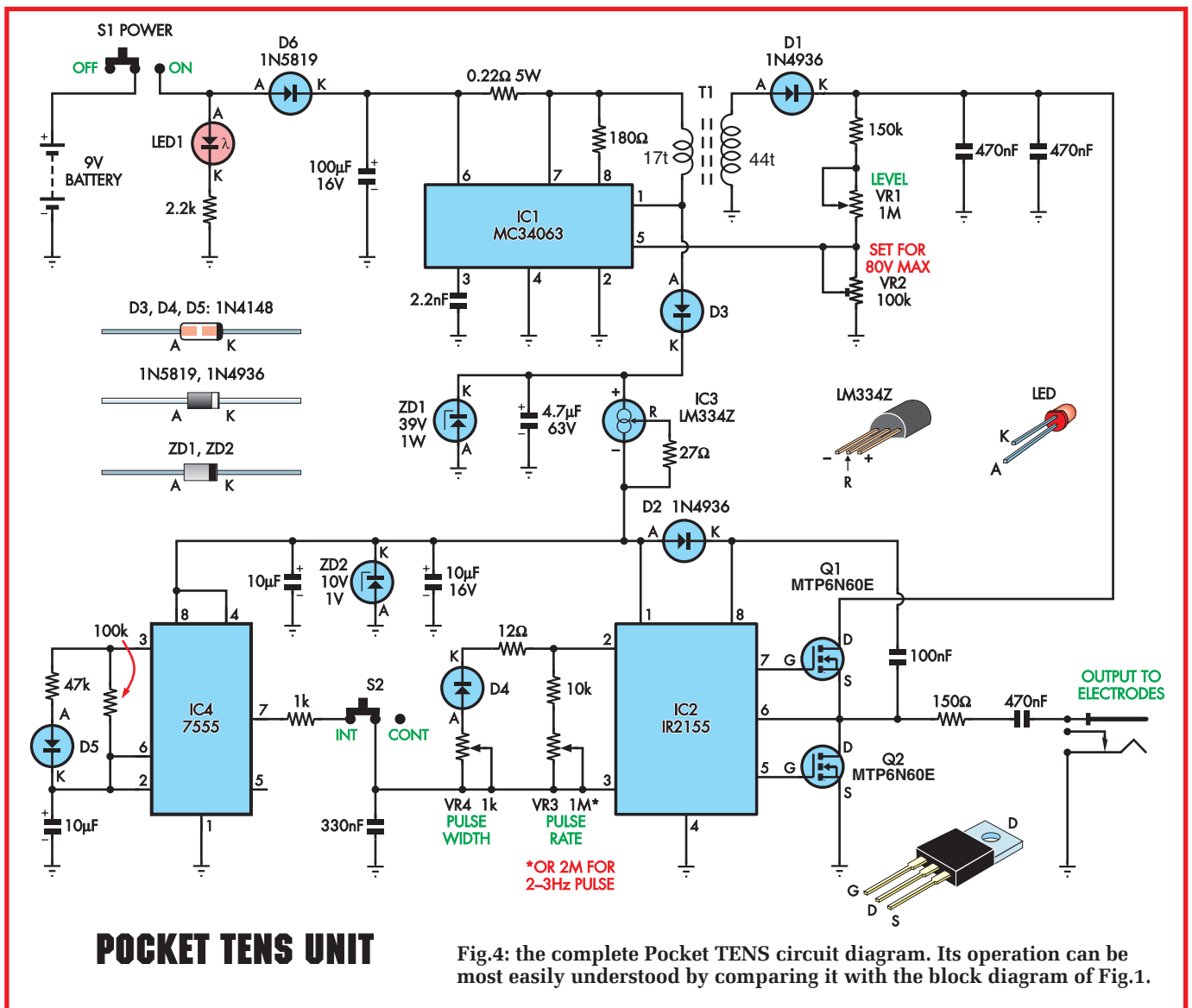


Fig.4: the complete Pocket TENS circuit diagram. Its operation can be most easily understood by comparing it with the block diagram of Fig.1.

it is limited to +39V by Zener diode ZD1. Diode D3 also clamps the maximum voltage at pin 1 of IC1 to one diode drop above 39V.

IC2's power is then derived via an LM334Z constant current source, IC3.

The 27Ω resistor between the R and V – pins of IC3 sets

the constant current to about 2mA. The current source supplies a 10V Zener diode (ZD2) that regulates the supply voltage to 10V. This supply also powers IC4.

Note that we need to derive the supply for IC2 in this way because the 9V directly from the battery is just not enough for satisfactory operation. This is because IC2 has an internal voltage shutdown that operates at below 8.4V. IC2 will therefore not operate when its supply drops to this level.

If we were powering this IC directly from batteries, we would need at least 8.6V from the battery to ensure operation if we include the drop across D6.

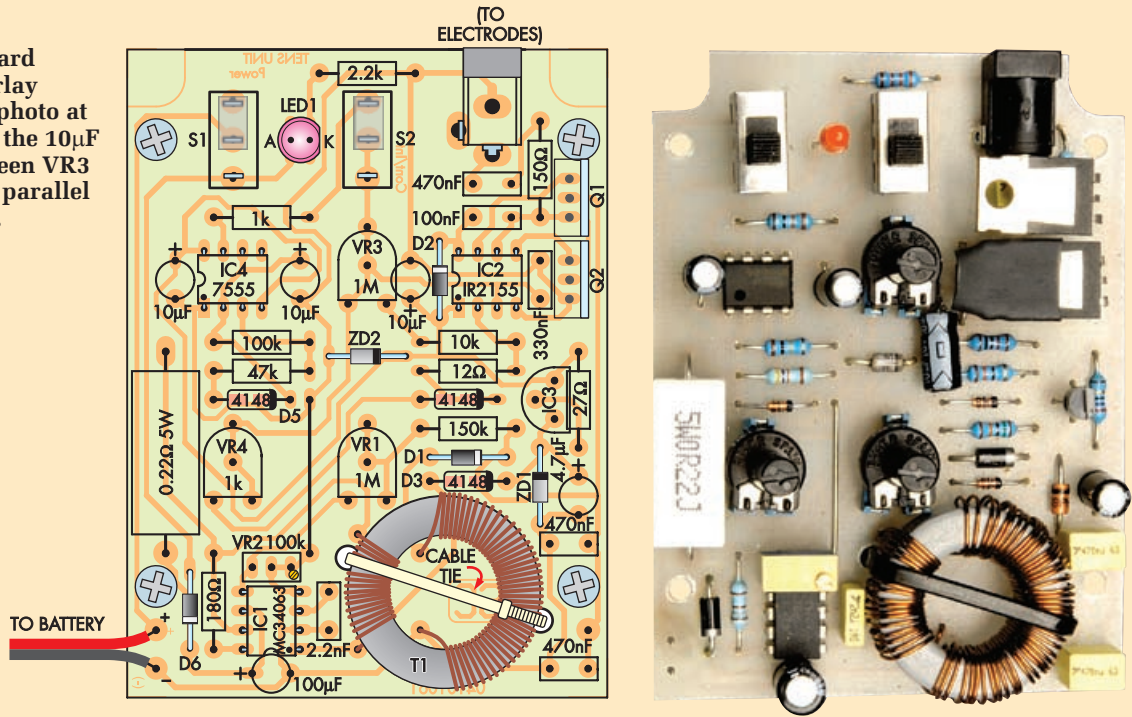
This would give an extremely short operation time with a 9V battery. By contrast, using the power supply system described above, the battery can be used down to at least 7.2V and in most cases down to 4V.

Q1 and Q2 are high voltage MOSFETs and are used to switch the high voltage on and off to produce the requisite output

Specifications

| | |
|-----------------------|--|
| Output Voltage | Adjustable from 12V to 80V |
| Pulse Rate | Adjustable from 4.6Hz to 410Hz |
| Pulse Width | Adjustable from between 70 and 320μs |
| Intermittent | 24% duty cycle at 1.2Hz (220ms pulse burst with an 800ms off period) |
| Battery Drain | Typically less than 20mA (31mA at 80V output, 19mA at 50V output) |
| Battery | 9V Alkaline (or a 9V NiMH rechargeable) |
| Battery Voltage | 7.2V minimum for a 12V to 80V output range, 4V minimum for a 22V to 80V output range. |

Fig.5: the PC board component overlay with same-size photo at right. Note how the 10 μ F capacitor (between VR3 and IC2) is laid parallel to the PC board.



pulses on the electrodes. Q1 and Q2 constitute a 'totem pole' output stage with Q1 turning on to charge the 470nF output capacitor via the series 150 Ω resistor and the load resistance (which in this case is the patient). Each time Q1 turns off, Q2 turn turns on to discharge the capacitor via the series 150 Ω resistor. The amount of time Q1 is switched on determines the pulse width of the voltage output. Q2's on time controls the pulse rate (ie, the frequency).

In more detail, Q2 is switched on for the time set by the 330nF capacitor at pin 3 and the resistance between pins 3 and 2 of IC2. VR3 adjusts this time between about 0.22 and 2.4ms, giving a pulse rate between 4.6Hz and 410Hz.

Q1 is switched on for the time duration set by potentiometer VR4, the series 12 Ω resistor and diode D4. The pulse width ranges between 70 μ s and 320 μ s.

Intermittent mode

IC4 is a 7555 CMOS timer configured to provide the intermittent mode. It operates as a free running oscillator. The output at pin 3 is used to charge the 10 μ F capacitor at pins 2 and 6 via the 47k Ω resistor and diode D5 and discharge it via the parallel 100k Ω resistor. This gives a

pulse waveform at pin 3 with an uneven duty cycle, with the pulses being high for 0.22s and low for 0.7 seconds.

We don't use the pin 3 output to modulate IC2. Instead, we use the capacitor discharge output at pin 7. This pin 7 output is an open drain MOSFET which is open circuit when pin 3 is high and conducts signals to ground when pin 3 is low.

Each time pin 7 of IC4 pulls low, it discharges the 330nF capacitor at pin 3 of IC2 to stop IC2 from oscillating. This prevents any output to the electrodes and provides an intermittent modulation for the electrode output.

Construction

The TENS unit is built onto a PC board coded 635 and measures 85 \times 64mm. It is housed in a plastic case measuring 134 \times 69 \times 23mm. An adhesive plastic label measuring 49 \times 113mm can be fitted to the lid of the case.

Three trimpots are used as controls instead of potentiometers. They provide us with suitably sized components for the small box. 10mm long spindles are inserted into each trimpot to allow adjustment and these protrude through the front panel of the box. Note that the trimpots

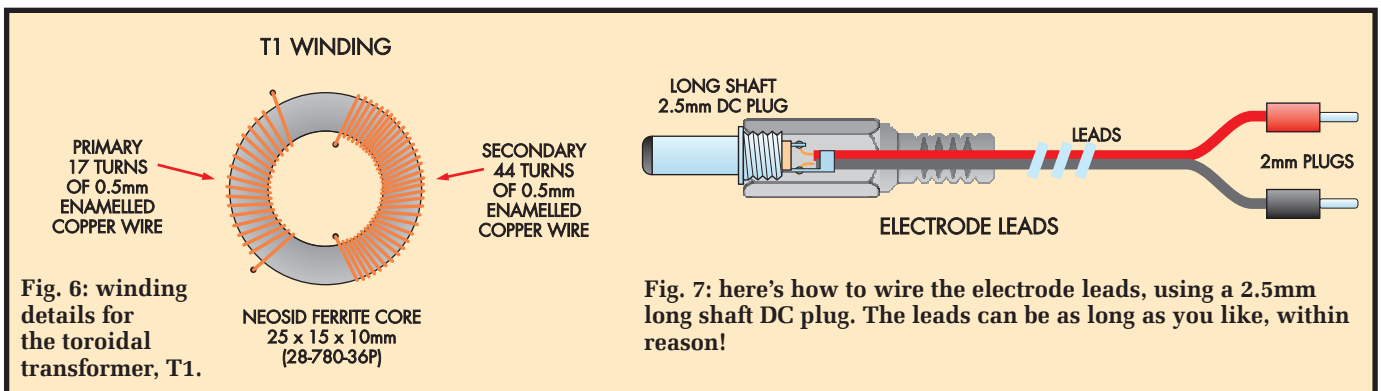


Fig. 6: winding details for the toroidal transformer, T1.

Fig. 7: here's how to wire the electrode leads, using a 2.5mm long shaft DC plug. The leads can be as long as you like, within reason!

specified are long-life components suitable for potentiometer use.

All components must be placed so that they sit no more than 13mm above the top surface of the PC board. This means that one electrolytic capacitor is mounted on its side and the two

MOSFETs (Q1 and Q2) are bent over at right angles. In contrast, the switches must be raised above the PC board using cut down IC sockets, to make them accessible when the lid is fitted to the case.

Begin construction by checking the PC board for any defects such as

shorted tracks or breaks in the copper pattern. Repair these before assembly. The component overlay diagram is shown in Fig.5.

Insert the two PC stakes at the battery wiring points first. Next, insert and solder in all the resistors. You can use the accompanying resistor colour code table when selecting the resistors and it is also a good idea to check each value using a digital multimeter before it is installed.

Next, install the six diodes and two Zener diodes, making sure that the correct diodes are used in each place. Each of the ICs is an 8-pin DIP device, so don't mix them up when installing them.

The capacitors can be mounted next. The MKT polyester types have codes stamped on them to indicate their value and we have provided a table of the different codes. The electrolytic types must be oriented as shown and the 10 μ F capacitor adjacent to VR3 must be laid on its side.

The switches are mounted on cut-down IC sockets. The sockets are made by cutting up IC sockets into strips of five contacts using a sharp utility knife. The two unused pin contacts for each switch socket are removed. Insert and solder the sockets in place and then insert the switches.

The trimpots are soldered next, taking care to place the correct value of trimpot in each position. The 10mm spindles are inserted with the pointer facing the centre pin of the trimpot. Check that the rotation to the left and right is correct, with the pointer rotation the same from each side of centre. Remove and readjust the spindle orientation if this is incorrect.

As mentioned earlier, the leads of Q1 and Q2 are bent over at right angles as shown in the photographs. They must lie over the adjacent components so that their bodies are no higher than 13mm above the PC board.

Fig.6 shows the winding details for the toroidal transformer T1. It is wound with 0.5mm enamelled copper wire. It is important to get the

Parts List – Pocket TENS Unit

- 1 PC board code 635 available from the *EPE PCB Service*, 85 x 64mm
- 1 plastic case, 134 x 69 x 23mm, with 9V battery compartment
- 1 front panel label, 49 x 113mm
- 1 TENS electrode set (available from pharmacy suppliers and chemists)
- 1 Neosid ferrite core, 25 x 15 x 10mm (28-780-36P)
- 1 9V battery clip lead
- 1 9V alkaline or 9V NiMH rechargeable battery
- 1 2.5mm PC-mount DC socket
- 1 2.5mm DC line plug with long shaft
- 2 2mm plugs for electrodes
- 1 1m length of figure-8 light duty flexible cable
- 2 PC-mount SPDT slider switches (S1,S2)
- 2 DIP-8 low-cost IC sockets to mount switches
- 3 15mm spindles for VR1, VR3 and VR4
- 2 200mm long cable ties
- 2 PC stakes
- 4 M3 x 6mm screws
- 1 2m length of 0.5mm enamelled copper wire
- 1 12mm length of 9.5mm heatshrink tubing
- 1 15mm length of 3.3mm heatshrink tubing

Semiconductors

- 1 MC34063 DC-DC converter (IC1)
- 1 IR2155 MOSFET driver (IC2)
- 1 LM334Z current source (IC3)
- 1 7555 CMOS timer (IC4)
- 2 MTP6N60E N-channel MOSFETs or similar, rated at 200V 1A minimum (Q1,Q2)
- 1 39V 1W Zener diode (ZD1)
- 1 10V 1W Zener diode (ZD2)
- 2 1N4936, UF4004 fast diodes (D1,D2)
- 3 1N4148 switching diodes (D3-D5)
- 1 1N5819 Schottky 1A diode (D6)
- 1 3mm red LED (LED1)

Capacitors

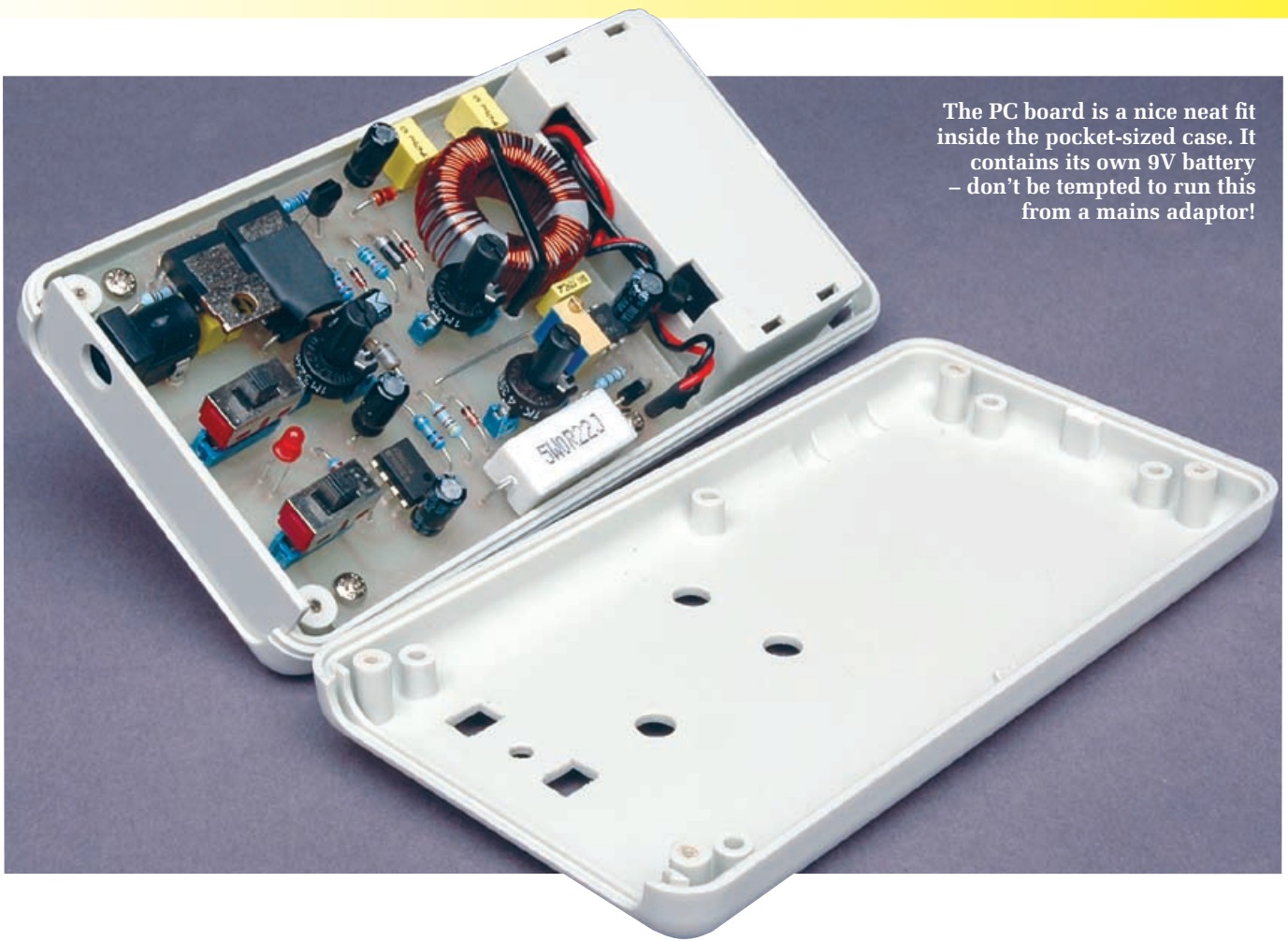
- 1 100 μ F 16V PC electrolytic
- 3 10 μ F 16V PC electrolytic
- 1 4.7 μ F 63V PC electrolytic
- 3 470nF MKT polyester
- 1 330nF MKT polyester
- 1 100nF MKT polyester
- 1 2.2nF MKT polyester

Resistors (0.25W 1%)

- 1 150k Ω 1 100k Ω 1 47k Ω 1 10k Ω 1 2.2k Ω
- 1 1k Ω 1 180 Ω 1 150 Ω 1 27 Ω 1 12 Ω
- 1 0.22 Ω 5W
- 2 1M Ω horizontal trimpot (Piher PT10MV10 105A 202E) (VR1,VR3) (or 2M Ω for VR3 for a 2.3Hz minimum rate)
- 1 100k Ω multi-turn top adjust trimpot (VR2)
- 1 1k Ω horizontal trimpot (Piher PT10MV10 102A 202E) (VR4)

Capacitor Codes

| Value | μ F Code | IEC Code | EIA Code |
|-------|----------------|----------|----------|
| 470nF | 0.47 μ F | 470n | 474 |
| 330nF | 0.33 μ F | 330n | 334 |
| 100nF | 0.1 μ F | 100n | 104 |
| 2.2nF | 0.0022 μ F | 2n2 | 222 |



The PC board is a nice neat fit inside the pocket-sized case. It contains its own 9V battery – don't be tempted to run this from a mains adaptor!

winding direction and number of turns correct.

Start by winding on 44 turns for the secondary in the direction shown. The primary is also wound in the direction shown, with 17 turns. Strip the enamel insulation from the wire ends before soldering them to the PC pads. Then secure the finished toroid to the PC board with a cable tie, see Fig.5.

Indicator LED1 is mounted with the top of its lens 15mm above the PC board. Make sure its orientation is correct. Attach the PC board to the base of the case with the four M3 screws

directly into the integral standoffs in the case.

A front panel label can be attached to the lid of the case and the holes drilled and filed to shape for the two slide switches, the 3mm LED and the three trimpot spindles.

Drill a hole in the end panel for the output socket to allow access for the DC plug.

The battery clip wires are fed through from the battery compartment side via the holes in the box. Secure these wires with a cable tie and solder them to the PC stakes,

then use heatshrink tubing (the small diameter length cut in half) to cover the PC stakes and wire.

Note that MOSFET Q2 also has its tab covered in heatshrink tubing to avoid its tab shorting to the tab of Q1.

Testing

Fit the battery and plug in the DC socket with the backing piece removed. Connect a multimeter (set to the 200V DC range) between the outside terminal of the plug (–) and the tab of Q1.

Switch on power and check that LED1 lights and that there is a voltage reading. Set the voltage pot VR1 fully clockwise and adjust trimpot VR2 for a reading of +80V.

If you are not able to obtain the correct voltage, check that the transformer is wound correctly. In particular, check the winding directions for each winding.

Check that the voltage at pin 1 of IC2 is around +10V DC. Set the pulse width pot VR4 fully clockwise and select the continuous mode.

Connect your multimeter set for AC volts across the DC socket terminals.

Resistor Colour Codes

| No. | Value | 4-band Code (1%) | 5-band Code (1%) |
|-----|-------|----------------------------|--------------------------------|
| 1 | 150kΩ | brown green yellow brown | brown green black orange brown |
| 1 | 100kΩ | brown black yellow brown | brown black black orange brown |
| 1 | 47kΩ | yellow violet orange brown | yellow violet black red brown |
| 1 | 10kΩ | brown black orange brown | brown black black red brown |
| 1 | 2.2kΩ | red red red brown | red red black brown brown |
| 1 | 1kΩ | brown black red brown | brown black black brown brown |
| 1 | 180Ω | brown grey brown brown | brown grey black black brown |
| 1 | 150Ω | brown green brown brown | brown green black black brown |
| 1 | 27Ω | red violet black brown | red violet black gold brown |
| 1 | 12Ω | brown red black brown | brown red black gold brown |

You should measure about +18V AC, indicating that switching is taking place.

Note that this is only an indication of the output, as some multimeters may give different readings. The readings should alter with different control settings. With intermittent mode selected, you should see the voltage changing from 0V to a higher reading.

If you have access to an oscilloscope, then the output pulses can be observed to verify that the pulse width and frequency are to specification.

Using TENS

Make up electrode leads using the 2.5mm DC plug and the two 2mm plugs. Now connect to the electrodes. The electrode sockets may need to be slightly crimped with pliers to close up the socket hole. This will hold the 2mm plugs more securely.

The electrodes are usually supplied with an adhesive back that allows them to be easily attached to the skin. If the adhesive dries out, a smear of personal lubricant will be helpful.

The electrodes can then be attached to the skin using any of the variety of tapes or bandages used to secure wound dressings. Attach the electrodes in position on either side of the pain source or possibly on the back for pains in the leg/foot – to confuse the nerves. A useful chart showing typical TENS pad locations may be found at www.vitalityweb.com/backstore/tensplacement.htm

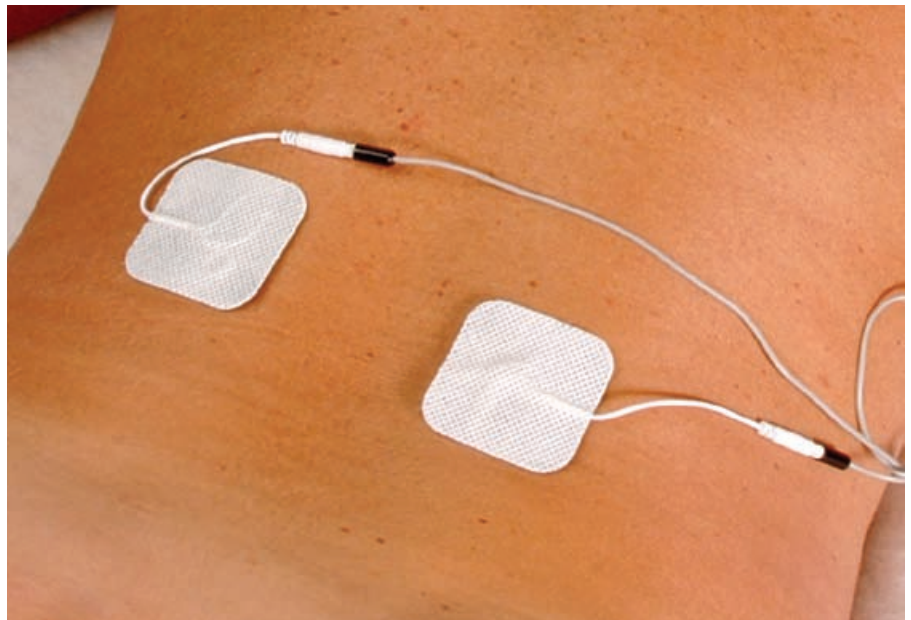
Before switching on the TENS unit be sure that the output voltage is turned down to the minimum.

Wind the voltage up until a tingling sensation can be felt and adjust the pulse rate and width for the desired effect. The voltage will need to be wound up during the period of treatment to compensate for the body's adaptation to the stimulation.

The intermittent selection is used if the treatment period is long (normal treatment sessions are typically for 20 minutes) or where the user finds the continuous effect to be waning.

It is possible that the TENS pads will irritate the skin, not (usually) so much from the TENS itself but the adhesive used on the pads. If so, we suggest trying a different brand or type of pad.

There is a wealth of information



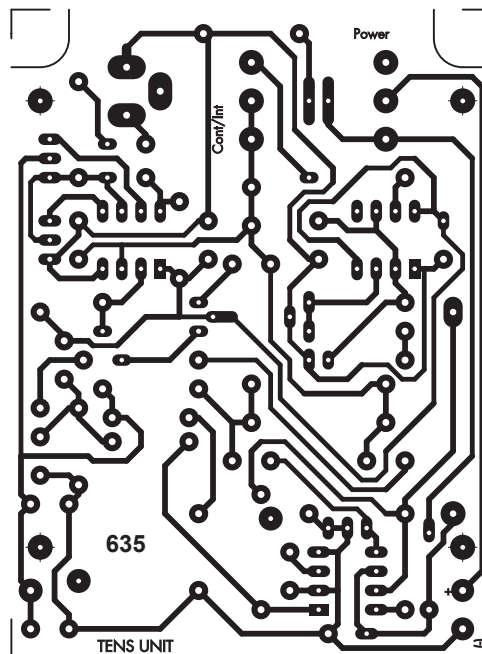
TENS pads are normally self-adhesive and, with care, can be used many times. When not in use, they should be stuck onto the backing sheet they came with. The most usual position for pads is each side of a painful area, bearing in mind the warnings published in this article.

on the internet about TENS units and their use.

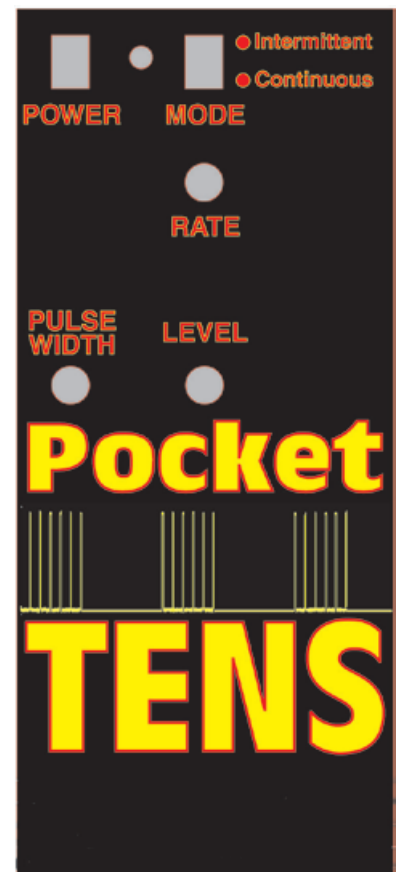
Like any treatment regimen, we suggest you ask your General Practitioner for advice before commencing treatment with the TENS unit. Remember,

TENS does not treat any underlying condition; it merely masks the pain and makes it more bearable. **EPE**

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Figs 8 and 9: same-size artwork for the PC board and front panel. A photocopy of the front panel can also be used as a drilling template for the case.



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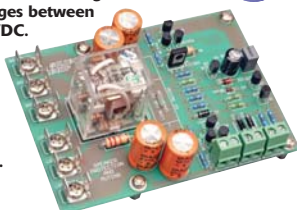
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Protects your expensive speakers against damage in the event of catastrophic amplifier failure such as a shorted output transistor. In addition, the circuit also banishes those annoying thumps that occur when many amplifiers are switched on or off, especially when the volume is set to a high level. The design also incorporates an optional over temperature heat-sensor that will disconnect the speakers if the output stage gets too hot. Configurable for supply voltages between 22VDC-70VDC.

Supplied with a silk screened PCB, relay and all electronic components.



Water Level Indicator Kit

KC-5449 £10.25 + post & packing

This simple circuit illuminates a string of LEDs to quickly indicate the water level in a rainwater tank. The more LEDs that illuminate, the higher the water level is inside the tank. The input signal is provided by ten sensors located in the water tank and connected to the indicator unit via-light duty figure-8 cable. Kit supplied with PCB with overlay, machined case with screenprinted lid and all electronic components.

• Requires: 8mm (OD) PVC hose/pipe (length required depending on depth of tank)

Requires 9-12VDC or AC wall adaptor (Maplin JC91Y £14.99)



Beat water restrictions with a water tank and this great kit!

4 Channel Guitar Amplifier Kit

KC-5448 £28.75 + post & packing

The input sensitivity of each of the four channels is adjustable from a few millivolts to over 1 volt, so you can plug in a range of input signals from a microphone to a line level signal from a CD player etc. A headphone amplifier circuit is also included for monitoring purposes. A three stage EQ is also integrated, making this a very versatile mixer that will operate from 12VDC. Kit includes PCB with overlay and all electronic components.



Stereo VU and Peak Meter Kit

KC-5447 £20.50 + post & packing

Accurately monitor audio signals to prevent signal clipping and ensure optimum recording levels. This unit is very responsive and uses two 16-segment bargraphs to display signal levels and transient peaks in real time. There are a number of display options to select, and both the signal threshold and signal level calibration for each segment are adjustable. Kit supplied with PCBs, LCD and all electronic components. Accuracy within 1dB for signals above -40dB.

• Case not included use HB-6082 £2.95



Requires 9-12VDC wall adaptor (Maplin #JC91Y £14.99)

IR Remote Control Extender MKII

KC-5432 £7.25 + post & packing

Operate your DVD player or digital decoder using its remote control from another room. It picks up the signal from the remote control and sends it via a 2-wire cable to an infrared LED located close to the device. This improved model features fast data transfer, capable of transmitting Foxtel digital remote control signals using the Pace 400 series decoder. Kit supplied with case, screen printed front panel, PCB with overlay and all electronic components.

Requires 9VDC wall adaptor (Maplin #GS74R £10.99)

2 Channel USB Oscilloscope

QC-1930 £83.75 + post & packing

Using Plug 'n Play USB technology and providing full optical isolation from the computer, this oscilloscope is easy to setup and use, as well as providing protection for the computer. The software is a fully featured chart recorder, function generator, logic generator, logic analyser, and spectrum analyser all in one easy to use package. See website for specifications.



Jacob's Ladder High Voltage Display Kit

KC-5445 £11.75 + post & packing

With this kit and the purchase of a 12V ignition coil (available from auto stores and parts recyclers), create an awesome rising ladder of noisy sparks that emits the distinct smell of ozone. This improved circuit is suited to modern high power ignition coils and will deliver a spectacular visual display. Kit includes PCB, pre-cut wire/ladder and all electronic components.

• 12V car battery or >5 amp DC power supply required

Improved model for 2007

Improved model for 2007



Fuel Cut Defeat Kit

KC-5439 £6.00 + post & packing

This simple kit enables you to defeat the factory fuel cut-out signal from your car's ECU and allows your turbo charger to go beyond the typical 15-17psi factory boost limit.

Note: Care should be taken to ensure that the boost level and fuel mixture don't reach unsafe levels. Kit supplied with PCB, and all electronic components.

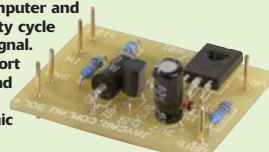


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Variable Boost Kit for Turbochargers

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Everyday Practical Electronics Feature Kits

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested down under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

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As published in this month's Everyday Practical Electronics Magazine!

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As published in Everyday Practical Electronics Magazine June 2007



RFID Security Module Receiver Kit

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As published in Everyday Practical Electronics Magazine August 2007



SMS Controller Module Kit

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* Requires a Nokia data cable which can be readily found in mobile phone accessory stores.

As published in Everyday Practical Electronics Magazine April 2007



Lead Acid Battery Zapper Kit

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PIC N' MIX

MIKE HIBBETT

Our periodic column for your PIC programming enlightenment

Single-wire communication protocol interface for PICs

THE 1-wire interface is a communication protocol originally designed by a company called Dallas to simplify the connection of multiple peripheral devices to a microcontroller. Dallas were bought out by Maxim, so although the protocol is widely referred to as the 'Dallas 1-wire interface' it's now Maxim who own the name and maintain the development of the protocol.

The correct name for the interface is 'MicroLan', but the term 1-wire seems to have stuck. MicroLan best describes a collection of devices on a 1-wire bus but it is quite normal to interface to a single device, and that is what we will be demonstrating in this article.

The protocol was designed as a way to add memory to a microcontroller using a single port pin – very efficient on I/O, although much slower of course. Over time, people have found new and quite original ways in which to use the bus, and it has now developed into a multi-device, multi-function bus not dissimilar to the Philips I²C bus in its application. Devices that conform to the 1-wire standard include EEPROM memory, temperature sensors, RAM and more; in a later article we will see just how easy it is to create your own custom, compact peripherals.

Physical interface

The physical interface is not really a single wire but two, since you must provide a ground connection. The single data signal, however, provides receive data, transmit data and power to multiple devices on the bus – quite an achievement! Fig.1 shows a simplified version of the communication flow.

The host sends a short negative pulse on the wire to signal the start of each bit, and the device responds by pulling the bus low for a zero or leaving high for a one. Each bit is transmitted in a 60 μ s 'window'. It's a strange mix between synchronous and asynchronous communication.

The data signal is pulled up to +5V by a resistor, which provides the power source, and communication is achieved by leaving the data pin pulled high for a logic '1', and actively pulling it low for a logic '0'. This enables multiple devices to exist on the bus

without any possible damage occurring should several devices attempt to communicate simultaneously. An example physical connection is shown in Fig.2. The choice of pull-up resistor will depend on the length and loading of the bus, and is specified as being between 1.5k and 5k ohms. For a short, typical application a value of 2k Ω should be sufficient.

many developers, since it simplifies the mechanical interface required to connect an external device onto the bus. The most popular physical realisation appears to be the iButton product range which encapsulates a simple IC into a steel case not dissimilar to a lithium coin cell. Wrapped up into a plastic key-fob attachment, these have proven ideal for security access control systems, vending machine 'electronic cash' tokens and various car alarm systems.

The author's own car uses an iButton to turn the alarm on or off. (That iButton was not hacked while developing this article – didn't want to risk being left without a driveable vehicle!) An example device is shown in Fig.3,

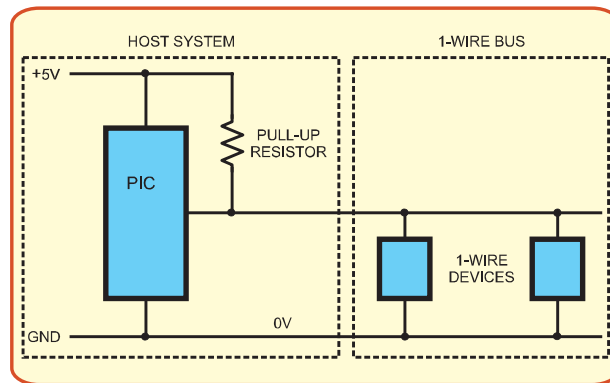


Fig. 2. Typical Connection

1-wire devices are allowed to operate over the 2.8V to 6.0V range, although the data pull-up is normally brought to 5.0V to provide power to the remote device and give good signal integrity and resilience to noise. The devices and bus specification has been designed so that the bus can run over very long lengths, hundreds of metres in some cases, so you are not limited to simple IC to IC connection on a PCB.

iButton

The simple two-wire interconnection seems to have scratched an itch for



Fig. 3. Example device

which consists of an iButton in a keyfob holder. The iButton sockets are available with built in protocol converters that can provide an RS232 or USB interface to the host system, significantly simplifying the design of a 1-wire system.

Because access control and vehicle alarm systems are a relatively large market, Maxim produce a special, ultra-low cost IC which consists of nothing more than a 64-bit read-only memory register

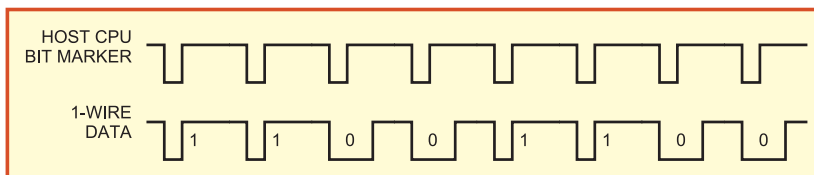


Fig. 1. Communication

containing a unique serial number. Devices like these cost less than a pound even when bought in small quantities from the usual big distributors.

The iButton devices and receiving sockets are readily available and very cheap, making experimentation and practical system development a breeze. If you are building your own hardware, the two-conductor interface opens up a number of easy to use solutions, such as fitting into 2.5mm jack plugs, reducing the cost of developing a system to pennies.

Although we are normally interested in interfacing devices like these to microcontrollers, a PC interface may also be of interest, and is certainly useful during system debugging to read and write data to a device. A very simple interface utilising a PC's RS232 interface and commonly available passive components has been proposed by Dallas, and is shown in Fig.4. This interface uses a 'virtual ground' signal to the device which must not be connected to real ground – doing so could destroy your PC's RS232 interface. Several other simple interface designs are available, and can be found in the Dallas Tech Brief 1 datasheet available from the Maxim website – see Ref.1 for details. The author found the simple interface perfectly usable, however.

Interface range and cable choice

An achievable cable length of 300 metres has been tested by Dallas, but you will need to start adding hardware at the host processor end to control the slew rate (signal rise and fall time) of signals on the bus to achieve this, due to the increased loading of the cable. Over short distances (e.g. a few metres) and with only a few devices connected to the bus, signal conditioning is not such an issue and you can effectively ignore it and use a very basic bus circuit with just a pull-up resistor. The article in Ref.1 goes into the detail of slew rate control in considerable detail for those of you with an electronics background and an interest in very long cable runs.

The use of twisted pair wiring is important to avoid data corruption from noise in the environment. You can twist your own, or use normal telephone cable. CAT-5 network cable is the best solution, but will be rather expensive for long distances and somewhat defeats the ideal of the 1-wire interface: there are eight wires in a CAT-5 cable! If you are working with short distances (say a few

metres) then the requirements are much simpler and twisted wires are not likely to be necessary.

Static protection

As the 1-wire devices are likely to be used in key-fobs with unrestricted physical access to the data contact, the devices must be much more resilient to damage from static electricity discharge than normal ICs. (Static electricity is the charge that builds up when we walk across synthetic carpets and then discharges on metal door handles with a painful zap!) It's quite normal for the human body to build up a charge that is unnoticeable to us (several hundred volts, say) but which would still cause permanent damage to an IC.

All 1-wire devices are designed to withstand 10kV static electricity discharges, which sounds a lot but may itself not always be sufficient – especially in hot, dry countries. If you are using an external device, such as an iButton or similar home made plug, additional ESD protection should be provided at the host end. We have described ESD protection in a previous *Pic n' Mix* article but if you are simply experimenting with 1-wire devices or have shrouded device connections, this should not be an issue. If you decide to create your own 1-wire device using a standard microcontroller (as we will be doing in next month's article) then you must provide additional ESD protection if the pins on your device are going to be accessible. More on that next month.

Device communication

Communication with the devices is quite straight forward, similar to PC and SPI, but with a few extra commands that make discovering which devices are attached to the bus possible (more on that later). There are some interesting, practical issues to do with working with devices which may be connected manually to the bus, as in an access control system. When connected to the bus, a device must power up, be detected on the bus and then communication exchanged between the device and the host.

Humans, however, are not very good at making a single, reliable, noise free connection. Imagine sitting in your car and pressing an iButton on your key fob onto a receiver on the dash board; there will be partial connections and lots of debounce noise before a suitable connection is made. And the communication must be quick: you don't want to have to wait several seconds before the action is completed.

These problems are dealt with in several ways. First, the communication protocol is quite quick – the data rate is 16kbits/s, and the amount of information that can be exchanged is kept low. Within software, you will be responsible for

providing protection against intermittent connection. This is really just a case of making sure that the data has been written. A simple algorithm that uses a temporary buffer for the data to be written is:

1. Write new data to temp register
2. Set a 'write in progress' bit
3. Write temp register to update location
4. Clear 'write in progress' bit

Then the device can, on power-up, check the status of the 'write in progress' bit. If it is set, then you repeat the process above from step 3.

Needless to say, this only applies to non-volatile memory, and the temporary register must be in non-volatile memory too. For some standard data write commands the 1-wire specification already allows some level of write integrity by using a temporary write buffer or scratchpad to the IC itself.

Language and programming

Although we will be providing a full set of example software to communicate with a 1-wire device, you are not limited to writing in assembly language. The 1-wire interface has been implemented in BASIC on some PIC development systems which can significantly reduce your development time, if the BASIC language is suitable for your application.

Let's take a look at the 1-wire protocol, as described in the datasheet for the DS2430A EEPROM. This part is readily available in a TO92 package and also forms the heart of the iButton device, so the technical description matches both parts. This part is available from Farnell with the part code 9724834, and no doubt from other suppliers.

In common with most 1-wire parts, the DS2430A is equipped not only with its main function (EEPROM in this case) but also with some basic read only memory and a small, separate area of flash to store an application register.

The read only memory consists of 64 bits of 'identification ROM' which is unique to each 1-wire part. Eight bits are used as a 'family' ident, which specifies the type of the part, 48 bits are the unique serial number for the IC and the remaining 8 bits are a CRC – a check byte which helps you determine, on reading the data, that you have read it correctly. Remember, these devices are designed to be used in applications where the IC is being pressed onto some kind of connector, so debouncing and noise can be an issue. These 64 bits are stored in read only memory and therefore cannot be changed.

The 'application register' is a general purpose 64-bit memory area that you can use to store any information. Unlike the main EEPROM, this register can be written to only once – making it useful for storing a product serial number or calibration data, for example.

Both the application register and the main EEPROM have equivalent RAM-based 'scratch' registers. These are buffers into which you write the data that you wish to store in the main memory. Having

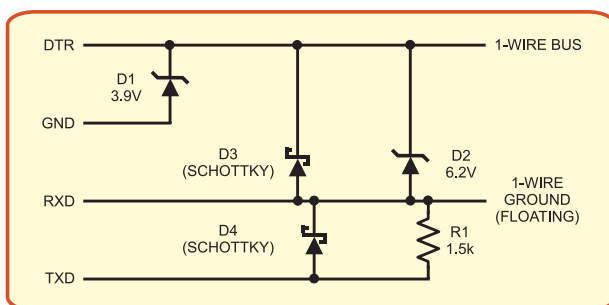


Fig. 4. PC Interface

written into the scratch RAM, you then send a special command to cause the data to be written to the appropriate memory area. There are no 'byte write' commands, although you can specify a starting address in the buffer from which to start writing data. This way you can write just a few bytes or the full 32.

On the DS2430A, the EEPROM is 256 bits, or 32 bytes. Not a lot, but remember these devices are mainly used for identification purposes. Other 1-wire parts have larger memories and alternative functions.

On command

As you might guess, these are not simple memory devices like I²C EEPROM. There is quite a wide range of commands that can be executed, and a strict order in which they should be used. These commands are separated into two groups: ROM commands and Memory commands. As will become clear shortly, a ROM command must be executed first before a memory command. The commands are:

Skip ROM: This is the simplest ROM command, which tells the attached 1-wire device to get ready for a memory command.

This command can only be performed if you know that only a single 1-wire device is on the bus, since otherwise, all devices on the bus will respond to the subsequent command simultaneously and you will get data corruption. Its use does simplify the communication when it is known that only one device can be fitted onto the bus, however, and should be used in that case.

Read ROM: Instructs the 1-wire device connected to the bus to start sending out its unique serial number, which enables your software to identify the type of device that is connected, and its serial number.

This command can only be used when it is known that only a single 1-wire device is on the bus. If there are more than one then they will all start to send their data, resulting in data corruption.

Match ROM: Used to select a specific device on the bus when more than one may be present. The application software sends the 64-bit identification value of the device to be interrogated as part of the command.

Search ROM: Enables the application software to gather the identification values of all devices connected to the bus. Very useful in circumstances where the exact configuration is unknown, but can potentially take many seconds to identify all devices on a large network.

Once a ROM command has been sent, the application can then send one (and only one) memory command. The Memory commands available are:

Write Scratchpad: Used to transfer up to 32 bytes of data to the device's scratchpad RAM in preparation for transfer to EEPROM.

Read Scratchpad: Reads the contents of the EEPROM scratchpad. The application cannot read the contents of EEPROM directly; it must first copy the data into the scratchpad, and then use this command to transfer the data out to the host processor.

Copy Scratchpad: Transfers the contents of the scratchpad into the EEPROM. Following the issue of this command the data line should be left high (i.e. do not use the bus) for 10ms to permit the write to occur.

Read Memory: Transfers data from the EEPROM into the scratchpad. The application specifies a starting address (0 to 0x1F) which determines the first address within EEPROM from which to perform the read.

Write Application Register: Transfer up to eight bytes of data to the device's application register scratchpad RAM memory in preparation for transfer to the application register.

Read Application Register: Read data from one of two locations: before the application register has been written to and locked, it returns the content of the scratchpad memory. Once the application has been locked, the data returned is from the application register directly.

Lock Application Register: Copies the contents of the Application Register scratchpad to the Application Register. Having written it once, the register is locked and no further writes can be made to it.

Status Register: The status register is an 8-bit variable that indicates whether the Application Register has been programmed.

A value of 0xFF means unprogrammed, while 0xFC means that the 'Lock Application Register' command has been performed.

Deriving power

Each device on the bus gets its power from the data line, using an internal diode and storage capacitor to maintain +5V, even when the data signal is driven low. You can use this technique yourself (and we do so in the example device design which follows next month) to power your own devices. You have to be careful with the choice of capacitor, since larger values will add to the overall bus capacitance (even though the capacitor is on the 'other' side of the diode to the bus.) Determining a safe value – as low as possible – will also be discussed in next month's article. There is, of course, nothing to stop you providing local power to your device if it draws too much current, either through a battery, mains derived or other technique.

In next month's article we will discuss the EPE 1-wire software library that has been developed for this series of articles and demonstrate an example home-brewed 1-wire device.

Brain teaser

We have often alluded to the vast range of PIC devices available from Microchip. This month's brain teaser is, excluding different package types and low voltage parts, how many different devices are available in total in the PIC10, PIC12, PIC16 and PIC18F product ranges. As a bonus, how many other sources are there of PIC compatible micro-controllers?

Once again, no prizes are available but an honorary mention in a later article for the most accurate (and possibly, amusing!). Submissions by email to mike.hibbett@gmail.com or in writing to EPE.

References

Ref.1. *MicroLan Design Guide Tech Brief 1*. www.pdfserv.maxim-ic.com/en/an/tb1.pdf

Ref.2. DS2430A Datasheet. www.maxim-ic.com

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PLEASE TAKE NOTE

Sorry to say that there were a couple of mistakes in last month's issue – notably a couple of page number references, some dreadful spelling in the Teach-In advert and some incorrect text in the 'Next Month' panel – the *Telephone Dialler* was actually published back in August '06.

IC3 was also missed off the parts list for the *V2 PC Scope* – it is a MAX118, 8-channel, 8-bit ADC as shown on the circuit diagram (Fig.1.)

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Flexitimer

An Easy-To-Programme Digital Timer

This multi-purpose timer is much more flexible than previous designs. You can programme it for a single time period ranging from one second to 99 minutes and 59 seconds, or a sequence of two such (independently programmed) time periods, or up to 99 cycles of one or two time periods. It's also easy to program.

By **JIM ROWE**

ELECTRONIC TIMERS have always been popular. In fact, there are so many applications for this kind of project that it's only scratching the surface to mention the following: parking meter reminders, EPROM erasure timing, darkroom printer/enlarger timing, PC board etch timing, battery charge timing, industrial process timing, chess and other board game timing, debate timing and even kitchen timing.

If you want to make a timer with the widest range of applications, it needs to have at least two independently adjustable or 'programmable' timing periods. Ideally, it also needs to be flexible in terms of the number of time periods and/or time period sequences (or cycles) that can be programmed.

Some applications need just a single time period, timed in 'single shot' fashion, while others need a single sequence of one time period followed

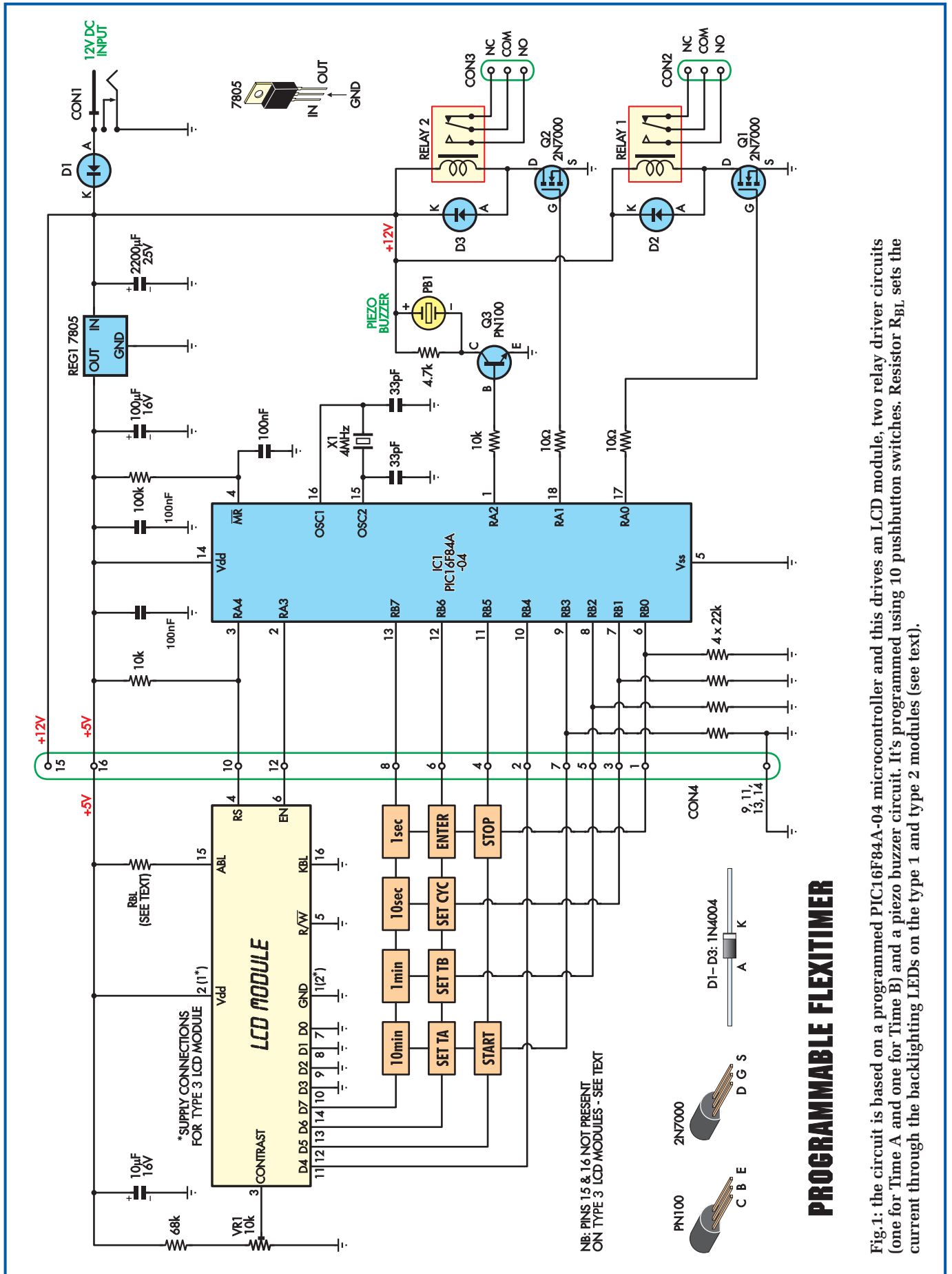
by a second (and probably different) time period. Still other applications may need a sequence of two time periods repeated many times, say for a total of 20 cycles.

Previous timer designs have provided most of these features but at the cost of operating and programming complexity. This made them a bit daunting to use and limited their popularity as a result.

By contrast, this timer is programmed in exactly the same intuitive fashion as some microwave ovens. First, it has tens and units buttons to allow you to key in the exact number of minutes and seconds for the time period(s) you want and also the number of timing cycles you want. There are also buttons to start and stop the timer manually and to save its settings for the next time it's used and so on.

Main features

Here's a quick summary of the flexitimer's capabilities. First, it provides



Parts List - Flexitimer

- 1 plastic box, 158 x 95 x 58mm
- 4 6mm-long untapped spacers
- 5 12mm-long untapped spacers
- 1 M3 x 6mm machine screw
- 4 M3 x 12mm machine screws, csk head
- 5 M3 x 20mm machine screws, csk head
- 11 M3 nuts and star lockwashers
- 1 75mm length of 16-way IDC ribbon cable
- 2 16-way IDC ribbon connectors

Main Board

- 1 PC board, code 631, available from the *EPE PCB Service*, size 141 x 83mm
- 1 12V piezo buzzer (WD1)
- 1 4MHz quartz crystal (X1)
- 2 12V SPDT relays to suit
- 1 PC-mount 2.5mm DC input connector (CON1)
- 2 PC-mount 3-way terminal blocks (CON2, CON3)
- 1 PC-mount 16-way DIL pin header (CON4)
- 1 18-pin DIL IC socket
- 1 TO-220 heatsink, 6021 type, 30 x 25 x 13mm

Semiconductors

- 1 PIC16F84A (IC1) programmed with PICTIME2.HEX firmware – see text. Preprogrammed chips are available from Magenta Electronics, see their advert in this issue.
- 1 7805 5V regulator (REG1)
- 2 2N7000 MOSFETs (Q1,Q2)
- 1 PN100 NPN transistor (Q3)
- 3 1N4004 1A diode (D1,D2,D3)

Capacitors

- 1 2200 μ F 25V radial elect.
- 1 100 μ F 16V radial elect.
- 3 100nF multilayer monolithic
- 2 33pF disc ceramic

Resistors (0.25W 1%)

- 1 100k Ω 1 4.7k Ω
- 4 22k Ω 2 10 Ω
- 2 10k Ω

Display Board

- 1 PC board, code 632, 633 or 634 to suit LCD – see text, available from the *EPE PCB Service*, size 132 x 84mm
- 1 LCD module, 2 lines x 16 chars (see text)
- 1 14-way or 16-way length of SIL or DIL pin header strip, to suit LCD module used
- 10 PC-mount SPST pushbutton switches (S1 to S10)
- 1 90° PC-mount 16-way DIL header (CON5)
- 4 M2.5 x 10mm machine screws, round head
- 4 M2.5 hex nuts and lockwashers
- 8 M2.5 flat washers
- 4 M3 hex nuts (used as spacers)

Capacitors

- 1 10 μ F 16V radial elect.

Resistors (0.25W, 1%)

- 1 68k Ω
- 1 12 Ω to suit type 2 LCD module (R_{BL}) – see text
- 1 18 Ω to suit type 1 LCD module (R_{BL}) – see text
- 1 10k Ω mini horizontal trimpot (VR1)

either one or two programmable time periods (Time A and Time B), each of which can be set independently to any time between one second and 99 minutes 59 seconds – with a resolution of one second.

Second, you can set it for just a single Time A period, or a single (Time A + Time B) sequence, or for multiple Time A or (Time A + Time B) cycles. In fact, there can be anything from 2-99 such cycles.

Third, the timer has two internal relays, one of which is activated during the Time A period and the other during Time B. Both relays have a set of mains-rated single pole, double throw (SPDT) contacts, so

they can be used either separately or together to switch a wide variety of loads.

Finally, the unit operates from 12V DC, which can come from either a battery or a plugpack power supply.

Programming

As mentioned earlier, the time periods and cycles are programmed very easily using four pushbuttons: one each for tens of minutes, units of minutes, tens of seconds and units of seconds. The '10-minute' and '1-minute' buttons are also used to programme the desired number of cycles, when you want more than a single cycle (the default).

Three further buttons allow you to set the current input as either Time A or Time B, or to set the number of cycles.

Another button (Enter) is then used to save all of the current time and cycle settings in the PIC's non-volatile memory, so that it 'remembers' them when it's powered up next time.

Finally, the Start and Stop buttons do exactly as their names suggest – ie, either start the timer operating or manually stop it if the need arises.

All of the timer settings and operations are displayed on a small 2-line x 16-character LCD module. This makes it really easy to operate.

How it works

Fig.1 shows the circuit details of the Programmable Flexitimer. All of the real work is done by microcontroller IC1, a PIC16F84A which is programmed with a dedicated firmware program called PICTIMER.HEX.

In operation, the microcontroller runs from a 4MHz crystal clock and does all of the timing by counting clock cycles – using a combination of both hardware and software counting. This gives a timing accuracy of better than $\pm 0.02\%$.

The 10 buttons used to programme the various settings and commands into the PIC microcontroller are connected in a 3 x 4 matrix configuration. As shown, the three rows are connected to the three most significant bits of IC1's Port B (RB7, RB6 and RB5), while the four columns go to the four least significant bits of this port (RB3, RB2, RB1 and RB0). This allows the microcontroller to scan all the keys very efficiently and respond quickly when they are pressed.

The LCD module is directly driven by the microcontroller. It's connected to the four most significant bit Port B lines (RB7 to RB4) and to the two most significant bit Port A lines (RA4 and RA3).

The two Port A lines are used to enable the LCD controller input for writing (EN) and to select either its data or address/instruction registers (RS). By contrast, the four Port B lines are used as a data bus to feed display character codes and position addresses to the LCD controller, along with various other function commands.

Trimpot VR1 is used to adjust the display contrast. It does this by varying the DC voltage applied to pin 3 of the LCD module.

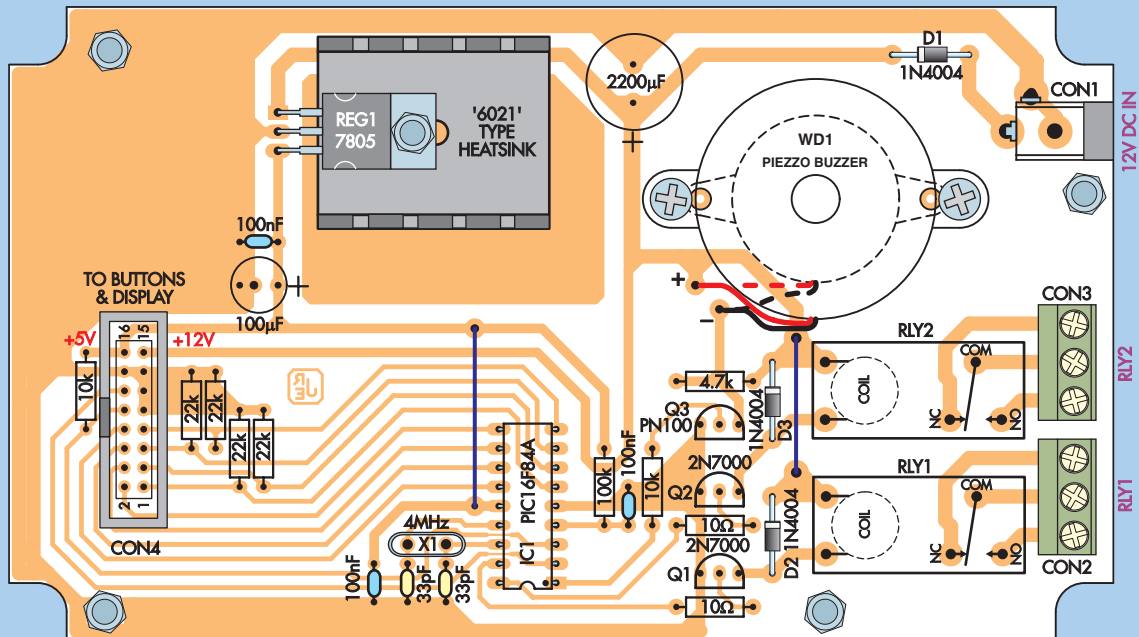
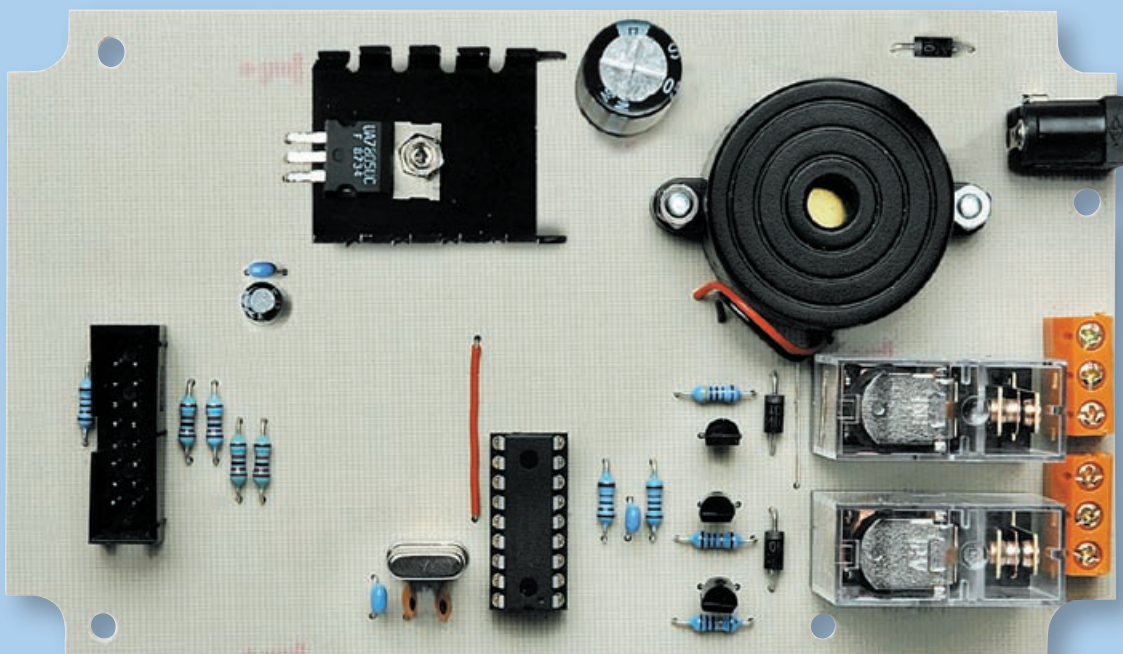


Fig.2: install the parts on the main PC board as shown here. Take care to ensure all polarised parts are correctly orientated and note that connector CON4 goes in with its keyway slot to the left.



A small heatsink is fitted to REG1, so that it can handle the current requirements of backlit LCDs.

The two least significant bit Port A lines (RA0 and RA1) function as outputs and are used to drive MOSFETS Q1 and Q2, which then control the two relays. When the unit is running, the microcontroller turns on Relay 1 (via Q1) during Time A and Relay 2 (via Q2) during Time B.

The remaining Port A output line (RA2) is used to control Q3, which in turn controls piezo buzzer WD1.

In operation, output RA2 briefly goes high and turns on Q3 to produce a short 'beep' at the end of the programmed time period(s) or cycles.

Power supply

Power for the unit comes from a 12V DC pluggack (or battery), with diode D1 providing reverse polarity protection. This then feeds regulator REG1 which provides a +5V rail to power IC1

and the LCD module. The relays and the buzzer (WD1) are powered directly from the +12V rail after diode D1.

Construction

Construction of the Programmable Flexitimer is easy, with all parts mounted on two PC boards – a main board coded 631 (141 × 83mm) and a separate display board (132 × 84mm). The latter carries the LCD and the

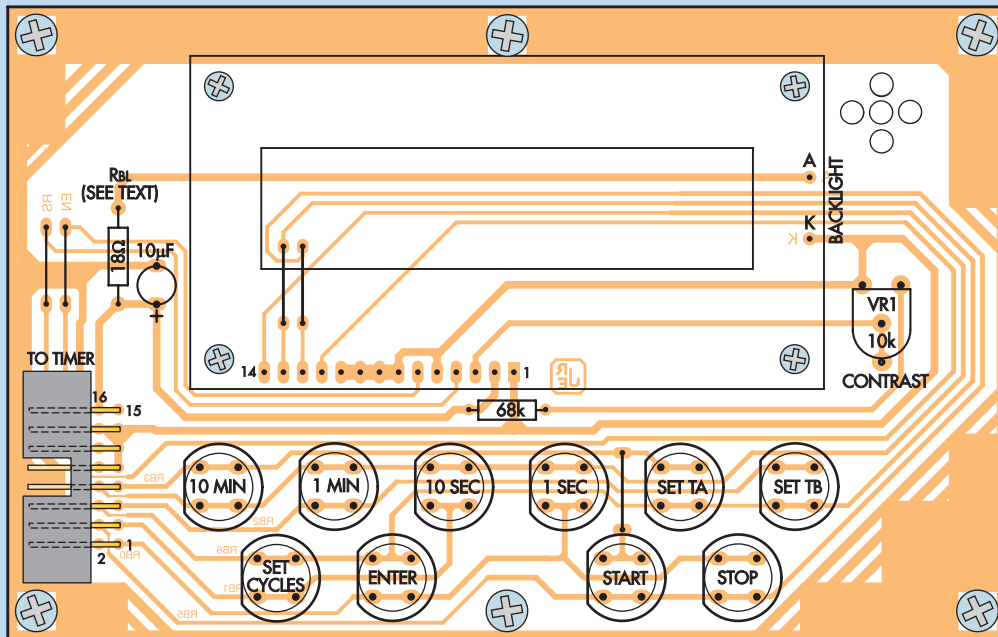


Fig.3: the display board layout for the display type 1 modules (PCB code 632). Install resistor R_{BL} (18Ω) only if you are using a backlit display and don't forget the backlight

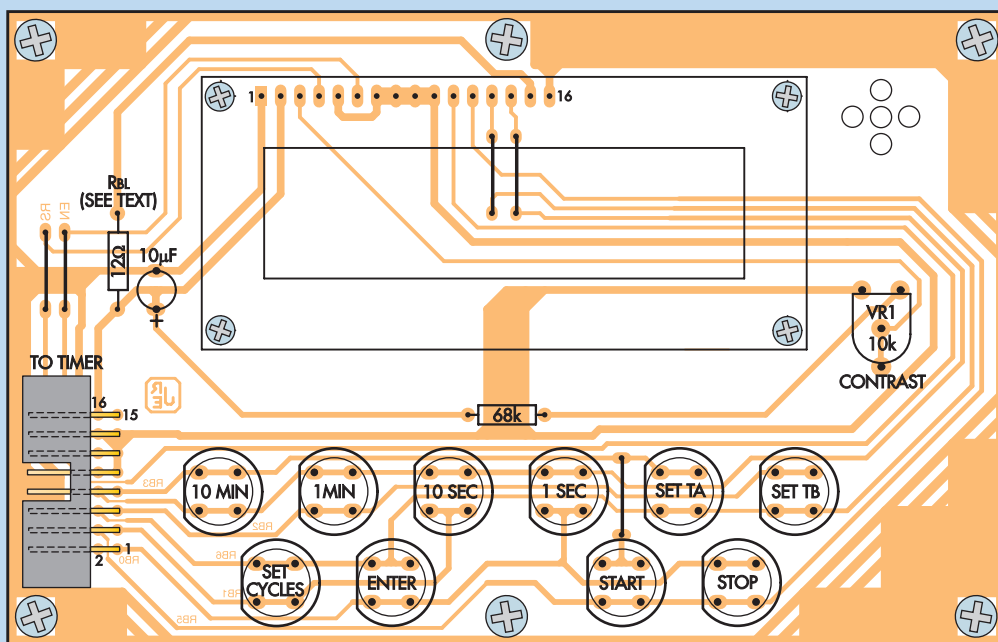


Fig.4: follow this display board layout if you are using a display type 2 module (PCB code 633). Again, resistor R_{BL} (12Ω) is installed only for the backlit display.

pushbutton switches, plus a few other minor parts. These boards fit inside a standard UB1 plastic box ($158 \times 95 \times 58\text{mm}$) and are interconnected by a short 16-way ribbon cable fitted with 16-way IDC connectors at each end.

The connections to the timer relay contacts are made via screw terminal blocks located at one end of the main board.

Note that there are actually three different versions of the display board,

to suit the three different LCD modules currently available. These are coded 632, 633 and 634 and one should be selected to suit the type of display used – see Figs 3 to 5.

Fig.2 shows the assembly details for the main board. Start by fitting the DC input connector CON1 (you may need to elongate the PC board holes slightly with a needle file before the connector lugs will pass through), then fit

the two screw terminal blocks (CON2 and CON3). Note that the latter must be fitted with their wire entry sides facing the edge of the board.

Next, fit the 16-way DIL pin header CON4, making sure its locating spigot slot goes towards the lefthand end of the board. That done, fit the two wire links, followed by the resistors and the three diodes (D1 to D3). Make sure that the diodes are correctly oriented.

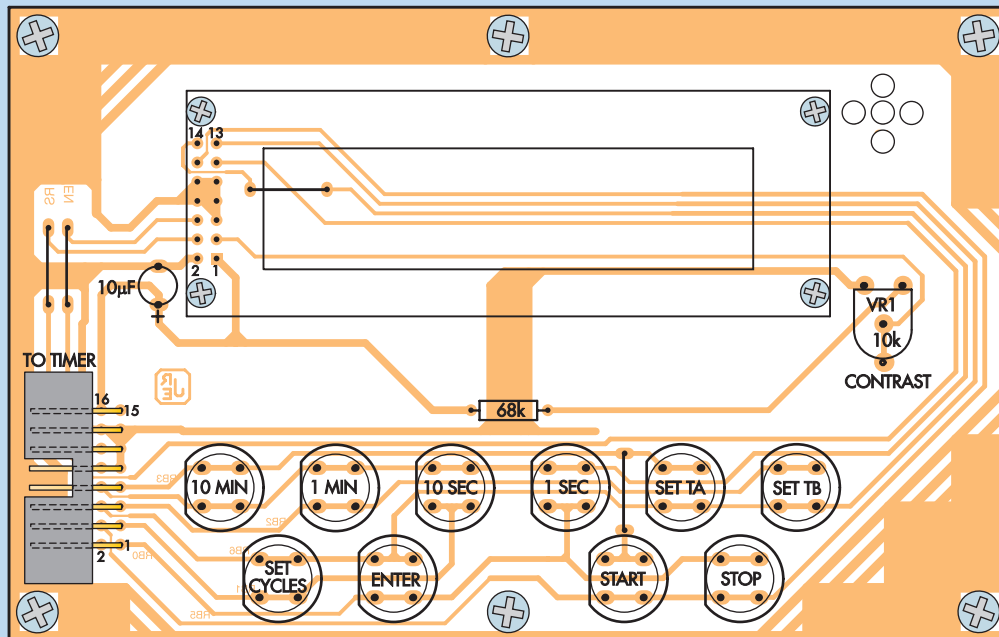
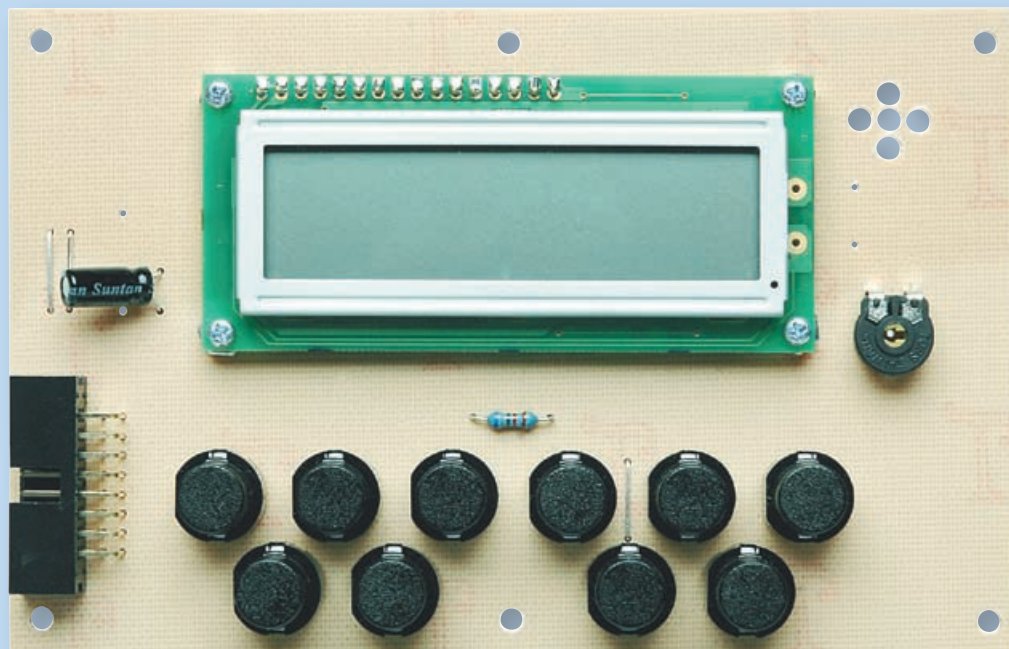


Fig.5: the display type 3 module (PCB Code 634) have only 14 pins and don't require an external resistor to set the current through the backlight LEDs.



This completed display board uses the type 2 module with no backlighting, so R_{BL} is left out. Take care to ensure that the flat side of each switch goes to the left.

The 4MHz crystal (X1), regulator REG1 and transistors Q1, Q2 and Q3 are next in line. Take care with the orientation of REG1 and the transistors and be sure to use the correct transistor type at each location.

Regulator REG1 is installed by first bending its pins downwards through 90° about 6mm from its body. It's then fitted to the PC board, along with its heatsink and secured using an M3 ×

6mm machine screw and nut, before soldering its leads. Smear its metal tab with heatsink compound before mounting it, to ensure good heat transfer.

The next step is to fit an 18-pin socket for IC1 – it goes in with the 'notch' end facing the adjacent edge of the board (see Fig.2). Follow this with the two relays and the piezo buzzer (WD1). There are two buzzer types commonly

available and the PC board caters for both. It's just a matter of fastening the supplied unit in position using two M3 × 12mm machine screws and nuts and soldering its leads to the board (red to '+', black to '-').

In either case, the buzzer's connection wires can be cut fairly short before soldering, to keep the assembly neat and tidy.

The small non-polarised capacitors can now be fitted, followed by the two

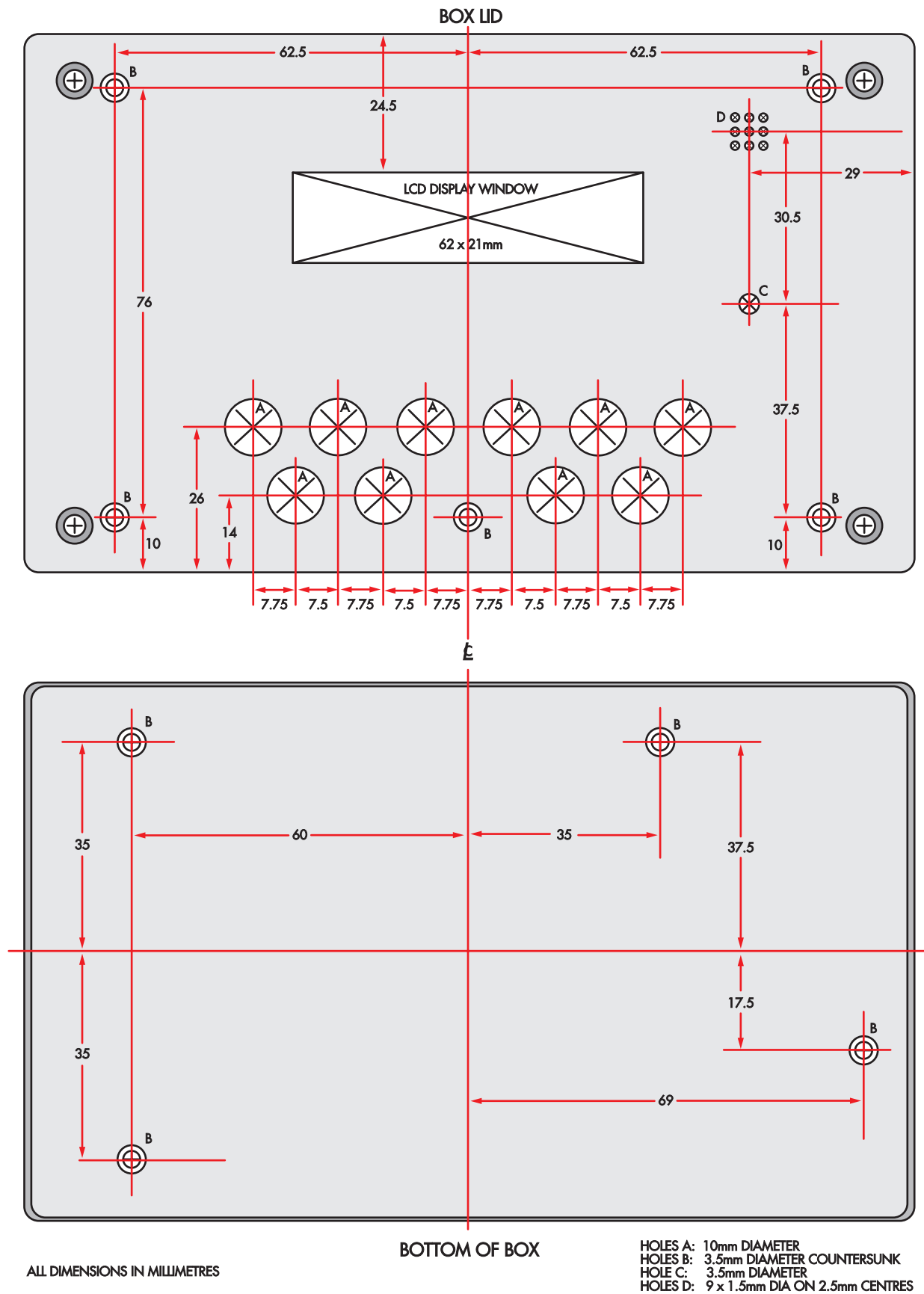


Fig.6: here are the drilling and cutting details for the base of the case and for the lid. They are reproduced actual size, so that you can use photocopies as drilling templates.

larger polarised electrolytics. Be sure to install the electrolytics with the positive leads oriented as shown.

The main board assembly can now be completed by plugging the programmed PIC16F84A chip into its socket. It must be installed with its notched end towards the bottom edge of the board, as shown in Fig.2

The PICTIMER.HEX program file is available as a free download from the Downloads section of the EPE website.

Display board assembly

Before installing any parts on this board, make sure it suits the particular LCD module you're using. Figs.3, 4 and 5 show the parts layouts for the various versions.

Begin construction by installing the wire links and the 68k Ω resistor, then fit the 16-way 90° DIL pin header. Follow these with trimpot VR1 and the 10 pushbutton switches. Note that the latter are all mounted with their 'flat' side facing towards the left.

The 10 μ F electrolytic capacitor is next on the list. As shown in one of the photos, it should be mounted 'leaning over' to the left by a small amount, to reduce its effective height to below 10mm (to ensure it later clears the back of the front panel).

Take care with its orientation. The next step is to fit the header strip for the LCD module. This is a 16-way SIL strip for the type 2 module, a 7 x 2-way DIL strip for the type 3 module or a 14-way SIL strip for the type 1 module. In each case, push the shorter ends of the pins through the board from above and solder them carefully to the pads underneath.

Basically, there are six different LCD modules that can be used with this unit – three with backlighting and three without.

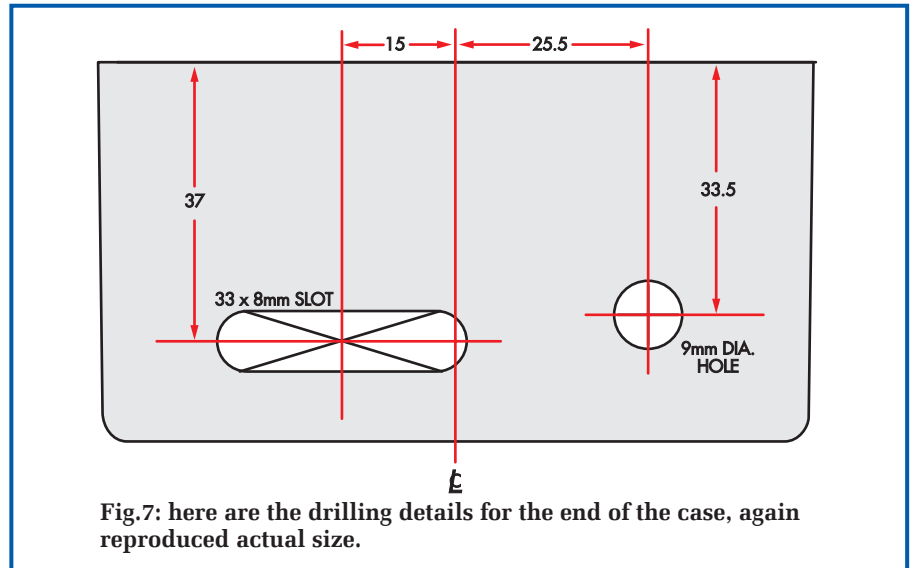


Fig.7: here are the drilling details for the end of the case, again reproduced actual size.

Installing the LCD module is easy – it slips down over the header pins and is secured using four M2.5 x 10mm screws, lockwashers and nuts. In addition, an M3 nut and two M2.5 flat washers are used to form a 3mm-3.5mm spacer between the module and the board at each mounting screw point. Alternatively, you can use two M3 'half nuts' to make the spacer at each point.

Once the module is in position, it's simply a matter of soldering its connection pads to the header pins.

The display board will now be complete, except for resistor R_{BL} which sets the current for the backlighting LEDs. **This is fitted only if you're using an LCD module with backlighting, but it is not required for the type 3 LCD, since the resistor is part of the module.**

Note that for the type 1 module, you'll also need to make the 'A' and 'K' connections for the backlighting power (at right).

Once the assembly is completed, adjust contrast trimpot VR1 with a

small screwdriver to about 10° back from fully clockwise. This will ensure you get some kind of display when the timer and module are first powered up. The control can be 'fine tuned' for best contrast later, via the small hole in the front panel.

The next step is to make the short ribbon cable that's used to link the two boards. This is formed from a 75mm length of 16-way IDC ribbon, with a matching IDC connector at each end – see Fig.8. The connectors fit the opposite way around at each end, so that the cable can link the two boards without having to be twisted.

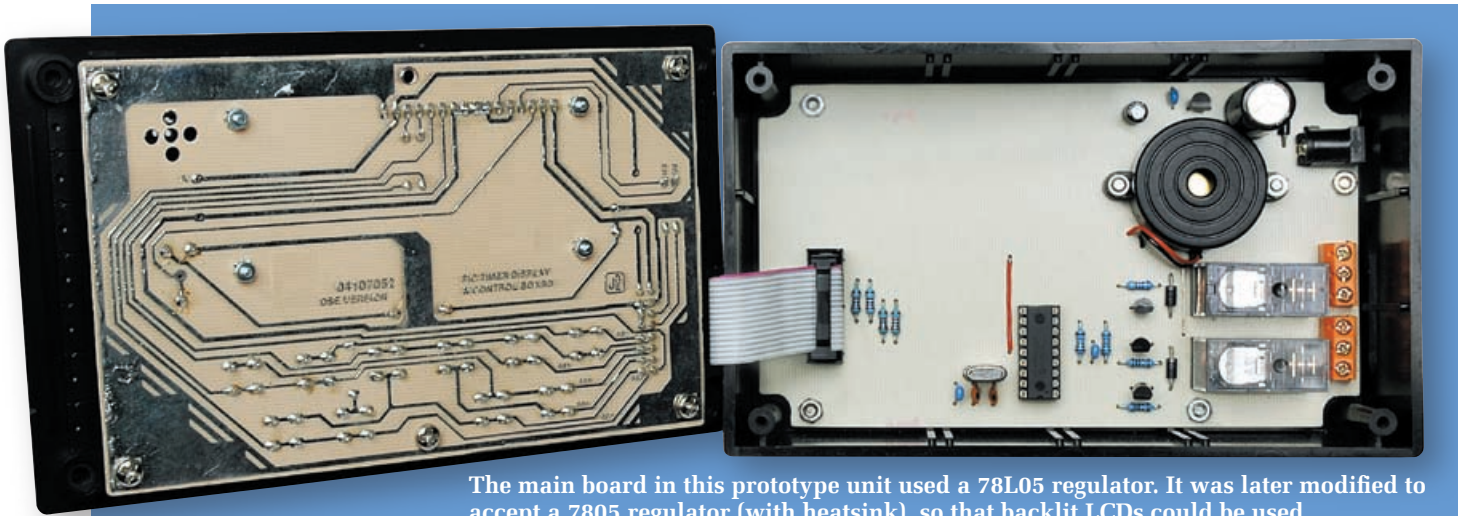
Preparing the box

Figs.6 and 7 show the drilling and cutting diagrams for both the box and its lid. These are reproduced actual size, so you can directly use photocopies as drilling templates.

Make sure you countersink the 3.5mm holes in the bottom of the box and also those in the lid. This can be done with a 7mm or larger twist drill if you don't have a countersink bit. Also,

Table 1: Resistor Colour Codes

| | No. | Value | 4-Band Code (1%) | 5-Band Code (1%) |
|---|-----|---------------|--------------------------|---------------------------------|
| □ | 1 | 100k Ω | brown black yellow brown | brown black black orange brown |
| □ | 1 | 68k Ω | blue grey orange brown | blue grey black red brown |
| □ | 4 | 22k Ω | red red orange brown | red red black red brown |
| □ | 2 | 10k Ω | brown black orange brown | brown black black red brown |
| □ | 1 | 4.7k Ω | yellow violet red brown | yellow violet black brown brown |
| □ | 1 | 18 Ω | brown grey black brown | brown grey black gold brown |
| □ | 1 | 12 Ω | brown red black brown | brown red black gold brown |
| □ | 2 | 10 Ω | brown black black brown | brown black black gold brown |



The main board in this prototype unit used a 78L05 regulator. It was later modified to accept a 7805 regulator (with heatsink), so that backlit LCDs could be used.

make sure that you cut the access holes for the timer's DC input connector and relay terminal blocks at the right-hand end of the box – see Fig.7.

Next, the front panel artwork can be attached to the lid. That done, you can cut the various holes in the label using a sharp hobby knife. These include the clearance holes for the switches, an access hole for the contrast trimpot and a pattern of nine small holes above the piezo buzzer.

Final assembly

The main board mounts on the bottom of the box on four 6mm-long untapped spacers and is secured using four M3 x 12mm countersink-head screws and nuts (it only fits one way, due to the asymmetrical mounting screw positions).

By contrast, the display board is mounted on the box lid and is secured on 12mm-long untapped spacers using five M3 x 20mm countersink-head machine screws, star lockwashers and nuts. With some LCD modules, you may also need M3 flat washers to augment each of the spacers, to make sure there is enough clearance.

Your timer can now be completed by fitting the ribbon cable between the

two boards and securing the case lid.

Using the timer

When you first connect the timer to 12V DC power, it initially displays 'FlexiTimer3' on the LCD panel. This message then disappears after a few seconds and is replaced with a 'screen' giving you the timer's current settings – plus 'Stop' at lower right to show that it's not running.

When the timer is powered up for the very first time, its initial settings are these defaults: Time A programmed to 10 seconds, Time B not programmed at all (and not even displayed), and the Cycles set to 1 (for a single timing sequence). But if you programme it with other settings and save them, these settings will appear when the timer is next powered up.

Changing the settings for Time A or Time B is done using the four uppermost buttons on the left – marked '10 MIN', '1 MIN', '10 SEC' and '1 SEC'. Pressing any of these buttons causes the timer to change into 'Input' mode, to allow you to key in any desired time setting from 00 minutes and 1 second up to 99 minutes and 59 seconds.

If you press any button too many times, just keep pressing it until the dig-

it concerned reaches the maximum and then returns to 0, after which you can programme the value you wanted.

When you have entered the time value you want, the timer can be directed to make this the setting for either Time A or Time B, simply by pressing either the 'Time A' or 'Time B' button. It's as easy as that.

Changing the Cycles setting is just as easy. In this case, you use only the '10 MIN' and '1 MIN' buttons to enter the number of cycles (from 1-99), and then press the 'SET CYCLES' button.

Once the settings for Time A, Time B (optionally) and Cycles have been entered, the timer can be started simply by pressing (you guessed it) the 'START' button. You'll then see it counting down on the LCD panel, where its status is also shown continuously – ie, whether it's in Time A or Time B and the current cycle. When it reaches the end, it will give a short beep from the piezo buzzer and display 'Stop' again on the LCD panel (at lower right). This will also happen if you press the 'STOP' button, to stop the unit before the end of the programmed time settings.

To save the current settings in memory for use next time it's powered up, just press the 'ENTER (SAVE)' button when the timer is stopped. As soon as the settings have been saved, the message 'Settings Saved' will be displayed for a few seconds, to confirm that it has been done.

To programme Time B as well as Time A, all you need do is enter its time setting and then press the 'TIME B' button. Time B will then be enabled and its setting displayed after Time A.

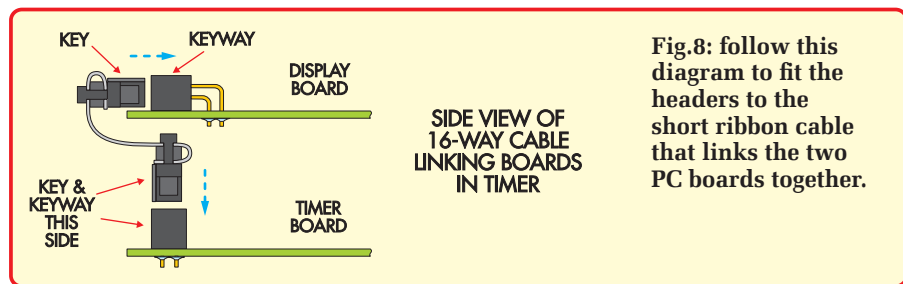


Fig.8: follow this diagram to fit the headers to the short ribbon cable that links the two PC boards together.

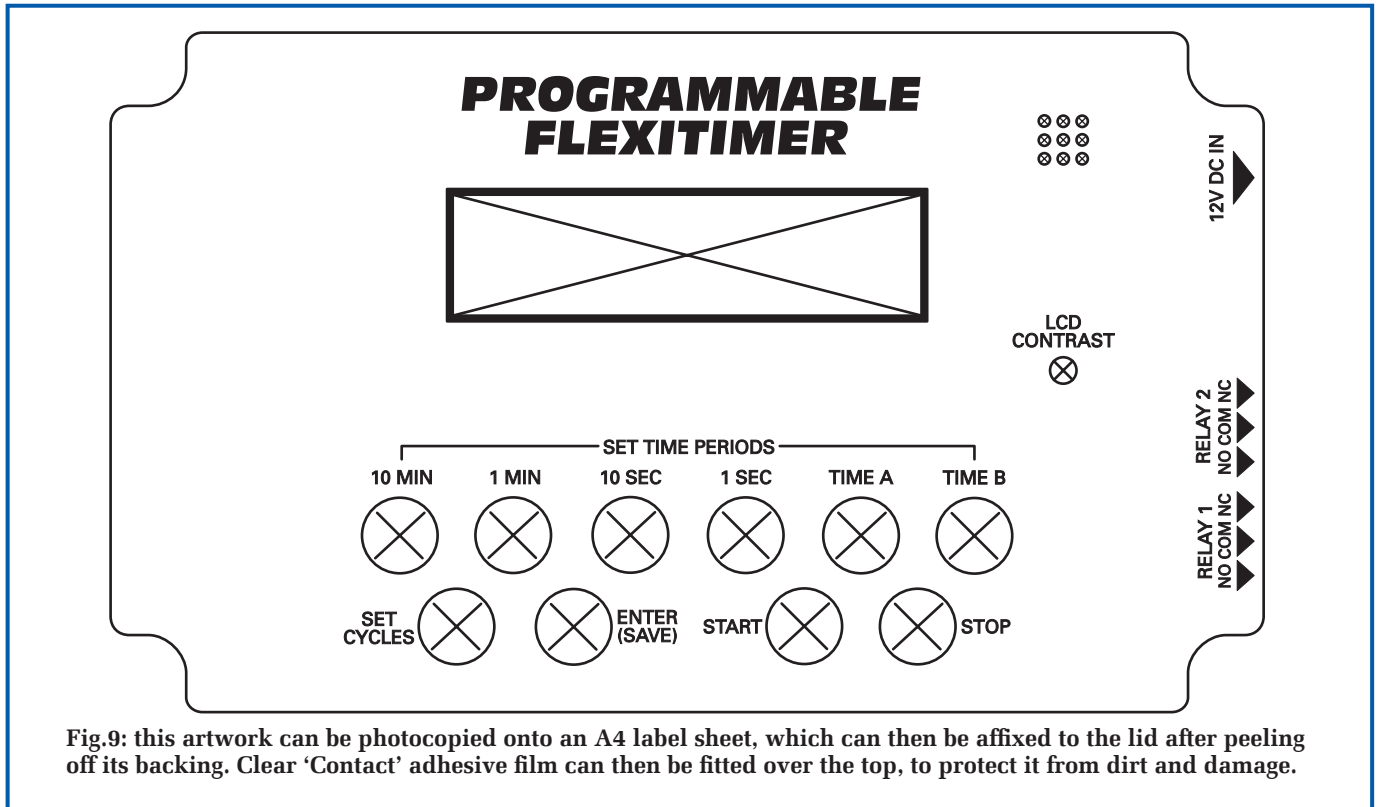


Fig.9: this artwork can be photocopied onto an A4 label sheet, which can then be affixed to the lid after peeling off its backing. Clear 'Contact' adhesive film can then be fitted over the top, to protect it from dirt and damage.

Specifications

- Two independent timing periods: Time A and Time B
- Time A and Time B periods can be set from 00min-01sec to 99min-59sec
- 1-99 timing cycles or continuous cycling
- Relay outputs for switching external devices

On the other hand, if you have Time B already programmed and you want to disable it again, simply enter a zero time value (ie, 00:00) and again press the 'TIME B' button. The timer will recognise the zero time setting and Time B will be disabled and disappear from the display.

Making contact

You can use the timer's relay contact terminals to allow it to control all manner of things. All you need to know is that when the timer is running the contacts of Relay 1 are activated during Time A, while those of Relay 2 are activated during Time B. So by connecting to these terminals, you can arrange for the timer to turn things on or off during Time A and/or Time B.

Continuous Cycling

A late software modification to this unit involved adding a continuous cycling mode. This mode is set simply by entering zero (00) as the setting for 'Cycles'.

The second line of the display shows 'Cont' when the timer is in this mode. It can be returned to finite multiple cycle mode simply by setting the number of 'Cycles' to any allowed non-zero value – ie, 1-99.

Finally, note that this project should be used to control low voltage equipment only (up to about 50V). DO NOT use it to directly switch mains voltages. If you do want to switch mains voltages, we suggest that you use this unit to trigger an external relay which then does the switching.

Make sure that this external relay and any mains wiring that's run to it is properly anchored and isolated.

Do not attempt this unless you know what you are doing and are completely familiar with mains wiring practices and techniques.

EPE

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Using MPLAB

How to use MPLAB when writing the source code for your PIC projects Part Four – Relocatable Development by Mike Hibbett

IN this final installment we will review the subject of relocatable development and demonstrate the use of the librarian by producing a simple, useful program. We will then wrap up with a whistle-stop tour of some of the remaining interesting (but less essential) MPLAB features.

Before we start, a quick comment on mixing object code files from different assemblers.

Mixing object code

As you are probably aware, when you have assembly code written for one vendor's assembler it will not assemble with another vendor's tools, without some minor modification or 'tweaks'. This has come up several times on the *EPE Chat Zone* forum (via www.epemag.co.uk) when, for example, people have taken code written for MPLAB and tried to assemble it with TK3 or gpasm. Different vendors implement assembler directives in subtly different ways, as there is no industry standard for them. The result is a huge list of error and warning messages which can appear quite daunting. These kind of issues are, however, usually quick and easy to correct once you are aware of what is involved.

With object code files (i.e. pre-assembled source files) a similar issue exists, but cannot be dealt with so easily. Object files have a binary format and cannot be 'hand tweaked' using a text editor. In general, an object file created with one assembler or compiler can only be used with object files create by a program from the same vendor. It's a small inconvenience, and if you want to share your object files with other users you should make it clear which tool you used to create them, or share the source code.

Using the librarian

We finish our code development examples with a simple project to flash a random sequence on eight LEDs connected to a PIC16F917. The choice of CPU is simply because it is the one fitted to the PICKit2's demo board; a simple convenience for the author but easily transferred to another PIC16F device if you want to try the example out directly. The source code and MPLAB build files are available for download from the *EPE* website – via www.epemag.co.uk in the *PIC n' Mix* folder in the downloads area.

So let's run through what we want the software to do. It's quite simple: at approximately one second intervals, illuminate a random selection of eight LEDs connected to PORTD. Nothing exciting, possibly useful as a Christmas decoration, but it demonstrates the use of the linker and librarian in a simple manner.

The code for generating random numbers has been 'lifted' from a previous *PIC n' Mix* article, so we won't discuss how it

works here. It's not the operation of the code that's important, but rather how we partition it and use the linker and librarian to create re-usable object files.

So let's start by designing the program. Initial thoughts about the design, simple as it is, give the follow breakdown:

```
Setup PORTD outputs
Seed random generator
loop:
Get random value
output value
delay 1s
goto loop
```

Now this could quite easily be written in a single source file, but that avoids the point of the exercise. This is a simple program, but others may be much more complicated and would not so easily fit in a single file. Some of the features we are about to write may well be useful in other programs, so let's split these out into different groups suitable for placing in separate files:

```
Random
Seed random generator
Generate random
Get random value

delays
delay 1s
```

The 'random' file seems well defined; there isn't much else that we would want to add to it, so let's leave it as it is. The 'delays' file however could easily contain some other useful routines such as ones to provide other delay times, and perhaps some way to make the functions independent of the clock speed, making the file more general purpose. Let's say we want a routine to provide a 1ms delay, another to provide a 1s delay and an initialisation function that you call before using these that specifies the clock frequency (in some way) so the other two routines can generate the correct time period. This gives the following list of routines for the **delays** file:

```
delay1s
delay1ms
clocksPerMs
```

The routine `clocksPerMs` is our initialisation routine which you will call with a parameter that defines how many instruction clock cycles occur in one millisecond. At 40MHz the value would be 10,000, at 4MHz it would be 1000. This value will be passed to the routine via two predefined variables, called **clocks_high** and **clocks_low**, which together will hold a 16-bit value. These variables, like the routines, will be accessible by other source files even though you will have pre-assembled the source file.

Remembering the 'good practice' advice from earlier articles, we should think about

what files we will need to create. From our ideas in the previous paragraph, it's looking like this:

delays.asm: This file will define the delay routines, the initialisation routine, the global variables used to pass the clock speed to the initialisation routine and any internal variables required.

random.asm: This defines the three random number generator functions, and whatever variables they use.

main.asm: Holds the actual application: the 'glue-logic' which simply connects the routines from the other files together in your own special way. Sounds easy when stated like that, and with a good set of library routines developed over time, it could be!

Now it would not be unreasonable to simply build these three files together and keep them in a single project, but then it would not be quite so easy to re-use them at a later date. When you think about separating out functions into a library at the beginning of a problem, you have to consider two things:

Keep all the variable definitions required by the routines (and *just* those routines) local to the file.

Give the routines very specific, independent, functionality. Don't try to lump lots of features into each one, it makes them less likely to be re-useable in the future. Functions should be small and self-contained. They should do a single, simple job, and do it well.

Into practice

So let's put our ideas into practice. If you remember from previous articles, it's always a good idea to get your files created and in a project, even when you intend to place them into a library. The first step is always to develop and test your code, and *then* organise them into a library. So fire up MPLAB and let's start by getting the basic system framework in place.

On the main menu bar in MPLAB, click on **Project** followed by **Project Wizard...** Click **Next** and select the processor that we will be coding for, the PIC16F917. Click **Next** again, make sure the Active Toolsuite is displaying 'Microchip MPASM Toolsuite' and click **Next**. You are now prompted to 'Create New Project File'. Type in a directory and filename that you would like to give the project. We suggest, to keep things simple, choosing:

```
c:\epe\randle
```

which will create the project **randle** in the **C:\epe** directory.

When you click **Next**, MPLAB will warn you that the **epe** directory does not exist. Click **OK** to allow MPLAB to create it.

You are now prompted to add any existing files to your project. This is a rather

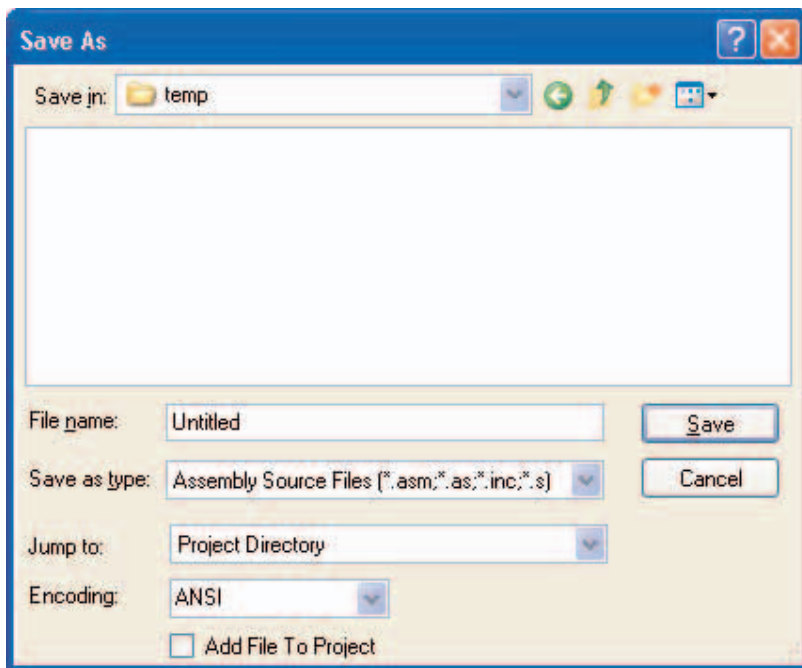


Fig. 1. Saving project files

odd thing to ask at this stage, since we are creating a new project, but in some cases you may have already created some source files in another editor (or simply want to re-use some existing source files from another project). You can skip this step by pressing **Next**. We can always add files to the project later on. Click **Finish** to end the Project Wizard's activity, and bring us back to the IDE's main window.

Now let's create the three source files, **random.asm**, **delays.asm** and **main.asm**.

Click on **File** followed by **New** to open a new Untitled editor window. Save this file to the project directory by clicking on **File** then **Save As**. A dialog appears, similar to Fig.1, that prompts you to enter the file name, its type and where to place it. Give the file a name of **main.asm**, click on the down arrow next to the 'Save in' drop down menu and navigate to the **epe** directory. Click on the 'Add File To Project' check box – this will ensure that the file isn't only saved, but included in our build.

Repeat the above steps to create the other two files.

Now add the linker file to the project so that we can link the final object files together into a **.hex** file. Remember how to do this? Right click over the line 'Linker Scripts' in the **.mcw** window, select **Add File..** from the menu and navigate to the directory:

C:\Program Files\Microchip\MPASM Suite\LKR

And select the file:

16F917.lkr

Now it's time to type in the main application code into **main.asm**, which you can open by double-clicking on the filename in the **.mcw** window. With the detailed work performed by routines in the other two files, the code for the main application will be simple. Inside the file **main.asm** we start by specifying the processor *include*

file, select the CODE memory section and provide the outline of the application, as shown in Fig.2.

Note how the TODO comments reflect the design breakdown listed earlier in the article – we re-use those original design thoughts in our code, since they explain what it will do. The file finishes with an END statement, as all source files must.

Before we can build this trivial piece of code we must place END statements into the other two source files **delays.asm** and **random.asm**. Even though there is no code inside these files, the assembler still requires the files to contain at least an END statement. So stick them in, and then build the program by clicking on **Project** followed by **Build All**. Your files should assemble without errors.

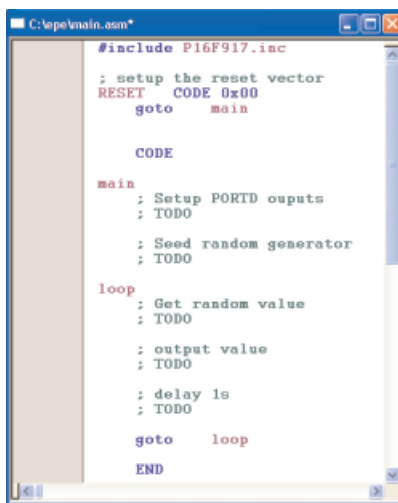


Fig. 2 Initial main application

Final step

Of course, we still have one final, crucial step to do: set the configuration bits. Click on **Configure** followed by **Configuration Bits...** Untick the 'Configuration Bits set in code' flag, and turn the watchdog timer to OFF. All the other settings are fine for this project – the PicKit2 demo board uses an external RC oscillator, which is the default in the configuration settings. Close this window, then do a **Build All**.

There isn't much point in downloading this program to the demo board and trying to run it yet because it doesn't really do anything; it will start up and turn the LEDs connected to PORTD off – which they are already!

As this article is about use of the library rather than software development, you can copy the source code for the files from the example ones that have been created for this article, and are available for download from the *EPE Downloads* site referred to earlier, in the file *step1.zip*. This contains the source files and the MPLAB project files, so you can open it up, build it and run it immediately if you wish, or cut and paste the code from the three **.asm** files into yours.

As the routines in the files **delays.asm** and **random.asm** are fully tested and working (you really should make sure that they are before creating a library file; no point sharing bugs) we can now proceed to create a library of the useful utilities, held in the files **random.asm** and **delays.asm**. There is no point in including the file **main.asm** in the library – this file is your unique application file and is unlikely to be re-used in another project.

So let's create the library file now. Although you can do this in the MPLAB IDE, it is much easier and quicker to do it from the command line. Open up a command shell (DOS box) and change directory to our project:

CD c:\epe

Creating the library is done by running the MPLIB program (*Note: NOT MPLAB!*). On the command line you specify the name for the new library file, and list all the object files that you want added. In our case we do this:

MPLIB utils.lib random.o delays.o

and that will create a library file for us, containing the routines from the two object files. You can now share **utils.lib** with other people, or use it in your own new projects. Of course you will have to tell people what functions are in the file and how to use them, but you do not need to give them the source code and they will not have to re-build the files.

So how do we use the library file in our project? Very easily. In the **.mcw** window in MPLAB, right click over the file **delays.asm** and select 'remove'. Don't worry, this doesn't delete your valuable source file – it just removes it from this project.

Repeat for the file **random.asm**.

Now right click over the 'Library Files' entry in the **.mcw** window, click 'Add Files' and select the **utils.lib** file (you will probably have to navigate to the **c:\epe** directory). That's it! If you do a 'Build All'

from the IDE you will find the program builds much faster as only the **main.asm** file needs to be assembled – the routines in **utils.lib** are, of course, pre-assembled.

Don't forget to keep your source files safe – you cannot re-create them from the **.lib** file if you lose them.

Other features

While we have demonstrated programming in only one language at a time (assembly or C with an optional C compiler) it is possible to mix both languages together. Routines can be written, compiled or assembled into a **.o** file and then linked into another project (directly or via a library file), just as we have been doing here.

It is also possible to include assembly language instructions directly into C language source files. Putting assembly language code in C source files is quite normal; you typically do it when you want a piece of code to run as fast as possible, assuming you have the skill to write better assembly code than the C compiler. Details are available in the IDE and C compiler documentation.

MPLAB provides a built-in option for programming devices directly from the IDE if you have a supported programmer interface connected. Bear in mind that in the case of some programmer hardware

(the PicKit2 for example) the programming software built into MPLAB may not support as wide a range of PIC devices as the programmer's own programming software. Our advice, for the PicKit2 at least, is don't bother with MPLAB's programmer option – for now.

One feature that you will want to use is the simulated UART. This feature allows you to simulate (inside the simulator – not available in the hardware debugger) an RS232 interface connected to the standard UART peripheral on the microcontroller. You can view in an output window tab any data sent out of the UART, and feed data into the program from a text file as though it were coming in on the RX pin.

To enable the feature click on **Debugger** followed by **Settings...** and click on the 'Uart1 IO' tab. Click on 'Enable Uart1 IO' and select the 'Window' option from the 'Output' section. When you close the dialog an extra tab will appear on the 'Output' window in the main IDE. Any data sent to the microcontroller UART from your program while running in the simulator will appear in this window.

You can also specify a file from which any bytes read by the UART will be re-directed. Not so easy to use, but it can save you the trouble of wiring up an RS232 interface during initial development.

An extension of this UART simulator is the 'Stimulus' feature that provides a very powerful – and consequently, very complicated – means of simulating external signals being applied to your program. You can inject data into registers or signal levels onto pins, and even allow MPLAB to choose random values, all under user control via a GUI based scripting language. It's rather complicated but if you want to thoroughly test your software during development it could save you a lot of effort. The feature is found under the **Debugger** menu item and full help is supplied on the **Stimulus** dialog.

Where next?

We have only scratched the surface of the facilities of MPLAB. There are many other features, and new features are being added as time goes by. The Help system within the MPLAB program provides a quick description of all these features, and you can find full details in the documentation that can be downloaded from the Microchip website on the 'MPLAB IDE' download page. Reading documents is unlikely to be enough, however; try a few projects, make mistakes and find the solutions – it's what the game is all about. There's plenty of help available on the Microchip forum and on our own *Chat Zone* forum via www.epemag.co.uk.

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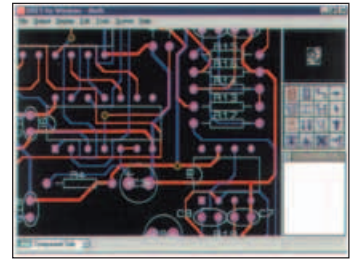


Logic Probe testing

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.

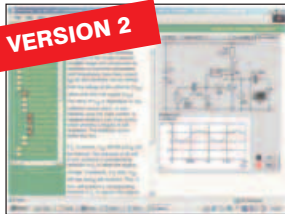
ELECTRONICS CAD PACK



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.

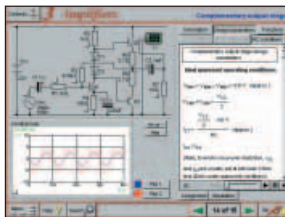
ELECTRONIC CIRCUITS & COMPONENTS V2.0



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

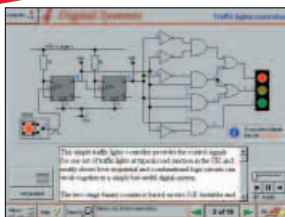


Complimentary output stage

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.

ROBOTICS & MECHATRONICS

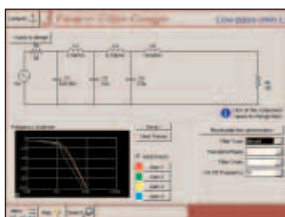


Case study of the Milford Instruments Spider

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

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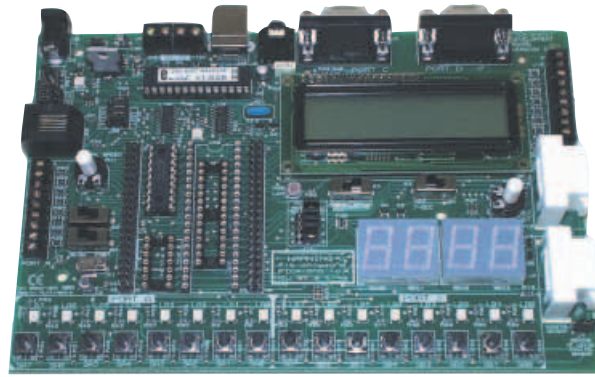
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- Comprehensive instruction through 45 tutorial sections
- Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator
- Tests, exercises and projects covering a wide range of PICmicro MCU applications
- Includes MPLAB assembler
- 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



'C' FOR 16 Series PICmicro VERSION 4

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
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- Includes a compiler for all the PICmicro devices.



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FLOWCODE FOR PICmicro V3

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Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and I.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming. Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

- Requires no programming experience
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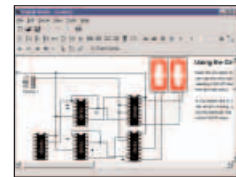
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Circuit Surgery

Ian Bell



Linear Voltage Regulators and Capacitors – Part Three

Two months ago we started looking at a question posed by *Techno* on the *EPE Chat Zone*, who was asking about the capacitors that are required on the output of some regulator ICs. These capacitors are needed to ensure the stability of the regulator's negative feedback loop – by stability we mean that the circuit does not undergo unwanted oscillations. To provide a foundation for understanding this issue, in the first article we looked at some of the basics of feedback in the context of op amp circuits.

For op amps, the negative feedback allows properties of the circuit to be largely independent of the op amp's characteristics, in particular the gain of an op amp in an amplifier circuit is determined only by the external resistor values. For a regulator, the feedback loop controls the output voltage by comparing it with a fixed reference value. If an amplifier has a gain of A and the feedback is a fraction β then the value βA is called the *loop gain* – the manner of variation of the loop gain's magnitude and phase shift with frequency are critical to a system's stability.

Unfortunately, negative feedback has the potential to produce instability. As the signal frequency increases the phase shift produced by the circuit often tends to increase and at some point may reach 180° .

This is equivalent to inverting the signal, at which point any negative feedback becomes positive feedback and oscillation may result. To prevent this unwanted oscillation we have to make sure that as frequency increases the phase shift of the loop gain remains less than 180° until the

magnitude of the loop gain is less than one. We can characterise how much stability 'headroom' we have using *gain margin* and *phase margin*, which we defined previously.

Last month we saw how special circuitry in an op amp is used to ensure that the circuit is stable with negative feedback. This is known as *compensation*. The capacitors at the output of the regulators mentioned by *Techno*, are also compensation components. In general, in order to design compensation circuits we need to be able to analyse and manipulate the circuit's gain and phase frequency response. Full mathematical analysis of this requires the use of advanced techniques involving *complex numbers*. Last month we had a brief look at this without getting too involved in the actual mathematics.

Complex numbers

Complex numbers are so called because they are two-dimensional, unlike the one-dimensional everyday numbers we all use. We can write circuit equations in terms of a special 'complex frequency variable' (usually denoted s). The two-dimensional nature of s means that it simultaneously encompasses both gain and phase shift. If we write an equation for the circuit's output in terms of the input, the component values and s , we can find values of s where the circuit's response (in the complex number domain) goes to infinity (called *poles*) and to zero (called *zeros*).

Poles and zeros indicate significant points in the circuit's frequency response. At frequencies above a pole, the gain of a circuit

will drop by 20dB per decade (6dB per octave) more than at the pole frequency.

At frequencies above a zero, the gain of a circuit will increase by 20dB per decade (6dB per octave) more than at the zero frequency. To achieve compensation (ensure stability) circuit designers add poles and zeros to a circuit in order to modify the frequency response. Last month we saw how *dominant pole compensation* achieved stability for op amps used with negative feedback.

Phase response

The phase response associated with poles and zeros is also critically important. Poles create a phase shift of -90° and zeros a phase shift of $+90^\circ$. The phase shift effect associated with both poles and zeros starts at about a tenth of the pole or zero frequency and finishes (with a full 90° shift added to the circuit's response) at about ten times the pole or zero frequency. The phase shift contributed by the pole or zero at the pole or zero frequency is 45° (positive for a zero and negative for a pole).

Compare this with the effect on gain – poles and zeros affect the gain for all frequencies above the pole or zero frequency, whereas they affect the phase shift only in the decade above and below the pole or zero frequency.

This means that the relative spacing of pole and zero frequencies, not just the total number of poles and zeros, has a strong effect on the nature of the circuit's frequency response, and hence on stability. It is also worth noting the effect of poles and zeros are opposite so, for example, the effect of pole on a circuit's response could be removed by adding a suitable zero.

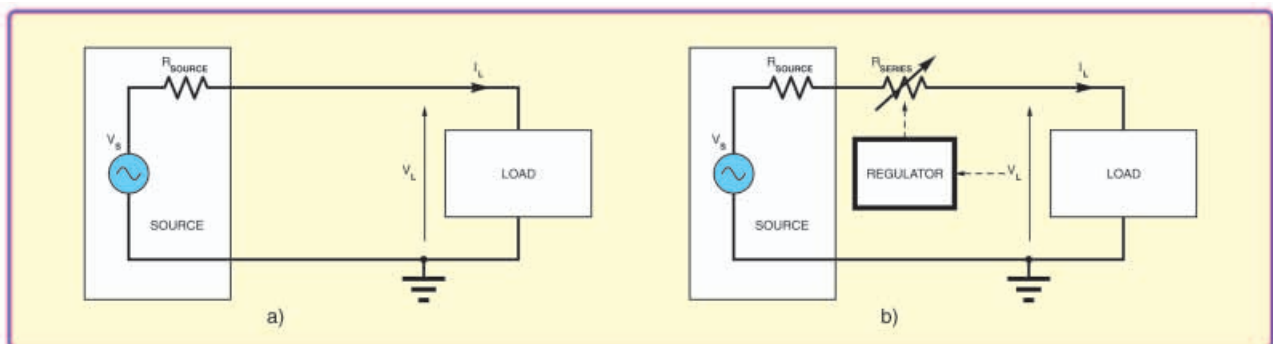


Fig. 1. (a) Unregulated supply. (b) Basic concept of series regulation

Regulators

We will look at the poles and zeros relevant to regulator compensation later in this article, but first we will turn our attention to the regulators themselves, so we can familiarise ourselves with the circuits we will be trying to stabilise. Techno's question concerned the reason for connecting capacitors across the output of certain linear regulators. The circuits, which must have these capacitors to ensure stability, are of a type known as *Low Drop Out* (LDO) regulators. More basic linear regulators do not suffer from the same problem.

LDO regulators are needed in applications where the voltage drop across the regulator must be as small as possible to minimise dissipation and maximises efficiency, typically this is the case in battery powered systems. Early linear regulators such as the 7805 and LM340 suffered from relatively high power dissipation due to the large voltage drop (typically a couple of volts) from input to output of the regulator.

The minimum input to output voltage drop is called the *dropout voltage*, and LDO regulators typically have dropout voltages of less than 500mV, and as low as 20mV for low current loads. Switching regulators can also achieve high efficiency but produce more power-line noise than linear regulators. So, LDO regulators are used in systems requiring low-noise power supplies. In battery powered systems, the regulator's quiescent current (current taken when there is no load) is also important. Low quiescent current also improves efficiency.

To understand the basic idea behind a linear regulator see Fig.1. In the circuit in Fig.1a there is no regulation – as the load changes, variations in load current cause a varying voltage drop across the source's internal resistance and hence variation in the voltage across the load. Similarly, if the source voltage changes then the load voltage will also change. The source could be a battery or the DC output of a mains transformer with rectification and smoothing.

In Fig.1b, a variable resistor is added to the circuit in series with the load – so this arrangement is known as a series regulator. The series regulator is not the only possible linear regulator configuration, but it is the most widely used.

For the circuit in Fig.1b, as the load varies, or the source voltage changes, the regulator adjusts the series resistor value so that the voltage across the load is constant. The voltage across the series resistor is called the *dropping voltage*. Regulating in this way dissipates power in the series resistor, so ideally the dropping voltage should be as small as possible.

In practice, the series 'resistor' is actually a transistor circuit (the pass transistor), which means that a certain minimum dropping voltage is required to keep the device operational (called the *dropout voltage*). A smaller dropout voltage means the regulator is likely to be more efficient.

Linear regulator

In Fig.2 is shown a simplified schematic of a typical linear regulator. This circuit structure applies to both LDO and non-LDO regulators, with the key difference being in the pass transistor circuit. The regulator controls the current supplied to the load in such a way

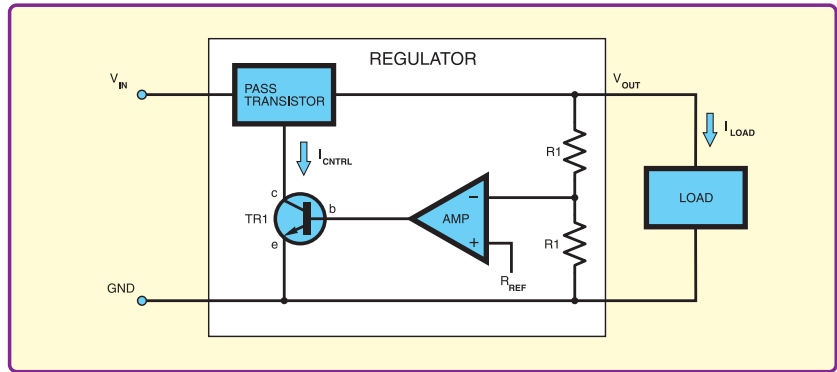


Fig.2. Typical linear regulator circuit

as to keep the supply voltage (regulator output voltage, V_{out}) constant.

The regulator contains a potential divider which produces a fixed fraction of the regulated supply voltage. This is compared to a fixed reference voltage. If the output voltage decreases the amplifier output will increase because the potential divider is connected to the inverting input.

The increased output voltage will increase the control current to the pass transistor and hence the current to the load, which will tend to increase the output voltage and offset the initial decrease. This negative feedback loop will keep the potential divider voltage equal to the reference voltage and hence keep the output voltage fixed as the load varies. However, as with any negative feedback loop there is the possibility of instability, depending on the frequency response of the loop.

Pass transistor circuit

The pass transistor circuit used in a standard, or *NPN*, regulator is shown in Fig.3. This circuit requires a minimum of two V_{BE} and one $V_{CE,SAT}$ voltage drop across it, accounting for the typical dropout voltage in the range 1.5V to 2.5V for this type of regulator. The feedback loop in the *NPN* regulator is somewhat similar to an op amp in terms of its 'natural' frequency response, this enables dominant pole compensation to be used in the same way (as described last month).

The graphs in Fig.4 show the frequency response of a typical *NPN* regulator. Pole 1 is the low frequency pole introduced to provide dominant pole compensation (typically around 100Hz) and pole 2 is the first high frequency pole (in the order of megahertz), which is

associated with the power transistor in the pass transistor circuit.

Two poles produce a total phase shift of 180°, which has the potential to create instability. However, with a dominant pole, as frequency increases, the gain drops by a large amount before the next pole has any effect on phase shift. The circuit has a respectable phase margin and is fully stable.

Note that although *NPN* regulators are inherently stable, datasheets often

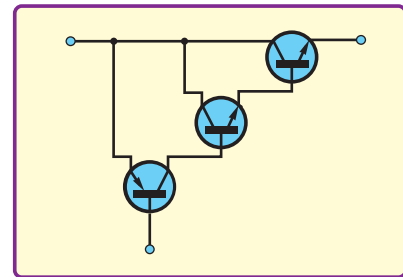


Fig.3. Typical 'pass transistor' for a standard (NPN) regulator

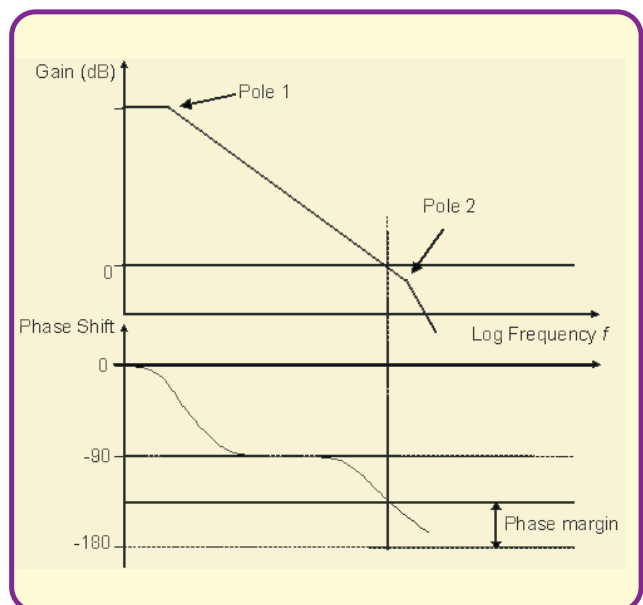


Fig. 4. Typical frequency response of an NPN regulator

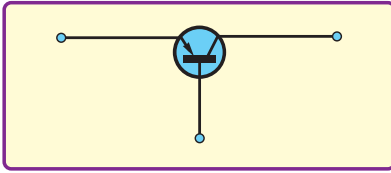


Fig. 5. Typical 'pass transistor' for a low dropout (LDO) regulator

recommend the use of an output capacitor similar to that required for LDO regulators. This is not for stability, but to improve the transient response of the regulator, that is its ability to deal with fast changing load demands.

The pass transistor circuit used in an LDO regulator is shown in Fig.5. Use of a single PNP transistor reduces the dropout voltage as we now only need one $V_{CE,SAT}$ across the pass transistor for the circuit to be operational. However, compared with the NPN pass circuit in Fig.3, this circuit has far higher output impedance. This adds a low frequency pole to the circuit's response (in the order of hundreds of Hertz).

However, the pole which was deliberately shifted to a frequency for dominant pole compensation is still present – it need not be at such a low frequency but it cannot be entirely removed. Thus, we have two poles at quite low frequencies. These create a phase shift of 180° at frequencies at which the loop gain is still large. The circuit is therefore inherently unstable. The frequency response is shown in Fig.6, which shows the two low frequency poles just discussed and the first high frequency pole. Note that the gain is well above unity (0dB) at the frequency at which the phase shift is -180° .

Alternative stabilisation

We cannot achieve stability in the LDO regulator with dominant pole compensation – an alternative strategy is required. What we do is add a zero to the circuit's

response. Last month we looked at the circuit in Fig.7 in detail and concluded that it had one pole and one zero. If we add a capacitor and series resistor across the output of the regulator we will create a version of this circuit in which R1 is the output impedance and C and R2 are the added capacitance and resistance.

The effect of adding a zero between pole 2 and pole 3 on the regulator's frequency response is shown in Fig.8. Adding the zero negates the effect of one of the low frequency poles and prevents the phase shift reaching 180° until the first high frequency pole (pole 3) comes into effect, at which point the gain is below unity as required, as shown in Fig.8.

Resistor R2 is not usually added as an actual resistor, but is provided by the equivalent series resistance (ESR) of the compensation capacitor. The zero frequency (in Hertz) is given by $1/(2\pi C_O R_{ESR})$ where C_O is the capacitance of the compensation capacitor connected across the regulator's output, and R_{ESR} is its equivalent series resistance.

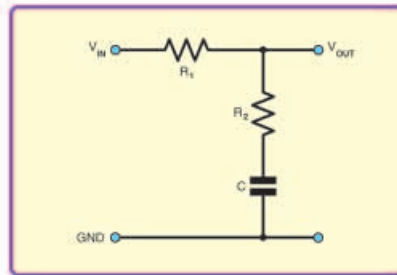


Fig.7. This circuit has a pole and a zero

All capacitors have ESR, but in many applications its actual value is not very critical; however, in this case the ESR value is very important as it helps set the frequency of the zero. This is why LDO regulator datasheets are very specific about what type

of capacitor to use. If the ESR value is not within a given range (either too high or too low) then the zero will not be at a suitable frequency and the circuit will not be stable.

Relatively stable

Most LDO regulators are specified for use with solid tantalum compensation capacitors. This is because tantalum capacitors not only have appropriate ESR values, but also because their ESR values are relatively stable with temperature variation. This guarantees that the regulator circuit will remain stable over its specified operating temperature range.

The need to use tantalum in LDO circuits and other demanding applications in modern electronics has caused some difficulties for electronics manufacturers due to fluctuations in world supply and demand for tantalum, and hence in the price of the capacitors. For example, there was a world shortage of tantalum around 2000 and about this time concerns were expressed about mining the raw materials for these devices since the revenue was being used to fund warring rebel groups in Africa.

Semiconductor manufacturers have strived to produce LDOs with less stringent requirements on the compensation capacitors. For example, the LP3871 series of 0.8A Fast Ultra Low Dropout Linear Regulators from National Semiconductor (www.national.com) require tantalum compensation capacitors, but devices in the similar LP3852 series (1.5A) are stable with some types of ceramic capacitors as well.

However, not all types of ceramic capacitor are suitable for regulators quoted as being stable with ceramic capacitors. This is due to the differing properties of different ceramic dielectrics, for example, some have capacitance which is quite voltage dependent.

Always read the datasheet for an LDO regulator to find out the requirements for the compensation capacitor and regulator stability, and follow these instructions carefully.

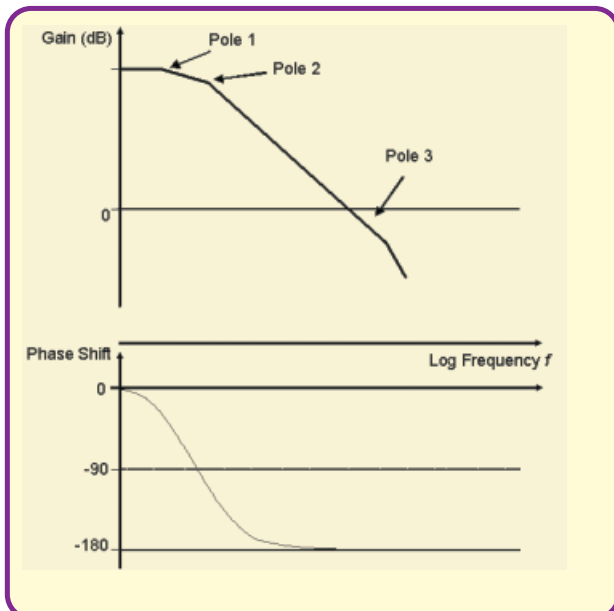


Fig. 6. Typical frequency response of an LDO regulator without compensation

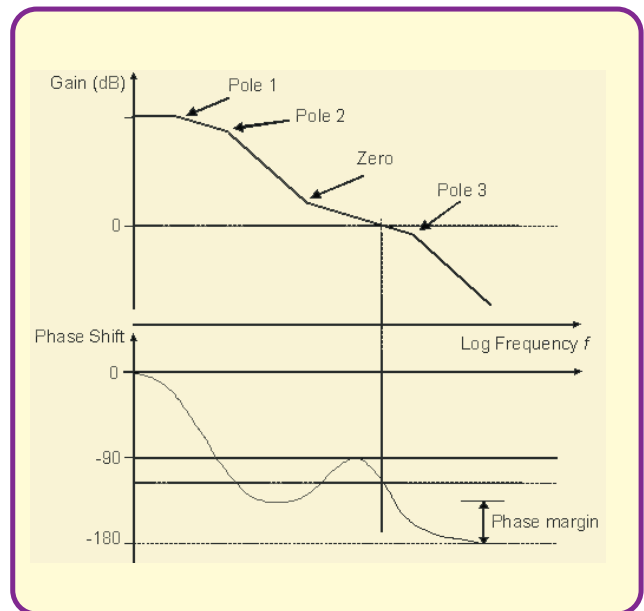


Fig.8. Typical frequency response of a compensated LDO regulator



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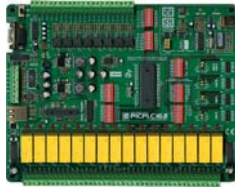
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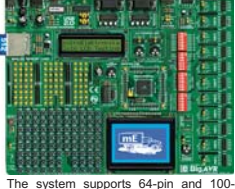
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Easy8051B Development Board

with on-board USB 2.0 programmer



System is compatible with 14, 16, 20, 28 and 40 pin microcontrollers (It comes with AT89S8253). Also there are **PLCC44** and **PLCC32** sockets for 32 and 44 pin microcontrollers. **USB 2.0 Programmer** is supplied from the system and the programming can be done without taking the microcontroller out.

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The Power of Mechatronics

Part Four – Adding Speech to Your Application by Darren Wenn

Following on from the Motor Control discussion, we will continue looking at uses for the PWM module in a PIC microcontroller. This time, however, we will be looking at how we create a PWM based Digital-to-Analogue Converter (DAC) and use it to provide speech output.

Mechatronics and speech

Let's look at where we might use this type of capability within a mechatronics context. If we are to consider the types of audible or visual interaction we may currently have with a piece of equipment, then it may be nothing more than a simple bell being sounded or an indicator illuminated. This is a perfectly functional output and has served us well for many years, but how much does it tell us about what the indicator or sound actually means?

What if we were to add a new dimension to the warning, where it actually informed us what was happening? Let's take an over-temperature warning for example. An indicator is lit but does that mean we are just above the set point or about to go critical?

What about the classic fire alarm scenario? How many of us sit and look at one another when the fire alarm sounds wondering if it is simply a test and waiting for someone to make the first move? How about if the fire alarm actually told you it was a test or, more importantly, that a fire had been detected? Adding yet more intelligence, what if it were actively able to guide you to an exit away from the fire if your nearest exit is blocked?

These are examples of a system based purely on output from a given stimulus. The extension of this is to add a microphone to our system and create a speech recorder or intercom type system. With the correct back-end hardware in place, we can consider a simple telephony application or even the heady heights of Voice over IP (VoIP).

All of these applications stem from a relatively simple and low cost circuit to implement a microphone input or an output circuit to drive a loudspeaker or headphones. If we want to head up the scale in terms of quality then we may wish to add an audio DAC or even a CODEC to our system. Other considerations we can look into are compression algorithms for storage or compression of data prior to sending across a communication medium. The scope of these applications can take us from a relatively simple PIC MCU all the way up to the high performance dsPIC Digital Signal Controller.

Taking a lead from the motor control example, we can look at a feedback mechanism once again. This time, however, we aren't looking at a closed loop control example but how do we make our PIC quite literally talk back to us. In our example we will use the PIC24F since this lends itself easily to this application.

Creating a DAC

We will start out by looking at how to create a simple DAC and filter circuit using the PWM or Output Compare from a PIC.

This can be seen in Fig.1. This simple form of PWM DAC uses a first order RC filter connected to the Output Compare/PWM pin of the PIC. This is perfectly suited to the creation of an analogue output voltage for use as a variable set point or similar capability. In our case we want to create speech output, with frequencies in the range of 300Hz to 3300Hz.

For this the basic RC circuit is insufficient for our needs. The reason for this is that we generate the analogue signal using a PWM with a switching frequency equivalent to 16kHz at 10-bit resolution. Our first order RC filter is chosen to have a corner frequency or $f_{\text{cut-off}}$ at 4kHz to encompass the frequencies in human speech.

The filter design is based on the equation, $RC = 1/(2 \times \pi \times f)$, where $f = 4\text{kHz}$ and $C = 0.01\mu\text{F}$. This provides a value for $R = 4\text{k}$. If we look at the frequency response graph in Fig.2, we can see that the roll-off from our first order RC filter is very gentle. As a consequence the rejection of the 16kHz PWM switching frequency is minimal, with the result that it will remain audible and painful to listen to. How do we solve this?

The answer is to increase the filter order. However, is it best to use higher order RC or active filters? The answer to this question, which can be seen from the graph, is to use at least a fourth order active filter. The frequency response for this ensures that we have a suitable roll-off and rejection of the 16kHz PWM frequency. We can also note from the graph that it is possible

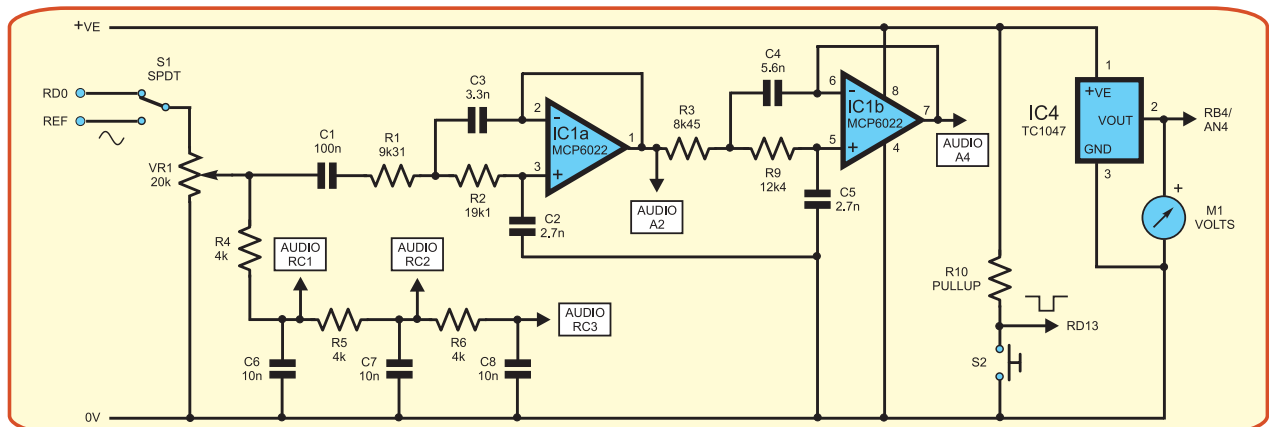


Fig.1 Modified speech PICtail with interactive components and RC filter(s). Select RD0 to use the audio graph and replay audio generated by the PIC24. Select REF to use the frequency graph and display the frequency response of the filter

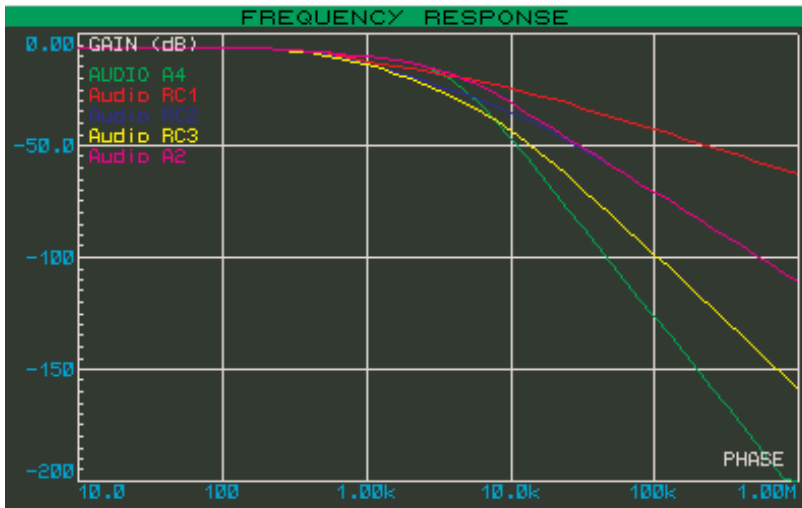


Fig. 2. Frequency response graph

to use a third order, or higher, RC filter, but the slope of the filter will start to encroach on the active signal region and therefore may potentially degrade our generated speech signal. The Fourier Analysis graph in Fig.3 shows the increased rejection capabilities of each of the filter types such that the fourth order active filter is barely visible and therefore should be inaudible.

PWM frequencies

An alternative approach can also be performed, which is to combine the analogue filter with an increased PWM frequency. It is possible to increase the PWM frequency to greater than 20kHz, which is effectively beyond the audible range for human hearing, which will also improve the rejection by several dB for a given filter type.

The drawback of this is that PWM resolution is limited by the clock frequency of the MCU. If you wish to operate at a high bit rate and high frequency, then the clock rate of the MCU will need also to be increased since the three are linked.

The data sheet for a PIC explains how to set up the PWM module and also the

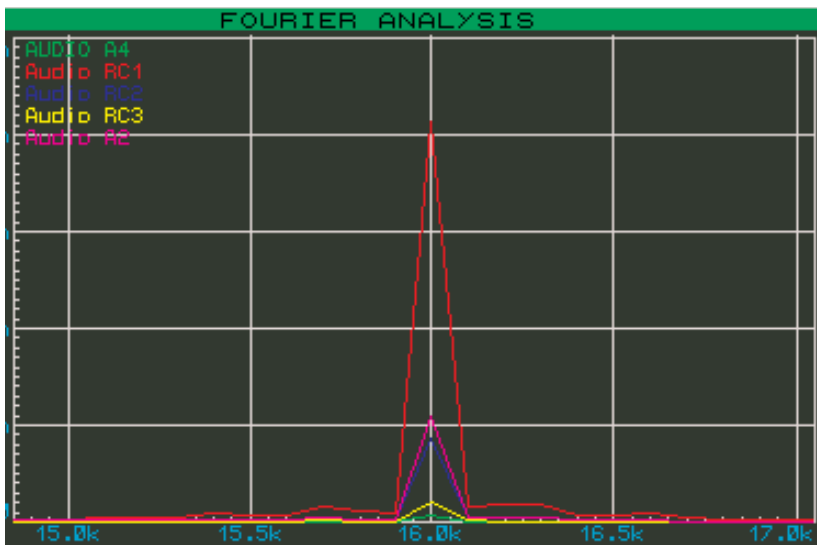


Fig. 3. Fourier Analysis graph

$$\text{Maximum PWM resolution} = \frac{\log_{10}(F_{cy}/F_{PWM}) \text{ bits}}{\log_{10}(2)}$$

Fig. 4. Maximum PWM resolution calculation

calculations for PWM frequency and the maximum bit resolution which can be obtained for a given clock and PWM frequency. The maximum resolution is calculated as shown in Fig.4. The table in Fig.5 shows some of the PWM frequency vs. bit resolution options for a range of PICs and dsPIC DSCs. The limitations imposed by the maximum clock frequency of the

| Device | F _{PWM} (KHz) | F _{cy} Max (MHz) | Theoretical Resolution Max(bits) | Working Resolution Max (bits) |
|------------------------|------------------------|---------------------------|----------------------------------|-------------------------------|
| PIC18F* | | | | |
| | 8 | 10 | 10.29 | 10 |
| | 10 | 10 | 9.97 | 9 |
| | 12 | 10 | 9.70 | 9 |
| | 16 | 10 | 9.29 | 9 |
| PIC24F | | | | |
| | 8 | 16 | 10.97 | 10 |
| | 12 | 16 | 10.38 | 10 |
| | 16 | 16 | 9.97 | 9 |
| | 24 | 16 | 9.38 | 9 |
| | 44.1 | 16 | 8.50 | 8 |
| dsPIC33F/PIC24H | | | | |
| | 8 | 40 | 12.29 | 12 |
| | 12 | 40 | 11.70 | 11 |
| | 16 | 40 | 11.29 | 11 |
| | 24 | 40 | 10.70 | 10 |
| | 44.1 | 40 | 9.83 | 9 |
| | 48 | 40 | 9.70 | 9 |

* maximum 10-bit (8+2 bits) PWM resolution on PIC18F

Fig. 5. Relationship between clock rate, PWM frequency and resolution for various PICs

device and bit resolution available can be seen and quickly highlights the devices that would need to be considered for a given desired output quality.

Given this limitation, is it possible to obtain high PWM frequencies, at high resolution with a lower MCU clock frequency? In short, yes. The technique is to create a binary weighted DAC output from more than one PWM output. The topology is very similar to that seen already, except we split the value to be output across two or more PWM modules, in most cases two is sufficient. If we wanted to have 16-bit at 16kHz, for instance, we would split the 16-bit value into 2 × 8-bit values and send each half to a separate PWM. We can then benefit from the ability to clock the PWM at a significantly faster rate for a higher PWM frequency or, at the same rate with a lower system clock speed.

A lower clock rate or higher frequency can be used since the effective overall PWM resolution has been increased for a

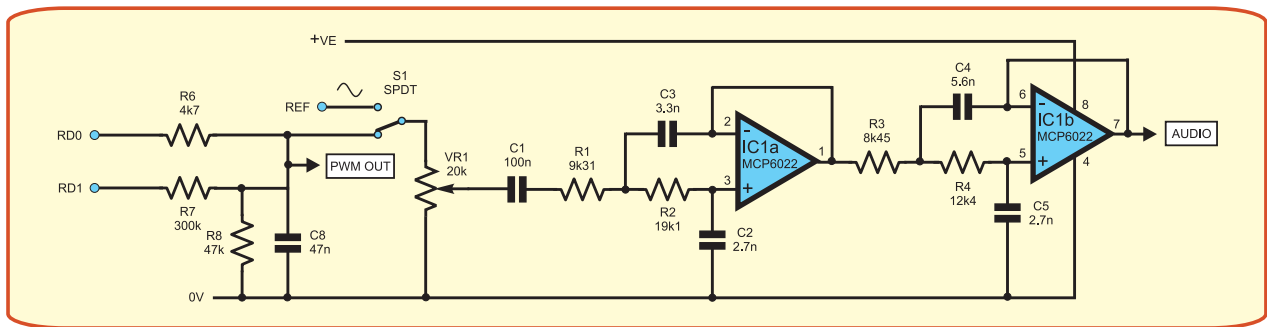


Fig.6. Dual weighted DAC. Select RD0 to use the audio graph and replay audio generated by the PIC24. Select REF to use the frequency graph and display the frequency response of the filter

given PWM frequency. External to the MCU, the outputs are weighted with a resistor such that the $LowR = 2n \times HighR$, where 'n' is the number of bits of resolution for each PWM. The resultant outputs are then combined in the analogue domain and fed to an appropriate filter as for a single ended output, as shown in Fig.6.

To account for tolerances in the weighting resistors it may be necessary to tune the DAC output and as a result scale it to suit. This can be achieved with a look-up table or equation in the MCU.

Getting the data out

The application chosen to demonstrate speech output is a talking thermometer. This is useful as it shows how to perform several operations within the PIC24. The ADC is used to read a TC1047A analogue output temperature sensor. The ADC result is converted to an equivalent temperature value and parsed to determine the speech samples to output. The speech is stored in the device as a table of samples, from which all of the values required for the temperature range of the sensor can be created.

For example, if the temperature was 23°C we would playback the individual words '20, 3, degrees, celsius'. Storage of the samples in this manner significantly reduces the storage overhead and increases the options for data storage. In our case, the complete vocabulary and application is stored in the 128K of internal program memory afforded by the PIC24F J128GA010. Other storage options exist, external to the MCU, including Data EEPROM, Serial Flash and Flash Memory Cards. Use of these we will leave for another article and continue with our use of Internal Program Memory.

So, now we have a large number of samples available in program memory, how do we access them? To make this task as simple as possible we have opted to use a filing system called MPFS. This is a proprietary Microchip file system which has been borrowed from the Microchip TCP/IP Stack application. It affords us the use of MS-DOS style 8.3 filenames but with a very low system overhead for the filing system.

This means we can create our sound samples on a PC and then use the MPFSv2

```
//Filename setup in array of characters
```

```
filename[0] = 'd'; // filename = 'deg.dat"
filename[1] = 'e';
filename[2] = 'g';
filename[3] = '.';
filename[4] = 'd';
filename[5] = 'a';
filename[6] = 't';
filename[7] = 0;
```

```
hFile = MPFSOpen(filename); // Open file
PlayClip(hFile); // Play audio clip
for(time=0;time<65534;time++); // delay
```

Fig.7. File access using MPFS

application to create an image file for use by the embedded portion of the MPFS filing system on the PIC24. An example of file access using MPFS is shown in Fig.7.

While we have a method to access our stored data files, we do have to pay some attention to the quantity of memory used to store data. Certainly the easiest way to access data is from raw files. However, this is memory intensive and in an embedded system memory is an expensive commodity. Therefore, we need to use some form of compression algorithm to make best use of available memory.

Consider the situation where we wish to store telephone quality speech. This is sampled at 8kHz 8-bit, which results in a bandwidth of 64kbps. If we start to increase the sample frequency or resolution to say 16kHz 16-bit, this results in a 256kbps data stream. Thus, if we wished to store it as raw data, would require 1Mbit for four seconds of speech.

Clearly, from a storage perspective, especially in an embedded system, this would be unacceptable for any useful quantity of data. Since bandwidth costs money, it makes sense to compress the data as best we can. If we consider that for very few MIPS simple algorithms can be implemented on a MCU providing 2:1 and 4:1 compression and if we moved to DSP then 8:1 and 16:1 compression ratios are common, whilst retaining real

time functionality, then this is a huge benefit to our storage and communication system overhead.

However, we do need to consider the knock-on effects that the choice of algorithm has on our choice of processor. The options currently available for a PIC or dsPIC DSC are shown in Fig.8. In our case we are using the PIC24, so we are limited to the non-DSP algorithms and, since we want the best compression, we will opt to use the IMA-ADPCM algorithm (full details are explained in Microchip application note AN643). This algorithm affords us a 4:1 compression ratio, which helps reduce internal program memory requirement to 25% of that if raw data had been used, so our 1Mbit of memory now allows us to store 16 seconds of speech. If we were to reduce the sample rate and resolution the effective storage capability also increases. The IMA-ADPCM algorithm also allows us to record and manipulate samples on the PC prior to packaging with the MPFSv2 filing system tool.

All of these capabilities can be explored in the demos provided in this article's support package available on the EPE Downloads website (via www.epemag.co.uk). This will allow you to explore speech playback and the filter choices using MPLAB IDE and the Proteus VSM package.

| | Comp- ression Ratio | MIPS Required Enc/Dec | 24F | 24H | dsPIC 30F/33F | App Note / Library | Licence Required |
|-----------|---------------------------|-----------------------------|-----|-----|------------------|-----------------------|---------------------|
| G.711 | 2:1 | 1 | | | | | |
| IMA-ADPCM | 4:1 | 3/2 | | | | AN643 | |
| G.726 | 3.2 - 8:1 | 15 | | | | | |
| Speex | 16:1 | 19/3 | | | | | |

Fig.8. Available compression algorithms for PIC and dsPIC DSC

Talking to your Machine

Speech Control: Speech control is the long awaited, much vaunted capability for control of devices. This is somewhat distorted by the movies, where an almost human level of interaction is possible between man and machine. The reality is somewhat different however, and the complexity of creating a faultless recognition system, capable of understanding all users, with multiple languages and dialects, remains a significant technical hurdle.

One of the better examples of speech recognition is voice dialling on a mobile phone. This is good but still drops numbers and it is still a long way short of human-to-human level interaction.

There has, and continues to be, a continued effort from commercial companies and universities to perfect speech recognition, and maybe one day we will have intelligent conversations with a machine. For now, however, we will take a look at relatively simple voice recognition provided by the dsPIC Speech Recognition Library.

The speech recognition capability provided by the dsPIC DSC is limited to a vocabulary of around 100 words. These have been chosen for their suitability for control oriented tasks with commands such as On, Off, Light, CD, Computer etc., and the numbers 0 to 9. The vocabulary should provide sufficient recognition and therefore control capability for most tasks. It is possible to add words to the system, but the sample set of independent voices required and post manipulation of the samples is considerable in time, effort and cost.

Speech recognition falls into two main categories, speaker dependent and speaker independent. Let's take a look at the key differences between them.

Speaker Dependant: A speaker dependant system is limited to the voice of a single user. More users can train a system but the overall effect is a library of users with dependant voice characteristics.

A speaker dependant system requires significant training to cope with changes of pronunciation and differences in the voice coupled with environmental noise. The pattern matching is therefore only as good as the input to the algorithm, the algorithm itself and the quality and variability of the training. However, the vocabulary and base language may be less restricted.

Speaker Independent: The flipside of speaker dependant systems is speaker independent systems. The aim here is to have a vocabulary of words available such that many users can interact with a system without additional training. To create a word model for an independent speaker, the vocabulary has to be recorded by a significant and variable enough sample set of voices. Often greater than 1000 may be required, to provide a good cross section of the way each word is spoken.

The words are chosen in a specific language, in our case US English, and once sampled the individual words are processed and manipulated to ensure there is a high probability of recognition by the system of all the sampled voices.

To aid recognition when in use, the expected vocabulary and keywords can be created using a word builder application on

a PC. This allows the expected commands to be built and tuned to suit the environmental conditions the system is expected to work within. This aids the probability of recognition, but by no means makes a speech recognition system infallible.

Therefore, using a speech recognition capability and an appropriate set of control actions, it is possible to perform speech control of equipment, such as speaking a telephone number, rather than dialling, turning lights, thermostat or white goods on/off, up/down. The possibilities are limitless but they are bounded by the limitations and capabilities of a given speech recognition system.

Speech input

While full human interaction is at one end of the scale, adding the ability to record speech or provide a capability such as a telephone or intercom, is certainly more within our reach. For all of the audio input functions available the input system comes down to the same basic requirement, a microphone. Again, we could use a CODEC for this since it will provide a high quality input capability. However, keeping cost in mind, we can look at a more common interface for a microphone which is then sampled and digitised via our on-board ADC.

Once digitised, many options of what to do with the data exist. In the DSP world we can perform additional filtering or signal manipulation, such as noise and echo cancellation. We may simply wish to store our sampled speech or send it along some form of communication medium. This then

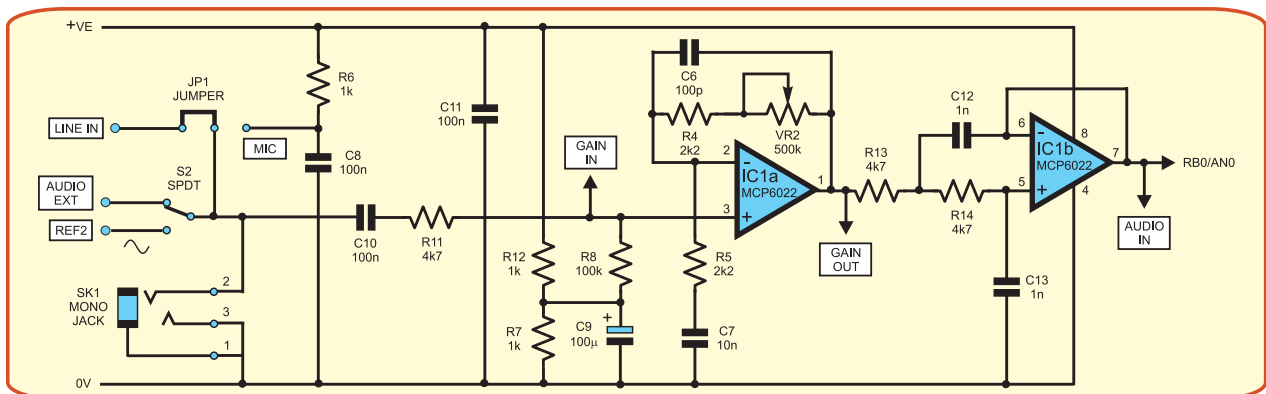


Fig.9. Microphone interface to ADC. Select Audio EXT to play input WAV file and use the audio graph to replay the audio generated input stage to the PIC24. Select REF2 to use the interactive graph and display the various stages of gain and filtering prior to input to the PIC24. Select MIC for biased microphone input, select LINE IN for non-biased input from external source

| | ADC No. of Bits | Sample Frequency (kHz) | Bandwidth (kbps) | | | | | Comment |
|-------------------|-----------------|------------------------|------------------|-------|-----------|----------|-----------|-----------|
| | | | Raw | G.711 | IMA-ADPCM | G.726* | Speex* ** | |
| Compression ratio | | | 1:1 | 2:1 | 4:1 | upto 8:1 | 16:1 | |
| | 8 | 8 | 64 | 32 | 16 | 8 | n/a | |
| | 16 | 8 | 128 | 64 | 32 | 16 | 8 | Use CODEC |
| | 16 | 16 | 256 | 128 | 64 | 32 | n/a | Use CODEC |
| | 10 | 12 | 120 | 60 | 30 | 15 | n/a | |
| | 10 | 16 | 160 | 80 | 40 | 20 | n/a | |
| | 12 | 12 | 144 | 72 | 36 | 18 | n/a | |
| | 12 | 16 | 192 | 96 | 48 | 24 | n/a | |

* dsPIC DSC required for these algorithms

**Speex Encode Decode Library currently fixed at an 8kHz 16-bit sample rate providing 8kbps output

Fig. 10. ADC sample rates and resultant data rate with compression options

highlights our earlier discussion regarding bandwidth and compression. If we are to create a playback/record system or an end-to-end communication system, then attention must be paid to reducing the total amount of data stored or transmitted through use of a compression algorithm of some form.

Let's take a look at a microphone interface to our ADC, see Fig.9.

This requires a bias circuit, amplifier and a filter similar to the playback filter discussed earlier. We are interested in a signal range of approximately 300Hz to 3300Hz, so a low pass filter with a cut off frequency of 4kHz should be sufficient. This will impose a minimum sample rate of 8kHz, which is twice our maximum expected signal as defined by the low pass filter cut-off frequency. This will allow us to meet the Nyquist sampling theorem requirements of minimum $2 \times f_s$ to ensure sufficient information is sampled to fully re-create the original waveform.

We can, of course, sample at a higher rate than 8kHz which should serve to improve the quality of our signal. However, we do need to determine the quality we need rather than the quality we desire. As discussed above, the higher our sample rate the greater the requirements placed on the onward system, see Fig.10.

If, as in this case, the quality of our analogue system ultimately limits the overall signal quality, then opting for a higher sample rate and high bit quality may simply be unnecessary. Also, we need to consider that we may have only a 10- or 12-bit ADC available internally to the device, so a

compromise of some form will be required. Often we will find that a perfectly good quality signal can be reproduced from one sampled at 10-bit 12kHz or variations around this point.

Creating a Voice Recorder

Using the microphone interface and adding a suitable storage medium it is possible to create a speech recorder, as in Fig.11.

Some consideration has to be made for the sample rate and resultant stored data size. Use of some form of compression technology will help reduce stored size of the sampled data. A further consideration when storing data however, is the resultant

data rate and matching this to the speed at which we can access and write to our storage medium.

Non-volatile memory technologies are limited by the time it takes to write the data into a memory cell, normally in the order of a few milliseconds. To help alleviate this, some storage devices provide a buffer and are best written to in data packets. Therefore, we may need to buffer a packet in RAM prior to sending this to our non-volatile memory storage device. The packet size can range from a few bytes for a Data EEPROM up to 512 bytes if we were storing a sector's worth of data using the FAT16 filing system on a flash memory card.

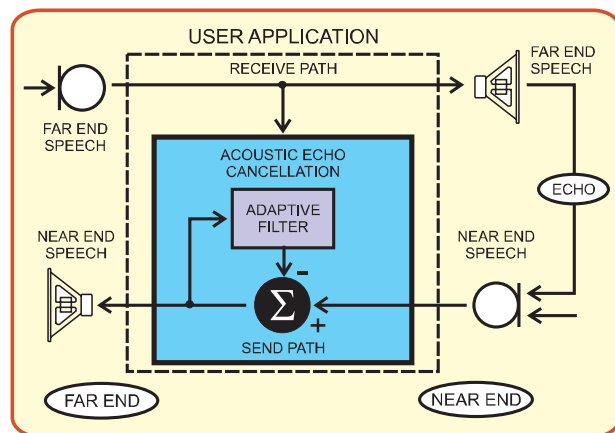


Fig. 12. Acoustic echo cancellation system diagram

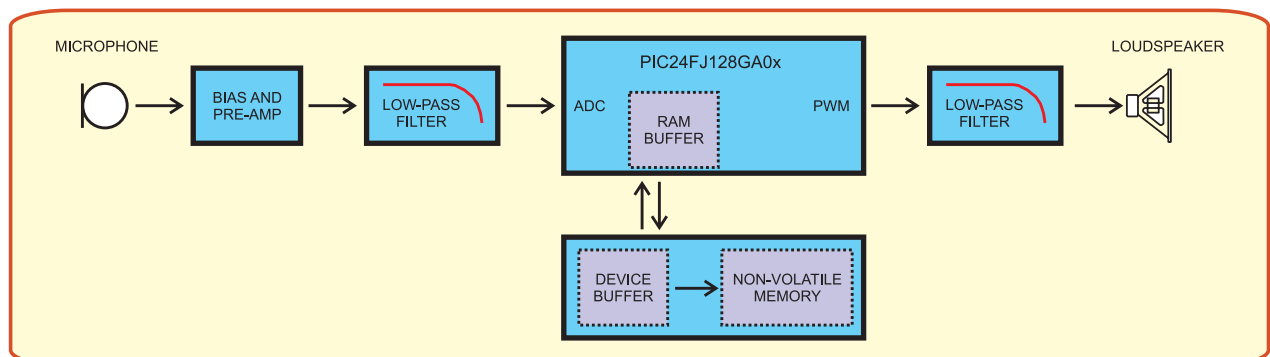


Fig. 11. Block diagram of voice recorder

Creating an Intercom

Once we have the microphone interface and the playback mechanism, we are at the point where adding a communications channel will allow us to create an intercom. We may then want to consider the addition of such technologies as echo and noise cancellation to help clean up our end-to-end system.

As we have now entered the realm where multiple algorithms may be in progress, we have to consider moving into the DSP arena to gain additional processing performance. Many of the algorithms which will provide the most benefit for speech compression also require DSP capability. If we consider the 16:1 compression ratio that the SPEEX algorithm provides and the resultant reduction in bandwidth this offers for storage and communications, then it is easy to see why moving up to the dsPIC makes sense.

Since we are considering an end-to-end system, then additional environmental factors such as noise and acoustic echo may need to be handled. These can help to create a significantly improved experience for the user.

Noise cancellation is basically the spectral reduction of noise in a system with the effect that speech appears to be enhanced as a result. To operate, the algorithm constantly monitors blocks of sampled data to determine if they contain noise. A component known as a VAD or Voice Activity Detect module is used to determine if a given sample block also contains speech. This combination allows the algorithm to build up a picture or profile of the noise in a system and as such performs a scaling of the noise to suppress it.

Acoustic Echo Cancellation is used to eliminate the inevitable acoustic wraparound which occurs in a system where the speaker emits into open space and the microphone is therefore able to pick-up this noise and return it to its source. Fig.12 should help to explain the problem.

The solution is to use the dsPIC to monitor the far-end speech and using an adaptive filter it is able to remove the far end speech from the near end speech. The result is such that it isn't returned to the far end and no echo is heard. It is a simple theory but extremely complex algorithms are required to perform echo and noise cancellation.

Can I play music?

Yes, you can play music or audio but, bear in mind all of the discussion regarding

PWM frequency and filter cut-off. If we consider that the audio bandwidth is around 20Hz to 20kHz, then our filter will need to have a cut off frequency around 20kHz so our sample rate would need to be around 40kHz. This has implications on our PWM and its relationship to clock frequency and available bits. Therefore, to achieve the playback rate, we would need to consider using a dual-weighted PWM, or more sensibly use a CODEC to provide a good quality output.

Can I decode MP3 or similar?

MP3 decoding may be possible on dsPIC33F devices, but it is possible to playback .WAV files, so if a device is coupled with a memory card, this should be easy to achieve. However, consider that to playback audio the most suitable signal chain is to include a good quality stereo audio CODEC. This will improve the playback quality, provided equally good quality amplifier and speakers are used, but it will increase the system cost. For simple speech playback via this route may therefore require careful consideration.

A further consideration is the increased power consumption required for the computation needed to perform the decoding on complex algorithms. If you are in a power sensitive application then often a much simpler algorithm like those implemented in our application will be more than sufficient. Suppliers such as Wolfson Microelectronics (www.wolfsonmicro.com) have an excellent range of CODEC devices with an I²S interface so they can be connected easily to the dsPIC digital signal controller.

Final message

The scope of options when it comes to adding some form of voice interaction with a system is quite large. We have concentrated on providing this capability via a low cost, easy to implement method using the ADC and PWM modules provided on PICs. We have focused on using the 16-bit PIC24F MCU as this provides the most versatility in terms of cost, memory and ease of use.

While the PIC24F isn't supported directly on the PICDEM Mechatronics hardware, you can still experience speech playback using the examples provided on the *EPE* website for use with the Proteus VSM simulator provided on the CD with the first article in the series.

Exclusive board offer

The Microchip PICDEM Mechatronics Development Board not only supports all of the projects featured in this series of articles but also includes nine example projects, each complete with source code.

To claim your exclusive *EPE* 20% discount on the Microchip PICDEM Mechatronics Development Board contact ACAL Semiconductors on Telephone: +44 (0)118 902 9702. Fax: +44 (0)118 902 9614. Email: sales@acalsemis.co.uk. Website: www.acalsemis.co.uk

If you download the support package for this article from the *EPE* website, you will be able to use the Proteus VSM simulator with various demonstrations. The demonstrations are node locked, but will allow you to modify the passive component values, and hence modify the filter characteristics. However, you will be unable to modify any of the topologies. The source code for the device can be modified as desired, so it is possible to change the PWM rate and bit quality etc within the bounds imposed by the PIC24FJ128GA010 modelled.

A set of instructions is included with the demo to help you add traces to the graphs, run simulations and therefore compare each of the filter circuits. Used within MPLAB IDE, the VSM Simulator is an excellent tool for testing designs and learning about a system without the need to create any physical hardware.

Next month we will be looking into using the PICDEM Mechatronics board using Proteus VSM.

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AN538 Using PWM to Generate Analog Output

AN643 Adaptive Differential Pulse Coded Modulation using a PIC

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Programming 16-bit Microcontrollers in C – Learning to Fly the PIC24, Lucio DiJasio, ISBN-13:978-0-7506-8292-3, Newnes

A Baker's Dozen – Real Analog Solutions for Digital Engineers, Bonnie Baker, ISBN: 0-7506-7819-4, Newnes

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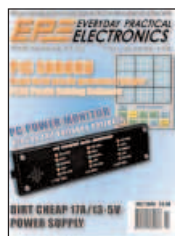
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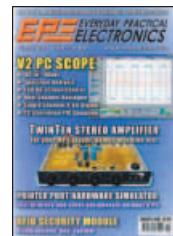
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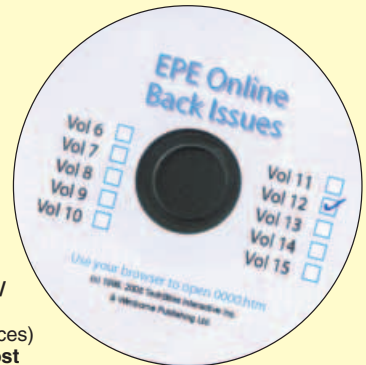
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The USB port has made PC expansion so delightfully simple it's a wonder no-one thought of it before . . . but it has its limitations. Most PC users are completely unaware of this and wonder why the computer starts giving error messages or the USB devices themselves either stop working or misbehave. Here's a really simple way to find out what those devices are doing.

Computer interfacing via Universal Serial Bus (USB) ports, in either 12Mbps (Version 1.1) or more recent 480Mbps (Version 2.0) offerings, has deservedly become such an indispensable connection method that it's hard to realise USB has only been in use for just a few years.

Apart from seamless 'smart' data connections for digital cameras, flash RAM dongles, WiFi adapters, modems and mice, etc, the availability of a regulated 5V DC supply at relatively generous currents has also lead to such diverse 'dumb' devices as mobile phone chargers, coffee cup warmers, cooling fans and inspection lights.

Dumb, of course, refers to the hi-tech USB data lines (middle pins 2 and 3) being ignored and just the low voltage DC being exploited at (outer) pins 1 and 4.

The PC's USB port can supply up to 500mA at 5V; however, downstream ports on USB devices are generally limited to 100mA maximum.

Although it may be considered frivolous to use a £500 PC to just power a light or charge batteries, the computer may be on anyway and equipment powered by the 5V USB supply is often conveniently associated with one's needs at the time.

Cold coffee, when trying to tame a late night spreadsheet macro, can easily ruin one's concentration!

The USB specification allows up to 5m of connecting cable, since signal timing issues may give data corruption with longer lengths. However, basic DC electrical issues also arise, with heavier currents giving unacceptable supply line voltage drops that infringe typical $5V \pm 0.25V$ load electronics needs.

As an example, Ohm's law tells us if 250mA is flowing through a wire of resistance 0.5Ω , then a tolerable drop of $I \times R = 0.25 \times 0.5 = 0.125V$ will occur.

This wire with the 500mA maximum load, however, would drop $0.25V$ and deliver only a borderline

by Stan Swan

4.75V to the load, which may therefore work unreliably.

An additional issue relates to the power needs of the numerous items now in use. Even with short cable lengths, multiple USB devices (and up to 127 are possible!) can eventually demand more current than is permitted, with resulting port shutdown.

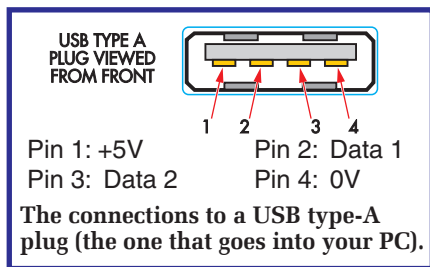
Unpowered hubs are particularly prone to this, which explains the need for powered USB hubs that will cater for multiple, energy-hungry add-ons.

Alternatively, a simple USB power injector could be used with an unpowered hub to achieve the same result.

EPE published such a project in the December 2006 issue, capable of supplying 5V DC at 1A to a USB device. Need more power than this for other devices? Add more power injectors!

Even though itself is now threatened by other advances in technology, Bluetooth has made a solid showing. Particular interest in verifying the output power of USB Bluetooth adaptors has therefore arisen.

The three Bluetooth classes have decreasing wireless power and range, and innocent purchase of a low power Class 2 adaptor may frustrate when range has to be maximised. The most powerful Class 1 is typically good



to 100m, with Class 2 some 10m and Class 3 just a metre 'across a motherboard'.

Although not specified in classes, (instead usually having power quoted in dBm [$15\text{dBi} = 10^{1.5} \sim 40\text{mW}$]),



Here's Stan's prototype USB breakout 'box', potted in some hot-melt glue. The idea is to poke your multimeter probes into the terminal block (avoiding shorts) for voltage measurements; for current measurements, you remove the header pin shorting block and connect your multimeter in series.

increasingly popular USB WiFi adaptors also differ significantly in their transmitter output power.

This is especially important when receiving some distance from an access point, since you may be able to 'hear' its strong signals – but it may not sense your weak out-going ones.

Given these issues, it's surprising USB supply breakout adaptors haven't become more popular, since simple current and voltage measurement of assorted loads can be extremely revealing, especially if device specs are being stretched.

Make your own!

With the cheapness of short USB M-F cables and DMMs, a simple supply breakout adaptor can quickly be organised by just cutting the cable. The position of the cut is unimportant – just ensure the data wires (usually green and white) and the braid are

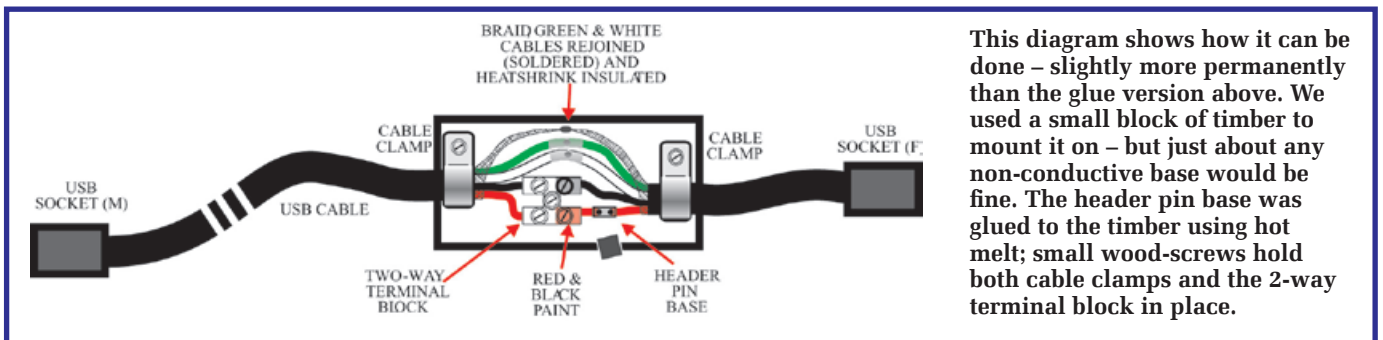
neatly resoldered and heatshrink covered, with no mischievous whiskers from the braided shield!

A small terminal block makes for convenient voltage test points across the red and black supply wires – even though a DMM won't be worried by reverse polarity, we painted our terminal block red and black to identify '+' and '-'.

For current measurement (which, of course, must be in series), we included a 2-pin header pin base in the +ve (red) wire. To measure current, the shorting block is removed revealing a handy pair of terminals for our multimeter clip leads – see below.

Table 1 shows some sample measured currents, using a short 600mm cable to typical loads, supplied from a mains-powered Toshiba laptop.

This laptop PC's unloaded USB supply was measured at 5.04V, which dropped when loaded by the power-



This diagram shows how it can be done – slightly more permanently than the glue version above. We used a small block of timber to mount it on – but just about any non-conductive base would be fine. The header pin base was glued to the timber using hot melt; small wood-screws hold both cable clamps and the 2-way terminal block in place.

Table 1: Current measurements

| Device | Measured load current (may vary with load demands) |
|--|---|
| Pocket 40GB USB Hard Disk | 300mA |
| Atmel 'b' WLAN adaptor DSE XH7947 (2002) | 270mA |
| DSE 'b' WLAN adaptor XH6822 (2004) | 90mA |
| Genius 'g' WLAN adaptor GW-7200U | 63mA |
| Logitech Quick Cam(2000) | 60mA |
| 'My Flash' 256MB Flash RAM | 50mA |
| DSE Class 1 BlueTooth dongle (2003) XH4104 | 48.5mA |
| 'Itsy-Bitsy' USB LED lamp (ref SILICON CHIP, March 2002) | 30mA |
| Genius Mini Traveller USB mouse | 10mA |
| Prolific USB-serial D9 adaptor (Picaxe use) | 8mA |
| Olympus C-1 digital camera (64MB Smart Media). Perhaps camera batteries supplying too? | < 1mA |

hungry Atmel WLAN adapter (drawing 270mA) to 4.88V with a 600mm cable and just 4.75V when at the end of a 5m USB 2.0 extender.

This 5m cable was measured as having 0.5Ω resistance in the supply wire (therefore 1Ω, considering return too), which tallies closely with the example above.



This active USB 5m extension cable uses some of the power available from the USB port to amplify the data signal. Up to five can be connected in series.

Adding another 5m extender dropped the load voltage to almost 4.5V, with the PC then reporting 'USB device not recognised', presumably because of timing and low supply voltage issues.

Given the lowered supply voltage at the end of these lengthy USB cables, it's feasible that heavier (paralleled?) DC supply cables could be used if longer runs are needed and data propagation timing is not an issue – perhaps to serve a rooftop USB webcam.

Some of the now-common external USB hard disks and CD/DVD writers actually have two USB connectors at the PC end, wired in parallel, to achieve the currents required. They rely on the fact that (hopefully!) most PCs these days have several USB port sockets close together.

Remote DC supplies via completely separate lines and a 7805 voltage regulator, perhaps with higher voltage (9V?) initially, may serve to stretch runs as well.

This is precisely the scheme involved in the *EPE* USB Power Injector mentioned above right; however, it also included line sensing to turn the power on and off in sympathy with the power at the USB port itself.

Perhaps even a small photovoltaic solar panel could be used to charge a rooftop battery, providing a regulated 5V supply. It's rather akin to 'corporate' power over ethernet (POE) approaches – well known for rooftop/masthead WiFi Access Points energised via cheap CAT-5 cable.



EPE's USB Power Injector from the December 2006 issue. It doubles the amount of power available from a USB port.

Aside from the tedious energy issues, ultimate cable lengths really are limited by the data speeds. Although such signals travel near the speed of light in cables, even a few extra metres of conductor can delay things unacceptably.

The recently-announced Wireless USB still only offers modest ranges (3-10m) but given the lack of wires(!), there certainly won't be any voltage drops – or convenient 5V supplies. Active Extender and doubled 'Bus' power cables may, of course, better suit demanding USB setups.

But if only modest extensions are needed, cheap passive extending techniques are well worth considering – if only to keep your coffee warm while lounging some distance away from the PC!

With the breakout adaptor shown above and a DMM, you can at least be easily informed of your loads' DC demands, something that currently is largely unknown. **EPE**

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PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

SEMICONDUCTORS are possibly the most confusing aspect of modern electronics. Not only are there numerous categories of semiconductor component, but there is also a vast range of different shapes types and sizes within each of these categories.

In many cases there are even various forms of the same device. The semiconductor section of an electronic components catalogue is normally huge, and represents a substantial proportion of a complete catalogue.

Deceptively simple

The diode is the simplest form of semiconductor, and it is a sort of electronic valve. It permits an electric current to flow in one direction, but blocks any significant flow in the opposite direction. The diode is obviously a form of polarised component, and it will only operate properly if it is connected the right way round.

If you connect a diode with the wrong polarity it will allow a current flow in the wrong direction, and block any flow of current in the right direction. This is more or less guaranteed to prevent the circuit from working, and in some circumstances can have disastrous consequences.

Although they are the simplest of semiconductor components, diodes often seem to be problematic when building electronic projects. Even experienced constructors sometimes find that the polarity markings of a diode something less than obvious. In some cases they are very confusing or even absent. In general, normal diodes do not cause too many problems. They are usually in the form of small tubular components in glass or plastic encapsulations. Fig.1 shows the circuit symbol for a diode, together with various physical representations for this type of component.

The two terminals of a diode are called the 'anode' and 'cathode', and these are often shown in the abbreviated forms 'a'

and 'k' respectively. The circuit diagrams that appear in *Everyday Practical Electronics* normally include the 'a' and 'k' markings, but they will not necessarily be included in circuit diagrams that are found elsewhere. Instead, there will sometimes be a '+' in place of the cathode marking.

Strictly speaking, none of these legends are actually required at all since the polarity is indicated by the diode symbol itself. However, these marking should be helpful to those of limited experience with circuit diagrams and circuit symbols.

By far the most common method of indicating the polarity of an actual diode is to have a band marked around the body of the component near the cathode (k) lead. This band corresponds to the bar at the cathode end of the diode's circuit symbol. There are a couple of common exceptions to this way of doing things. With one method the usual band is retained, but there are additional bands marked around the body of the component.

Banding together

In most cases the type number of a diode is simply marked on the body in tiny lettering, but with this method of marking the type number is indicated using a method of colour coding that is based on the system used for resistors. This system is used for diodes that have a '1N' prefix, and three or four bands are used to indicate the main three or four digit type number.

The band that indicates the cathode end of the component is normally much wider than any of the others, which should help to avoid the confusion that is possible with this method of marking. However, with real-world diodes the polarity is often less obvious than would be ideal, and careful scrutiny of the bands may be needed in order to sort things out.

Another method of polarity marking has a thinning at the cathode end of the

component's body. Again, this corresponds quite well with the physical shape of the circuit symbol. This method of polarity indication is mainly used with rectifiers, which are simply diodes that are intended to handle relatively high currents. Rectifiers are often much larger than ordinary diodes, with thick leadout wires. In the past they were often housed in some quite exotic encapsulations, and in some cases these were intended to be bolted direct to a metal heat fin.

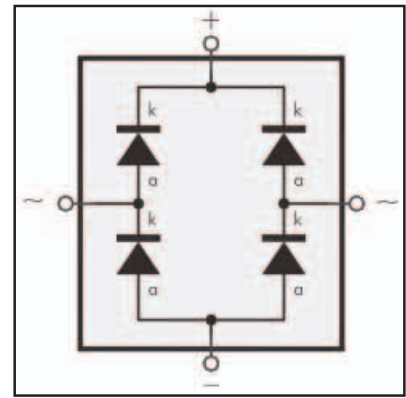


Fig.2. A bridge rectifier consists of four rectifier diodes connected in this ring configuration. The AC input is applied to the '~' terminals and the DC output is obtained from the '+' and '-' terminals.

On the bridge

Exotic encapsulations are now something of a rarity though, and are normally only found on rectifiers that handle very high currents. One exception is the bridge rectifiers that are often used in power supply circuits. A bridge rectifier is just a ring of four diodes connected in the manner shown in Fig.2. An AC supply is fed to one pair of leads, and a DC supply is obtained from the other two.

Bridge rectifiers are sometimes marked to show the polarities of the individual diodes, but a completely different method is often used to show the functions of the four leads. The two leads that connect to the AC input signal are marked with a wave '~' sign, and they can be connected to the AC signal either way around. The other two leads are marked '+' and '-', to show the polarity of the DC output signal. It is, of course, imperative that these two leads are connected with the correct polarity.

Heat of the moment

Most modern semiconductors are based on chips of a material called silicon, with a few using something more exotic such as gallium arsenide. The early semiconductors were based on germanium, and were generally much less tough than their modern equivalents.

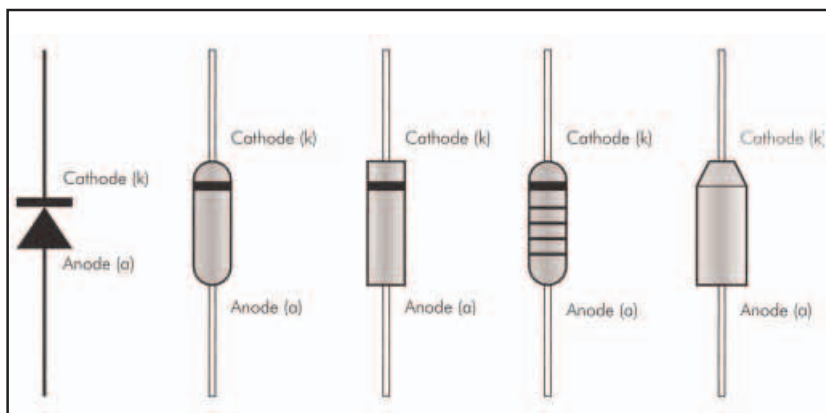


Fig.1. The diode circuit symbol (left) and various methods of identifying the anode and cathode leads on the actual components. These methods are loosely based on the circuit symbol.

Connecting the battery to your newly constructed project using the wrong polarity could easily result in most of the semiconductors being destroyed. While this sort of thing is not to be recommended with modern semiconductors, they will often survive short bursts of the wrong supply polarity.

Modern semiconductor components are also much more tolerant of heat than their predecessors. This is not to say that you can take all the time in the world when soldering silicon diodes and transistors, but it is not necessary to go about things in a mad rush. The more leisurely approach was not useable with germanium devices. The mad rush approach was not conducive to producing good quality soldered joints, but it gave germanium semiconductors a better chance of survival.

Germanium transistors are now long obsolete, but germanium diodes are still used to a certain extent, and usually in the form of the OA90 and OA91 diodes. When dealing with components such as these it is important to bear in mind that they are much less tolerant of heat than the more familiar silicon semiconductors. The design of modern germanium diodes seems to be such that heat from the soldering iron is less readily transferred to the semiconductor material than it was with some of the early germanium components.

Hot tips

However, it is still necessary to complete the soldered joints reasonably swiftly, and ideally a heat-shunt should be used. A heat-shunt looks a bit like a pair of tweezers, but it clips in place and does have to be manually held in position. It is fitted on the lead between the body of the component and the joint, prior to making the joint.

The idea is for some of the heat that flows along the leadout wire to be diverted into the heat-shunt and away from the semiconductor material. The time that can be taken to complete the joint is increased, but remember that a significant proportion of the heat will still flow up the leadout wire, and you should not get lulled into a false sense of security.

A heat-shunt is not expensive to buy, but it is something that will probably not be needed very often. It is not too difficult to improvise one using something like a pair of tweezers and a small rubber band, or a crocodile clip will work reasonably well in this role. Methods such as these are unlikely to be as effective as a proper heat-shunt though.

It is worth mentioning that diodes such as the OA90 and OA91, which have glass encapsulations, are not as physically tough as most other components. Even where the cases have an opaque covering, diodes that have glass encapsulations are easy to spot, because they are very rounded at both ends of the body.

With diodes of this type, it is not a good idea to bend the leadout wires close to the body, as this can result in them breaking off. Try to avoid too much tension between the body and the leadout wires, and always use the 'kid gloves' approach with this type of diode.

Seeing the light

The light emitting diode (LED) is another component that seems to cause more than its fair share of problems. It is a true

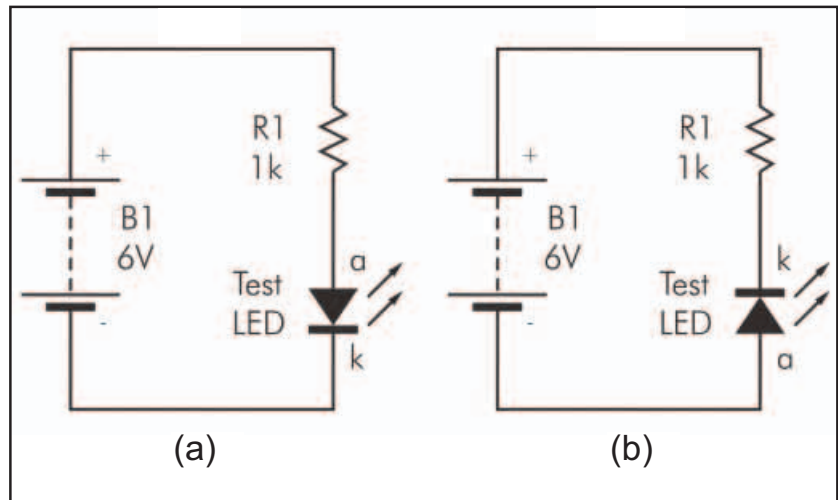


Fig.3. The test component will light up when connected as in (a), but not when it is connected as shown in (b).

diode, and unlike an ordinary filament bulb it will only light up if it is fed with a supply of the appropriate polarity.

The most common method of indicating the polarity of an LED is to have the cathode leadout wire slightly shorter than the anode lead. While the vast majority of LEDs conform to this scheme of things, there is a small percentage of these components that do things the other way around, or have two leadout wires of equal length.

Most LEDs have an additional means of indicating the polarity, which is to have one side of the body flattened slightly. This flattening is next to the cathode lead. Of course, there may well be some exceptions to this rule, and in the world of LEDs it seems to be inevitable that there will be a few components that flout the conventions. I have certainly encountered plenty of LEDs that do not have any flattening of the casing. In fact, I have come across a few LEDs that lack the flattening and also have two leadout wires of equal length.

Polarity check

Various 'surefire' methods of determining the polarity of an LED simply by looking at it have been put forward over the years, but none of them seem to be totally reliable. One problem is that modern LEDs seem to come in an ever increasing range of shapes and sizes, and the normal methods of determining the polarity are not applicable to some of the fancier types. The supplier's component catalogue will often include a helpful connection diagram.

In some circumstances it might be all right to use trial and error to determine the correct method of connection. Getting a LED connected the wrong way round should not result in any damage, but in some cases it could be difficult to disconnect and reconnect it if you get things wrong at the first attempt. It is clearly better to be certain as to which lead is which and to get it right first time, especially where a project uses a number of LEDs.

Most test meters can be used to check the polarity of a diode, but some of these do not work with LEDs due to the relatively high

forward threshold voltages. If you have a suitable test meter, then this certainly represents the easiest way of checking the polarity of the LEDs, and it is a good idea to check the polarity of these components before connecting them into circuit.

Where a suitable test meter is not available, it is quite easy to rig a simple test circuit that will enable the polarity to be checked. The simple circuit of Fig.3 is all that is required.

Specials

There are some special types of diode that are not used as electronic valves at all, but instead exploit some other feature of semiconductor diodes. Zener diodes are deliberately designed to 'breakdown' if the reverse voltage exceeds a fairly low voltage that is usually in the range 2.7V to 33V.

The reverse resistance of a Zener diode is normally very high indeed, just like that of an ordinary silicon diode. However, the reverse resistance rapidly falls when the so-called 'avalanche' potential is reached. This enables a Zener diode to be used in a simple voltage regulator circuit.

In practice, Zener diodes do not seem to be used a great deal these days. This is probably due to the advent of low cost integrated circuits (ICs) that can provide highly stable voltages. These have rendered Zener diodes, with their relatively modest levels of performance, largely obsolete. Anyway, Zener diodes look just like ordinary diodes, and have their polarity marked using the normal methods.

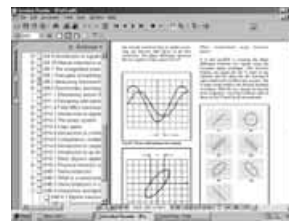
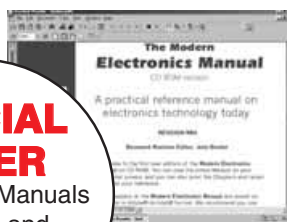
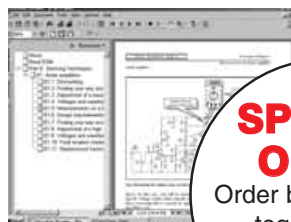
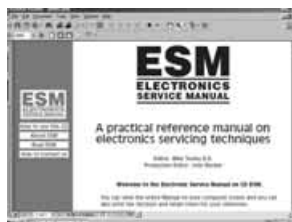
Variable capacitance diodes (varicaps) exploit the fact that the capacitance of a diode falls as the reverse voltage is increased. This can be used to provide a voltage controlled variable capacitor for use in radio sets, certain types of test equipment, and other specialised applications.

Some variable capacitance diodes have standard diode encapsulations, but they are often in the form of several diodes in one non-standard encapsulation. With any unusual component, the project article should always make the correct method of connection entirely clear.

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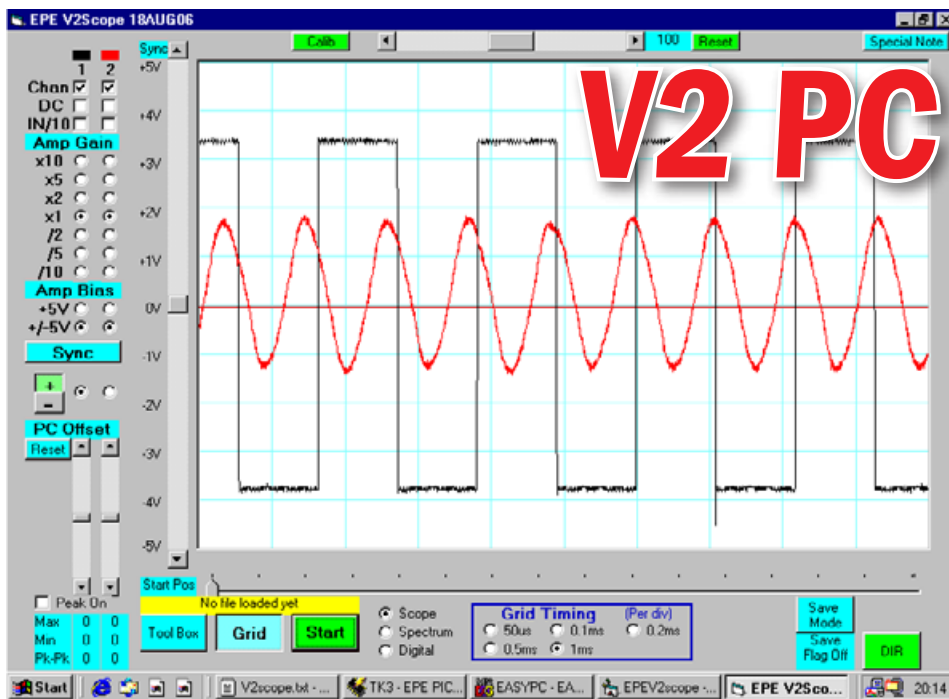
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V2 PC Scope

Part Two

By JOHN BECKER

A simple signal tracking and display unit for the typical hobbyist workshop

- ★ PC controlled PIC sampling
- ★ Frequency range DC to >40kHz
- ★ Dual channel analogue
- ★ Single channel spectrum analysis
- ★ Single channel 8-bit digital
- ★ On-screen control of all functions

LAST MONTH we tackled the task of building the master control and the 2-channel analogue interface circuit boards. This month we turn our attention to the software requirements and outline the various screen functions.

Software

Software for the PIC and the PC, including the source codes, is available for free download from the *EPE Downloads* website, access via www.epemag.co.uk. Download (copy) all the files into a common folder named according to your choice, on the C drive (in theory the program can also be run from another drive, but this has not been proved).

The PC software was designed through Visual Basic 6 (VB6) and supplied both as source code and a standalone EXE file. The latter does not need VB6 to be installed on the PC and is run simply by double-clicking on its icon.

Note that if attempting to run the source code files instead of the EXE, Joe Farr's *Serial Interface* software *must* be installed as well, otherwise the PC will crash.

On running the software, the program undergoes a brief one-time

setting-up procedure, in which various aspects of the program are established by creating some additional files. The choice of which COM port and Baud rate is used is made later by the user from within the program.

Screen tour

On completion of the start-up procedure, the screen shows a display similar to that in our heading picture, but without any waveforms shown.

At the left of the screen are several controls, principally one set per channel. As shown, both channels have been selected by clicking the CHAN 1 and 2 boxes at the top to reveal a tick mark in each.

Either channel may be selected or inhibited, depending on whether a CHAN box is clicked to reveal a tick, and or clicked again to turn that tick off. When the CHAN box is unticked, the remaining controls for that channel are removed from the display.

AC/DC and Attenuation

Whether the signal for that channel is being treated as AC or DC is determined by clicking its DC box: unticked for AC, ticked for DC. If the IN/10 box

is clicked for a tick mark, the input signal level for that channel is attenuated by one-tenth (1/10). Without a tick, the signal is unattenuated, i.e. 1:1. Clicking a second time on any box alternates the mode choice.

Channel Gain

The gain for that channel is selected by clicking on an Amp Gain 'radio' button to reveal a black mark within it, automatically clearing any previous gain selection. As shown, the choice is for each channel to have unity gain (×1). The other choices are self-explanatory.

Beneath the gain selection buttons are the basic bias setting 'radio' buttons. The choices are +5V, for positive signals, and +/−5V for signals part of whose polarity is both positive- and negative-going.

Sync Selection

Next come the waveform synchronisation options. There is a main button marked Sync. When Sync is inactive, the button background colour is grey. Clicking the button turns Sync on and the colour turns to green. Clicking the

button once more turns Sync off again. Sync polarity, positive or negative-going, is determined by which of the '+' or '-' buttons is clicked, the chosen one becoming highlighted.

Channel sync triggering selection is set by the allocated 'radio' button for that channel to the right of the polarity buttons. Only one channel can be chosen at any one time.

When Sync is turned on, the voltage level at which it is triggered is controllable by the position of the Sync slider to the left of the display. The trigger position is confirmed by the associated horizontal red line on screen.

Vertical Adjustment

Adjustment of the vertical aspect of any channel waveform on the screen is controllable by the respective PC Offset slider, its setting varying the position upwards or downwards. The Reset button causes the sliders to return to their central, no offset position.

These controls only affect the PC screen display, not the op amp bias of the signals on the PCB.

Peak Levels

Relative assessment of the signal amplitudes is calculated as determined by whether a tick mark is shown in the Peak On box, selected alternately by a mouse click on it. The assessment is only made when requested, since it adds time to the rate at which display samples are processed.

When Peak is on, the maximum and minimum signal peak levels for the channels are shown in boxes, plus the difference between maximum and minimum (Pk-Pk).

Display Block

Normally the quantity of samples within each 8K block is too great to display fully on screen. The section of samples which is displayed can be chosen by adjusting the slider below the screen.

Grid Timing

The displayed samples selection also varies depending on which Grid Timing option is chosen. This expands

or contracts the display so that each screen grid square width (division) approximately represents the period stated alongside the 'radio' button highlighted. The precision of this grid can be adjusted, as described shortly.

Mode Choice

There are three basic modes of operation for the PIC unit and its PC display, as selected by the three 'radio' buttons to the left of Grid Timing. The choices are oscilloscope mode (Scope), spectrum analyser (Spectrum), and digital logic waveform display (Digital).

More will be said on the latter two in a moment. Scope mode is shown to be selected at this time.

Grid

The grid display can be turned on and off alternately by clicking the Grid button.

Tool box

A separate screen is available, through which a choice of control options can be selected, see Fig.8. Click the Tool Box button to reveal it.

At the top of the screen are three 'radio' buttons through which a mode choice is made, selecting to change certain screen display colours (Colour), the bias level applied to the PCB's output op amps (Bias), and the basic gain provided by any analogue channel (Gain).

Colour Setting

Of interest perhaps on one occasion only, just to set the display cosmetically, the colour which is used to display various screen aspects is controllable by the user. First there is the colour used to display the individual waveform for a channel, the channel selection being made via the boxes to the left of the screen. This mode is available when the Colour 'radio' button is highlighted.

For any of these three options, the required colour button (any one of the 48 offered) is clicked. The chosen colour



Fig.8: The Toolbox screen in colour setting mode

is stored on exit from this sub-screen. It is then recalled for future use each time the program is run, until such time as it might be changed again.

Bias Setting

When the Bias mode is selected, the screen changes to that shown in Fig.9.

The channel which is affected by the control value chosen via the slider is selected by clicking either Chan 1 or Chan 2. Whether the bias is to be applied to the selected channel's output op amp when in +5V or +/-5V bias mode, is selected via the 'radio' buttons offered. The value required is selected by the slider, whose setting is displayed in numerical terms to the

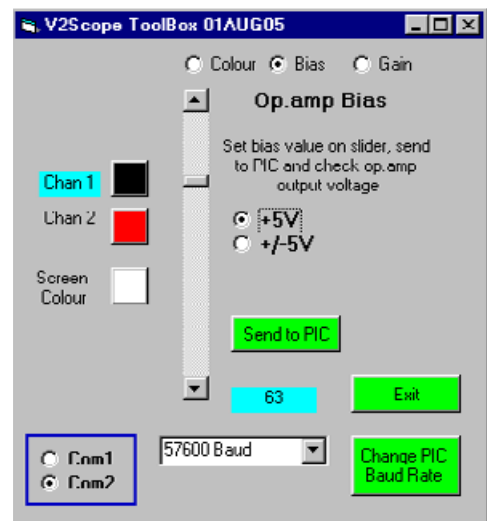


Fig.9: The Toolbox screen in op amp bias setting mode

bottom right of it. On clicking the Send to PIC button, the chosen value is sent to the PIC (which must be connected and switched on of course).

When next Scope or Spectrum mode is run, the new bias level will be applied.

Gain Setting

When the Gain mode is selected, the screen changes to that shown in Fig.10. This allows the setting of the precise amount of gain or attenuation provided by the unit's output op amp for the selected channel. Each setting for each channel must be set separately (certain approximate values are automatically provided during the initial setting up process). These values are applied appropriately when the Send to PIC button is clicked, overwriting the previous value for that mode.

Com Port Choice

The values are applied when Scope or Spectrum mode is next run.

Any of the three previous screens allow the COM Port and Baud values to be set from them.

Setting the COM Port needed simply entails clicking COM 1 or COM 2, with the 'radio' button confirming the choice.

Baud Rate

Setting the Baud rate affects both the PIC and the PC. The PIC's Baud rate must be at a known value before any different value can be applied.

Back on the main control PCB, are two terminal pins marked Baud Reset. Switch off the power supply to the unit, short the two pins together and reapply power. This causes the PIC's Baud rate to be set to 9600 Baud, and it will remain at that value until a different value is sent by the PC. Now disconnect the shorting link.

With the PC screen showing any of the screens in Figs 8, 9 or 10, select the Baud value required by clicking the Baud value combo box to reveal the choices, then click on the rate required. Then click the Change PIC Baud Rate button.

The new value is sent to the PIC at 9600 Baud, which stores it. Upon handshake acknowledgement that the PIC has received the value (a screen message will appear if it hasn't), the

PC program sets itself for the same Baud rate, stores the value for future recall, and the PIC applies it. The new value is now used from then on until the rate is again intentionally changed in the same way.

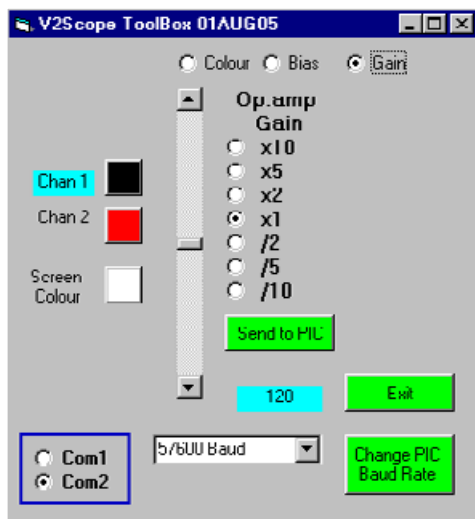


Fig.10: The Toolbox screen in op amp gain setting mode

Note that not all PCs will accept the higher Baud rates, and a slower rate may need to be used.

Run Mode

The screen display of the signal waveform commences when the Start button is clicked (the PIC's power supply must be switched on and the serial connector lead plugged in – using a standard cable such as used normally with a modem). The button legend changes to Stop. To end run mode, click Stop.

Calibration

Referring back to the main screen shot, as shown in the title page, the waveform timing, as displayed on screen, can be slightly changed from that which is basically provided. The rate at which signals are sampled inevitably varies depending on the exact rate at which the PIC's crystal X1 is actually running. Its accuracy is only within a certain percentage of the rate marked on its casing.

To re-calibrate the Scope waveforms, feed a square wave signal into the input of Channel 1, setting Sync on and selecting a suitable gain and bias value. Adjust the signal frequency and its waveform duration period (a normal scope will show this if available) to correspond with one of the

Grid Timing values and select the Grid Timing to suit that duration, so that each complete waveform cycle roughly spans a complete screen display grid width.

Using the Calib slider at the top of the screen adjust its setting until the waveform duration fills a complete grid square width. When the display is satisfactory, click the Calib button at the top of the screen. This causes the slider value to be stored for future recall next time the program is run.

The value itself is displayed to the right of the slider. Clicking the Reset button resets the slider to a default value if required.

Saving waveforms

Waveform data values may be stored to the hard disk for future examination. To do so, click Stop if necessary to end Run mode, click the Save Mode button to enter Save mode, and then click the Start button. The screen display is repeatedly updated and each block of incoming data is stored to disk as well as shown on screen. Click the Stop button when you are ready to stop recording. Then click Save Mode to end that mode, returning to normal display when Start is next clicked.

Each time recording is started, a new file is opened with a unique time and date stamped file name. The name is arranged in a format similar to:

S122206111453B.V2S

Splitting that name as

S 12 22 06 11 14 53 B.V2S

it translates as a starting date and time of:

| | |
|------|---|
| S | just a prefix ID associated with all V2 Scope files |
| 12 | the month number |
| 22 | the day of the month |
| 06 | the year (2000-2099 era) |
| 11 | hour (24 hr clock) |
| 14 | minute of the hour |
| 53 | seconds of that minute |
| B | just another general ID marker |
| .V2S | the extension given to all V2 Scope recorded files |

Thus the recording was started on 22 Dec 2006 at 11.14:53.

Recalling recordings

When in Stop mode, any previously recorded V2 Scope file can be recalled for display, allowing closer examination.

Click the DIR (Directory) button to display the file names available (see Fig.11). Details of the Directory screen are given in the Notes file, viewable when that screen's Notes button is clicked. The screen functions are similar to those used in many such screens of the author's projects over the last several years. They will not be further discussed here beyond what is about to be said, read the Notes file.

Single left clicking on any displayed file name does not select it, but causes a translation of the file name to be displayed. Double-click the file name to select the file for display on screen. This automatically closes the Directory screen and the recorded waveform is displayed.

The loaded file name is shown at the bottom of the screen.

The full data recorded will usually be much longer than the single data blocks normally displayed. The display may be panned by using the slider bar at the bottom of the screen.

When changing the Grid Timing, while displaying recorded data, click the Refresh button to refresh the screen in the new mode.

For interest, there are various demo files supplied with the software, prefixed 'Simul'.

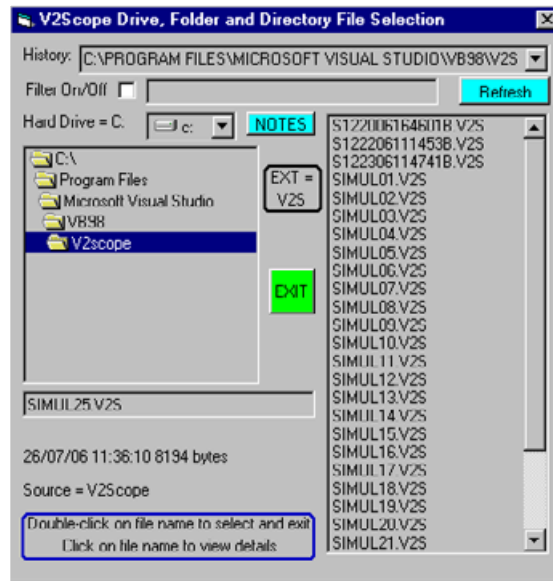


Fig.11: Example of the Directory screen

Special notes

Clicking the Special Notes button at the top of the screen displays brief text about possible pitfalls when sampling data.

Spectrum screen

When in Stop mode, clicking the Spectrum button reveals a screen similar to that in Fig.12, but normally without any waveform display.

The data displayed is always in relation to the signal data being input via Channel 1. No screen controls are provided for signal manipulation in this mode.

The upper section of the screen shows the waveform of the signal being input. The main screen section shows a frequency analysis of that waveform,

showing the frequency peaks at which harmonic frequencies are found. A lower legend scale shows the approximate frequency of those peaks.

Calibration of the data may be done in a similar fashion to that used for the Scope screen, inputting a pure sine wave of a known frequency.

The analysis method used is similar to that used in the author's previous designs of this nature, and is based upon the original routines written by the late Paul Cuthbert for *EPE's* sister publication *Modern Electronics Manual* some years ago.

Grid Timing selection is available, as per Scope mode.

Digital screen

When in Stop mode, clicking the Digital button reveals a screen similar to that in Fig.13, but again normally without any waveform display.

The data displayed is always in relation to that being input via SK1 in Fig.1 (last month) when that data is 'Live'. Recorded data can also have its logic levels for each sampled bit recorded via Channel 1. Again, no screen controls for signal manipulation have been provided.

The screen is split into eight sections, each one corresponding to the logic levels of each bit, as numbered down the righthand side of the screen.

Calibration and Grid Timing selection are available as in Scope mode, though are perhaps unnecessary for this mode.

Conclusion

That concludes the description of the V2 PC Scope. May its simple facilities be of benefit to your workshop. *EPE*

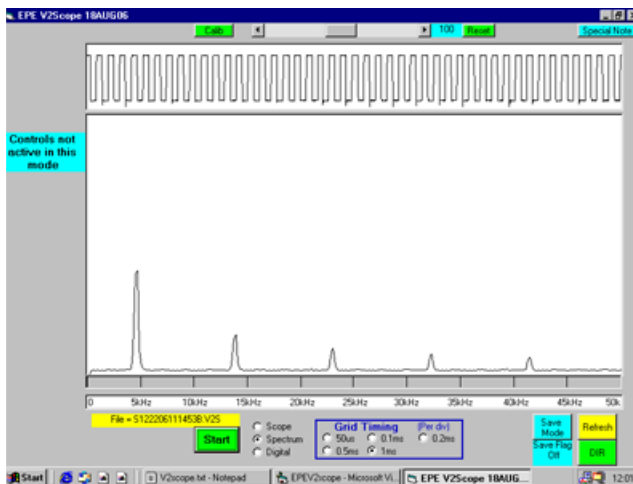


Fig.12: Example PC screen when in Spectrum mode

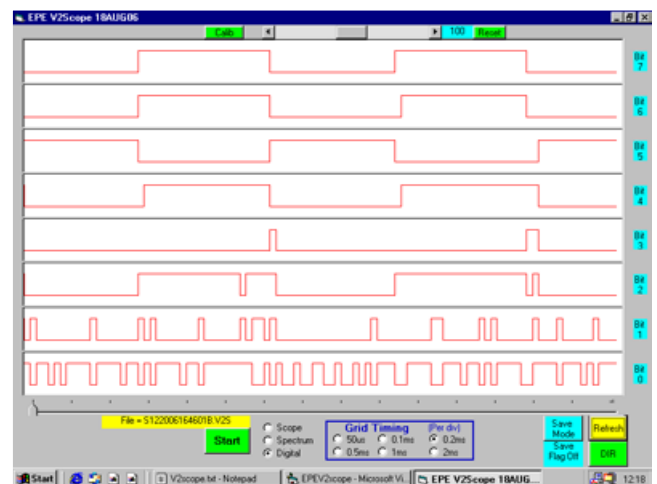


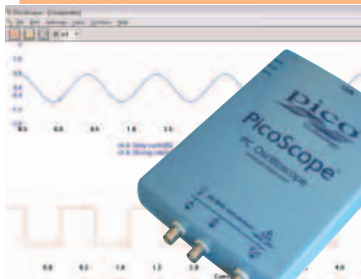
Fig.13: Example PC screen when in Digital mode

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Measuring Colour Temperature - *Multimeter Rainbows?*

The term 'Colour Temperature' is often used to describe the 'whiteness' of light from a luminous source. It is measured in degrees Kelvin and relates to the temperature of a radiating 'black body'. The higher the temperature, the 'whiter' the radiated colour. For incandescent (filament) light bulbs, a colour temperature value is sometimes quoted by manufacturers, but can also be measured using an optical spectrometer. If you don't have an optical spectrometer to hand then a multimeter will do.

According to Wikipedia, tungsten (as used for lamp filaments) adheres very closely to the theoretical 'black body' referred to in the colour temperature definition (see http://en.wikipedia.org/wiki/Color_temperature). So that means that if we know the actual running temperature of a lamp's filament, then that gives us the colour temperature. Like most metals, the electrical resistivity of tungsten over temperature is very well defined (see <http://hypertextbook.com/facts/2004/DeannaStewatewat.shtml>). Using this relationship it is possible to work out a very accurate figure for a filament's running temperature by calculating the ratio between the lamp's electrical resistance when lit and the lamp's resistance at room temperature (around 300°K) (see Fig.1).

The running electrical resistance (R_{HOT}) can be simply calculated from the lamp's voltage and power ratings:

$$P = V^2/R_{HOT}$$

$$\text{therefore } R_{HOT} = V^2/P$$

The room temperature resistance (R_{COLD})

can be measured using a multimeter. Calculate the ratio of:

$$x = R_{HOT}/R_{COLD}$$

Plug this ratio figure into the formula derived using Excel from the tungsten resistivity vs. temperature information:

$$\text{Colour_Temperature (y)} = -1.62x^2 + 203x + 128^\circ\text{K (see Fig.2.)}$$

A final thought: many folk desire lovely 'white' light with very high colour temperatures (halogen lamps tend to be whiter than standard lamps). However, this implies a larger ratio between the hot and cold resistances, and that leads to higher inrush currents when switching on the lamp. So yellow lamps yield lower inrush currents than whiter ones.

Jez Siddons, Derbyshire

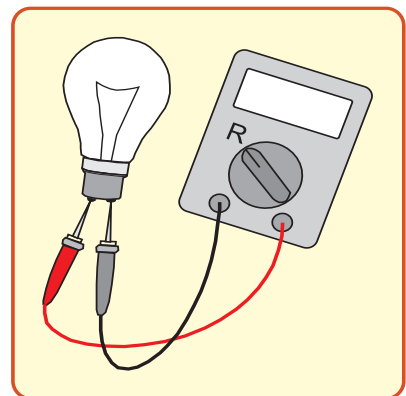


Fig.1. Checking a lamp's room temperature (R_{COLD}) resistance using a multimeter

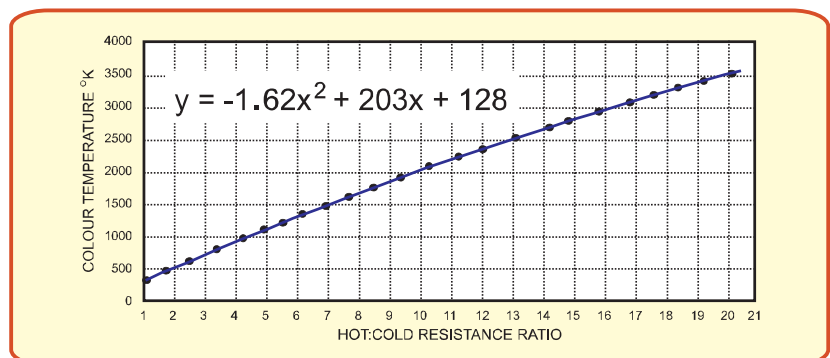


Fig.2. Colour temperature (°K) vs tungsten Hot/Cold resistance ratio graph



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READOUT

Email: editorial@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.

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Common vices

Dear EPE,

Looks as though *Net Work* July '07 gives a clue that Alan and myself share a couple of vices – chocolate and ice-cream! Chris and I have just come back from a short break in Stratford-on-Avon where there are ice-cream opportunities at strategic locations, including sales from a barge (really a converted narrow-boat) permanently moored in the canal basin near the theatre!

In *Readout* of the same issue, you've probably covered the licence requirements of the 1949 Act, but just to clarify, anyone may build a transmitter (not quite what Mike said) but emitting a radio signal is controlled by legislation.

There are two possibilities. If a licence is required, it's illegal to transmit without one. The other possibility is the exception where the individual owner needs no licence as long as the manufacturer has achieved type-approval for equipment operating on a licence-exempt frequency. This is how John's RF remote control is permissible. But, broadcast bands are out of the question – unless you are a permitted broadcaster. So, yes, the simple electronics kits (such as the 'Tandy 150-in-1') are illegal. Yes it's low powered, yes, that's how its users escaped detection and retribution!

The law lags behind technical developments and the legal knickers got twisted when someone was found with a radar speed-camera detector in his car. Illegal, not licenced! (said the judge). Ah, but m'learned friend pointed out that there were plenty of other broadband receiving devices for this part of the spectrum, such as microwave oven RF leakage detector alarms (I've got one) and that, if Their Honours were to ban the radar trap detector, then the law would at a stroke also make microwave safety alarms illegal. Because the legal draftsmen have yet to understand the difference between these devices, the national papers are now full of adverts to help the speeding, illegal and dangerous motorist to get away with their crime.

(W.S. Gilbert comes to mind from *Trial by Jury*, in his younger days the judge states that, by the eloquence of his orations, "Many a burglar I've restored to his friends and his relations.")

Case law also invokes a concept of *Availability for Use*. If someone builds an unlicensed transmitter, tests it into a dummy load and then packs it up for despatch to a licenced recipient, then the law is not broken, as the builder will say that it wasn't available for use as he hasn't got the necessary aerial. Another legal nicety that could earn a fortune for lawyers. Sorry, I don't know the actual cases to quote.

The Coastguard is not the agency with authority to stop an interfering transmission. Of course, they are right to point out

★ LETTER OF THE MONTH ★

Battery Zapper

Dear EPE.

Regarding the Battery Zapper in the July issue – one of the major influences in the life of a battery is the cavity area underneath the battery where all the debris falls and as soon as this fills up you get the dreaded short-circuit and the high battery charging current described.

There have been numerous chemical ways of converting lead sulphate to an inert material but they all fail due to the inadequate cavity area for the rubbish to park in. Where I worked we had 600 volts of submarine batteries and it was routine to withdraw the plates periodically and siphon the debris out. Several guys re-energised car batteries by making a hole in each battery section low down in the casing, filtering the acid through blotting paper and using threaded nylon screws to re-seal the battery before putting the filtered acid back and topping up with demineralised water.

A word of warning, though, all these operations need to be carried out in the open air as the acid and the hydrogen given off can be quite corrosive and explosive. Familiarity always breeds contempt and several times we had qualified electrical individuals charging batteries in enclosed spaces and we used to hear a big bang and a door would come flying off. There would be the culprit, sitting in the corner, covered in dust and when you asked if he was ok he would answer 'Wednesday' cos he was temporarily deaf!

Also, if you vent the place, use an induction motor as you don't want brush gear causing sparks.

George Chatley,
via email

George, thanks, a most worthwhile warning. Must admit I'm still laughing about that poor guy's response!

the danger to safety-of-life marine services and anyone thus warned would be negligent to continue the nuisance. But, legally, enforcement can only come through the licencing agency, now Ofcom. Also, did you know about their general licence? Applies to all transmissions, even if licence-exempt! Little known fact. Don't worry, though, it only contains obvious stipulations such as don't use offensive language on air or cause avoidable interference.

Did I ever tell you the difference between doctors and lawyers? No? Put three doctors together and you'll get three different diagnoses. Put three lawyers together, you'll get four different opinions – and even then, one of them will want to appeal.

Finally, one of those basic questions that I always took for granted but should have asked about. It's prompted by *Circuit Surgery* (same issue) and, first, well done Ian on a much clearer explanation of feedback and compensation than I've seen elsewhere. Let me develop the subject further. Why is it preferable to configure op amps in the inverting sense? What is the advantage over non-inverting amplifiers?

Godfrey Manning, G4GLM,
via email

Thanks for that Godfrey. Hopefully Ian will answer your query in CS in due course.

Program complexity

In the July '07 *Readout*, Edward Chase writes, 'I cannot conceive of going

straight to assembler or C from an idea in my head for a complex routine like a setup menu, because it has so many branches and loops.'

Complexity is a common problem in programming and can be dealt with in various ways. Complexity is bad, because the code is hard to design and write, and difficult if not impossible to test thoroughly.

First of all, ask yourself if all the complexity is really needed. Unnecessary functions can be discarded, or the logic restructured to simplify the process. Ultimately, if the program is too complex, the chance of failure becomes significant. Using a high level language like C instead of assembler will decrease the complexity of any program considerably.

Breaking the program into subroutines is the way to go to manage complexity. Experience is important in determining the best way to do this. Subroutines must have clearly defined inputs and outputs and processes. Always place a commentary block ahead of each subroutine to document it. Further, structure your subroutines into manageable source code files of related functions. Huge source code files are very bad.

Put a lot of thought into using global variables. It should be clear in your mind where a variable is updated and where it is tested. Sometimes hiding global variables in functions that manage them, as is done in object oriented programming languages, is a useful idea if things get out of hand. Abstracting the problem you are solving into the global variables required is crucial to the complexity of the result-

ing code. This is a hard concept to grasp until you've done it wrong and struggled with the resulting mess. Give your subroutines and variables meaningful names.

Experience is a great teacher, and the only way to get it is to start programming now. Good Luck.

Jack Botner,
via email

Jack, inexperienced programmers, and even more advanced ones, should take note of what you say

Thanks for LOM

Dear EPE,

Thank you for the LCR Analyser won for my *Letter of the Month* in the July issue. I have always wanted this analyser but could never quite justify the cost.

Brings to mind the fact that it is about 40 years since *Practical Electronics* published the first letter I ever wrote to a publication. The few shillings Postal Order they sent me for it was useful to a teenager to fund his component buying, which has continued ever since. Glad to see that *PE* is still going, albeit under a new name, but it's essentially the same concept. Keep it up team!

What was the *PE* letter about? Well, despite the technical advances in our hobby, it is just as relevant today so I'll repeat it below:

When you wire a mains plug do not cut all three wires to the same length, even on those few plugs designed to take equal length wires. This is because, if the cable is pulled hard/stepped on/tripped over, the earth wire will part from its terminal first, leaving your appliance earthless. Instead, leave most slack on the earth wire and the least on the live wire. Then the live parts disconnect first and the earth last.

I enjoyed Robert Penfold's *Flowcode* review in the July issue as well as John's *PC Scope*. I note that Robert disagrees with John in that he said, "Many programmers produce a chart of this type (a flow-chart) as a preliminary step when producing a program".

Edward Chase,
via email

Thanks Edward, I felt you deserved LOM. Thanks too for that timeless tip. Re disagreement – as always, there are many different opinions (see Godfrey's earlier comment).

Online camera shopping

Dear EPE,

I've just read Alan's July '07 *Net Work* column in Toronto, Canada and I wanted to add another caveat re NYC online/mail order camera and electronics stores. Such shops are notorious for stripping out extras that were supposed to come in the box and selling them off separately. This can be things like earphones for audio players, cases, memory cards, or kit lenses for cameras, basically anything they think they can unload for extra cash.

This wouldn't be so bad, except they rarely advertise this fact, and unsuspecting

purchasers wind up comparing apples with oranges when doing local research. That terrific 20 or 30 per cent discount over buying on the high street isn't so attractive if 40 per cent of the value has been stripped out of the box by unscrupulous dealers.

This doesn't just happen to remote buyers in NYC tech shops. My brother lived in NYC for four years some time ago and he bought an identical Sony Discman there that I had just purchased in Toronto. I got the full package with AC adapter, case, rechargeable batteries, and remote control earbuds. He got the same box, but just the player alone.

Martin Green,
Hamilton, Ontario,
Canada, via email

Alan replied to Martin:

Point taken and I do recommend comparing the specs closely. B&H shows what's included and I agree that buying 'blind' online is not for the faint hearted (or those easily separated from their money).

Alan Winstanley,
via email

Mass change of PC file attributes

I recently raised a question on our Chat Zone (via www.epemag.co.uk) and felt that the responses were worthy of a larger audience – here are edited extracts of the discussions –

john_becker: *I've just had to have PC World fix a faulty PC which would not load Windows due to some files having become corrupted. It now works. But all the files have become read-only files, and there are hundreds if not 1000s of them.*

With many it doesn't matter, but with others it does. Trying to do all the changes manually for so many files is daunting. Does anyone know of a command one can give as a global instruction to make all files readable/writeable?

It's a PC running Win 95, and is in constant use for its many workshop files which will not run on Win platforms later than ME.

scott2734: *If you want to clear the 'read only' attribute bit of all the files in a directory, execute the following command line through DOS:*

```
ATTRIB -R c:\WINDOWS\*
```

where

+ Sets an attribute.

- Clears an attribute.

R Read-only file attribute.

A Archive file attribute.

S System file attribute.

H Hidden file attribute.

/S Processes files in all directories in the specified path.

(I entered DOS and went back to the root directory using cd\ I then amended Scott's command line to suit the folder I wanted:

```
ATTRIB -/S -R C:\PICS\*.*
```

Which cleared all the file attributes from read-only)

john_becker: *Scott, many thanks – having by trial and error remembered how to use DOS after many years of not, using your basic info I succeeded in getting all the files in a main folder and its sub folders all back to writeable.*

I wonder though how those who cannot get DOS access on their later PCs would have fared on the read-only etc aspect. I understand some PCs do not provide DOS access. Is that correct?

philwarn: *I cannot vouch for Windows Vista – do not want to touch it with a bargepole, yet!*

With Windows XP, XP SP1, or XP SP2, using the RUN command from the START button and then running CMD from the popup box, gives access to DOS commands and to DOS programs.

john_becker: *Phil, I agree about Vista, especially after what I've seen written about it. And I understand that not even Service Pack 1 has been released yet. I'd be interested to know if it has DOS access in anyway – does anyone know?*

afferrari: *Use the Windows 'search' function, inside the file where all those archives are. Search for "*.*". That will list all of them. Do a right click on the list. Click to eliminate the setting you don't like. (You can use this to set something you like as well). No need to go through DOS. Neat and faster.*

riki: *popped into PCW a couple of months ago when Vista came out and played with a couple of their computers. No problems going into the DOS prompt and also DEBUG is still there. Appears that the old DOS commands will live forever.*

afferrari: *Win 98 and Win ME for sure. I think I heard this working also with XP but not tried.*

john_becker: *Found a snag with Scott's answer – the DOS limit of eight characters in a file name. Have tried to clear read-only settings in other folders, having quite lengthy names. DOS does not like it. I perhaps should also point out that Scott's *.* extension should be *.* to cover all files and extensions in a folder.*

Agustin (atferrari), I've figured out how to use your solution. I opened the folder in the normal way, selected Edit to then select all the files. When they were blue highlighted, I right-clicked on one of the icons of the selection, that allowed me to select Properties from which I then could adjust the attributes for all the selected files in one operation.

I could have selected just those files I wanted by changing file order arrangements, and then using the same technique. It was only when the files were highlighted and an icon right-clicked that the option was available.

I could not find a way with DOS to select files within folders within folders in order to change their attributes. Length of file names also became a problem.

Once again the power of the knowledge available via the Chat Zone has proved beneficial. Thanks all – problem now solved.



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Welcome to *Net Work* – the column specially written to help *EPE* readers make more of their Internet access. New readers may not be aware of our website at www.epemag.co.uk where you can check out the latest constructional projects or search for magazine details of previous projects. Back issues can be ordered via our Online Shop: we accept popular debit and credit cards, we have no minimum order charge and we deliver worldwide.

For the benefit of constructors we have started to supply printed circuit board/printed wiring board artwork online for most projects published since March 2006. Where available, they can be fetched in PDF format from our Downloads pages at www.epemag.wimborne.co.uk/downloads.html.

One of the most popular areas of our website is our source code download service. *EPE* was among the first to offer free source code for its projects and, as regular readers will know, we chose to mainly focus on one particular brand of microcontroller, the PIC micro from Arizona Microchip. Occasionally a designer will utilise alternatives, mainly using the Atmel range.

Source code for almost every project is available on our Downloads page, and in the rest of this month's *Net Work* we offer more background information and suggest alternative methods for fetching our source codes.

Mainly for historical reasons, our entire source code library is hosted on an FTP (file transfer protocol) server – type <ftp://ftp.epemag.wimborne.co.uk> into your web browser to see. This was because the world wide web barely existed when we started to distribute our source codes via the Internet, so an FTP site was the only solution. As the website gradually evolved, an HTML (web-style) front end was created to simplify the access to our file area for web users, by using a simple 'tree' format on the Downloads page. This simply links over to the relevant files on our FTP site. Note, however, that our PCB files are currently hosted directly on our web server at <http://www.epemag.wimborne.co.uk/pcbs/>

We would again like to thank *EPE* enthusiast Thomas Stratford for his continued dedication to hosting the Official *EPE* Mirror Site, at <http://homepages.nildram.co.uk/~starbug/epemic.htm>. *EPE* readers owe Thomas a large token of gratitude for diligently hosting an easy to use web-style interface for many years.

FTP for free

One of the best ways to download our source code files is with proper FTP software such as WS FTP from www.ipswitch.com or perhaps Cute FTP from www.cuteftp.com. If you can use Windows Explorer then you can use FTP software: it is simply a question of connecting then dragging and dropping files from the 'remote' server on to your 'local' machine. If you are a broadband user then it is worth checking FTP software options to enable the 'Passive FTP' option for better compatibility.

For our printed circuit board/printed wiring board files, simply click on a PCB link in the download tree (such as Sept '07...) and you will be asked to save a file to your hard disk. Our PCB files are 'zipped' to

combine several pieces of artwork into one convenient file, so a simple unzipping utility is needed, such as the freeware 7-Zip archiver/for Windows or Linux (command line) from <http://www.7-zip.org>. To view the PCB artwork also required is, of course, a PDF viewer, such as Adobe Reader free from www.adobe.com.

Unfortunately, it was found more recently that Microsoft's IE7 web browser is not entirely compatible with the 'tree' script used on our Downloads page, so the best way is to right-click over a project name and choose Open in New Window... then save the files to your hard disk.

Which brings me neatly to the alternative web browser, Firefox. This is available for free from www.mozilla.com and has an extremely loyal following among its fans. (Incidentally, the name 'Mozilla' derives from the green lizard – or is it a dinosaur? – mascot used by Netscape Corporation in the 90's before their commercial web browser was spun into Firefox. See www.iconarchive.com/mozilla/).

The current version of Firefox is 2.0.0.5 and, apart from its high degree of usability, one of the joys of the browser is its wide range of add-ons, including a British dictionary... and an FTP plug-in called FireFTP. This extremely useful plug-in offers an FTP-style display when browsing an FTP site, and is an ideal way for *EPE* readers to find their way around our file area. After installing the add-on, an icon will appear in the toolbar (see screenshot).

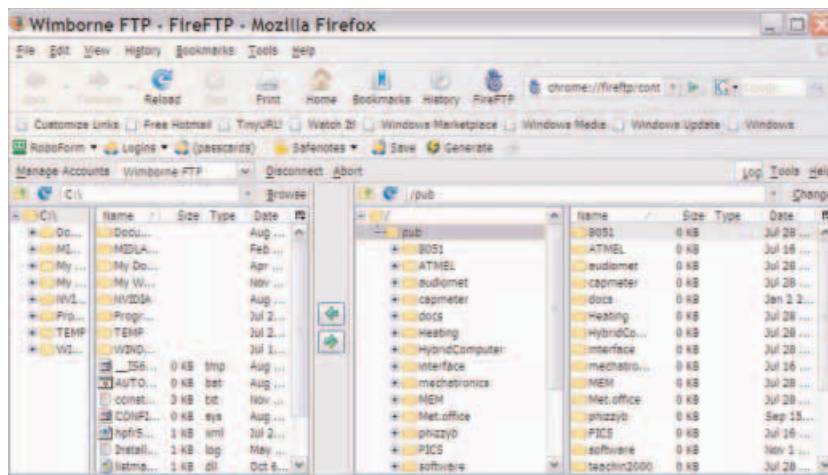
Simply go to Manage Accounts... / New... /

Account Name (a meaningful name for your benefit, e.g. *EPE* FTP site)

Host <ftp://ftp.epemag.wimborne.co.uk/pub>

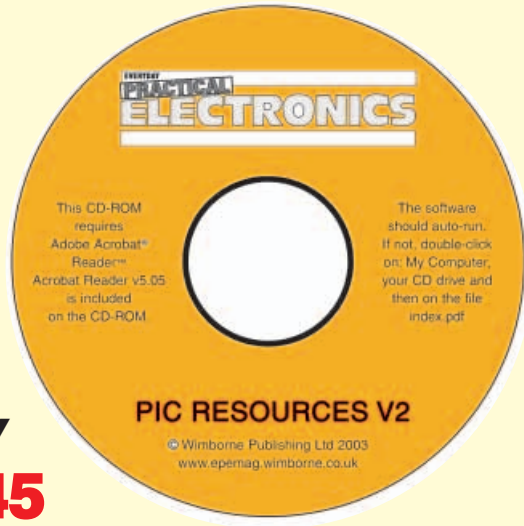
Lastly, tick the 'Anonymous' box because you are not logging in with a dedicated username and password. The new account name will appear in a drop-down selector box, then press Connect and you will see our file area in FTP folder view. You can choose some options in the plug-in's Tools button. Simply click the FireFTP icon to open the software in future.

As can be seen, the internet is not just about the world wide web and hopefully this month's column shows some alternatives for you to explore. You can email me at alan@epemag.demon.co.uk



The free Firefox web browser with the FireFTP add-on, displaying a folder view of our FTP server

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.

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BECOME A PIC WIZARD WITH THE HELP OF EPE!

Electronics Teach-In + Free CD-ROM

Mike Tooley

A broad-based introduction to electronics – find out how circuits work and what goes on inside them. Plus 15 easy-to-build projects. The 152 page A4 book comes with a free CD-ROM containing the whole *Teach-In 2006* series (originally published in *EPE*) in PDF form, interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The *Teach-In* series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC.

In addition to the *Teach-In* series, the book includes 15 CMOS-based simple projects from the *Back-To-Basics* series by Bart Trepak, these are: Fridge/Freezer Alarm, Water Level Detector, Burglar Alarm, Scarecrow, Digital Lock, Doorchime, Electronic Dice, Kitchen Timer, Room Thermometer, Daily Reminder, Whistle Switch, Parking Radar, Telephone Switch, Noughts and Crosses Enigma and a Weather Vane. There is also a MW/LW Radio project in the *Teach-In* series.

152 pages + CD-ROM **Order code ETI** £8.50



THE AMATEUR SCIENTIST 3-0 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 ASICD-ROM** £19.95

PROJECT CONSTRUCTION

IC 555 PROJECTS

E. A. Parr

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are over 70 circuit diagrams and descriptions covering basic and general circuits, motor car and model railway circuits, alarms and noise makers as well as a section on 556, 558 and 559 timers. (Note. No construction details are given.) A reference book of invaluable use to all those who have any interest in electronics, be they professional engineers or designers, students or hobbyists.

167 pages **Order code BP44** £5.49

POWER SUPPLY PROJECTS

R. A. Penfold

This book offers a number of power supply designs, including simple unregulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench power supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits. The information in this book should also help the reader to design his own power supplies. Includes cassette PSU, Ni-Cad charger, voltage step-up circuit and a simple inverter.

91 pages **Order code BP76** £5.49

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT

R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers and crystal calibrators.

104 pages **Order code BP267** £5.49

DIRECT BOOK SERVICE

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS
AND CDROMS SEE THE SHOP ON OUR UK WEBSITE –
www.epemag.co.uk

All prices include UK postage

ELECTRONIC PROJECT BUILDING FOR BEGINNERS

R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Order code BP392** £5.49

TEST EQUIPMENT CONSTRUCTION

R. A. Penfold

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

The following designs are included:-

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

104 pages **Order code BP248** £4.49

COMPUTING

COMPUTING FOR THE OLDER GENERATION

Jim Gatenby

Especially written for the over 50s, using plain English and avoiding technical jargon. Large clear type for easy reading.

Among the many practical and useful ideas for using your PC that are covered in this book are: Choosing, setting up and understanding your computer and its main components. Writing letters, leaflets, invitations, etc., and other word processing jobs. Keeping track of your finances using a spreadsheet. Recording details of holidays and other ideas using a database. Using the Internet to find useful information, and email to keep in touch with family and friends. Making "back-up" copies of your work and checking for viruses. How to use Windows XP to help people with impaired vision, hearing or mobility.

Provides the basic knowledge so you can gain enough confidence to join the local computer class.

308 pages **Order code BP601** £8.99

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

RADIO

SETTING UP AN AMATEUR RADIO STATION

I. D. Poole

The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.

Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

86 pages **Order code BP300** £4.45

EXPERIMENTAL ANTENNA TOPICS

H. C. Wright

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

The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc.

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

72 pages **Order code BP278** £4.00

25 SIMPLE INDOOR AND WINDOW AERIALS

E. M. Noll

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

This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers.

50 pages **Order code BP136** £2.25

TICKLING THE CRYSTAL Domestic British Crystal Sets of the 1920's

Ian L. Sanders

The first book dedicated to the topic of British crystal sets to be published in the last 25 years. For a very brief period during the early 1920's, these simple receivers played a crucial role in the expansion of domestic wireless throughout the United Kingdom. For many families, rich and poor, the crystal set provided an introduction to the new pastime of listening-in to broadcast programmes. Rapidly made obsolete from homes as suddenly as it had arrived, but not without leaving its mark on the history of wireless.

Written by a long-time authority and enthusiast, *Tickling the Crystal* is the most comprehensive work on the subject ever assembled. Containing almost two hundred excellent quality photographs and a wealth of previously unpublished material, it cannot fail to be an invaluable reference for anyone interested in the history of early wireless receivers.

256 pages hardback **Order code TC1** £34.00

THEORY AND REFERENCE

BEBOP TO THE BOOLEAN BOOGIE

Second Edition

Clive (call me Max) Maxfield

This book gives the "big picture" of digital electronics. This in-depth, 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.

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.

470 pages – large format **Order code BEB1 £26.95**

BEBOP BYTES BACK (and the Bebopter Computer Simulator)

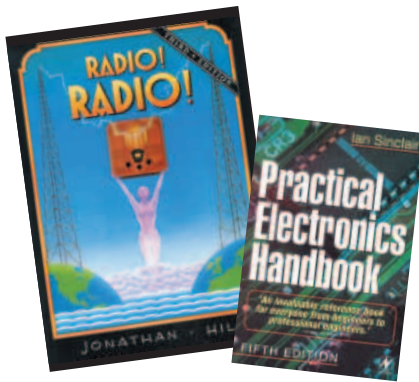
CD-ROM

Clive (Max) Maxfield and Alvin Brown

This follow-on to *Bebopter to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebopter" 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**



RADIO! RADIO! (Third Edition)

Jonathan Hill

A celebration in words and pictures of the development of the British wireless set from its experimental beginnings in Victorian England, to the foundation of a domestic wireless manufacturing industry and the inception of broadcasting in the early 1920's. The story continues on through the design-conscious 1930's (where the radio really came into its own as a piece of furniture), to the war-torn and austere days of the 1940's.

The first transistor radios began to appear in the second half of the 1950s and in this new edition, this rather neglected area has been fully covered by a section all of its own which includes a directory listing of nearly 3,000 different transistor models. The book finishes after the 1960s, by which time our long established and once great radio industry had all but been destroyed by foreign imports.

Now with 320 pages and over 1,000 illustrations, informative captions and carefully researched text *Radio! Radio!* is the first and still the only truly comprehensive book of its kind ever to be published.

320 pages (A4 Hardback) **Order code RR1 £40.95**

GETTING THE MOST FROM YOUR MULTIMETER

R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239 £5.49**

DIGITAL GATES AND FLIP-FLOPS

Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106 £9.95**

OPERATIONAL AMPLIFIER USER'S HANDBOOK

R. A. Penfold

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

120 pages **Order code BP335 £5.45**

PRACTICAL ELECTRONICS HANDBOOK –

Fifth Edition. Ian Sinclair

Provides a practical and comprehensive collection of circuits, rules of thumb and design data for professional engineers, students and enthusiasts, and therefore enough background to allow the understanding and development of a range of basic circuits.

Contents: Passive components, Active discrete components, Circuits, Linear I.C.s, Energy conversion components, Digital I.C.s, Microprocessors and microprocessor systems, Transferring digital data, Digital-analogue conversions, Computer aids in electronics, Hardware components and practical work, Micro-controllers and PLCs, Digital broadcasting, Electronic security.

440 pages **Order code NE21 £24.50**

MUSIC, AUDIO AND VIDEO

QUICK GUIDE TO DIGITAL AUDIO RECORDING

Ian Waugh

Covers:

- What computer system you need
- Sound and digital audio essentials
- What to look for in a sound card
- What effects to use
- The art of mixing
- How to burn your music to CD
- How to post your songs on the Web

All modern music recordings use digital audio technology. Now everyone with a computer can produce CD-quality recordings and this book shows you how. Written in a clear and straightforward style, it explains what digital audio recording is, how to use it, the equipment you need, what sort of software is available and how to achieve professional results.

Computer-based recording is the future of music and 208 pages **Order code PC121 £7.95**

this book shows how you can join the revolution now.

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.

60 pages **Order code PC119 £7.45**



ELECTRONIC PROJECTS FOR VIDEO ENTHUSIASTS

R. A. Penfold

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

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

109 pages **Order code BP356 £5.45**

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. **£10.95**

124 pages **Order code PC115 £5.45**

ALL PRICES INCLUDE UK POST & PACKING

FAULT FINDING, CIRCUITS AND DESIGN

PIC BASIC PROJECTS – 30 PROJECTS USING PICBASIC AND PICBASIC PRO

BOOK + CDROM

Dogan Ibrahim

Covering the PICBASIC and PICBASIC PRO compilers, this thoroughly revised edition, previously entitled PICBASIC Programming and Projects, provides an easy-to-use toolkit for developing applications with PICBASIC. Numerous simple projects give clear and concrete examples of how PICBASIC can be used to develop electronics applications, while larger and more advanced projects describe program operation in detail and give useful insights into developing more involved microcontroller applications.

Packed with simple and advanced projects which show how to programme a variety of interesting electronic applications using PICBASIC. Covers the new and powerful PIC16F627 and PIC16F73, and the popular PIC16F84 and PIC16F877 models. The CDROM includes program source files, HEX code, data sheets of devices, sensors and schematics of the circuits used in the book.

358 pages **Order code NE44** **£21.50**

DISCOVERING PICS

W.D. Phillips

BOOK + CDROM + HARDWARE

A good introduction to PIC programming, covering everything you need to know to get you started. No previous knowledge of microcontrollers is required, but some previous experience with electronic circuits is assumed. Covers the basic concept of a microcontroller, fundamentals of a PIC-based circuit and using the MPLAB program. Further chapters introduce binary, PIC architecture, the instruction set, the PIC memory map and special registers plus real world programming. Four simple projects are also fully described; a Wavy Wand, an Electronic Dice, a Games Timer and a Pulse Monitor.

The associated CDROM contains the book in PDF format, MPLAB (plus instruction manuals in PDF format) and all the programs covered in the book as assembler (ASM) files. Those that wish to programme their own PICs will require a PIC programmer.

In addition a p.c.b. based hardware kit is also available that makes up into the Wavy Wand which will spell out a short message via a line of I.e.d.s when waved through the air.

190 pages, A4 spiral bound

Book + CDROM Order code DOC1 **£22.00**

Book + CDROM + Hardware Order code DOC2 **£28.50**

PRACTICAL OSCILLATOR CIRCUITS

A. Flind

Extensive coverage is given to circuits using capacitors and resistors to control frequency. Designs using CMOS, timer i.c.s and op.amps are all described in detail, with a special chapter on "waveform generator" i.c.s. Reliable "white" and "pink" noise generator circuits are also included. Various circuits using inductors and capacitors are covered, with emphasis on stable low

frequency generation. Some of these are amazingly simple, but are still very useful signal sources.

Crystal oscillators have their own chapter. Many of the circuits shown are readily available special i.c.s for simplicity and reliability, and offer several output frequencies. Finally, complete constructional details are given for an audio sinewave generator.

133 pages **Order code BP393** **£5.49**

PIC IN PRACTICE (2nd Edition)

David W. Smith

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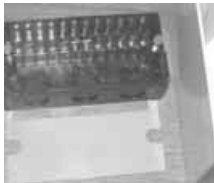
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