THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

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iPOD AND MP3 CHARGER

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DEC 2007 PRINTED IN THE UK

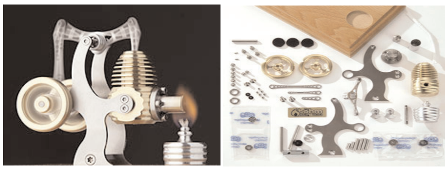
12

0 74470 07806 7

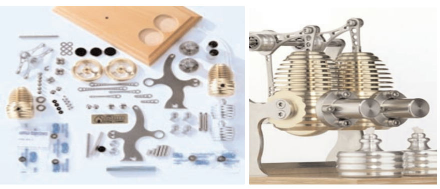
HB7 Stirling Engine
Base measurements: 128 mm x 108 mm x 170 mm, 1 kg Base plate: beech - Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
Bearing application: 10 high-class ball-bearings
Material: screw, side parts all stainless steel
Cylinder brass, Rest aluminium and stainless steel. Available as a kit £80.75 or built £84.99
www.mamodspares.co.uk

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

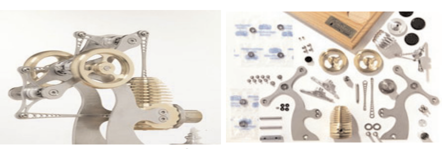
HB10 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,6 Kg Base plate: beech Working rpm: approx. 2,000 rpm
Bearing application: 6 high-class ball-bearings
Material of the engine: brass, aluminium, stainless steel
running time: 30-45 min
Available as a kit £97.75 or built £101.99
www.mamodspares.co.uk



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



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



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
Available as a kit £97.75 or built £101.99

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

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 steelCylinder brass Rest aluminium, stainless steel Available as a kit £140.25 or built £144.50
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

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

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

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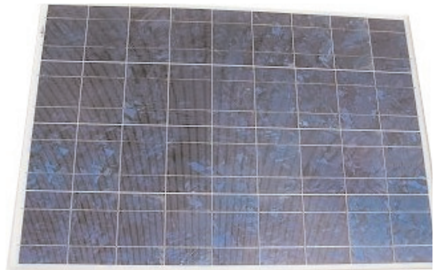
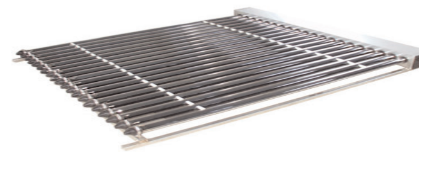


Solar Panels
We stock a range of solar photovoltaic panels. These are polycrystalline panels made from wafers of silicon laminated between an impact-resistant transparent cover and an EVA rear mounting plate. They are constructed with a lightweight anodised aluminium frame which is predrilled for linking 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



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 (3-4people), 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 conponents 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 intergrated 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

ISSN 0262 3617

PROJECTS . . . THEORY . . .
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POPULAR FEATURES . . .

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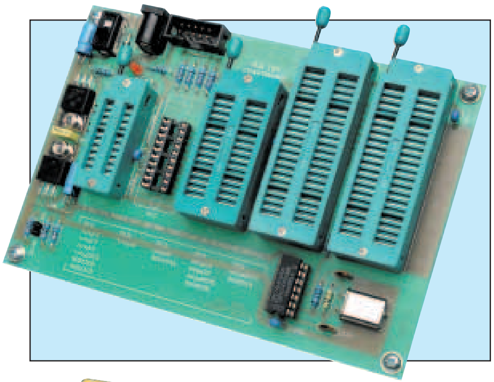

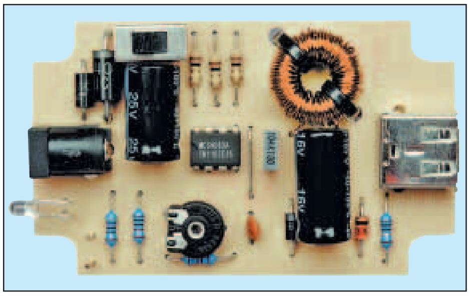

Projects and Circuits

Series and Features

Regulars and Services

Our January 2008 issue will be published on Thursday, 13 December 2007, see page 80 for details.

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An electronics course in a box! All assume no previous knowledge and require NO solder. See website for full details
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Future engineers can learn about the operation of transmissions steered through gears or pulleys. Easy to build, no glue or soldering required.
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P0701 USB PIC

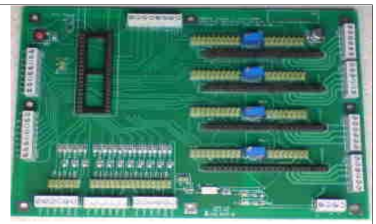
USB 2.0 interface. Can be bus powered or self powered.
Powerful PIC18F4580 Microcontroller running at 40MHz. Up to 10MIPS performance.
All microcontroller I/O pins available except RA6, RA7 (oscillator) and RC6, RC7 (serial port).
Bootloader pre-programmed and download software included, enabling quick 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.

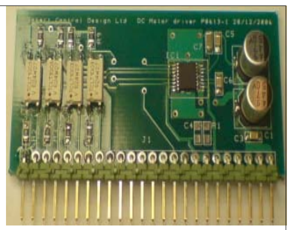


All options are configured using jumpers, and stepper motor drive current can be easily adjusted for each module by variable resistors.
All connections are made by high quality screw terminals.
The board has been designed to accommodate other driver modules as they become available.

PRICE:£55.00 + VAT

P0613 DC Motor

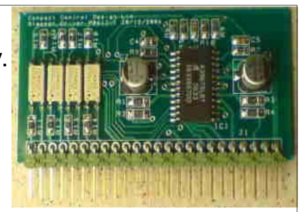
Pulse width modulation control for DC motors, electro-magnets etc.
It has a motor supply voltage of 8 to 36V.
The maximum drive current is 2.5 Amp.
There are pulse and direction inputs.
The PWM control is up to 100KHz.
Mode input for controlling motor braking and sleep input for power saving.
There is 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.

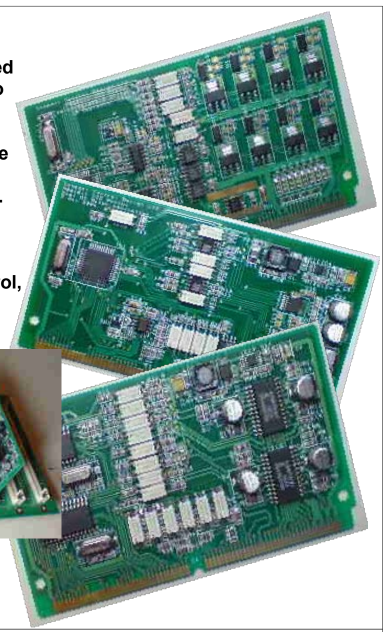


PRICE:£15.00 + VAT

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.



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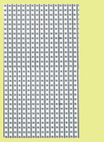
0.1" Copper Stripboard

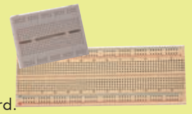
Size	Tracks/Holes	
25 x 64mm	9T / 25H	£0.24
64 x 95mm	24T / 37H	£0.87
95 x 127mm	36T / 50H	£1.41
95 x 432mm	36T / 170H	£4.39
100 x 100mm	39T / 38H	£1.40
100 x 500mm	39T / 199H	£6.20
119 x 455mm	46T / 179H	£5.40
Stripboard track cutter		£1.99



Solderless Breadboard

Tie Points	& Size	Power Rails	
390	81 x 60mm	2	£2.75
840	175 x 67mm	2	£4.86
740	175 x 55mm	1	£4.03
640	175 x 42mm	0	£3.08

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



PCB Production - Drafting Materials

A4 Artwork Film (per 10 sheets)

Clear Manual Film	£1.20
Clear Laser Film	£1.75
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Etch Resist Pens

"Dalo" Pen	£3.36
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Etch Resist Transfers

Seno mixed DIL pads	£2.24
Seno mixed Rnd pads	£2.24
Alfac mixed pads	£1.84
Transfer Spatular	£1.25

We carry the full range of Seno & Alfac 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.

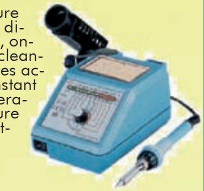
20W 240V Basic	£3.74
25W 240V Ceramic	£7.14
30W 240V Basic	£4.68

Desolder Pumps

Basic 165 x 18mmØ	£2.85
Antistatic 195mm	£3.92
Antex Mini 198mm	£6.02
Antex Pro 210mm	£10.26

Soldering Station

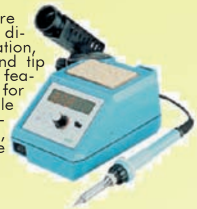
A 48W adjustable temperature soldering station with a rotary dial, LED Temperature metering, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 420°C, Low voltage iron with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



Model 167-540 £41.66

Soldering Station

A 48W 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 multitester 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

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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

Aerosols

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 prewired for panel illumination. Meter size 46 x 60mm, Cutout size: 38mmØ.

Range	Int Ω
0-50uA	6k5
0-100uA	1k0
0-500uA	430Ω
0-1mA	200Ω
0-10mA	2Ω6
0-50mA	1Ω2
0-100mA	0Ω65
0-1A	60mΩ
0-3A	20mΩ
0-5A	12mΩ
0-15A	4mΩ
0-10V	10k
0-15V	15k
0-30V	30k
±50uA	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 flourescent tube provides illumination. Magnification: 3x Lens: 120mmØ
Tube: 22W Daylight simulation.

Model: 028-205 £28.80

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Sound & Lighting equipment for the Entertainment Industry

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 305g/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 Single	Double	Glass Fibre 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
10 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			£4.83	£5.32
233 x 220mm			£6.83	£7.70

PCB Production - Chemicals

100ml	Aerosol Photoresist spray, covers 2m²	£4.62
50g	Powder developer, makes 1lt	£1.09
500g	Powder developer, makes 10lt	£7.08
250g	Ferric Chloride Pellets, makes 500ml	£1.68
500g	Ferric Chloride Pellets, makes 1lt	£3.04
2.5kg	Ferric Chloride Pellets, makes 5lt	£9.84
1.1kg	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

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

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130mm Low cost	£1.99
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115mm Box Jointed	£4.26
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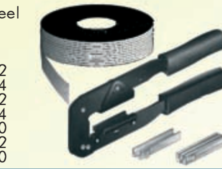
Non insulated crimps	£24.38

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



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305m Box	£45.31
100m Reel	£22.28

exc carriage.

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

Tools

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Professional punch down IDC & trim tool	£7.38

Outlets

CAT5e Outlet Module	£1.70
1Gang Plate (2 Mods)	£0.50
2 Gang Plate (4 Mods)	£0.75
½ Module Blank	£0.25
1 Module Blank	£0.35
2 Module Blank	£0.45

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Timely

It seems that our *Banning The Bulb* feature and *Standby Power Saver* project, both published last month, were very timely with the recent Government announcement of a voluntary initiative, led by major retailers and energy suppliers, to replace incandescent lamps with energy efficient types over the next few years. Secretary of State Hilary Benn also said "I want to see more retailers, manufacturers and service providers taking action to phase out the least efficient products from their ranges, for example, certain set top boxes and TVs, and so help offer greener choices to their customers".

The government has proposed the following schedule for retailers: By January 2008, cease replacing stock of all inefficient (General Lighting Service, GLS) A-shaped incandescent lamps of energy rating higher than 100W (predominantly 150W lamps). By January 2009, cease selling all inefficient GLS A-shaped lamps of energy rating higher than 60W (predominantly 150W lamps, 100W lamps, plus some 75W lamps). By January 2010, cease selling all GLS A-shaped lamps of energy rating higher than 40W (predominantly 60W lamps). By 31 December 2011, cease selling all remaining inefficient GLS A-shaped lamps and 60W 'candle' and 'golfball' lamps. (predominantly 40W and 25W A-shaped GLS bulbs, and 60W candles and golfballs).

Confusion

Although golfball, candle and GU10 reflector versions of CFLs are now available (see *Banning The Bulb* in the October issue), the government's *Notes To Editors* indicate that they expect these types, together with tungsten halogen lamps and lamps for "non-lighting electrical appliances", to continue to be available "because suitable energy-efficient alternatives do not currently exist." At this stage, there seems to be no recognition of the fact that very few CFLs will work with standard incandescent dimmers. We see this as being a major problem when dissatisfied customers return their CFLs because they won't work in a dimmer circuit. Maybe there will be a greater range of dimmable CFLs available before the 2009 suggested ceasation of supply of 100W GLS lamps.

AVAILABILITY

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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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News . . .

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

Photographer's Paradise

Barry Fox wonders if Hewlett Packard's got the answers for photographers' nightmares

Do you have shoeboxes full of photo negatives and slides? Do you have fat friends who don't like being photographed? Hewlett Packard has answers for both problems.

As well as scanning paper documents in the usual way, the new Scanjet G4050 can be used to automate the digitisation of photo film negatives or transparencies. The scanner comes with three A4 size carriers, one for 30 negative frames in five 35mm film strips, one for 16 slides, and one for larger format pictures. The carrier is loaded with film and placed on the scanner glass. Whereas most scanners have a light source in the base under the glass, the 4050 also has a light source in the lid that hinges down over the glass. So it can scan an image either by reflection (from below) or by transmission (from above).

Resolution is 4800 × 9600 dpi, with an option to make two passes using two lamps which scan for six colours, with frequencies between the usual single lamp, single pass, Red, Green and Blue. This gives 96-bit accuracy. PC software creates JPEG negative or positive image strips to match the film sequence. An infra-red lamp helps identify scratch marks and repair by pixel-by-pixel replacement from surrounding content. The software can be switched to distinguish between different film colour balances, such as Kodachrome and Ektachrome.

Two new digital photo printers due this autumn, the A626 And A825 have touch screen controls for all the usual crop and red-eye editing. But each also has a new one-touch feature called 'slimming'. This can doctor an image to 'make subjects more slender'. In plain English it makes a fat person look thinner.

The picture is displayed on the printer screen before printing and the 'slimming' option selected to show a touch slider control for squeezing the centre area of the image to a variable degree. The sides of the picture are left unaffected. So if a 'fattie' is standing between two slim friends, moving the slider makes the fattie look slender to match.

HP has tried putting the feature in cameras but now thinks it belongs in a printer so that all pictures, old and new, can benefit from a touch of digital surgery without the hassle of having to transfer the picture to a PC and use complicated editing software.

HP's new Pavilion HDX Entertainment Notebook PC has a 20-inch HD screen and HD-DVD read/write drive. This is a surprise because HP has always been a staunch supporter of the rival Blu-ray format.

A spokesman says this is purely because HD-DVD drives were ready earlier. "We are committed to Blu-ray" he assures. "We expect to introduce it in a Combo this Christmas which takes either HD or Blu-ray discs".

MEGAMAN DIMMERABLE LAMPS

The latest addition to Megaman's energy saving lamps is their Dimmerable Range, which enables users to enjoy the benefits of dimmable fluorescent lighting without the need for special control gear or control wiring. This unique product can be used with a conventional light switch and with normal lamp holders, meaning no change to the existing on/off fitting and saving on any extra retrofit costs. No additional control wiring or transformers are required for use.

Lamps in the range can change the ambience of a room at the flick of a switch, providing dimming of GLS replacement compact fluorescent lamps using a built-in electronic ballast and offering a high performance, linear dimming capability. Dimming is stepless from 10% to 100%, with no delay in response to dimming signals from the switch. Lamps can also be switched off at any dimming setting. The lamps provide a 10,000 hour life, flicker-free operation with stable light output and are compatible with most electronic dimmers and digital dimmers for incandescent and halogen lamps.

The range is currently available in 11W and 18W tubular lamps, an 11W GLS Style, PAR38, 7W and candle and 11W GU10 lamp.

Browse **www.megamanuk.com**.

Smile When You're Ready!

Hot on the heels of HP's home printer, which makes people look slimmer, comes a pair of new cameras from Sony that only take a picture when the subject is smiling. The Cyber-shot T200 and T70 digital cameras have a so-called 'Smile Shutter'. The camera uses optical facial recognition to spot the shape of a smiling mouth. It then snaps the shot automatically.

If there are several people in the view, the photographer uses a touch screen viewfinder to select one of them for smile control. The shutter then only fires when the selected subject smiles. The camera can also be set to shoot a rapid sequence of six pictures, so the photographer can choose later which one has captured the best smile. At the same time as detecting smiles, the camera automatically adjusts exposure, flash and focus. Prices range from £229 to £299.

Barry Fox

Budget LCD Oscilloscope

The PDS5022S bench Digital Storage Oscilloscope from Audon has been specifically designed as an entry level instrument for educational, hobby and budget-driven applications. Although low-cost, the PDS5022S is packed with a wide range of useful functions usually only seen on higher-end DSOs, such as video trigger and auto-measurement. The large full-colour LCD display makes for a clear unambiguous waveform display.

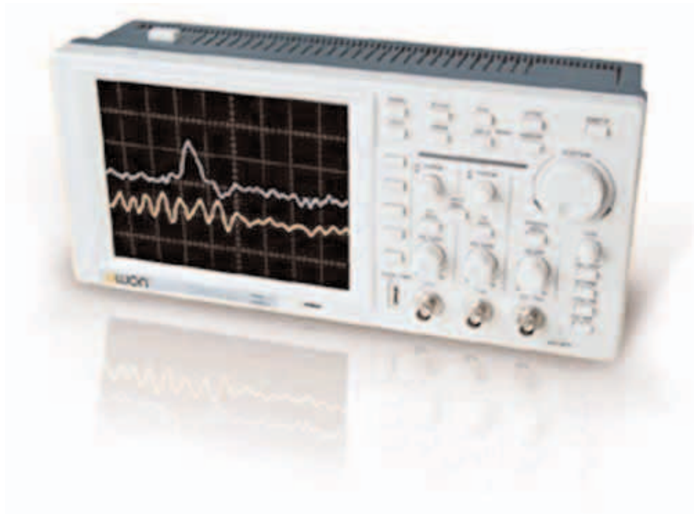
The PDS5022S is a 100MS/s dual channel 8-bit DSO with a 25MHz bandwidth, featuring a large 7.8-inch 640 × 480 pixel colour LCD display. It has easy-to-use controls and a simple and clear menu system. A compact and robust design that will not take up too much bench space.

There are several display modes: Normal mode operates like a standard 'scope, with simple manual control of timebase, triggering, etc. XY Mode is where CH1 is displayed on the horizontal axis and CH2 is on the vertical axis. When the oscilloscope is under the sampling mode in which no trigger is found, the data appears as light spots.

There is also an Auto-set mode, that allows the oscilloscope to display and measure unknown signals automatically. This function optimizes the position, range, timebase and triggering and assures a stable display of virtually any waveform. There is also an Average Display mode, where the displayed waveform is an average of a pre-set number of waveform samples. This can eliminate noise which can otherwise obscure readings.

The PDS5022S is supplied with carry case, scope leads, CD and manual and is available ex-stock for just £215.

For further information contact Audon Electronics, +44 (0)115 925 8412, Fax: +44 (0)115 925 9757. Email: info@audon.co.uk. Web: **www.audon.co.uk**



SQUIRES' 2008 CAT

We have received a copy of the *Squires Tools and Materials Catalogue 2008*. It is a good thick (over 480 pages) illustrated book, detailing products of interest to anyone who delights in electronics, modelling or craft hobbies.

Squires could no longer fit everything into just the one catalogue, so they will now be publishing a separate *Electronic Components Catalogue*. Anyone wishing to receive a copy of either of these catalogues should contact Squires. Tel: 01243 842424. Fax: 01243 842525.

Email: sales@squirestools.com. Or call at their shops in Bognor Regis.

At the beginning of this year, Squires opened a new, second shop in Bognor Regis, just two doors down from their existing one. The new shop was opened to accommodate their ever expanding range of tools, materials and electronic components, many of which are in great demand from amateur electronic hobbyists and professional users alike, and are often hard to find anywhere else.

The new shop has proved extremely popular with all of their customers, and can be found at 108C, London Road, Bognor Regis P021 1DD. The original shop is at 100 London Road.

Microchip's Student Support

Students will benefit from a newly-refurbished laboratory which has been opened at the University of Reading, thanks to a £40,000 investment from Microchip.

Microchip Technology – whose European Headquarters is based in Wokingham – is a major supplier of microcontrollers, digital signal controller and analogue ICs, and has an established track record of supporting education through the donation of funding, equipment and software.

The School of Systems Engineering already uses Microchip's devices in its teaching and project work and when an opportunity arose to refurbish an existing teaching laboratory, an approach was made to see if further support would be forthcoming.

Chris Guy, Head of the School of Systems Engineering, said: "Students on Electronic Engineering and Cybernetics courses will benefit greatly from this exciting new development. It will enhance the learning of all existing students while acting as a major recruitment tool for potential undergraduates."

Ganesh Moorthy, Executive Vice-President said "Microchip was delighted to offer a full package to enhance the laboratory – which now boasts a full suite of the latest Microchip Technology hardware, software and development tools ... It has been a pleasure to partner with one of the leading technology Universities and to help ensure students learn in a modern, hi tech environment."

For more information, visit the Microchip website at ***www.microchip.com***.

OPTIMISED 2.4GHz ANTENNAS

RF Solutions has announced its new range of high quality 2.4GHz antennas, specifically designed and manufactured for operation with low power, short range telemetry systems, Wi-Fi and computer systems. The use of these antennas gives optimum range and reliability to a wide range of applications.

Tuned to a frequency of 2.4GHz to 2.5GHz, the compact and flexible helical 'Stubby' whip antenna benefits from a rugged plastic finish and 90 degree SMA fixing. This antenna is available as BNC, 4BA, M4 screw fixing. A slightly different model is available with a 90 degree 'joint' with SMA fixing.

They also market a twin gain directional antenna, which is small enough to be used indoors or in an industrial environment and a compact mini dipole with a 2.5 metre coax lead. This mini dipole antenna is rugged and benefits from a +2.1dBi gain and SMA fixing.

Other antennas operating on a 2.4GHz frequency available from RF Solutions include a flat whip model, designed for panel mounting, and an onboard antenna suitable for PCB mounting for embedded applications which operates either a horizontal or a vertical polarisation. The company can also supply omnidirectionnal and multimode antennas of a rugged industrial construction, which can be fitted with TNC female connectors. Non-standard frequencies are available on request.

RF Solutions provide a wide range of high quality, passive and high gain antennas, including flexi 1/4 wave, helical, puk, embedded. dipoles and Yagi.

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.

TECHNO-TALK MARK NELSON

Mother Knows Best

Mother Nature, that is. Why reinvent the wheel when Mother Nature has already done the R&D work and the design optimisation for you? Plants and insects have developed ingenious techniques that can be replicated for industrial, medical and military purposes. Bionics and electronics have a great future in combination, as Mark Nelson explains.

MENTION bionics and many people will think of the 1970s TV series *The Six Million Dollar Man* or its spin-off *The Bionic Woman*. Based on the *Cyborg* novels, both programmes revolved around characters who had received artificial organs and body parts to enhance their human abilities. Back then, electronically-powered legs, arms, and eyes were purely fictional, but today medics and engineers are taking an increasing interest in natural processes and, by investigating them, harnessing them for new applications.

Wikipedia defines bionics as the replacement or enhancement of organs or other body parts by mechanical versions. The term is an amalgamation of biology + electronics, which makes sense, although some experts derive it from the classic Greek word element for 'life' and leave out the electronics. Either way, there's a very strong connection with our subject.

Neural networks

It's important to understand that bionics is a two-way technology transfer process. We can employ science to manufacture artificial body parts, or we can copy natural processes for manufacturing. In each case man is imitating – and possibly finessing – nature. Possibly the first was Velcro, conceived by a scientist who puzzled why plant burrs clung so tenaciously to the fur of his dog. Observation that the surface of the lotus flower plant, which is practically unsticky, led to the development of dirt and water-repellent coatings and paints for anything (the lotus effect). Sonar, radar, and ultrasound imaging in medicine borrow from the echolocation of bats, while in computing we have neural networks and swarm intelligence.

Three months ago, 1,800 medical engineering delegates to the annual *IEEE Engineering in Medicine and Biology Society* conference in Lyon, France were told they must leverage nature's forces. Keynote speaker, Prof David Beebe (University of Wisconsin) described how studying how flower petals fell off as they decayed led to the design of a toxin detector with two arms stuck together. In the presence of botulism the adhesive between the two arms degrades rapidly to provide a clear indication.

His lab has also developed an efficient microfluidic pump, based on what the researchers had learnt from studying the movement of fish. Others in his team used the hydrophobic properties of a lotus leaf to create a liquid lens with an adjustable focal length.

Telefantasy to truth

Spiderman is less 'old hat' than *The Bionic Man* and the sticky hands and feet that enable him to scale vertical walls could soon be fact rather than fantasy according to an Italian physicist. Not just arachnids but geckos too, it appears, use a combination of capillary action and molecular attraction to keep the tiny hairs on their legs 'magnetised' to surfaces. So says Professor Nicola Pugno of the Polytechnic University of Turin (Italy), who in June declared that synthetic suits could harness the same nanoscale forces to enable humans to hang onto walls or ceilings.

His *Spiderman* suit would be made by weaving millions of 10-nanometre thick carbon nanotubes into threads about one centimetre thick with their ends splayed out, fan-like, to maximize contacts and thus stickiness, it was reported in trade journal *EE Times*.

Copying nature could also save us energy. Research at the University of Bath comparing natural and man-made technologies indicates that 'mother nature' is far more efficient than our high-tech designs.

Explains Professor Julian Vincent, who is leading this research, "A man-made hammer has a very heavy head, so that it is heavy to carry around and lift but can do a lot of work with one hit. It relies on inertia. But the woodpecker's hammer, its head, relies on speed. It is very light to carry around, and functions rather like a whip, with the heavier body moving a small amount, and the lighter head, on its long neck, moving much faster. They can each deliver the same amount of impact energy, but they do it in a very different way."

Bionic bees

As well as working for nothing to provide us with honey, royal jelly and wax for church candles, the unpaid army of honey bees is doing us an even greater favour. No, we won't be employing bees to build nanocircuits in their hives, but scientists are looking to our fuzzy friends to learn new ways of performing electronic functions.

Last year, BBC *News* reported that an artificial lens array, containing more than 8,500 hexagonal lenses packed into an area the size of a pinhead, had been developed by scientists at the University of California, Berkeley. Modelled on a bee's eye, the lens array could be used in tiny, omni-directional surveillance devices, ultra-thin cameras or for high-speed motion sensors. It may also have medical applications, such as imaging the gut.

Designers of video surveillance systems are examining the way that insects can process images, combining extreme brightness and shade without batting an eyelid (they probably don't have eyelids anyway). According to Dr Russell Brinkworth of the University of Adelaide, a tiny insect can outperform any current artificial vision system.

The individual cells of an insect's eye can adjust independently to image areas with differing illumination so as to capture the maximum amount of information they see. You can judge the importance of this work by the fact that his team is receiving funding from the United States Air Force.

Israel is developing a nanotechnology-based bionic hornet the same size as the real insect. Functioning like existing 'drone' surveillance devices, but on a nano scale, this miniature weapon could chase and photograph targets, even in urban landscapes.

Prototypes for the new weapons are expected before the end of 2009, according to Reuters. The agency quoted the country's Deputy Prime Minister as saying: "The war in Lebanon proved that we need smaller weaponry. It's illogical to send a plane worth $100 million against a suicidal terrorist. So we are building futuristic weapons."

Flash in the pan

Well, not a pan but a kettle in fact. Right now a story that is engaging local radio and newspapers where I live concerns an unfortunate lady whose kettle has an unearthly influence over the street lamp outside her house. The tale may have gone national – and been solved – by the time you read this, but if not, it will give you an interesting puzzle to ponder.

Every time Northampton pensioner Sally Barnet makes a cup of tea at night, the lamp outside her kitchen window goes out and then comes on again a few seconds later. An engineer from electricity provider e-On confirmed an engineer had been to test the cables at her home, but it was too early to tell what the problem was.

I said the influence was unearthly and I suspect there's a missing earth cable somewhere but that's just my own speculation. If you have any ideas or have encountered even spookier symptoms of a similar kind, please do write in!

OK, ALL YOU BUDDING PHIL COLLINS AND RINGO STARRS OUT THERE . . . HERE'S YOUR CHANCE TO OWN A LOW-COST 'DRUM KIT' WHICH CAN PRODUCE JUST ABOUT ANY MUSICAL SOUND YOU CAN THINK OF – AND THERE'S NOT A DRUMSKIN IN SIGHT! YOU DON'T EVEN NEED TO BUY A PAIR OF DRUMSTICKS!

by John Clarke

MIDI DRUM KIT

PART 1

For centuries, drums have been an integral part of music, used in everything from tribal music, jazz, rock and blues, right through to symphony orchestras. In many cultures, drums play an integral part during ceremonies and religious events.

Modern drums tend to be based on instruments that are used in established cultures. For example, from the Afro-Cuban cultures we have been introduced to the bongo and the conga, while from the American native Indians comes the tom-tom. Cymbals of various descriptions have originated from Europe, Turkey and China.

Traditionally, drums have tended to be made from natural products such as carved timber and animal skins, while cymbals are usually manufactured from brass. These instruments have a charm of their own and produce a unique sound that is dependent on the products used in their manufacture.

Modern instruments are made using high-technology materials such as stainless steel, aluminium and its alloys, plus many types of plastics. The sound produced by these instruments can be tightly controlled so that each instrument has a distinctive and consistent sound.

Often, these sounds are recorded in a digital form so that they can be played back using a synthesiser. The technique for recording is called 'sampling'. Other synthesiser sounds are not recordings at all but synthesised sounds made using oscillators, noise and envelope control to recreate the required effect.

Once the drum sounds are recorded or created, we can replay them repeatedly just by signalling the synthesiser to play a particular sample.

The data sent to the synthesiser is in a format called MIDI (Musical Instrument Digital Interface) and includes information such as the required instrument to be played, its volume and its position in the left and right sound stage.

By adding sensors to detect when the recorded 'drum' sound is to be played, we can drive the synthesiser with the MIDI signal to faithfully reproduce the required drum sound whenever the sensor is struck.

This is the basis of an electronic drum kit – and the project presented here, the MIDI Drum Kit. It can reproduce a vast array of drum sounds without having to use conventional instruments to make the sounds.

Drum sounds can be initiated using an electronic keyboard to play the instruments or you can use a drum kit. The advantage of the drum kit is that it can be played in a similar way to a real drum set, so its operation is more natural.

There is no doubt that a real drum kit with its highly polished crash plates, finely crafted drums and the physical presence of the instruments all arranged in a group is an impressive sight. An electronic drum kit just doesn't quite have the same appeal because electronic drum kits are basically uninteresting to look at.

After all, with a real drum kit, you can see the instruments and even watch them working, particularly with the Hi-Hat, the cymbals and the foot-driven drum.

For these reasons, MIDI drum kits are not often used for live performances but mainly for recording and producing synthesised music.

An electronic drum kit's claim to fame is therefore not its looks but instead its versatility and the significantly lower cost than is available with any 'physical' drum kit.

It is also much easier to transport and it produces sound in a form that can be readily recorded.

Tables 1 and 2 show the drum sounds that can be used with the MIDI Drum Kit when connected to a synthesiser located within a musical instrument (such as keyboards), or via a computer that has a sound card.

Synthesisers supporting the MIDI level 2 standard can also reproduce the extra sounds ranging from 27 to 35 and from 81 to 87 for the standard kit plus the other drum sets. These include the Room, Power, Electronic, TR-808, Jazz, Brush, Orchestra and Sound Effects sets.

Most synthesisers and computers with sound cards manufactured after 1995 are likely to support these extra drum sets.

Of course, if you know enough about music software, you can generate your own set of sounds using VST (Virtual Studio Technology) or similar hardware emulators, or add in already created drum patches yourself.

Features

- Sound output via a computer and speakers or synthesiser
- Up to 21 instruments selectable for the standard drum kit set
- 7 extra kits (with MIDI 2) including Brush, Jazz and Orchestra sets
- 7 instruments can be played at the one time
- Footswitch control of instrument No.7 to select another instrument (eg, closed and open Top Hat)
- Instrument triggers include percussion plate, hand plate and foot activation units
- Volume level can vary with striking pressure on the trigger plate
- Four settings for sensor pad volume: wide variation, two compressed and a fixed full level
- LCD shows sensor selections, patch and volume level and settings
- Adjustable soundstage positioning within left and right channels
- Can be used with a synthesiser or computer (with sound card)
- MIDI out, sound card (DB15) or serial (DB9) connections available
- USB operation via a serial to USB converter
- Plugpack powered

Presentation

The MIDI Drum Kit electronics is housed in a plastic box that can be mounted on a stand along with the pad sensors, or used as a free-standing unit with the sensors remotely attached. It includes a Liquid Crystal Display, which can show the selected drum (or other sound) for each sensor pad input, the various settings and the overall volume and left to right positioning. Six pushbutton switches are used to change the settings.

Eight phono inputs at the side of the box are for the seven sensor pad connections and the footswitch. Other connections are at the rear of the box and are for the MIDI-out, the serial connector, the games port connector and the

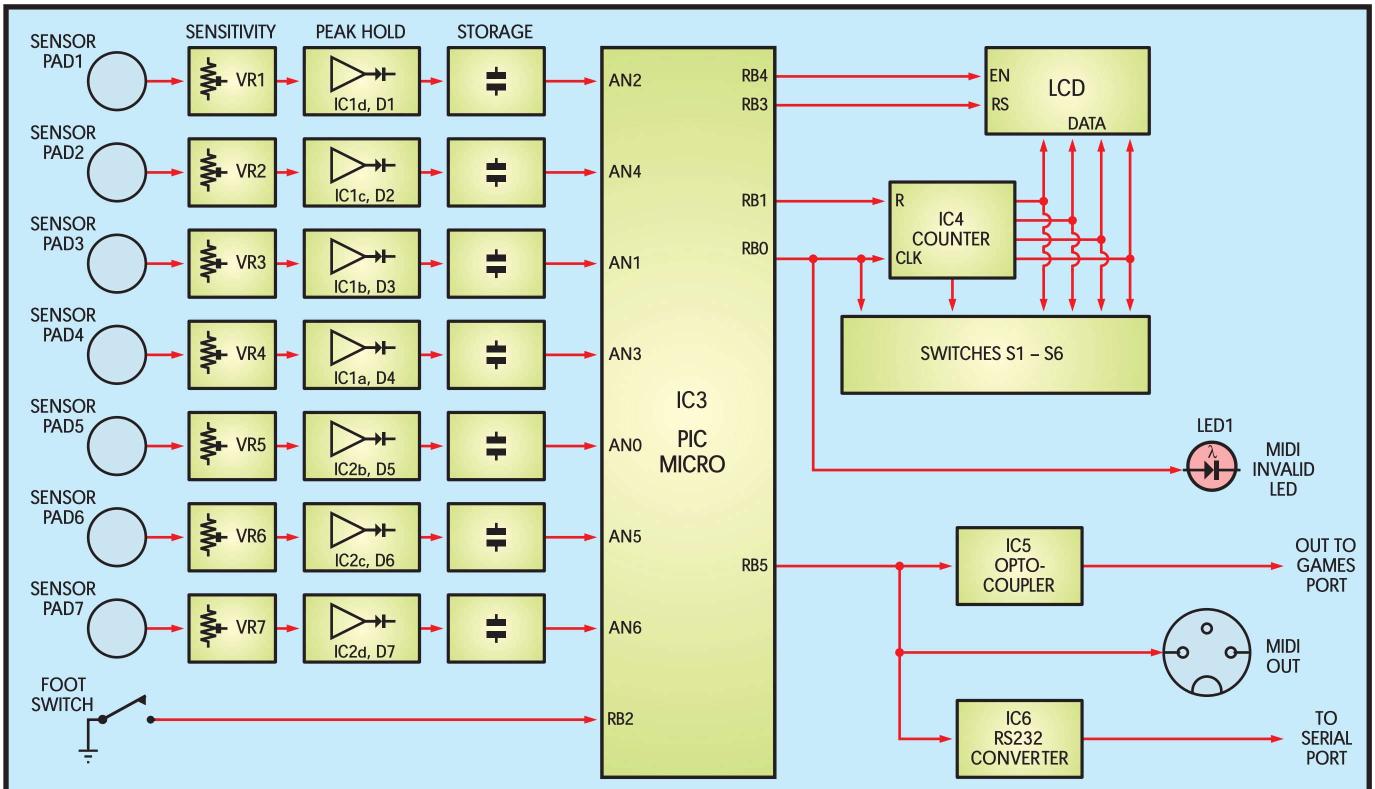


Fig.1: the block diagram of the MIDI Drum Kit. Its operation is explained in the text.

DC power sockets. One of the DC sockets is for the 9V DC plugpack input and the other for DC output to connect to optically-operated sensor pads. A power switch is included and the LED adjacent to the MIDI socket shows the 'MIDI invalid' indication. More about this later.

Synthesiser

As mentioned before, there is neither a synthesiser nor amplifier within the MIDI Drum Kit – it must be connected to an external synthesiser and the audio output of this synthesiser connects to headphones or to an amplifier and loudspeakers, mixing desk, etc.

By far the most common source of a synthesiser is the one inside a standard personal computer or laptop – every sound card has a synthesiser. Another source is an electronic instrument such as a MIDI keyboard. The MIDI Drum Kit can be used with either of these synthesisers.

Signals from the MIDI Drum Kit are sent as a series of codes that command the synthesiser to produce sounds. The codes are sent in MIDI format – this is a standardised signal used by the music industry to control synthesisers.

What is different about the drum sounds in MIDI is that they can only be used on one channel (or two channels for MIDI 2) out of a total of 32 channels available for use with MIDI. These are channel 10 plus channel 11 when using the MIDI level 2 standard. In addition, while other channels produce notes of a particular instrument setting, channel 10 produces a sampled sound of an instrument for the note selection instead. The instrument setting for the other channels becomes the patch number for the drum set.

To connect to a MIDI musical instrument, you connect a MIDI lead from the MIDI Drum Kit's MIDI socket to the instrument's MIDI input.

When connecting to a computer, you have three possible options:

(a) use the games port (if the computer has one), which connects directly to the computer's sound card; or

(b) use the serial outlet and connect this directly to a serial port on the computer (again, if the computer has one); or

(c) use the computer's USB port.

A games port, which has a DB15 connector, will accept MIDI signals directly. However, many modern computers do not have a games port and some modern ones don't have an RS232C serial port either. Those computers will, however, have at least one (and usually several) USB ports.

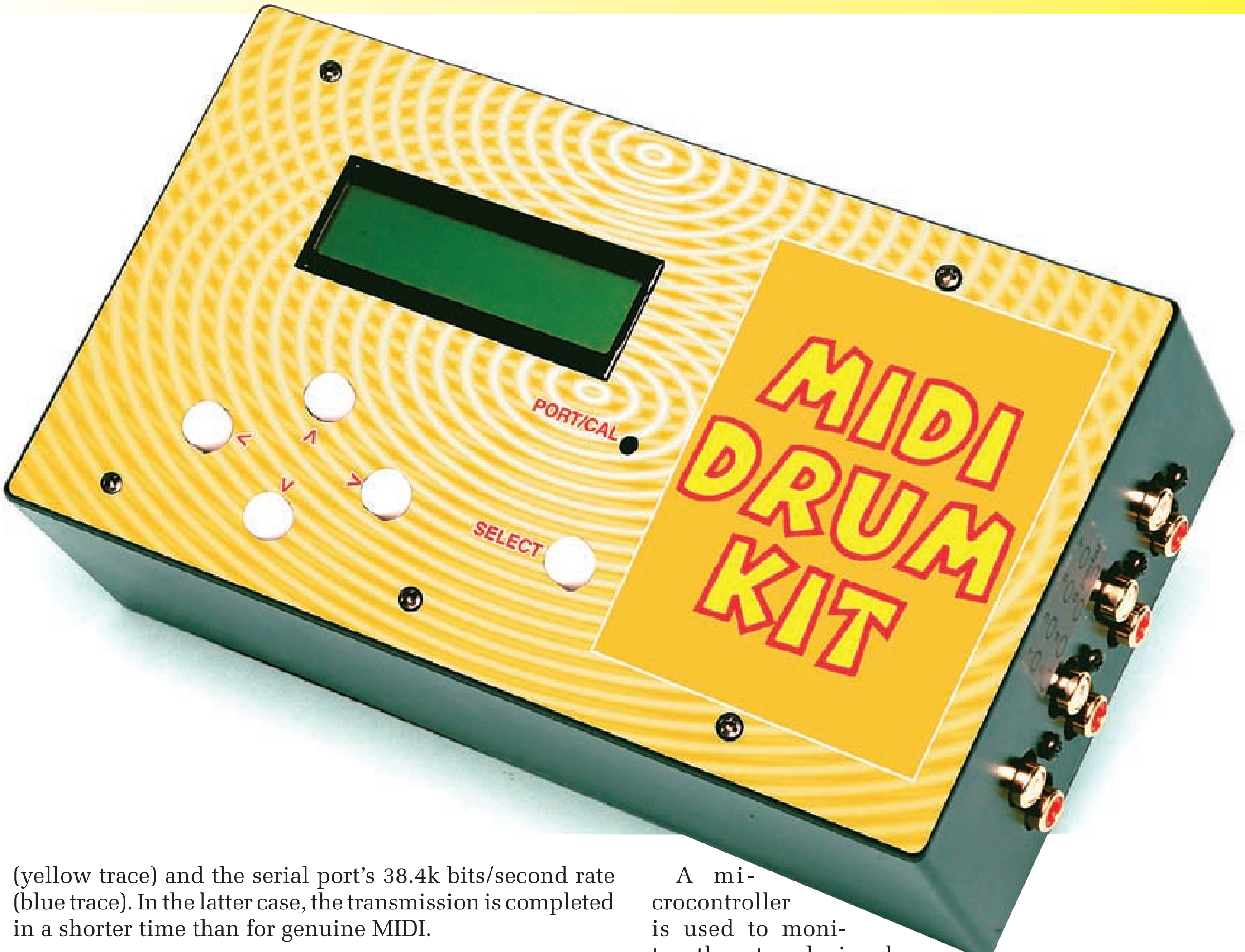
If you do not have a games port or serial port, then the only way to use the MIDI Drum Kit is via a USB port. For this, you will need either a MIDI-to-USB converter or a serial port to USB converter.

MIDI-to-USB converters currently cost around £30, while serial-to-USB converters are only about £15, so if you need to use the USB port we recommend the serial-to-USB option. In either case, software will need to be installed in order for the USB ports to respond to the signals sent by the MIDI Drum Kit.

There is a difference!

When using the serial output from the MIDI Drum Kit to make the computer connection, the signal sent by the MIDI Drum Kit is not genuine MIDI standard. This means that the MIDI signal provided on the MIDI output cannot be used to drive a MIDI instrument when the unit is configured for serial output. In this case an LED lights to indicate that the MIDI output is invalid.

The oscilloscope waveforms in Fig.2 show the difference between the genuine 31.25k bits/second MIDI signal



(yellow trace) and the serial port's 38.4k bits/second rate (blue trace). In the latter case, the transmission is completed in a shorter time than for genuine MIDI.

Software

Software is required when using the computer as the synthesiser source. The main software is the sequencer program. This accepts the MIDI signal sent by the MIDI Drum Kit and directs it to the sound card's synthesiser. The sequencer also provides many other functions such as the ability to record the music, store it and play it back. Panning from left to right, instrument change, looping and quantisation effects are also available.

We used Rave, a freely-available sequencer program that can be downloaded from the internet. The software works with Windows 95, 98, Me, 2000, NT and XP. We will explain how to download, install and use the software in a later issue. Professional sequencers can also be used and these have the advantage that you can edit and create your own sounds.

Software for the serial port driver works with Windows 95, 98, Me, 2000, NT and XP. The Serial to USB port driver works with Windows 98 through to XP.

Block Diagram

Fig.1 shows the block diagram for the MIDI Drum Kit. Sensor pads from PAD1 to PAD7 are connected to identical circuitry, including a sensitivity trimpot, a peak-hold buffer and storage. The sensitivity adjustment allows any sensor to be adjusted to match the sensitivity of other sensor pads. Following the sensitivity adjustment, the signal from each sensor plate is rectified and the peak value from the sensor is stored.

A microcontroller is used to monitor the stored signals from the sensor plates at the analogue inputs AN0 to AN6 and the 'footswitch' input RB2. If a signal at any of the PAD inputs reaches a predetermined value, then the microcontroller decides that the associated sensor pad has been struck and a MIDI signal is produced at output RB5. This is then applied to an optocoupler, the MIDI output socket and the RS-232 converter.

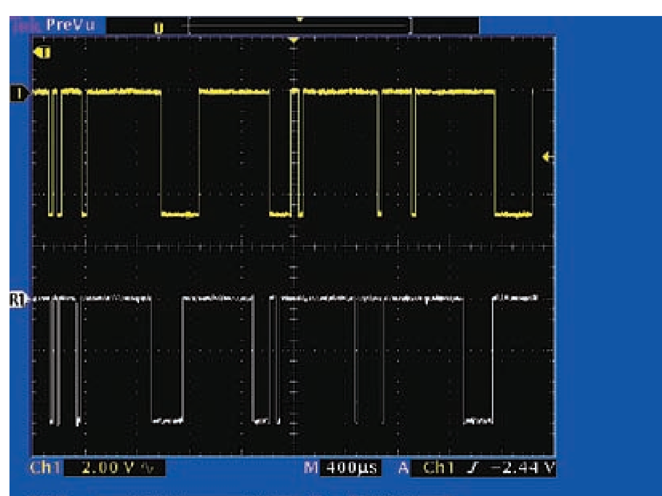


Fig. 2: these oscilloscope waveforms show the difference between genuine MIDI and the 'serial MIDI' for the computer's sound card. As you can see, the lower trace is completed over a shorter time.

The optocoupler provides isolation between the MIDI Drum Kit and the computer connection via the games port. This prevents hum loops forming if the MIDI output is also connected to a synthesiser.

The RS-232 converter converts the 0-5V signal from the microcontroller to a nominal ±10V signal for the serial port. When using the serial port connection, the 'MIDI invalid' LED lights to indicate that the signal on the MIDI outlet is not able to drive a synthesiser.

The microcontroller also drives the LCD and monitors switches S1 to S6. Input RB2 of the microcontroller checks if the footswitch is open or closed.

The circuit

The MIDI Drum Kit circuit (Fig.2) can be divided into two parts: the analogue section (sensor plate input circuitry) and the digital section (the microcontroller, LCD and switches and the MIDI output sections).

The circuitry for pad inputs PAD1 to PAD7 is identical. The signal source can be either a piezo transducer or an optical sensor circuit (as we shall see later).

The signal from each pad is tied to the +5V supply via the full 20kΩ resistance of the associated trimpot. In each case, the trimpot wiper can be adjusted between the full signal level, when set fully toward the Pad signal input, or to no-signal when the wiper is set at 5V. The signal is AC-coupled with a 100nF capacitor to remove the DC voltage, so that only the AC signal from the sensor passes. The DC level is then set at a nominal +2.5V using a voltage divider comprising two 100kΩ resistors across the 5V supply.

IC1 and IC2 contain operational amplifiers (op amps) wired as peak detectors. Normally, the output sits at the same voltage as the non-inverting input (eg, pin 12). When a signal is applied to pin 12, the op amp's output varies in response to this and the diode at the output charges the 1µF capacitor to the peak of the signal. When there is no signal at the input, the voltage across the 1µF capacitor will be discharged via the 100kΩ resistor across it, but not before microcontroller IC3 measures the peak voltage that was present on the 1µF capacitor (ie, at input AN2 of IC3).

Immediately IC3 detects this voltage, input AN2 is set to be an output and it is able to discharge the 1µF capacitor via the 2.2kΩ resistor as soon as the voltage at the cathode of diode D1 falls.

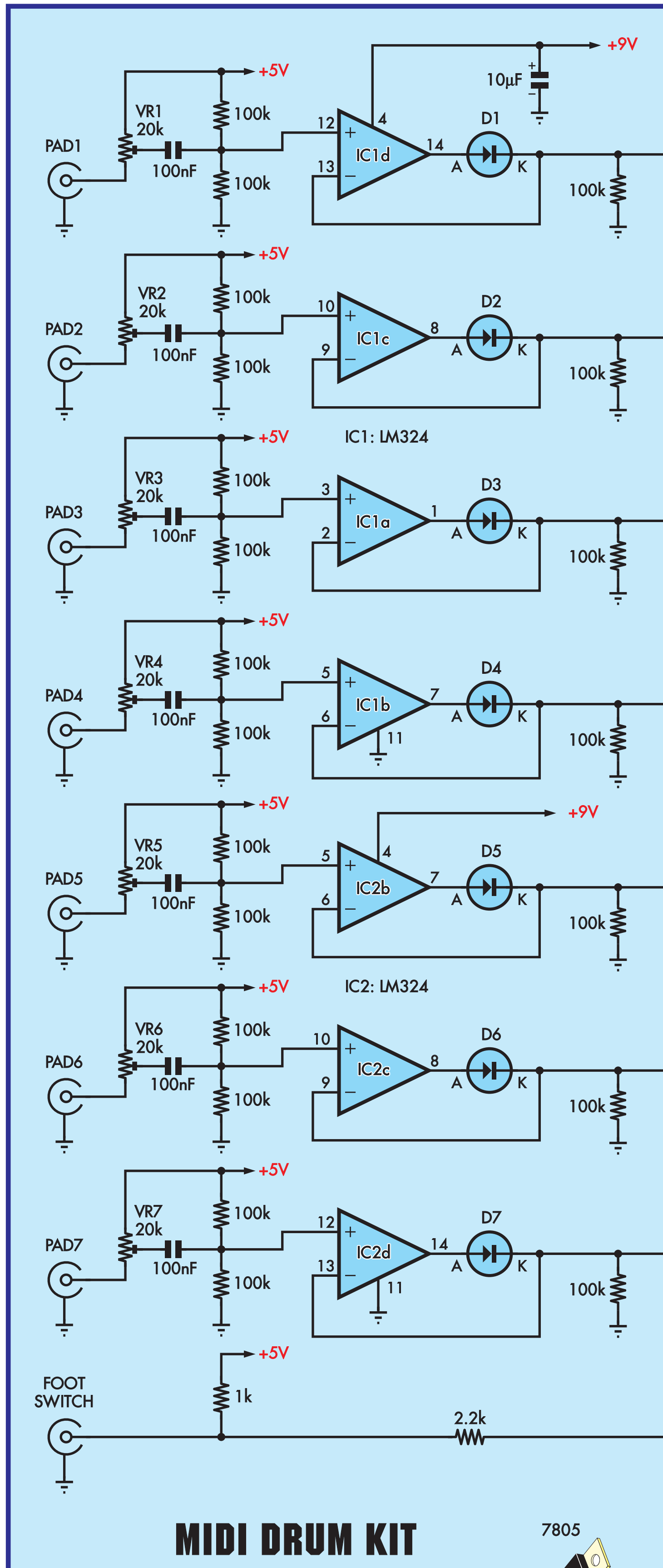
The footswitch input is tied to the 5V supply via a 1kΩ resistor. This sets IC3's RB2 input high when the switch is open. When the switch is closed, RB2 is pulled to ground. These levels are also detected by IC3.

Digital circuitry

The digital circuitry comprises IC3, IC4, IC5 and the LCD module. IC3 is a PIC16F88 microcontroller from Microchip. It includes features such as a 10-bit multi-channel analogue-to-digital converter and a serial output that can produce MIDI format signals at 31.25kHz bit rate, with the required stop and start bit.

The serial output can also be set to provide the 38.4kHz signal suitable for the serial port on a computer. Either of these two bit rates is accurate when the microcontroller operates at 16MHz and we do this using crystal X1 between pins 15 and 16.

IC3 is supplied with 5V between pins 14 and 5, with 100µF and 100nF capacitors decoupling this rail. The 100nF



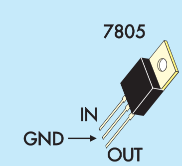
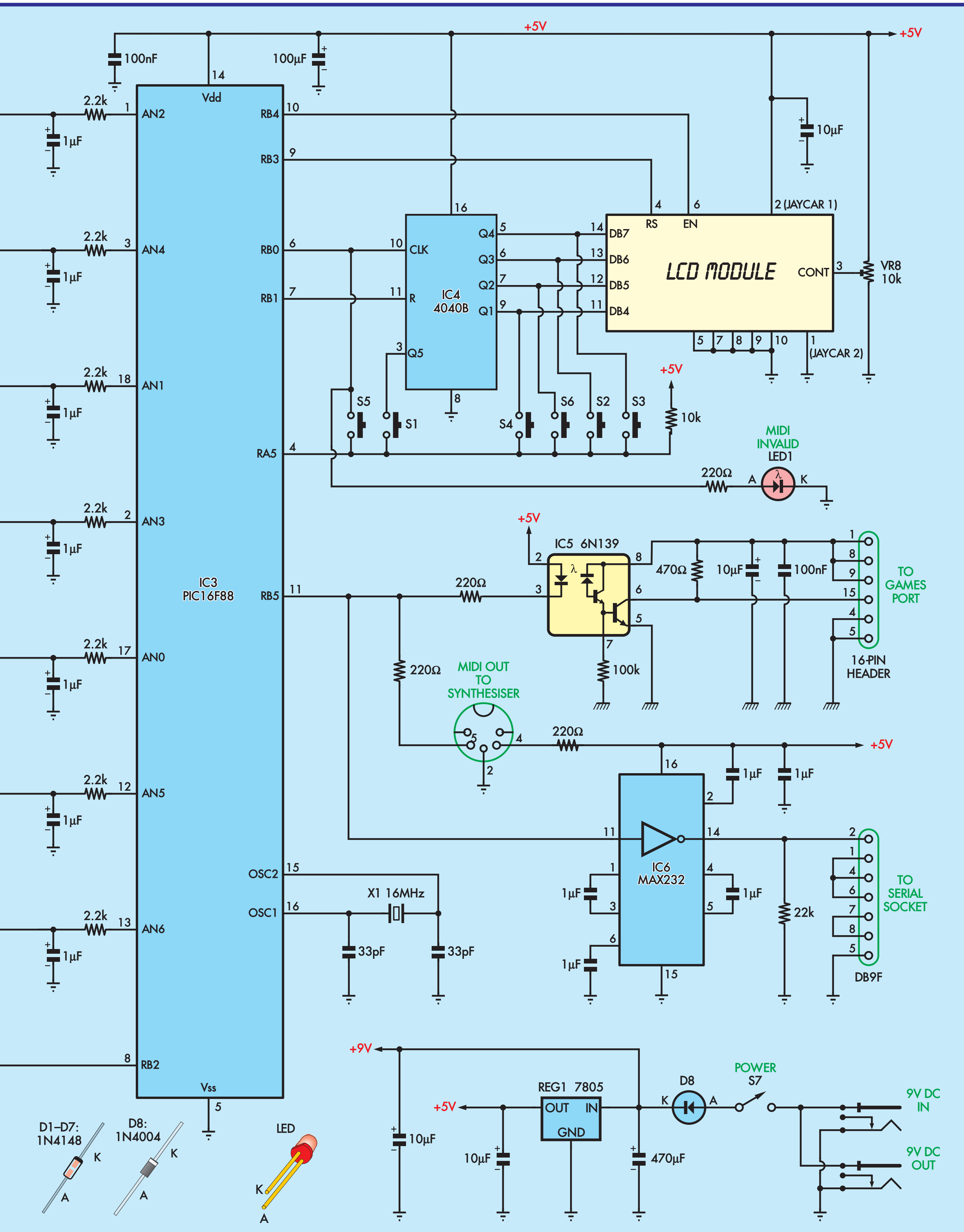


Fig.2: the circuit looks complex – but compare it to the block diagram and it's easy to understand the operation.



+5V
+5V
100nF
100µF
14
Vdd
2.2k
1µF
1
AN2
2.2k
1µF
3
AN4
2.2k
1µF
18
AN1
2.2k
1µF
2
AN3
2.2k
1µF
17
AN0
2.2k
1µF
12
AN5
2.2k
1µF
13
AN6
8
RB2
IC3
PIC16F88
Vss
5
RB4
RB3
RB0
RB1
RA5
RB5
OSC2
OSC1
X1 16MHz
33pF
33pF
16
CLK
R
IC4
4040B
Q4
Q3
Q2
Q1
Q5
8
10µF
RS
EN
2 (JAYCAR 1)
DB7
DB6
DB5
DB4
LCD MODULE
CONT
VR8
10k
1
(JAYCAR 2)
S5
S1
S4
S6
S2
S3
10k
MIDI
INVALID
LED1
220Ω
A
K
IC5 6N139
220Ω
470Ω
10µF
100nF
TO
GAMES
PORT
16-PIN
HEADER
100k
220Ω
MIDI OUT
TO
SYNTHESISER
220Ω
1µF
1µF
IC6
MAX232
1µF
1µF
1µF
22k
TO
SERIAL
SOCKET
DB9F
+9V
REG1 7805
OUT
IN
GND
+5V
10µF
10µF
470µF
D8
POWER
S7
9V DC
IN
9V DC
OUT
D1–D7:
1N4148
D8:
1N4004
LED
K
A

End-on and side-on views showing the eight inputs (left); above is the DC in/out, games port socket, serial socket, invalid MIDI LED and MIDI output

capacitor reduces high-frequency noise and the 100µF reduces the supply impedance at lower frequencies.

The LCD module is driven from IC3, using outputs RB4 and RB3 to control the Enable and Register Select inputs on the module. The data lines are obtained from IC4's counter outputs, Q1 to Q4. IC4 is driven at its clock and reset inputs via IC3 outputs RB0 and RB1 respectively. IC4 is included to expand the two RB0 and RB1 lines into four outputs to drive the data lines for the LCD module. This expansion also allows the circuit to monitor the opening and closing of six switches (S1 to S6).

Note that the LCD module has eight data lines, but we are only driving the upper four bits (DB4 to DB7). Data, therefore, must be sent as two 4-bit blocks in order to drive the display. The enable input and the register select input are control lines to place characters on the display and to set the character position.

IC3's RB0 line provides clock pulses for counter IC4 and simultaneously turns the 'MIDI Invalid' LED on or off, as required. It can do this because when the LED is supposed to be off, the clock pulses are so quick that they don't have time to light the LED.

Switches S1 to S6 are monitored using IC3's RA5 input, which is normally held high via the 10kΩ resistor to the 5V supply. The input will be pulled low if any switch is closed and its corresponding switch connection to IC4 is also pulled low. Since IC3 has full control over the state of IC4's inputs and outputs, it is able to determine if a switch is closed and which one it is.

The output comes from RB5 of IC3. This provides the signal for the MIDI output socket and the games port, via optocoupler IC5, along with the serial output via RS232 driver IC6. The signal to the MIDI output socket is fed via 220Ω resistors, one from output RB5 to MIDI socket pin 5 and the other from 5V to MIDI socket pin 4.

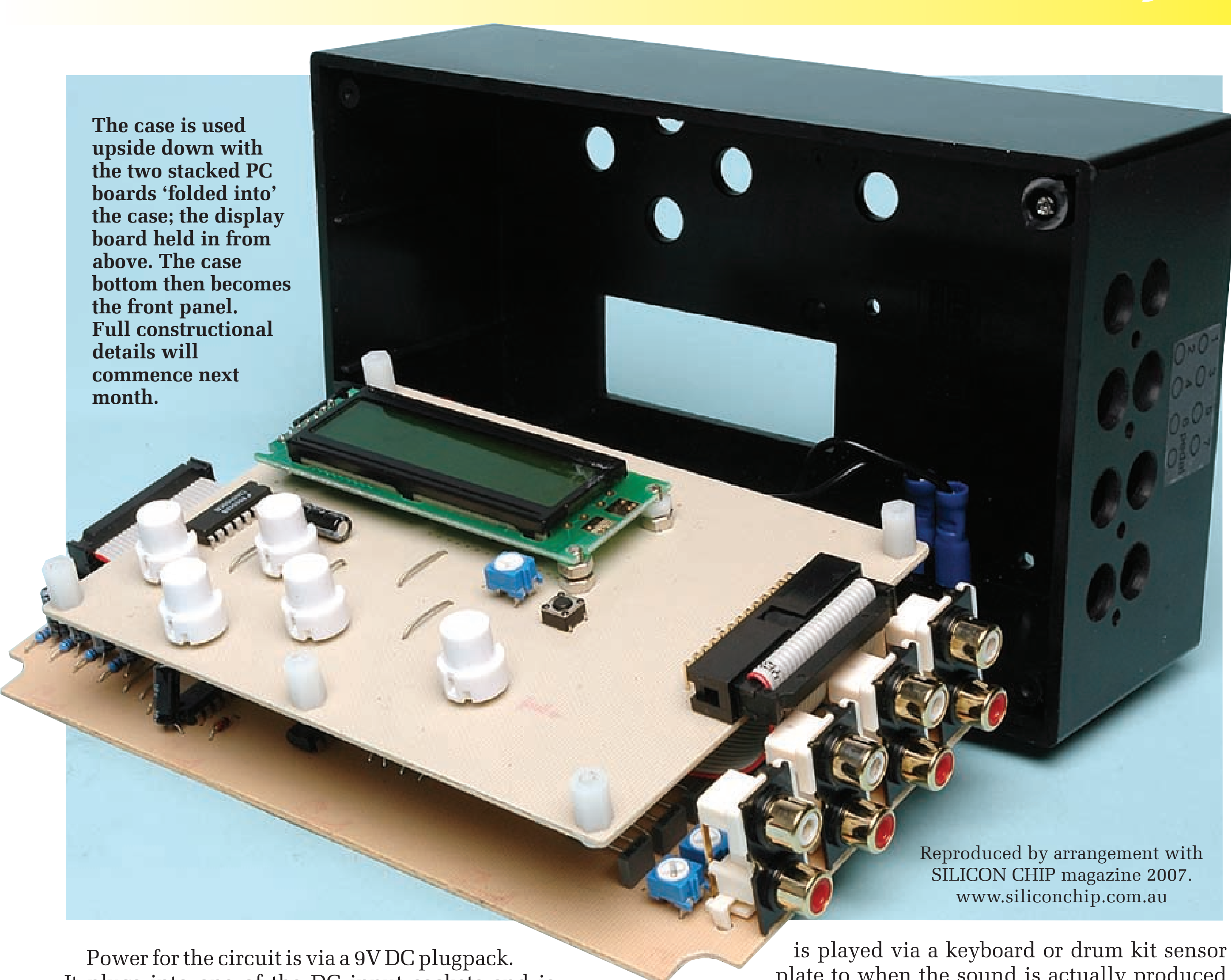
In the case of the LED optocoupler, when RB5 turns its LED on, the internal transistors are also switched on and the output (pin 6) is pulled to ground. When the LED is off, the transistor is off and the output is pulled to pin 8 via the 470Ω resistor. The 100kΩ resistor from the base of the internal transistor within IC5 to ground speeds up the transistor turn-off.

When the circuit is connected to a computer games port, pin 8 of IC5 is connected to the computer's 5V supply. Note that the 'grounds' are shown with a different symbol to the rest of the MIDI circuit. This indicates that the grounds are different – the transistor side of IC5 is connected to the computer's ground rather than the MIDI circuit's ground. The 5V supply on the transistor for IC5 is decoupled using 10µF and 100nF capacitors.

IC6 converts the logic levels (0-5V) on the micro's RB5 output to RS232 voltage levels (±10V) to drive pin 2 on the serial port. With only a +5V supply rail, the MAX232 generates the higher positive and negative voltages required for RS232 communications using two internal charge-pump voltage converters. One converter doubles the supply voltage to +10V (nominal) and the other inverts the result to obtain –10V. Four external 1µF capacitors provide the necessary storage and filtering.

Specification

Sensor pad volume range: .... From full to off in typically >120 steps
Left to right pan: .... 128 steps from 0 at full left to 127 for full right
Main volume: .... from full volume at 127 to off at 0
Sensor pad volume range: .... 36dB max range on Wide variation setting,
.... 18dB range on compressed 1 setting,
.... 12dB range on compressed 2 setting and
.... 0dB range on the Fixed maximum volume setting.
Delay from sensor strike to MIDI signal out: .... typically ≃1.2ms
Latency (delay between MIDI out signal to sound produced): .... depends on synthesiser
Repetition rate for sensor pad: .... adjustable from 0 to 255 in steps of 4 corresponding to a
.... maximum of 224ms or a slowest repeat rate of 4.4/s.
.... (Typically set at 100 for a repeat rate of about 9/s.)
Sensor threshold: .... adjustable from 0 through to 127 in steps of 1. Values of less than 5 typical.
Current consumption: .... 150mA with 9V DC in
MIDI out: .... 5mA loop, electrical isolation for games port (31.25k bits/second)
Serial out: .... RS232 levels (38.4k bits/second)



The case is used upside down with the two stacked PC boards 'folded into' the case; the display board held in from above. The case bottom then becomes the front panel. Full constructional details will commence next month.

Power for the circuit is via a 9V DC plugpack. It plugs into one of the DC input sockets and is switched by S7. After passing through polarity protection diode D8, a 9V (nominal) supply is available, as well as a +5V supply, provided by REG1.

Another DC socket, wired in parallel with the power input socket, provides a 9V outlet for the optical sensor pad circuitry. It doesn't matter which socket is used for which.

Sensor pads

The sensor pad circuitry comprises either a piezo transducer or an optical pickup – see Fig.3.

The optical sensing circuitry uses an infrared LED and a phototransistor in the one package. Light from the LED strikes the phototransistor which causes it to conduct. When the light is partially or fully interrupted between the LED and phototransistor, the conduction of the transistor reduces depending on the amount of light that is blocked. The LED is supplied with current from the 9V supply.

Since this is unregulated, the supply is heavily filtered using a series 470Ω resistor and 470µF capacitor. This smooths the voltage before driving the LED via another 470Ω resistor. Diode D9 is included to provide reverse polarity protection.

Latency

Sometimes, a troublesome aspect when playing sounds with MIDI is latency. This is the delay from when a sound is played via a keyboard or drum kit sensor plate to when the sound is actually produced and heard. The delay can sometimes be quite noticeable when the synthesiser in a computer is used for playing the sounds rather than the synthesiser in a musical instrument. The latency is largely dependent upon the sound card's capabilities and the software that's used with it. We'll look at this in more detail when we describe using the software in a later issue.

However, the latency of the MIDI Drum Kit between detection of a sensor plate being struck to sending the MIDI signal is minimal; typically 1.2ms. Generally, it is accepted that an overall 10ms delay is unnoticeable.

The MIDI Drum Kit can be used with up to eight sensor pads to allow playing seven instruments simultaneously (no, you don't need seven hands!).

The eighth input can be used with a footswitch that changes the instrument selection. It is ideal for operating the open and closed Hi-Hat cymbals – eg, the closed Hi-Hat sound is generated when the seventh sensor pad is struck and the footswitch is pressed (closed), while the open Hi-Hat sound is generated if it's struck and the foot-switch is open.

Sounds produced when the sensor pads are struck can be any that are available within the particular selected Drum Set, as shown in Table 1. Output volume level is dependent on how hard the sensor pads are struck. Alternatively, there are settings that compress the volume level or one that only

TABLE 1: DRUM SET DESCRIPTIONS

Patch Number	Drum Set Name	Description
1	**Standard Kit**	The General MIDI Standard drum kit. The only kit specified by General MIDI Level 1(35 to 81 inclusive).
9	**Room Kit**	Similar to the Standard kit but with more ambient percussive sounds.
17	**Power Kit**	Similar to the Standard kit but with a more powerful kick and snare sounds.
25	**Electronic Kit**	Made up of sounds emulating those of various electronic drum machines.
26	**TR-808 Kit**	Analogue drum kit that is reminiscent of the Roland TR-808 Rhythm Machine.
33	**Jazz Kit**	Jazz-styled set that is nearly identical to the Standard kit.
41	**Brush Kit**	Similar to the Standard kit but with many brush sounds added.
49	**Orchestra Kit**	An immense collection of concert drums and timpani for orchestral-styled music.
57	**Sound FX Kit**	A collection of sound effects.

TABLE 2: DRUM SETS

Patch	1	9	17	25	26	33	41	49	57
Note	**Standard**	**Room**	**Power**	**Electronic**	**TR-808**	**Jazz**	**Brush**	**Orchestra**	**Sound FX**
27	High Q	High Q	High Q	High Q	High Q	High Q	High Q	Closed Hi-Hat	-
28	Slap	Slap	Slap	Slap	Slap	Slap	Slap	Pedal Hi-Hat	-
29	Scratch Push	Scratch Push	Scratch Push	Scratch Push	Scratch Push	Scratch Push	Scratch Push	Open Hi-Hat	-
30	Scratch Pull	Scratch Pull	Scratch Pull	Scratch Pull	Scratch Pull	Scratch Pull	Scratch Pull	Ride Cymbal	-
31	Sticks	Sticks	Sticks	Sticks	Sticks	Sticks	Sticks	Sticks	-
32	Square Click	Square Click	Square Click	Square Click	Square Click	Square Click	Square Click	Square Click	-
33	Metronome Click	Metronome Click	Metronome Click	Metronome Click	Metronome Click	Metronome Click	Metronome Click	Metronome Click	-
34	Metronome Bell	Metronome Bell	Metronome Bell	Metronome Bell	Metronome Bell	Metronome Bell	Metronome Bell	Metronome Bell	-
35	Kick Drum 2	Kick Drum 2	Kick Drum 2	Kick Drum 2	Kick Drum 2	Jazz Bass Drum 2	Jazz Bass Drum 2	Concert Bass Drum 2	-
36	Kick Drum 1	Kick Drum 1	Mondo Kick	Electric Bass Drum	TR-808 Bass Drum	Jazz Bass Drum 1	Jazz Bass Drum 1	Concert Bass Drum 1	-
37	Side Stick	Side Stick	Side Stick	Side Stick	TR-808 Rim Shot	Side Stick	Side Stick	Side Stick	-
38	Snare Drum 1	Snare Drum 1	Gated Snare Drum	Electric Snare Drum	TR-808 Snare Drum	Snare Drum 1	Brush Tap	Concert Snare Drum	-
39	Hand Clap	Hand Clap	Hand Clap	Hand Clap	Hand Clap	Hand Clap	Brush Slap	Castanets	High Q
40	Snare Drum 2	Snare Drum 2	Snare Drum 2	Gated Snare Drum	Snare Drum 2	Snare Drum 2	Brush Swirl	Concert Snare Drum	Slap
41	Low Tom 2	Room Lo Tom 2	Room Lo Tom 2	Electric Lo Tom 2	TR-808 Low Tom 2	Low Tom 2	Low Tom 2	Tympani F	Scratch Push
42	Closed Hi-Hat	Closed Hi-Hat	Closed Hi-Hat	Closed Hi-Hat	TR-808 Closed Hi-Hat	Closed Hi-Hat	Closed Hi-Hat	Tympani F#	Scratch Pull
43	Low Tom 1	Room Lo Tom 1	Room Lo Tom 1	Electric Lo Tom 1	TR-808 Low Tom 1	Low Tom 1	Low Tom 1	Tympani G	Sticks
44	Pedal Hi-Hat	Pedal Hi-Hat	Pedal Hi-Hat	Pedal Hi-Hat	TR-808 Closed Hi-Hat	Pedal Hi-Hat	Pedal Hi-Hat	Tympani G#	Square Click
45	Mid Tom 2	Room Mid Tom 2	Room Mid Tom 2	Electric Mid Tom 2	TR-808 Mid Tom 2	Mid Tom 2	Mid Tom 2	Tympani A	Metronome Click
46	Open Hi-Hat	Open Hi-Hat	Open Hi-Hat	Open Hi-Hat	TR-808 Closed Hi-Hat	Open Hi-Hat	Open Hi-Hat	Tympani A#	Metronome Bell
47	Mid Tom 1	Room Mid Tom 1	Room Mid Tom 1	Electric Mid Tom 1	TR-808 Mid Tom 1	Mid Tom 1	Mid Tom 1	Tympani B	Guitar Fret Noise
48	High Tom 2	Room Hi Tom 2	Room Hi Tom 2	Electric Hi Tom 2	TR-808 High Tom 2	High Tom 2	High Tom 2	Tympani C	Guitar Cut Noise Up
49	Crash Cymbal	Crash Cymbal	Crash Cymbal	Crash Cymbal	808 Cymbal	Crash Cymbal	Crash Cymbal	Tympani C#	Guitar Cut Noise Down
50	High Tom 1	Room Hi Tom 1	Room Hi Tom 1	Electric Hi Tom 1	TR-808 High Tom 1	High Tom 1	High Tom 1	Tympani D	Double Bass String Slap
51	Ride Cymbal	Ride Cymbal	Ride Cymbal	Ride Cymbal	Ride Cymbal	Ride Cymbal	Ride Cymbal	Tympani D#	Flute Key Click

52	Chinese Cymbal	Chinese Cymbal	Chinese Cymbal	Reverse Cymbal	Reverse Cymbal	Chinese Cymbal	Chinese Cymbal	Tympani E	Laughing
53	Ride Bell	Ride Bell	Ride Bell	Ride Bell	Ride Bell	Ride Bell	Ride Bell	Tympani F	Screaming
54	Tambourine	Tambourine	Tambourine	Tambourine	Tambourine	Tambourine	Tambourine	Tambourine	Punch
55	Splash Cymbal	Splash Cymbal	Splash Cymbal	Splash Cymbal	Splash Cymbal	Splash Cymbal	Splash Cymbal	Splash Cymbal	Heartbeat
56	Cowbell	Cowbell	Cowbell	Cowbell	TR-808 Cowbell	Cowbell	Cowbell	Cowbell	Footsteps 1
57	Crash Cymbal 2	Crash Cymbal 2	Crash Cymbal 2	Crash Cymbal 2	Crash Cymbal 2	Crash Cymbal 2	Crash Cymbal 2	Concert Cymbal 2	Footsteps 2
68	Vibra-Slap	Vibra-Slap	Vibra-Slap	Vibra-Slap	Vibra-Slap	Vibra-Slap	Vibra-Slap	Vibra-Slap	Applause
59	Ride Cymbal 2	Ride Cymbal 2	Ride Cymbal 2	Ride Cymbal 2	Ride Cymbal 2	Ride Cymbal 2	Ride Cymbal 2	Concert Cymbal 1	Door Creaking
60	High Bongo	High Bongo	High Bongo	High Bongo	High Bongo	High Bongo	High Bongo	High Bongo	Door Closing
61	Low Bongo	Low Bongo	Low Bongo	Low Bongo	Low Bongo	Low Bongo	Low Bongo	Low Bongo	Scratch
62	Mute Hi Conga	Mute Hi Conga	Mute Hi Conga	Mute Hi Conga	TR-808 High Conga	Mute Hi Conga	Mute Hi Conga	Mute Hi Conga	Wind Chimes
63	Open Hi Conga	Open Hi Conga	Open Hi Conga	Open Hi Conga	TR-808 Mid Conga	Open Hi Conga	Open Hi Conga	Open Hi Conga	Car Engine
64	Low Conga	Low Conga	Low Conga	Low Conga	TR-808 Low Conga	Low Conga	Low Conga	Low Conga	Car Brakes
65	High Timbale	High Timbale	High Timbale	High Timbale	High Timbale	High Timbale	High Timbale	High Timbale	Car Passing
66	Low Timbale	Low Timbale	Low Timbale	Low Timbale	Low Timbale	Low Timbale	Low Timbale	Low Timbale	Car Crash
67	High Agogo	High Agogo	High Agogo	High Agogo	High Agogo	High Agogo	High Agogo	High Agogo	Siren
68	Low Agogo	Low Agogo	Low Agogo	Low Agogo	Low Agogo	Low Agogo	Low Agogo	Low Agogo	Train
69	Cabasa	Cabasa	Cabasa	Cabasa	Cabasa	Cabasa	Cabasa	Cabasa	Jet Plane
70	Maracas	Maracas	Maracas	Maracas	TR-808 Maracas	Maracas	Maracas	Maracas	Helicopter
71	Short Hi Whistle	Short Hi Whistle	Short Hi Whistle	Short Hi Whistle	Short Hi Whistle	Short Hi Whistle	Short Hi Whistle	Short Hi Whistle	Starship
72	Long Lo Whistle	Long Lo Whistle	Long Lo Whistle	Long Lo Whistle	Long Lo Whistle	Long Lo Whistle	Long Lo Whistle	Long Lo Whistle	Gun Shot
73	Short Guiro	Short Guiro	Short Guiro	Short Guiro	Short Guiro	Short Guiro	Short Guiro	Short Guiro	Machine Gun
74	Long Guiro	Long Guiro	Long Guiro	Long Guiro	Long Guiro	Long Guiro	Long Guiro	Long Guiro	Laser Gun
75	Claves	Claves	Claves	Claves	TR-808 Claves	Claves	Claves	Claves	Explosion
76	High Woodblock	High Woodblock	High Woodblock	High Woodblock	High Woodblock	High Woodblock	High Woodblock	High Woodblock	Dog Bark
77	Low Woodblock	Low Woodblock	Low Woodblock	Low Woodblock	Low Woodblock	Low Woodblock	Low Woodblock	Low Woodblock	Horse Gallop
78	Mute Cuica	Mute Cuica	Mute Cuica	Mute Cuica	Mute Cuica	Mute Cuica	Mute Cuica	Mute Cuica	Birds Tweet
79	Open Cuica	Open Cuica	Open Cuica	Open Cuica	Open Cuica	Open Cuica	Open Cuica	Open Cuica	Rain
80	Mute Triangle	Mute Triangle	Mute Triangle	Mute Triangle	Mute Triangle	Mute Triangle	Mute Triangle	Mute Triangle	Thunder
81	Open Triangle	Open Triangle	Open Triangle	Open Triangle	Open Triangle	Open Triangle	Open Triangle	Open Triangle	Wind
82	Shaker	Shaker	Shaker	Shaker	Shaker	Shaker	Shaker	Shaker	Seashore
83	Jingle Bell	Jingle Bell	Jingle Bell	Jingle Bell	Jingle Bell	Jingle Bell	Jingle Bell	Jingle Bell	Stream
84	Belltree	Belltree	Belltree	Belltree	Belltree	Belltree	Belltree	Belltree	Bubble
85	Castanets	Castanets	Castanets	Castanets	Castanets	Castanets	Castanets	Castanets	-
86	Mute Surdo	Mute Surdo	Mute Surdo	Mute Surdo	Mute Surdo	Mute Surdo	Mute Surdo	Mute Surdo	-
87	Open Surdo	Open Surdo	Open Surdo	Open Surdo	Open Surdo	Open Surdo	Open Surdo	Open Surdo	-

Table 1 (at top left) shows the number of drum sound kits that can be accessed with the MIDI Drum Kit. Note that older version synthesisers (pre-1995) may only provide for the standard drum kit. Table 2 (Drum Sets) shows the list of instruments or sounds that can be selected within each drum kit. As you can see, there are more than just a few available!

MIDI Drum Kit Controls

When first powered up, the MIDI Drum Kit display shows 'MIDI DRUM KIT -PLAY-'. This is the display that should be selected while actually playing the drum kit.

Pressing the Port/Cal switch displays the current port setting on the top line and ^ CALIBRATE ^ on the lower line. The port setting is changed from < MIDI PORTS > to < SERIAL PORT > using the left or right arrow switches as shown by the < and > bracketing around the words. The MIDI invalid LED lights when the Serial Port is selected. The Calibration selection is normally only ever used once, after the MIDI Drum Kit has been completed. Pressing the ^ switch calibrates the unit so that the quiescent voltage level for each pad sensor input is registered. This ensures that we get the best sensor response for each pad. To exit from the Port selection and calibration, press the Port/Cal switch again.

Note that the four switches arranged in a quad pattern below the LCD are labelled with < > ^ and v. These arrows are also shown on the display when the switches can be used to change the item within the two arrows. So a value or wording located within the < and > brackets can be altered by the < and > switches. The values within the ^ and v brackets can be altered using the ^ and v switches.

Pressing the SET switch selects one of several modes that are available to make changes to the way the Drum Kit sounds and works. The first press brings up the PATCH mode. This allows selection of the various drum kit patches available using this MIDI Drum Kit. The top line on the display shows the patch number, showing 1 for Standard, 9 for Room, 17 for Power, 25 for Electronic, 26 for TR808, 33 for Jazz, 41 for Brush, 49 for Orchestra and 57 for Sound Effects. These patch numbers refer to the MIDI instrument numbers. The lower line on the display shows the patch type in words, as indicated above. For example, the display shows < Standard > when patch 1 is selected. The patch is changed using the < and > switches. Note that if your synthesiser does not support the MIDI 2 standard, then only the standard drum set will be played, regardless of the patch setting.

The next mode is Pan and Volume settings, selected using the Set switch. At left, the word Pan is shown and below this is the Pan value surrounded by the < and > bracketing.

The value is changed by pressing the < switch to decrease the value and the > to increase the value. The pan sets the soundstage for the drum kit sound to be produced between the left and right channels. 0 sets the sound fully left, 63 is centred (equal left and right levels) and 127 is fully right.

Volume is shown at right with the value directly below this and surrounded by the ^ and v arrows. The value can be changed using these ^ and v switches from 127 (full volume) down to 0 for no sound and any value in between.

The next mode selected with the SET switch is the Repeat/Threshold system parameter settings. These are provided to compensate for physical factors that affect the sensor pads.

With any hard material that is struck with a drumstick or similar object, it is likely to ring or resonate for some time afterwards. The sensor pads have been carefully designed using materials that do not resonate excessively. However, there will always be some resonance in any design.

Resonance will affect the rate at which a sensor pad can be repeatedly struck. To cater for variances in the pads and their resonance, we have included the Repeat setting. This can be set to produce the best repeat rate that is possible. Values are adjustable from 0-255 in steps of 4, corresponding to a maximum of 224ms or a slowest repeat rate of 4.4/s. It's typically set at 100 for a repeat rate of about 9/s. Use the < or > switches to alter the value.

In a similar way, when there are several sensor pads attached to a common frame, there is likely to be a small amount of interaction between sensors. So if one sensor is struck, other sensors can detect the vibration through the frame. The adjustment of the Threshold value will prevent this interaction from happening. Typically, a value less than 5 will be correct. Use the ^ and v switches to alter the value.

Pressing the SET switch again will show the Pad Volume setting. The second line will show Fixed, Vary Wide, Compress 1 or Compress 2. You can change from one to the other with the < and > switches. The Fixed setting means that the drum's sounds will be always at their maximum volume when the sensor is struck. The other settings mean that the volume will be dependent on the degree that the sensor is struck. The wide variation setting gives the full 36dB dynamic range of control, while the compress 1 and compress 2 settings give an 18dB and 12dB dynamic range respectively. Basically, the compression boosts the minimum volume level for the drum sounds but does not change the maximum volume level available.

Pressing the SET switch will return the display to showing MIDI DRUM KIT -PLAY-. Be certain that this is the setting that you use when playing the drum kit properly. This is because this setting is designed to provide the best response from the pad sensors as they are struck. You can use the other display settings when setting up and changing instruments and patches but be aware that the sensors may not react as well as when the MIDI DRUM KIT -PLAY- is shown.

To select the PAD settings, press the SET switch or the < or > switches. The display will show for example <PAD 1> v #50 ^ on the first line. This indicates that the setting for PAD 1 is the 'drum' selection number 50. This is the Hi Tom 1 in the standard drum set. The second line on the display shows for example PATCH 1, then a speaker icon and a number. The Patch number indicates the selected patch (1 for standard patch).

Initial settings are Patch 1 and the Kick Drum selected for pad 1, the Snare Drum for pad 2, the Hi Tom for Pad 3, the Mid Tom for pad 4, the Ride Cymbal for Pad 5, the Crash Cymbal for pad 6, and the Open Hi-Hat and the Closed Hi-Hat for sensor 7. The pad 7 selections are changed with the footswitch. The pad selections can be changed to your own preferences using the list provided to make your selections.

The speaker icon and number is a diagnostic tool to allow checking which sensor pad is connected to which input. Basically, the number after the volume icon shows the detected volume level that is played by striking the pad. All you need to do is to repeatedly strike a sensor pad and change the PAD selection (with the < and > switches) until the number after the volume icon shows numbers greater than 0 as the pad is struck. The struck pad will be connected to the currently selected PAD input shown on the display. A right arrow appears also to indicate that a sensor is struck but not necessarily the sensor that you have currently showing on the display. Note that this feature is not easy to use if the Fixed pad volume is selected, since the volume does not change but stays at 127.

The PAD settings are adjusted using the ^ and v switches to select type numbers from 27 through to 87. These select the 'drum' sound required for the selected pad. The PAD selection is changed with the < or > switches selecting PAD 1 through to PAD 7. PAD 7 is shown as either 7a or 7b and is again selected using the < or > switches. The 7a pad 'drum' selection is the 'drum' selection when the foot switch is open and the 7b selection is when the foot switch is closed.

You can return to the MIDI DRUM KIT -PLAY- display by pressing the SET switch and return to the pad settings with the < or > switches without having to cycle through all the other settings that are available. Note that the pad number seen on the display will change up or down, depending on the < or > switch that is pressed.

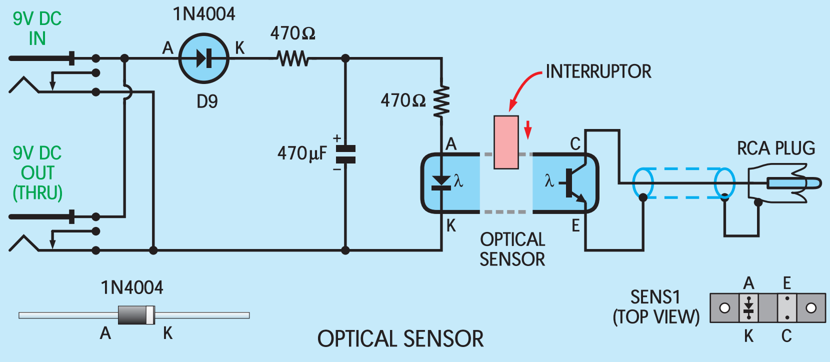


Fig.3: the two types of sensors, as described in the text – the simple piezo sensor (above) and the more complex (but better) optical sensor (right).

plays at the maximum level. In this latter case, the overall volume is then dependent on the master volume setting and the volume setting for the amplifier connected to the audio signal. The sound duration is fixed and is set by the sample within the synthesiser.

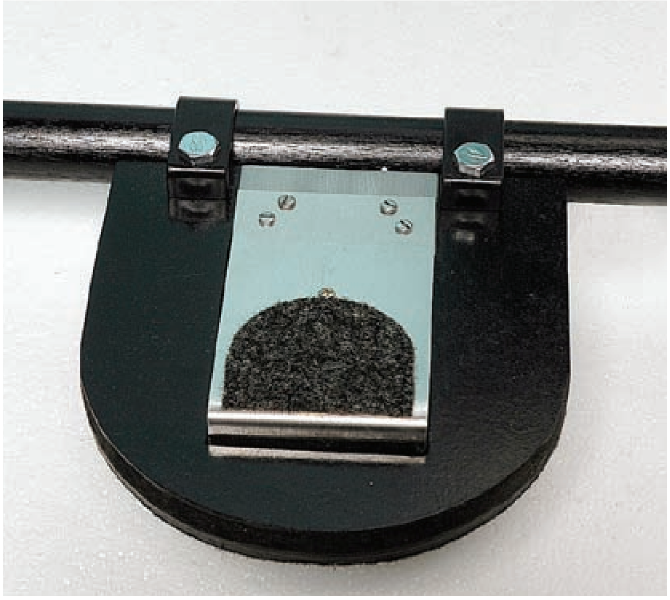
The sensor pad designs use readily available components that can be obtained from electronics stores and your local hardware shop. In its simplest form, a piezo transducer can be mounted onto a length of plastic tubing and wired to an RCA phono plug lead. The tube is then tapped with a fingernail, thimble or drumstick to trigger the sound production. This is an ideal sensor pad for stick, click, metronome, whistle and even cymbals or drums if you wish.

A piezo transducer is also used in the percussive sensor. This transducer is mounted onto a semi-circular shaped piece of MDF (Medium Density Fibreboard) and this board is then attached to a light-duty frame using plastic clamps. The pad is ideal for virtually all types of instruments as it can be mounted in space (on the frame), in the positions required for ease of playing. The sensor pad must also be struck with a stick or similar hard object. This type of pad has the advantage that it is very easy to build.

The percussive sensor pad does, however, have the disadvantage that it produces a sound of its own when tapped. This is normally drowned out by the actual drum sounds. It may, however, be a problem and so we have added settings that can play the drum sound at a louder level, even when the sensors are tapped very lightly. This keeps the unwanted sound at a low level. In addition, the pad can be covered with some vinyl or similar material to deaden the percussive sound or alternatively, the sticks can be rubberised. Such damping will also mean that the pads will have to be hit harder to develop the same sound level from the synthesiser.

High-precision sensors can also be made for the MIDI Drum Kit and are based on optical sensing. They can be operated by the palm of the hand, your feet or fingers. The optical pads provide a high degree of play control and good volume variation with different pad pressure. They also do not make any noise of their own. They have the disadvantage of being more complex to build, and if they are to be mounted on a stand, it must be of high strength to prevent movement when the sensors are played – particularly if the musician gets a little carried away . . .

Next month we will describe the construction of the MIDI Drum Kit, making the sensor pads and setting it up. That will include downloading and installing the required software and we'll also describe how to use it.



The two types of sensor: at left is the optical variety and at right the piezo model. The optical type, though more complex to construct, has several advantages.

Everyday Practical Electronics
Featured KITS

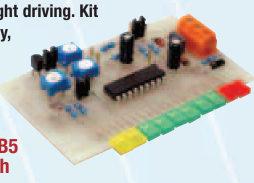
Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested down under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have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

Voltage Monitor Kit

KC-5424 £6.00 + post & packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your vehicle. The kit features 10 LEDs that light up in response to the measured voltage, preset 9-16V, 0-5V or 0-1V ranges complete with a fast response time, high input impedance and auto dimming for night driving. Kit includes PCB with overlay, LEDs, all electronic components and clear English instructions.

- Requires 12VDC power

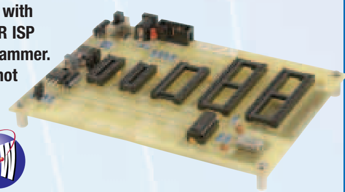


Recommended box UB5 (HB-6015) £0.83 each

AVR Adapter Board Kit

KC-5421 £10.25 + post & packing

A low cost system to program, erase, and rewrite the data and program memory in your AVR microprocessor. Kit includes everything you need to support in-system programming, complete with a regulated power supply, clock source and microcontroller IC socket. Designed in conjunction with KC-5420 AVR ISP Serial Programmer. Note: Does not include ZIF sockets.



NEW

Studio 350 High Power Amplifier Kit

KC-5372 £55.95 + post & packing

It delivers a whopping 350WRMS into 4 ohms, or 200WRMS into 8 ohms. Using eight 250V 200W plastic power transistors, It is super quiet, with a signal to noise ratio of -125dB(A) at full 8 ohm power. Harmonic distortion is just 0.002%, and frequency response is almost flat (less than -1dB) between 15Hz and 60kHz. Kit supplied in short form with PCB and electronic components. Kit requires heatsink and +/- 70V power supply (a suitable supply is described in the instructions).

- As published in Everyday Practical Electronics Magazine October & November 2006

The Flexitimer Kit

KA-1732 £5.95 + post & packing

This kit uses a handful of components to accurately time intervals from a few seconds to a whole day. It can switch a number of different output devices and can be powered by a battery or mains wall adaptor. The kit includes PCB and all components.

- As published in Everyday Practical Electronics Magazine October 2007

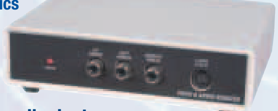
Requires 12-15VDC wall adaptor (Maplin GS75S £10.99)

Audio Video Booster Kit

KC-5350 £31.95 + post & packing

This kit will boost your video and audio signals preserving them for the highest quality transmission to your projector or large screen TV. It boosts composite, S-Video, and stereo audio signals. Kit includes case with silkscreened and punched panels, PCB and all electronic components.

- As published in Everyday Practical Electronics Magazine March 2006



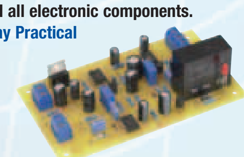
Requires 9VAC wall adaptor (Maplin #GU09K £9.99).

Delta Throttle Timer

KC-5373 £7.95 + post & packing

It will trigger a relay when the throttle is depressed or lifted quickly. There is a long list of uses for this kit, such as automatic transmission switching of economy to power modes, triggering electronic blow-off valves on quick throttle lifts and much more. It is completely adjustable, and uses the output of a standard throttle position sensor. Kit supplied with PCB and all electronic components.

- As published in Everyday Practical Electronics Magazine November 2006



Recommended box UB3 HB-6013 £1.05

Lead Acid Battery Zapper Kit

KC-5414 £11.75 + post & packing

This simple circuit is designed to produce bursts of high-energy pulses to help reverse the damaging effects of sulphation in wet lead acid cells. This is particularly useful when a battery has been sitting for a period of time without use. The effects are dependant of the battery's condition and type, but the results can be quite good indeed. Kit supplied with case, silkscreened lid, leads, inductors, and all electronic components, with clear English instructions.

- As published in Everyday Practical Electronics Magazine July 2007

RFID Security Module Receiver Kit

KC-5393 £28.95 + post & packing

Radio Frequency Identity (RFID) is a contact free method of controlling an event such as a door strike or alarm etc. An "RFID Tag" transmits a unique code when energised by the receiver's magnetic field. As long as a pre-programmed tag is recognised by the receiver, access is granted. This module provides normally open and normally closed relay contacts for flexibility. It works with all EM-4001 compliant RFID tags. Kit supplied with PCB, tag, and all electronic components.

- As published in Everyday Practical Electronics Magazine August 2007

PIC Based Logic Probe

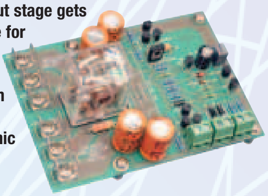
KC-5457 £4.50 + post & packing

Unlike ordinary logic probes, this one is driven by a PIC processor and operates over a wide supply voltage of 2.8VDC to 5VDC. It is extremely compact and uses surface mount devices on a PCB only 5mm wide. The probe includes a 'pulse stretcher' that will let you see very short pulses and a latch function to 'hold' infrequent pulses. Kit includes PCB and all specified electronic components including pre-programmed PIC. You'll need to add your own case and probe - a clear ballpoint pen and a needle work well.

Universal Speaker Protection and Muting Module Kit

KC-5450 £8.75 + post & packing

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.



Subwoofer Controller Kit

KC-5452 £29.00 + post & packing

Using this kit to control your external speaker and sub-amplifier can give you loads of bass without taking up much space. The kit has all the features you could want, including low and high pass filters, parametric equaliser and auto-turn on for external equipment. The controller is 12 volt DC powered and can also be used in automotive applications.

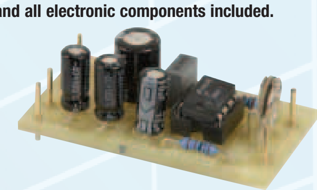
- Kit supplied with silk screened PCB and processed panels.

"The Champ" Audio Amplifier

KC-5152 £1.95 + post & packing

This tiny module uses the LM386 audio IC, and will deliver 0.5W into 8 ohms from a 9 volt supply making it ideal for all those basic audio projects. It features variable gain, will happily run from 4-12VDC and is smaller than a 9 volt battery, allowing it to fit into the tightest of spaces.

- PCB and all electronic components included.



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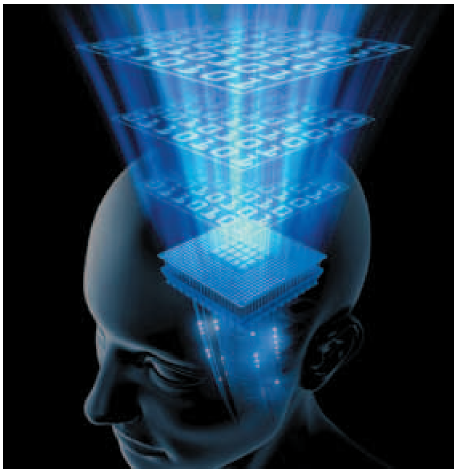
Teach-In 2008

Using PIC Microcontrollers

Part Two – Programme Basic Commands Plus Simple LED Control

JOHN BECKER



This month we start off by describing a simple demonstration program that shows how just a single LED can be turned on or off. Such actions can be useful in larger programs to indicate an occurence of an event or action in the software, either for cosmetic reasons, or for testing purposes when writing programs. We also describe a 'rotating' display of eight LEDs.

We then go on to describe a slightly more sophisticated program that can be used as a gaming dice, with LEDs to represent the spots on its surface. In the program discussed, the dice LEDs do not necessarily turn on in the order we expect them to in a conventional dice, however this will be remedied in the program discussed in Part 3.

Single LED control

This part's first circuit diagram for control of LEDs, is shown on the right hand side of Fig.1.2, from last month, comprising just LEDs D2 to D9 and their ballast resistors R14 to R21. The breadboard is not needed yet. Just connect LINK A as shown in Fig.1.3 last month on the Master Control PCB to allow the eight LEDs to be activated. (Ensure that LINK B is not connected.)

Let's examine the program commands that cause the LED display to be shown. The program listing is shown in Listing 2.1.

In Listing 2.1, the first things to notice are lines 1 and 2:

; TEACHINB01.ASM 07JUN07 - TEACH IN 2008 PT2
; turn on individual LEDs seperately

These lines describe the function of the program for the sake of the software writer, and anyone else who examines it. They are preceded by a semicolon (;). Any statement preceded by a semicolon, is ignored by the PIC programming software when assembling the code, and allows the software writer to place helpful comments against lines of program code, or elsewhere, so that their purpose is clear.

The next line is:

include p16f628.inc

Listing 2.1

```
         ; TEACHINB01.ASM 07JUN07 - TEACH IN 2008 PT2
         ; turn on individual LEDs seperately

         include p16f628.inc

         __config  $3F30         ; internal 4MHz oscillator

         CBLOCK h'20'
         CLKCNT
         ENDC

         ORG 0                   ; reset vector
         goto STARTIT
         ORG 4                   ; Interrupt vector address
         goto STARTIT
         ORG 5                   ; PIC program memory start location

STARTIT  bsf STATUS,5
         movlw b'00000000'       ; all PORTB as output
         movwf TRISB             ; data direction register for PORTB
         movlw b'10000111'       ; timer 1:256, pull-ups off (bit 7 =1)
         movwf OPTION_REG
         bcf STATUS,5

         call DELAY
         bsf PORTB,0             ; turn on LED at RB0
         call DELAY
         bsf PORTB,1             ; turn on LED at RB1
         call DELAY
         bsf PORTB,2             ; turn on LED at RB2
         call DELAY
         bsf PORTB,3             ; turn on LED at RB3
         call DELAY
         bsf PORTB,4             ; turn on LED at RB4
         call DELAY
         bsf PORTB,5             ; turn on LED at RB5
         call DELAY
         bsf PORTB,6             ; turn on LED at RB6
         call DELAY
         bsf PORTB,7             ; turn on LED at RB7

PROGEND  nop
         goto PROGEND


DELAY    movlw 25                ; set delay counter to 25
         movwf CLKCNT            ; (for 1/25th sec x 5)
         clrf INTCON             ; clear interrupt flag
DELAY2                           ;
         btfss INTCON,2          ; has a timer time-out been detected?
         goto DELAY2             ; no
         bcf INTCON,2            ; yes
         decfsz CLKCNT,F         ; dec counter, is it zero?
         goto DELAY2             ; no
         return                  ; yes

          END
```

This indicates to the assembly program that it is to *include* (import) a file named **p16F628.inc** at this point. Such *include* files can have many functions, and are particularly useful when chunks of code are 'library' code that can be used in many programs without change. They save having to rewrite the same code each time it is needed. It is common for code sections to be repeated in many programs, and using *include* files is one way in which it can be done. Simply copying and pasting a section is another method.

In this instance, the file is one provided by Microchip and specifies the many Special Function Registers (SFRs) that are used by the PIC named (PIC16F628 in this case). There are equivalent Microchip **.inc** files for all PICs, some of which are provided with the control software described last month. (They can also be downloaded from Microship's website.)

It is, of course, possible to also specify the same SFRs and their addresses as part of the program, but the use of the correct **.inc** file saves that task. You may examine the file's contents through a text editor, but do not change it in any way.

It is worth noting that *include* files such as this do not take up any PIC memory. They are simply used by the assembly program.

Examples of how you would code in (equate) SFRs and user registers are shown later in the series.

PIC configuration

Next comes the line:

```
__config   $3F30   ; internal 4MHz oscillator
```

An important concept to understand is that all PICs must be 'configured' for the application they are intended to control. Such configuration includes the selection of oscillator type, and matters such as Watchdog timer and Code Protection bits use (which are discussed in a future part). Once the configuration has been set it is not normally necessary to change it for the same application (and it is difficult to do so without special techniques).

In this case, the configuration (Config) code simply tells the PIC when it is being programmed by the software to use its internal 4MHz oscilator to control the rate at which the commands are processed when the program in run.

Be aware that the Config codes for various PIC functions vary widely between PICs. See the datasheet for the PIC in question (available via **www.microchip.com**).

The control software described last month allows the Config codes to be set/shown for a small variety of PICs, including the PIC16F628. For the sake of *Teach In 2008* you do not actually need to know the Config codes for the various demo programs, as they all have that information embedded into them as part of the PIC programming software.

Numerical formats

In this instance, the Config code is quoted in the hexadecimal format. There are three main formats that can be used to express numerical values in a program.

They may be expressed in decimal (e.g. 0, 4, 5) (which can also be specified in the form of D'xx' – where 'xx' is any decimal value between 0 and 255).

Hexadecimal format may also be used (indicated by a prefix of H), in the form H'00' and h'7F' for example. The range is normally h'00' to h'FF' (0 to 255), but it is possible to use double-byte values between 0 and 65525, with the range h'0000' to h'FFFF'. Note that H' or h' are normally used, though this may depend on the assembler software you are using.

Binary is the third format, prefixed by b' and terminated by an apostrophe ('), in the form and range b'00000000' to b'11111111' (0 TO 255).

ORG and GOTO statements

The next five program lines involve **ORG** and **GOTO** statements:

```
ORG 0           ; reset vector
goto STARTIT
ORG 4           ; Interrupt vector address
goto STARTIT
ORG 5           ; PIC program memory start location
```

At this stage they need not concern you, but they will be discussed later. Note, however, that no additional commands (other than Table statements which are discussed in a future part), may be added to the code before the next line (or its equivalent in another program): **STARTIT**.

STATUS register

PICs are 'told' in manufacture to adopt certain 'default' conditions when first switched on. One of these default conditions is that PORTA and PORTB are configured (set) to act as inputs. When in an input condition they are simply held in a high impedance state (floating), and so could be adversely affected by stray electrical fields (the default conditions for all PIC registers are shown in the datasheet).

The demonstration program in Listing 2.1 needs PORTB to be capable of outputting any value bewween 0 and 255 (an 8-bit byte). The STATUS register is that which is used to set the PIC's data direction bits (among other things). Its table of functions was shown in Part 1, Table 1.3.

After **STARTIT** (such sub-program identity statements are known as *Labels*), come the lines:

```
bsf STATUS,5
movlw b'00000000'   ; all PORTB as output
movwf TRISB         ; data direction register for PORTB
movlw b'10000111'   ; timer 1:256, pull-ups off (bit 7=1)
movwf  OPTION_REG
bcf STATUS,5
```

If you examine a PIC's datasheet, you will see that its user-memory is split into various sections, generally known as *Banks*. Part of an example memory map was in Table 1.2 of Part 1. The PIC has to be told which Bank it has to use and in which order to access certain SFRs within it. The SFRs which set the port data direction registers (DDRs) are in Bank 1 for the PIC16F628 (and many other PICs, but not all).

Selection between Bank 0 and Bank 1 is controlled by bit 5 of the STATUS register. When it is *clear* (equals 0), Bank 0 is selected, when s*et* (equals 1), Bank 1 is selected.

Only PORTB concerns us for this short program. Its DDR is known as TRISB.

In order to set all eight PORTB pins for use as outputs, as we need to, we first set STATUS to access Bank 1, with the statement:

```
bsf STATUS,5
```

Command **bsf** means Bit Set File register – set the named bit (5 in this case) of the named register (STATUS). (The terms 'set' and 'clear' were defined in Part 1.)

The binary value of b'00000000' (0) is then set into TRISB, with the two commands:

```
movlw b'00000000'
movwf TRISB
```

movlw means 'move the literal value that follows into the Working Register – known by the letter 'W') ('move' in this case means 'copy' – the original value itself remains where it is, and just a copy of it is placed into the named register).

movwf means move (copy) the value in W to the File then named. Thus the value in W is now copied to register TRISB.

Any bit set to a 1 in the DDR then behaves as an input pin and any bit set to a 0 can be used as an output (but also see later).

The DDR is now configured for all PORTB bits to behave as outputs.

All PIC ports can have their DDRs set via a suitable TRIS statement. The PIC16F628 also has a PORTA, which is shown in use next month, and its DDR is set via TRISA. Some PICs have more ports, eg PORTC, PORTD, PORTE and equivalent DDR registers, eg TRISC, TRISD and TRISE.

PICs can have any individual bit of any file byte acted upon directly. Each bit can be set high (as above with STATUS – bsf), or low by a single command bcf (Bit Clear File register), which is now used to return the PIC to Bank 0:

```
bcf STATUS,5
```

As we shall show in a future part, a single command will also determine the status of any individual bit.

Now we can change the value within PORTB (and then output byte values to the world) as we wish. Right now we can simply use the command:

```
bsf PORTB,0
```

This causes the LED on PORTB bit 0 (RB0) to turn on. The next seven lines then cause the other LEDs to turn on in the sequence shown.

Two commands remain:

```
nop
goto PROGEND
```

Command **nop** means 'no operation', allowing a command to be used but which does nothing except introduce a pause of one PIC clock cycle (whose timed length depends on the rate of the oscillator used).

The **goto PROGEND** command tells the program to go to (*loop back* in this case) to the Label **PROGEND**, which immediately precedes **nop**. The effect is that the program continues doing nothing active – for ever – until it is reset somehow to again perform the same total sequence of commands.

Ignore the DELAY calls and routines for the DELAY, DELAY 2. They will be discussed in a later part.

Finally, there is the statement **END**. Not all assemblers/programmers need this statement to indicate that the program has now reached its end. It is best, though, if it is always included.

Resetting the program

If the PIC were to be installed in another PCB rather than the provided Control one, there might be no way to end this demo program except by switching off its power supply. However, this Control PCB (and the *TK3* PCB) has a Reset switch built in, S1.

Pressing S1 causes the program to restart from the beginning without power being switched off.

There are now two facts that you need to consider, regarding the contents of the resisters, although their effect will not be apparent with this demo.

First, using the Reset switch causes all existing register values to remain as they were prior to the switch being pressed. This is beneficial in some applications, such as the single Dice program described later.

Perhaps more importantly in other applications, all the values held in the registers are unknown when power is switched on following a switch off.

It is usually essential that any register used in the program should always be given a known starting value at the moment of switch on. This will be demonstrated in the Part 3 discussion next month.

More on LED controlling

Let's examine LED control in a bit more detail, still using the LEDs on the Control PCB.

Load program **TeachinB03.hex** into the PIC and run it. What you will see is that the eight individual LEDs on PORTB are again being turned on at the same time that the preceding one is turned off. The movement will appear to be going from right to left, from bit 0 to bit 7 (D2 to D9), and restarting at bit 0.

There are several ways of doing this (and many reasons why you should need to). Two programming techniques are discussed here, the one in Listing 2.2, and then a much shorter one, later in Listing 2.3. The one in Listing 2.2 demonstrates the use of the commands MOVLW, MOVWF, RLF, BTFSS, and how two loops can be 'nested' and made dependent upon each other.

Referring to the display you see on the LEDs at the moment, controlled by **TeachinB03**, the Carry bit clearing technique is being used immediately prior to the RLF command. We shall show what happens if the Carry is not cleared when **TeachinB02** is viewed later.

Listing 2.2 contains the command MOVLW 1. The MOVLW command (MOVe Literal value into W, 1 in this case) is the command which allows literal values (numbers) contained within the program itself to be moved (copied) into the Working register for further manipulation.

The range of values is from 0 to 255, i.e. an 8-bit byte. Command MOVLW 1 instructs that the value of 1 is to be moved into W. Literal values may be expressed in decimal, hexadecimal or binary, eg:

MOVLW 73 (decimal)
MOVLW H'49' (hexadecimal)
MOVLW B'01001001' (binary)

Literals may also be the address values of other files whose names have been specified at the head of the program, or they may be the values assigned to be represented by other words or letters. The following are all legal commands:

MOVLW STATUS
MOVLW PORTB
MOVLW W
MOVLW LOOP1

Respectively, the commands would move into W the address value of STATUS (which is specified as 3 for the PIC16F628), the address value of PORTB (6), the value assigned to be represented by W (0), the address within the program at which the command line prefaced by label LOOP1 resides (a value known only to the program - unless you examine the LST file).

Listing 2.2

```
                    ; TEACHINB03.ASM 07JUN07 - TEACH IN 2008 PT2
                    ; STATUS Carry flag checking


#DEFINE BANK0 BCF STATUS,5
#DEFINE BANK1 BSF STATUS,5

                    include p16f628.inc

                    CBLOCK h'20'
                    CLKCNT
                    ENDC

                    __config  $3F30         ; internal 4MHz oscillator

                    ORG 0                   ; reset vector
                    goto STARTIT
                    ORG 4                   ; Interrupt vector address
                    goto STARTIT
                    ORG 5                   ; PIC program memory start location

STARTIT             clrf PORTA              ; clear Port A data register
                    clrf PORTB              ; clear Port B data register
                    BANK1                   ; BANK 1
                    clrf TRISA              ; Port A direction register for output
                    clrf TRISB              ; Port B direction register for output
                    movlw b'10000111'       ; timer 1:256, pull-ups off (bit 7 = 1)
                    movwf OPTION_REG
                    BANK0                   ; BANK 0

LOOP1               movlw 1                 ; load value of 1 into Working register
                    movwf PORTB             ; load this value as data into Port B
                    bcf STATUS,C            ; clear Carry flag

LOOP2               call DELAY
                    rlf PORTB,F             ; rotate value of PORTB left by 1 logical place
                    btfss STATUS,C          ; check Carry flag is set
                    goto LOOP2              ; this command is actioned only if PORTB is
                                            ; not yet 0
                                            ; the program jumping back to address
                                            ; LOOP2
                    goto LOOP1              ; this command is only actioned when
                                            ; PORTB now = 0

DELAY               movlw 25                ; set delay counter to 25
                    movwf CLKCNT            ; (for 1/25th sec x 5)
                    clrf INTCON             ; clear interupt flag
DELAY2                                      ;
                    btfss INTCON,2          ; has a timer time-out been detected?
                    goto DELAY2             ; no
                    bcf INTCON,2            ; yes
                    decfsz CLKCNT,F         ; dec counter, is it zero?
                    goto DELAY2             ; no
                    return                  ; yes

                    END
```

Following the MOVLW 1 command in Listing 2.2 is the command MOVWF PORTB, (MOVe W into File) which simply copies the contents of W into the file specified, in this case PORTB, still leaving that value in W (unimportant in this program, but it can be in other programs). Apart from the destination statement, no commas or other statements are needed (or allowed) with this command. The MOVWF command is the only way in which full bytes of data can be copied from W into other destinations. As used in Listing 2.2, it is the value of 1 which is copied.

Rotation and shifting

Many of you will be familiar with the concept of shift registers. Data can be loaded into the register either serially (bit entry) or in parallel (byte entry). The data can be shifted to the 'left' or 'right' in the chip, in response to a clock signal. The shifted data can then be made available either serially as bits, or in parallel as a byte.

When data is shifted left and read as a byte (parallel output), each shift has the effect of multiplying the value by two. Shifting to the right divides it by two. Take the 8-bit binary code 00000100 (decimal 4), for example. If this is shifted left by one place, the result is 00001000 (decimal 8). If the code had been shifted right by one place, the result would be 00000010 (decimal 2).

Most files within a PIC are capable of having their data shifted (rotated) to the left or to the right (although doing so on the SFRs may sometimes produce unpredictable results). The two commands are RLF and RRF (Rotate Left File and Rotate Right File). Both commands have to be followed by the file which is to have its data rotated, then a comma and then the destination, either F or W.

There are two problems associated with rotating a file's contents left or right. First, consider the situation when a file (for example, call it PORTB) contains a value such as 11010111 (decimal 215); there are many numbers that could illustrate the point about to be made.

Suppose the rotate left command **RLF PORTB,F** is given, all bits are rotated left by one place. The value retained in PORTB becomes 10101110 (decimal 174) which is definitely not 2 × 215; the original lefthand bit has vanished from this 8-bit byte – a 9-bit byte would be needed to show the correct answer.

Alternatively, suppose the rotate right command **RRF PORTB,F** is given, all bits are rotated right by one place. The value retained in PORTB becomes 01101011 (decimal 107), which is definitely not 215/2; the original right-hand bit has vanished from this 8-bit byte.

In some cases, of course, the intention of rotating left or right may have nothing to do with multiplying or dividing a value by 2. It may be that we simply want to change the position of the bits for another purpose, such as changing the commands sent to the outside world to turn equipment on or off. In this case, the arithmetic accuracy of the rotate result would be immaterial.

The other problem (although it can be used beneficially) is that bits rotated out from either end of the byte are rotated into the Carry bit of STATUS. Simultaneously, the previous value held in the Carry bit is rotated into the byte at the other end.

Suppose that the Carry bit is initially zero. In the first RLF example above, the original value of 11010111 would be rotated left and the result would be correct as shown (10101110) because the 0 has come in to the right from the Carry bit. However, the last lefthand bit of the original value (which is a 1) would now be in the Carry bit.

Suppose that another rotate left is made. The bits within PORTB would be rotated left but, at the same time, the Carry bit from the previous rotation would now be rotated into PORTB from the right. The value held in PORTB thus becomes 01011101 (decimal 93), and again the Carry bit now holds the 1 from PORTB bit 7.

Therefore, the next rotation will result in an answer of 10111011 (decimal 187). To avoid a set Carry bit (which retains the status last acquired anywhere in the program) being rotated automatically into a file byte from the other end, the Carry bit can be cleared by the command **BCF STATUS,C** prior to each rotate command, unless, of course you want a Carry bit rotated into a byte.

Bit testing

Another command we are introducing in Listing 2.2 is BTFSS, Bit Test File Skip if Set. What BTFSS does is to examine the status of the file bit specified in the remainder of the command (bit C of STATUS in this case: **BTFSS STATUS,C**). The word Set now becomes the important one. The PIC is being asked to test if the bit specified is Set (ie, is it logic 1?).

Programs are stored as instructions in consecutive memory bytes. These bytes are numbered from zero upwards, with location 5 being the true start of the full program for most PICs (although it can be a different later address).

In Listing 2.2, we know that the answer from BTFSS will be either true or false. When the PIC performs the BTFSS command, the answer is automatically added to the PCL. Therefore, if the answer is true (1) the PCL has 1 added to it and so the next-but-one instruction is performed. If the answer is false (0), then zero is added to PCL and so the very next instruction is performed.

With the command **BTFSS STATUS,C**, we are checking if bit C of STATUS is set (true). If it is true that the bit is set, then the 1 of the truth answer is added to PCL and so the command **GOTO LOOP2** is bypassed and that which says **GOTO LOOP1** is performed. If STATUS bit C is not set (false) then the program simply takes **GOTO LOOP2** as the next command because the 0 of the false answer is added to PCL.

What the program of Listing 2.2 does is the simple action of repeatedly 'moving' an active LED from right to left.

First, at label LOOP1, the value of 1 is moved into W, this is then moved into PORTB, setting its bit 0 to 1 and clearing bits 1 to 7. As a result, the first LED at the right is turned on (D2) and the others (D3 to D9) are turned off. In binary, PORTB's value is now 00000001.

Next, the Carry bit of STATUS is cleared to prevent it from interfering with the results of the rotate-left command that follows at label LOOP2 (as discussed earlier). You will see that this command is **RLF PORTB,F**. The F suffix means that the result of the rotation is retained in PORTB, and the contents of PORTB will have shifted so that the second LED (D3) has come on because the 1 previously set by the MOVWF command has shifted from PORTB's bit 0 to its bit 1. Since the Carry bit was previously cleared, 0 is moved into PORTB bit 0, turning off LED D2. The binary value has become 00000010.

Now the value of the Carry bit in STATUS is checked to see if a 1 has been shifted out from PORTB bit 7. In fact, it cannot have occurred yet, since it takes eight shifts to bring the 1 from the right and into Carry. However, the PIC is not aware of that fact, so the Carry bit has to be checked following each shift left. If the Carry bit is not yet set, the command **GOTO LOOP2** is performed, the program jumps back to that stated position and the RLF command is again actioned.

As a result, the third LED (D4) will come on and the second LED (D3) will go out, binary 00000100.

Eventually, after eight shifts, the 1 will have shifted through all eight bits of PORTB and into the Carry bit. At this point, there will be no bits set in PORTB, and so no LEDs will be on. Now, on the test for the Carry bit being set, the answer will be true, command **GOTO LOOP2** will be bypassed and the command **GOTO LOOP1** will be performed, the program jumping to that label. The whole sequence then recommences by a 1 again being loaded into PORTB bit 0. As written, the program will repeat until the PIC is switched off or the Reset switch is used.

Command BTFSC

There is a command which is the opposite of BTFSS, namely BTFSC (Bit Test File Skip if Clear). What this command does is to check if it is true that the bit being tested is clear (0). If it is true that the bit is clear, then the answer is 1. If it is false that the bit is clear (that the bit is not 0, but 1), then the answer is 0.

Using BTFSC in the program of Listing 2.2 would produce entirely the wrong result. Can you see why?

A faster LED rotation

Load the PIC with the program in Listing 2.3, **TeachinB02.hex** – it will be seen to be shifting the LED display to the left, as occurred when **TeachinB03** was run.

You should notice that **TeachinB02** is running a bit faster than **TeachinB03** did. This is because there are now fewer commands to process for the same result. Simplicity of code usually makes for faster processing speeds (or rather, fewer commands to be processed to perform a particular function, will result in a faster processing speed).

Look at Listing 2.3 and you will see how few commands there are in the loop, just two. Let's examine the program flow. In the listing everything up to the statement BANK0 is the same as in **TeachinB03**. Then advantage is taken of the fact that a set Carry bit will be shifted into a file when it is rotated left or right; the command BSF STATUS,C is given before the loop, so setting the Carry bit. Now when PORTB is rotated left with the command RLF PORTB,F, the Carry bit comes straight into PORTB bit 0, turning on LED D2.

Listing 2.3

```
            ; TEACHINB02.ASM 07JUN07 - TEACH IN 2008 PT2

#DEFINE BANK0 BCF STATUS,5
#DEFINE BANK1 BSF STATUS,5

            include p16f628.inc

            __config  $3F30         ; internal 4MHz oscillator

            CBLOCK h'20'
            CLKCNT
            ENDC

            ORG 0                   ; reset vector
            goto STARTIT
            ORG 4                   ; Interrupt vector address
            goto STARTIT
            ORG 5                   ; PIC program memory start location

STARTIT     clrf PORTA              ; clear Port A data register
            clrf PORTB              ; clear Port B data register
            BANK1                   ; BANK 1
            clrf TRISA              ; Port A direction register for output
            clrf TRISB              ; Port B direction register for output
            movlw b'10000111'       ; timer 1:256, pull-ups off (bit 7 = 1)
            movwf OPTION_REG
            BANK0                   ; BANK 0

            call DELAY

            bsf STATUS,C            ; set the Carry bit in STATUS

LOOP        rlf PORTB,F             ; rotate left PORTB
            call DELAY
            goto LOOP               ; repeat

DELAY       movlw 25                ; set delay counter to 25
            movwf CLKCNT            ; (for 1/25th sec x 5)
            clrf INTCON             ; clear interupt flag
DELAY2                              ;
            btfss INTCON,2          ; has a timer time-out been detected?
            goto DELAY2             ; no
            bcf INTCON,2            ; yes
            decfsz CLKCNT,F         ; dec counter, is it zero?
            goto DELAY2             ; no
            return                  ; yes

            END
```

Simultaneously, the Carry bit is cleared. The next command is GOTO LOOP, which the program does, again to rotate PORTB, causing D3 to come on and D2 to go out. For eight rotations left, the Carry bit remains clear, then on the ninth rotation the original 1 that has traversed PORTB will drop into the Carry bit, to be rotated back into PORTB on the next rotation. And so it goes on, indefinitely.

There are numerous situations in which rotation occurs and when the setting of the Carry bit is desirable. In this way, for example, several files can be coupled as a very long shift register:

BSF STATUS,C
RLF FILE1,F
RLF FILE2,F
etc. to
RLF FILE15,F

Gaming dice

To conclude this month we use LEDs to show the first stages of how a representation of the dots on a gaming dice can be simulated. The program is shown in Listing 2.4. The circuit diagram we shall use is in Fig.2.1, and the breadboard layout is given in Fig.2.2. Disconnect the LINK A wire on the Control PCB and connect LINK B to ensure that the LEDs are reverse biased.

Program the PIC with the hex file required.

Connect the PIC Controller board to the breadboard as shown, using insulated solid connecting wires. Switch on the power to the Controller. One or more LEDs will turn on, representing the dice value. Press the Reset switch on the Controller, and the LEDs should show a different value, between 1 and 6. Pressing the switch again will produce a different value, and so on.

The rest of the program up to STARTIT, and the next four commands after it, is as you have been using so far. Then follow:

```
DICELOOP   incf PORTB,F
           incf PORTB,F
           incf PORTB,F
DICEEND    nop
           goto DICEEND
```

Command INCF

Command **incf** means 'increment' (add one to) the value already existing in the named register that follows (PORTB). We don't actually know what value is aleady in PORTB, as we have not told it to start with any given value (although we can, as we shall see. Should adding 1 to the value within PORTB result in a total of 256, PORTB automatically rolls over to a value of 0. (The range of any 8-bit byte is always 0 to 255.)

The same INCF action is performed three times, so each time the switch is pressed, the existing PORTB value simply has three added to it each time the program

Parts List – Teach-In 2008 – Part 2

IC2	PIC16F628, (as listed in Part 1) programmed
R1 to R6	470Ω resistors 0.25W (6 off)
D1 to D6	red LED (6 off)

Control PCB (as described in Part 1)
Plug-in breadboard, 64 holes long (6.7in x 2.5in), 0.1in pitch
Solid, insulated connecting wire

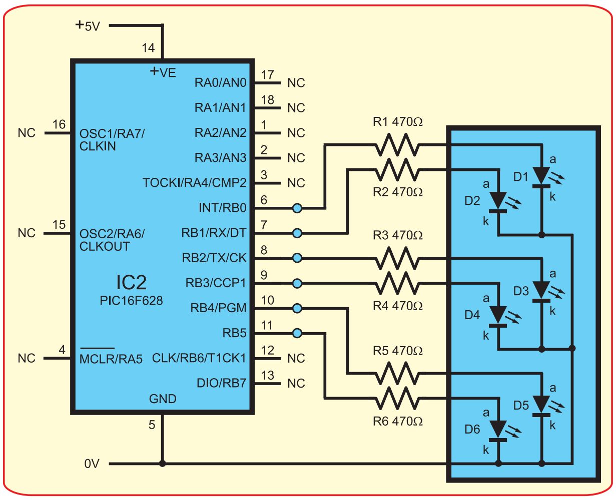


Fig. 2.1. Circuit diagram for the LED control demonstration

Listing 2.4

```
          ; TEACHINB04.ASM 07JUN07 - TEACH IN 2008 PT2

          include p16f628.inc

          __config  $3F30       ; internal 4MHz oscillator

          ORG 0                 ; reset vector
          goto STARTIT
          ORG 4                 ; Interrupt vector address
          goto STARTIT
          ORG 5                 ; PIC program memory start location

STARTIT   bsf STATUS,5
          movlw b'00000000'     ; all PORTB as output
          movwf TRISB           ; data direction register for PORTB
          bcf STATUS,5

DICELOOP  incf PORTB,F          ; increment PORTB count
          incf PORTB,F          ; increment PORTB count
          incf PORTB,F          ; increment PORTB count
DICEEND   nop
          goto DICEEND

          END
```

restarts, thus the number shown on the dice LEDs will be different each time. (Remember what was said about PIC registers and contents at the moments of switch and reset?)

(There are, of course, other ways to add to values, as will be discussed in the series.)

You will find that the dice display does not following the normal convention. We shall show how this can be changed in Part 3 next month. We shall also take the dice demo a stage further and discuss other commands that can be used with it to extend its usefulness.

Something to think about

Until Part 3 next month, have a think about how you would modify the rotating LEDs program so that alternate LEDs are turned on. As to quite how you interpret that is up to you. But imagine the flashing displays around fun fair stalls and think how you might simulate a simple one.

Also, try it with every *third* LED turned off in the rotating display, then every *fourth*, then every *fifth*, etc. Keep in mind what was said earlier about chaining registers with some of the rotating values.

There are no definitive answers – this is just to get you thinking as a programmer who has a display idea in mind.

You might also care to see what happens if RRF is used instead of RLF in the relevant demos, and what would happen if you incorrectly used W in place of F, or BTFSC in place of BTFSS where appropriate. Common mistakes to make sometimes!

Next Month

In Part 3 we show how a similar concept can be used to create the example of two normal gaming dice showing the dice dots resulting when they are 'shaken' (activated by a switch). The dice dot order will become as normally expected. Several new concepts and commands will be introduced and discussed.

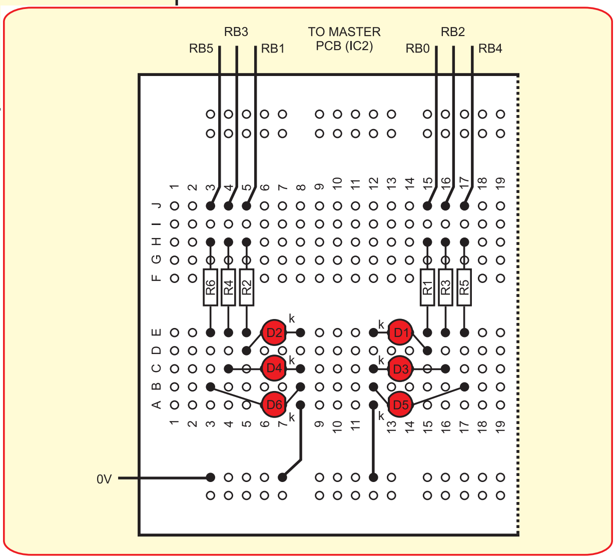


Fig.2.2. Breadboard layout for the circuit in Fig.2.1.

Regular Clinic

Circuit Surgery

Ian Bell

More on SPICE simulation

Last month we started to look at the use of SPICE circuit simulation as there have been a number of discussions related to this on the *EPE Chat Zone* forum (via **www.epemag.co.uk**).

For example, ***afferrari*** asks:

Using LT Spice, how could I simulate a repetitive signal with 12 levels between +2V and –2V?

For the benefit of readers less familiar with simulation tools, we provided a brief introduction to SPICE, with particular reference to LTSpice from Linear Technology (**www.linear.com**) because it is freely available for download and has featured in *Chat Zone* discussions.

This month we move on to discuss the topic of *afferrari's* question in more detail. As we discussed last month, the schematic for simulation must include voltage sources to model the power supply and signal sources. It is also often useful to include a load for the circuit so that the results are more realistic. Fig.1 shows a simple circuit schematic suitable for simulation, which we will use here as an example. It is not the circuit that *afferrari* was working on, but as it is the sources we are looking at, this does not matter.

In Fig.1 the voltage source labelled Vsignal provides the input signal for the simulation. VSupplyP and VSupplyN are 5V DC voltage sources for the power supplies. All the voltage sources are set up in more or less the same way, but more information is required if something other than a simple DC voltage is required.

Names and labels

Once a voltage source has been placed on the schematic it should first be given a meaningful name by right-clicking on the default name and entering the new name in the window that opens. Using meaningful names will help later when you are selecting simulated signals to view as waveforms. Similarly, the wires in the circuit (referred to as 'nets' in SPICE) should be named. At the very least you should give meaningful names to the nets whose waveforms you would like to view.

In Fig.1 we have labelled nets Input and Output. To label a net click on the 'net name' button on the toolbar, enter the name and then click on the relevant wire to name it.

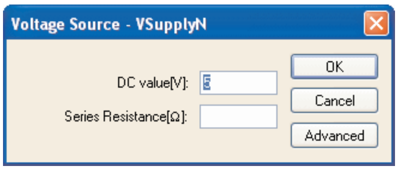


Fig.2. Setting the DC value of a voltage source

Configuration

To configure a voltage (or current) source right click on the voltage source. This will open a window in which the DC value can be entered (see Fig.2). For sources other than DC the 'Advanced' button must be clicked. You can also enter a signal component on the schematic, which will preconfigure the voltage source with a sinewave.

Afferrari wanted a complex waveform, not just a simple pulse train or sinewave. One way of doing this is to set the signal voltage source to have a Piecewise Linear (PWL) function. A PWL waveform is one defined by 'joining the dots'. You define a number of time and voltage coordinates in chronological sequence. The voltage of the source changes linearity from one step to the next over the time between the points. So if you used the pairs:

0 0 1m 2 2m 2 10m 0

The voltage would be 0V at time zero and rise in a linear ramp to reach 2V at time 1ms. It would then stay at 2V until time 2ms, after which it would ramp back down to 0V over the next 8ms, that is, reaching 0V at time 10ms.

To configure a voltage source to produce a PWL waveform, first right-click on the source, and if the DC voltage window appears click on the Advanced button. The 'Independent Voltage Sources' window will open. Select PWL from the list of functions as shown in Fig.3.

You can type in the four points as shown in Fig.3, but if you need more points you will need to click the 'Additional PWL Points' button. This will open a new window in which you can enter a long list of PWL points, see Fig.4.

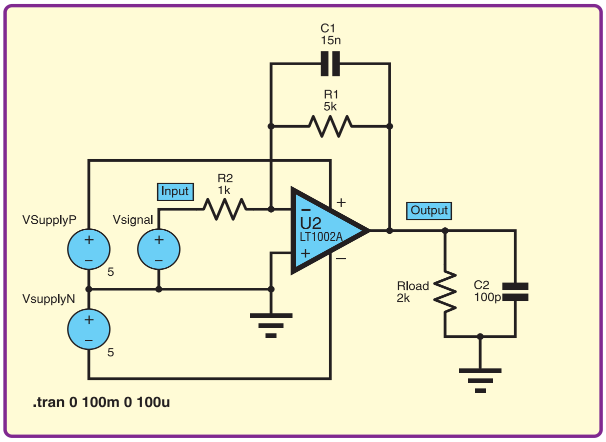


Fig.1. Example circuit schematic suitable for LTSpice simulation

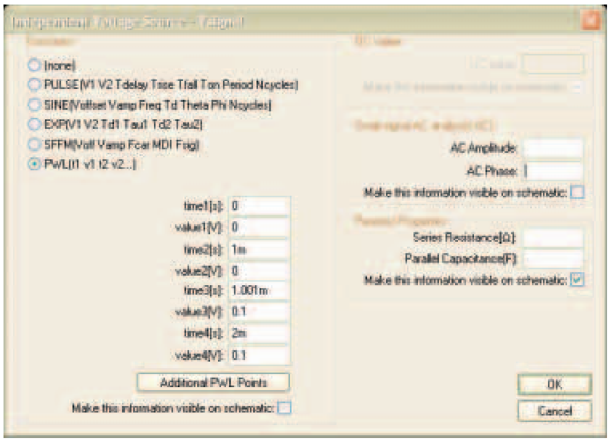


Fig.3. Selecting the PWL function for a voltage source

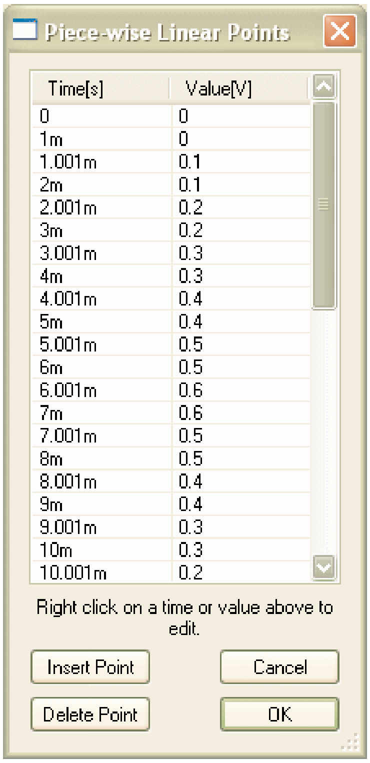


Fig.4. Entering PWL data points

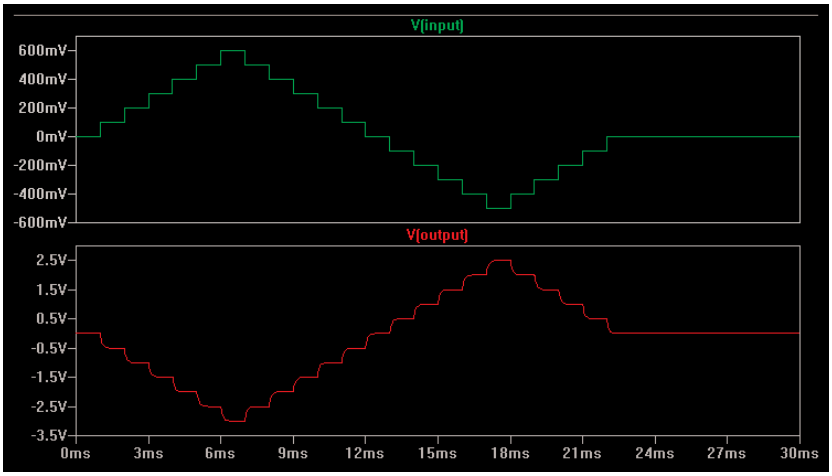


Fig.7. Simulation results using the defined PWL waveform

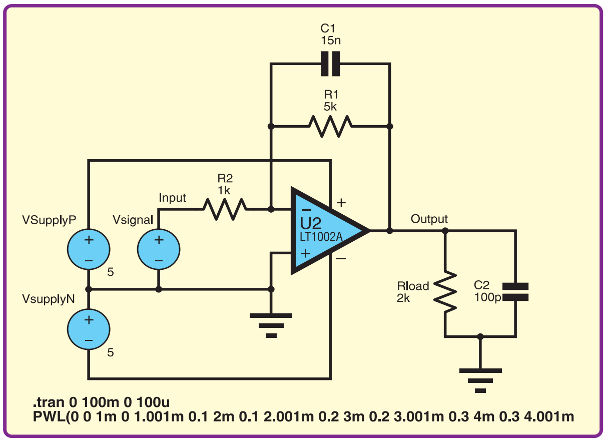


Fig.5. Example circuit with PWL function shown on the schematic

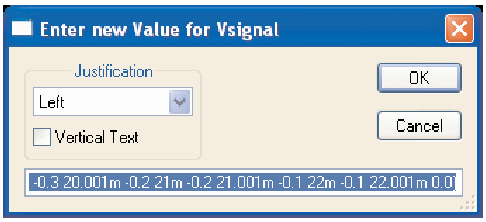


Fig.6. Editing the PWL command

Entering data into this table is a bit slow, but there is another way. If you tick the 'Make this information visible on the schematic' tickbox in the 'Independent Voltage Sources' window (see Fig.3) you will see the SPICE command used to invoke the PWL behaviour of the source on the schematic (see Fig.5).

You can right-click on this text to open a window in which you can edit the command directly. Even more usefully, you can copy the text and edit it elsewhere. When you right-click on the PWL command the command text is selected in the 'Enter new Value for Signal' window that opens (see Fig.6).

So just hit Ctrl-C on the keyboard to copy it to the clipboard. You can then paste the command text into an editor such as Notepad; it will look something like the following:

PWL (0 0 1m 0 1.001m 0.1 2m 0.1 2.001m 0.2 3m 0.2 3.001m 0.3 4m 0.3 4.001m 0.4 5m 0.4 5.001m 0.5 6m 0.5 6.001m 0.6 7m 0.6 7.001m 0.5 8m 0.5 8.001m 0.4 9m 0.4 9.001m 0.3 10m 0.3 10.001m 0.2 11m 0.2 11.001m 0.1 12m 0.1 12.001m 0.0 13m 0.0 13.001m –0.1 14m –0.1 14.001m –0.2 15m –0.2 15.001m –0.3 16m –0.3 16.001m –0.4 17m –0.4 17.001m –0.5 18m –0.5 18.001m –0.4 19m –0.4 19.001m –0.3 20m –0.3 20.001m –0.2 21m –0.2 21.001m –0.1 22m –0.1 22.001m 0.0)

This code creates a staircase triangular waveform. You can edit the PWL command relatively quickly and easily this way to create a large number of data points, but remember that the command has to be all on one line. Make sure 'WordWrap' is on if you use Notepad (in the Edit menu) so that you can see everything. To avoid confusion you can edit as shown below, putting a space at the end of each line, and then delete the end-of-lines. This makes it easier to see what you are doing.

18.001m –0.4
19m –0.4
19.001 –0.3
20m –0.3
20.001m –0.2
21m –0.2
21.001m –0.1
22m –0.1
22.001m 0.0
)

Once you have the complete single line of text of the PWL command in your text editor you can paste it back into the 'Enter new value' window. First copy, then with focus on the 'Enter new value' window in LTSpice, hit Ctrl-V on the keyboard. Then click OK in the 'Enter new value' window to update the command. If you get PWL values out of chronological sequence, you will get an error message when you run the simulation. You can edit and paste again or use the table in the source properties (as in Fig.4) to correct the problem.

If you are able to program in VB, C# or any other high level language you could write code to generate PWL points, written out as text formatted into a PWL command and then paste these into LTSpice.

Simulation result

Fig.7 shows the result of simulating our example circuit with the PWL waveform defined above. You can see that the integrator action of the circuit results in a rounded staircase waveform at the output compared with the input.

We have defined a complex waveform, but we have not quite solved *afferrari's* problem. He required a repetitive waveform, whereas we only have one cycle. At this point we find that LTSpice lacks a feature found in a number of other SPICE simulators; that is the ability to automatically repeat the PWL waveform. Typically, we could change the PWL command from say;

PWL (0 0 1m 0 1.001m 0.1 2m 0.1 2.001m 0.2 3m 0.2)

to something like

PWL (0 0 1m 0 1.001m 0.1 2m 0.1 2.001m 0.2 3m 0.2) R

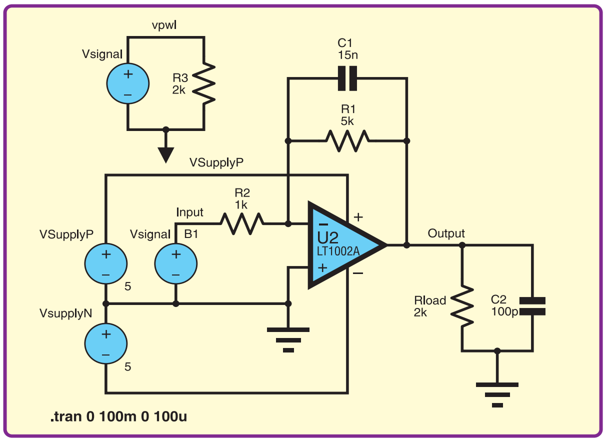


Fig.8. Adding a behavioural voltage source

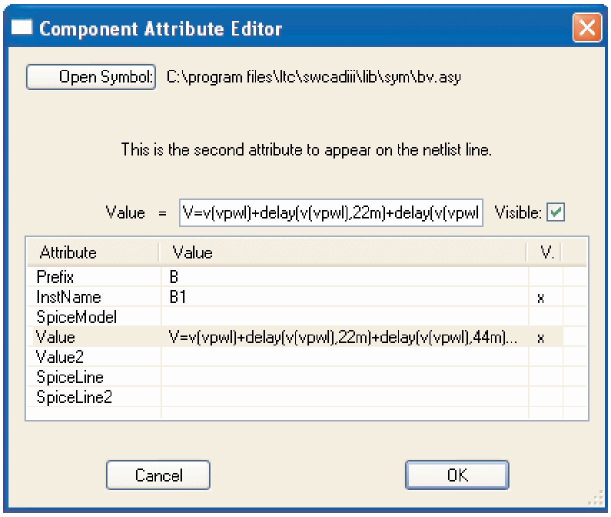


Fig.9. Component attribute editor for the behavioural source

to get a repeated version of the waveform. It appears that LTSpice does not allow us to do this.

Atferrari's solution to the lack of PWL repeat was to use a large number of pulse sources instead. The combined output provided the waveform he needed. This approach only works if the required waveform happens to be amenable to it.

Another workaround for the lack of PWL repeat is to use an arbitrary behavioural voltage (or current) source. These sources have output voltages (or currents) which are defined in terms of equations based on circuit voltages and currents, and time and temperature.

To apply this to Fig.1 first move (don't drag) the Vsignal source off on its own and add a resistive dummy load to it. Label the output net of the Vsignal source with a name, say **vpwl**.

Behaviour

Click on the component icon in the schematic editor toolbar and select **bv** (behavioural voltage source) from the list. Place this on the schematic in the place vacated by the moved Vsignal source. The schematic should look like Fig.8.

We now have to enter the equation for the behavioural source. We can use the **delay** function to create delayed versions of our PWL signal and add these together. Right click on the behavioural source to open the 'Component Attribute Editor' window as shown in Fig.9.

Click on the 'Value' attribute and enter the mathematical expression for the behaviour of the source:

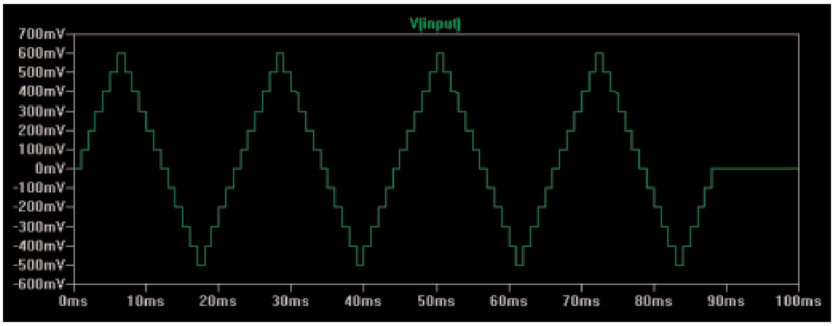


Fig.10. Repetitive PWL produced by behavioural source

V=v(vpwl)+delay(v(vpwl),22m)+delay(v(vpwl),44m)+delay(v(vpwl),66m)

This adds together the signals due to the voltage original PWL waveform, plus three copies delayed by 22ms, 44ms and 66ms. Note that vpwl is the net name and v(vpwl) is the voltage on that net, delay(x,t) creates a delayed version of signal × delayed by time *t*. There is one thing not quite right though, if we run the simulation and zoom in on one of the delayed parts of the waveform it will be seen that the edges are not as sharp as defined in the PWL. This can be resolved by changing the maximum timestep in the .tran simulation command to 1u instead of 100u that is shown on the schematic in Fig.8, this slows the simulation but increases the accuracy. We now get four repeats of the PWL, as shown in Fig.10. To change the simulation command right click on it on the schematic or select 'Edit Simulations Command' from the Simulate Menu.

Conclusion

We have looked at a couple of features of LTSpice which allow us to create complex waveforms, PWL functions and behavioural sources. It is also possible to put multiple voltage sources in series, as *atferrari* did in his only solution to the question he posted on spice sources.

LTSpice also provides the facility to read a .wav audio file and use this as a simulation waveform. Other versions of SPICE may provide other features for waveform input or definition, or have more flexible versions of the same functions, for example a PWL function that can be automatically repeated.

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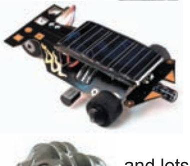

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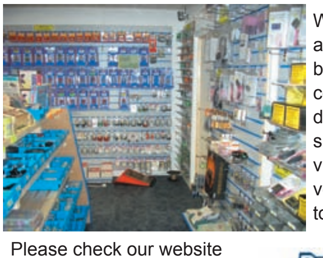

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PIC Speech Synthesiser

By John Becker

How to add speech to your PIC projects

FOR a long time it was felt that it would be useful if readers were able to add a speech phrase or two to their PIC projects, punctuating some sort of occurence in the software or external events. The design presented here allows that to be done, provided the user has PIC programming facilities.

It uses a set of pre-recorded phonemes (sounds that make up speech) and allows their recall to make up words when desired, outputting the audio to an existing amplifier. In the English language there are 59 phonemes widely used for such purposes. Any words and phrases can be created by users to suit their needs, triggering them when required.

Ideally, of course, a library of complete words would be available, but the memory capacity required by the PIC would be too great to handle. A PC and its harddrive would be needed. The phoneme compilation works, and indeed has been around electronically for perhaps 20 years or more. The drawback is that the speech sounds somewhat mechanical, without changes of emphasis such as we use when speaking normally. Ways round this are discussed later.

In English there are 26 letters to the alphabet, but each can have a different pronunciation depending on where in a word they occur, hence the need for more phonemes than there are alphabet letters. This does mean, of course, that a certain amount of respelling of words must be made to reflect the way the letters are pronounced. Guidance on this is given near the end of the text.

Phoneme sources

The set of phonemes supplied with the software was downloaded free from the internet. They originated for use with a speech chip once popular many years ago, the SP0256, but which is no longer manufactured. In fact the the author still has an SP0256, so could have actually extracted the phonemes from that, but was saved the necessity by the free download.

Provision has also been made for readers to record and use their own phonemes, instead of the supplied ones. This enables the speech to be tailored to the pronunciation more familiar to the user's own background.

The actual recording of the user's phonemes is via a dedicated circuit and printed circuit board, plus PC software written in Visual Basic 6 (VB6), and supplied as a standalone .EXE file, so VB6 itself does not need to be installed on the PC.

Speech play circuit

First, the circuit that does the actual 'talking' is discussed, and then the recording aspect. The Speech Playback circuit is shown in Fig.1.

Copies of this circuit can be used in your PIC design, or a different PIC used in which the source code (slightly modified perhaps) forms a seperate subroutine that can be called from the software for the main aspect of your program.

The heart of the circuit in Fig.1 is IC1, a PIC16F628 microcontroller running at 20MHz, as set by crystal X1. Speech playback timings are basically related to the 20MHz clock.

However, the PIC software introduces a brief delay into the playback loop, set by the resistance formed by resistor R1 and 'rate' preset VR1, and the capacitance of C3. Each time round the playback loop, the PIC discharges

C3 via R1/VR1 and then recharges it via the same path.

The software waits for the recharge to reach a certain level before it continues round the loop. By varying the rate of discharge/charge, the delay can be fractionally changed, causing a change in the speed at which the loop completes, and thus a change of pitch of the spoken tones.

Digital-to-analogue converter

The phonemes are held in the serial EEPROM chip IC2. This is capable of storing 64K bytes of data, just enough to hold all the phonemes. Each replay loop starts by retrieving a byte of data and incrementing the address counter. It outputs that byte to a digital-to-analogue converter (DAC) formed around the R2R (R4 to R11 and R12 to R19) resistive network on PIC Port B.

The functioning of this type of DAC has been covered previously in *EPE* and will not be discussed here. Mike Hibbett used it in his *Halloween Howler* of Oct '05, in that instance for playing the circuit's 'howling' sound. It is also Mike's code that has been used to read the serial EEPROM, as it is faster than the equivalent Microchip-derived code normally used by the author.

The changing EEPROM values cause a change in voltage levels seen at the ouput of the DAC, at the junction of resistors R11 and R19. Capacitors C4 and C6 slightly smooth the 'corners' of the resulting stepped waveform. Their use is optional and may be omitted or changed in value if preferred.

The DAC voltage is fed to the non-inverting buffer around IC3a. It is then passed to the inverter around IC3b. The gain is controlled by the ratio of resistors R20 and R23. Resistors R21 and R22 set the midway bias level applied to non-inverting input pin 5 of IC3b. The output from IC3b is capacitively coupled by capacitor C7 and fed to volume control VR2, which is then fed to an audio amplifier. The choice of amplifier is up to you, and anything from an ordinary domestic amplifer to a custom built circuit may be used. Many examples of the latter have been published in *EPE* over the years; the most recent being the *Experimenter's Audio System* last month (Nov '07).

Phoneme recording circuit

There are three circuit diagrams for the Phoneme Recording circuit, shown in Fig.2 to Fig.4. They are assembled on a single PCB.

The circuit in Fig.2 shows the phoneme recording input amplifier. There is a choice of two forms of input of the spoken phoneme – via a seperate microphone and its own existing preamp stage (via a dometic audio unit for instance), or via an in-built electret microphone module, MIC1. The use of either method is optional, but the mic-amp path is preferable in terms of quality.

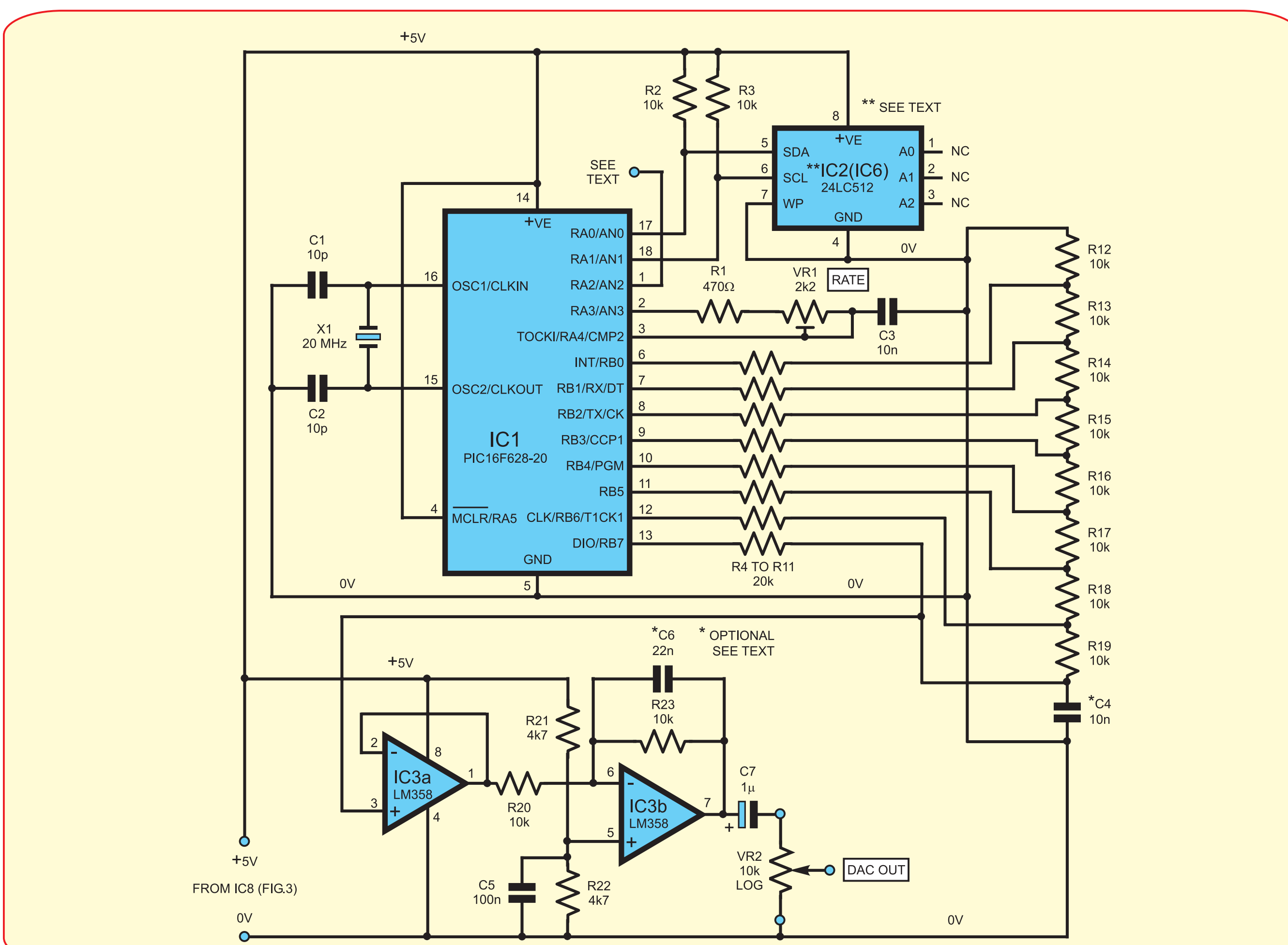


Fig.1: Full circuit diagram for the Playback section of the PIC Speech Synthesiser

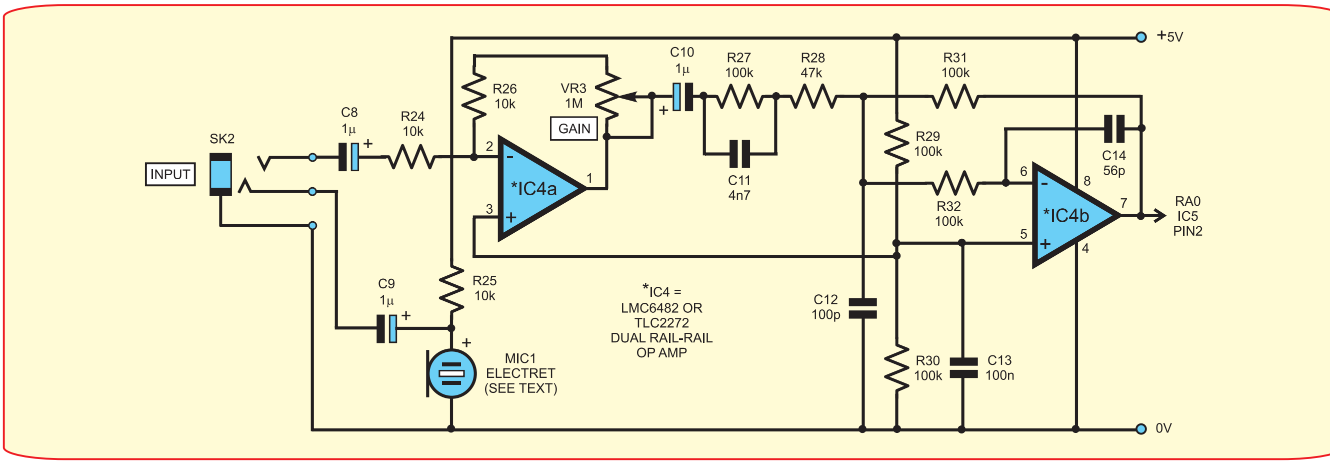


Fig.2: Mic input preamplifier circuit diagram. The Mic preamp is optional, and these components can be omitted

From the audio source, the signal passes to IC4a, which provides a signal level gain stage, controlled by potentiometer VR3. The output from IC4a is coupled, via capacitor C10, to the stage aound IC4b, which provides a small amount of frequency bandwidth correction.

From IC4b, the output signal is DC coupled to the analogue-to-digital conversion (ADC) input at pin RA0 of PIC IC5 (Fig.3). This PIC also works at 20MHz, as set by crystal X2. The PIC samples the ADC signal and outputs the digital result to the PIC's RS232 serial interface pin RC6 at the rate of 19200 Baud.

The output goes to the input of RS232 chip IC7 in Fig.4, which is configured and used as in many *EPE* projects. This chip connects to a PC via one of its serial port (COM) connectors. Note that USB ports *cannot* be used with this design. Specially written PC software then takes over.

A 9V DC power supply or battery is required to power the Record circuit. The 9V is reduced to 5V by regulator IC8. This 5V also powers the Playback unit.

PC recording software

It is believed that any PC running Windows platforms up to and including XP can be used with this design. The suitability of Vista is not known.

The Recording Mode software supplied for the PC takes the incoming RS232 serial data and stores it to disk. Each phoneme to be recorded is selected on screen and allocated a specific file name.

Having recorded all the user-spoken phonemes, the files can be edited and then combined into a single file for sending back to the Recording circuit for storage in the serial EEPROM, IC6 in Fig.3. That chip is then transferred to the Playback PCB, where it is used as the phoneme data source as IC2. Note that IC6 and IC2 are, in fact, the same chip.

Sending the phonemes to the serial EEPROM is required whether the supplied or user-recorded phonemes are to be used. More on this later.

Assembly

There are two PCBs for the Speech Synthesiser, with their component and track layout details shown in Fig.5 (Playback) and Fig.6 (Record). If the user-recording aspect of the circuit is not required, omit the components shown in Fig.2. All the components

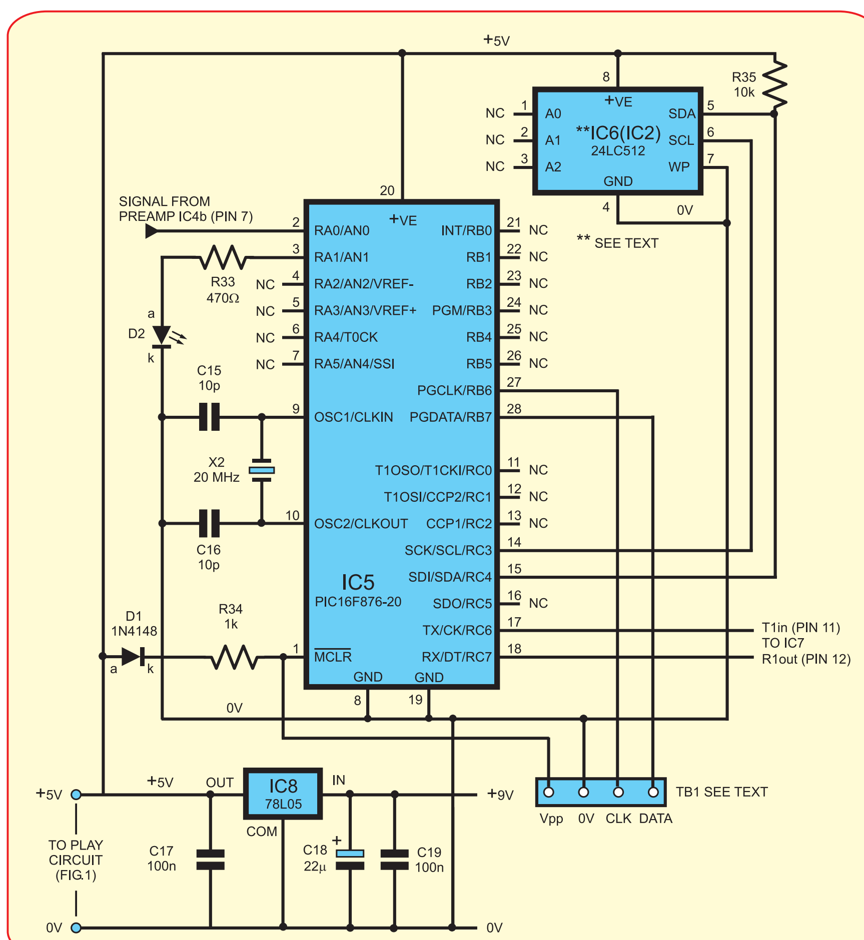


Fig.3: Circuit diagram for the speech recording control. Note that IC8 voltage regulator's +5V output also powers the playback circuit Fig.1

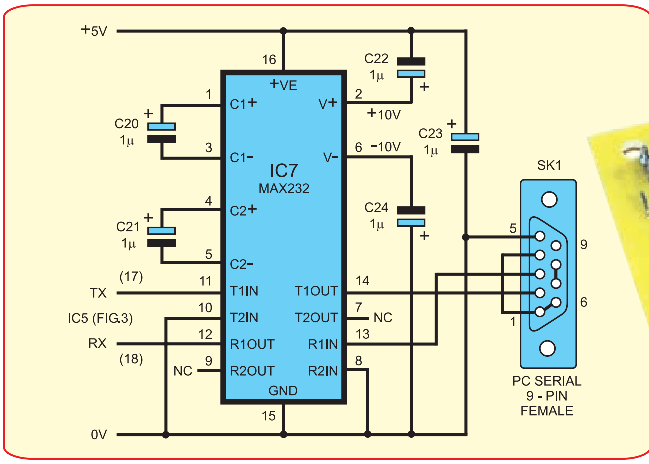
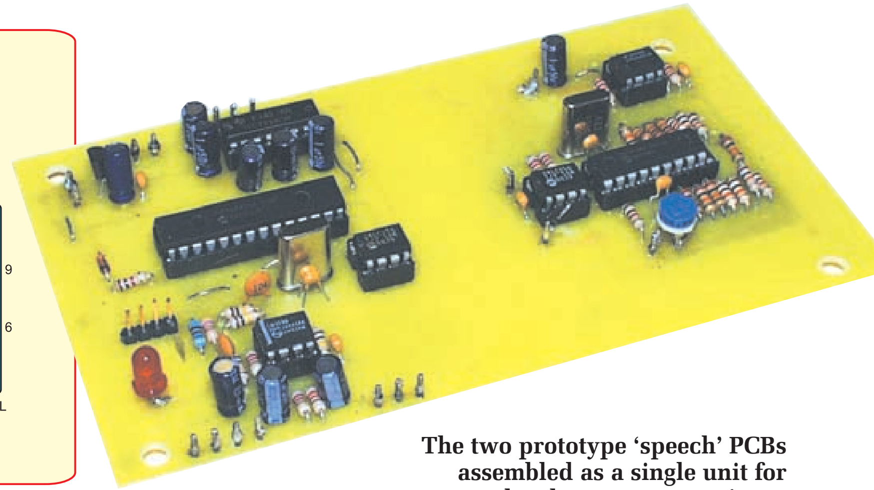


Fig.4: Circuit diagram for RS232 serial interface


The two prototype 'speech' PCBs assembled as a single unit for development convenience

Parts List – PIC Speech Synthesiser

PLAYBACK PCB

1 PC board, code 650 (Playback), available from the *EPE PCB Service*, size 71mm x 56mm
1 20MHz crystal (X1)
1 2k2 miniature round carbon preset (VR1)
1 10kΩ rotary carbon potentiometer, log. (VR2 – see text)
1 18-pin DIL socket
2 8-pin DIL socket
Multistrand connecting wire; plastic knob for VR2 (optional – see text); 4 solder stakes; solder, etc.

Semiconductors
1 PIC16F628-20 microcontroller, 20MHz (IC1)
1 24LC512 serial EEPROM (IC2 and IC6 – see text)
1 LM358 dual op amp (IC3)

Capacitors
2 10pF ceramic disc, 0.2in pitch (C1, C2)
2 10nF ceramic disc, 0.2in pitch (C3, C4)
1 22nF ceramic disc, 0.2in pitch (C6)
1 100nF ceramic disc, 0.2in pitch (C5)
1 1µF radial elect. 16V (C7)

Resistors (0.25W 5% carbon film)
1 470Ω (R1)   2 4k7 (R21, R22)
12 10kΩ (R2, R3, R12 to R20, R23)
8 20kΩ (R4 to R11)

RECORD PCB

1 PC board, code 651 (Record), available from the *EPE PCB Service*, size 84mm x 68mm
1 20MHz crystal (X2)
1 9-pin D-type serial connector, female (SK1)
1 28-pin DIL socket
1 16-pin DIL socket
1 8-pin DIL socket
1 4-way header pin (TB1)
Multistrand hook-up wire; serial comms cable (see text); 20 solder stakes; solder, etc.

Semiconductors
1 1N4148 signal diode (D1)
1 5mm red LED (D2)
1 PIC16F876A-20 microcontroller, 20MHz (IC5)
1 24LC512 serial EEPROM (IC6) – *This is also IC2 on Playback PCB (see text)*
1 MAX232 RS232 serial interface (IC7)
1 78L05 +5V 100mA voltage regulator (IC8)

Capacitors
2 10pF ceramic disc, 0.2in pitch (C15, C16)
2 100nF ceramic disc, 0.2in pitch (C17, C19)
5 1µF radial elect. 16V (C20 to C24)
1 22µF radial elect. 16V (C18)

Resistors (0.25W 5% carbon film)
1 470Ω (R33) 1 1kΩ (R34)
1 10kΩ (R35)

MIC INPUT PREAMP

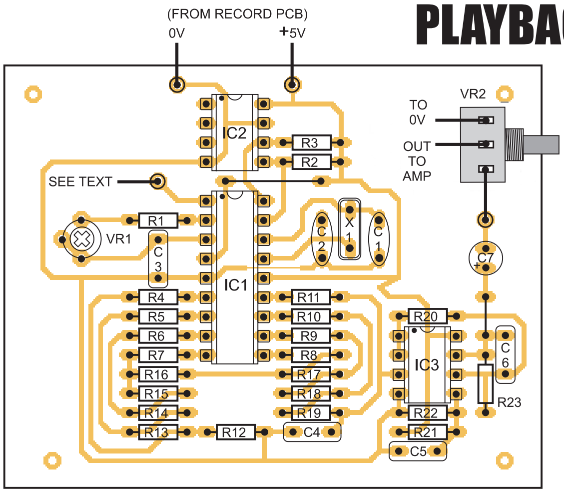
(*Fig.2. optional – see text*)

1 LMC6482 or TLC2272 rail - to - rail op amp (IC4)
1 8-pin DIL socket
1 electret microphone insert (MIC1)
1 switched mono jack socket, to suit external microphone if used (SK2)
1 1MΩ rotary carbon potentiometer, lin. (VR3)

Capacitors
1 56pF ceramic disc, 0.2in pitch (C14)
1 100pF ceramic disc, 0.2in pitch (C12)
1 4n7 ceramic disc, 0.2in pitch (C11)
1 100nF ceramic disc, 0.2in pitch (C13)
3 1µF radial elect. 16V (C8 to C10)

Resistors (0.25W 5% carbon film)
3 10kΩ (R24 to R26)
1 47kΩ (R28)
5 100kΩ (R27, R29 to R32)

PLAYBACK BOARD



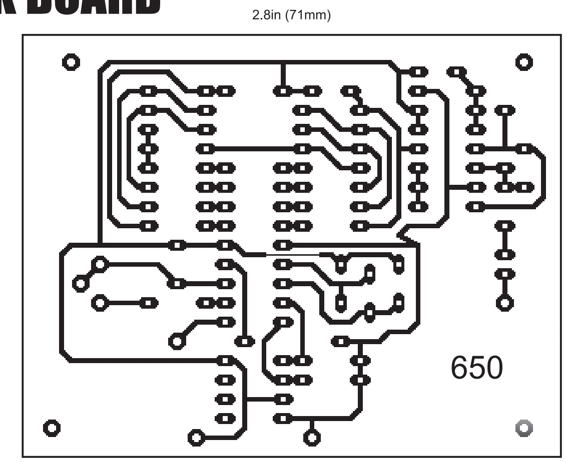
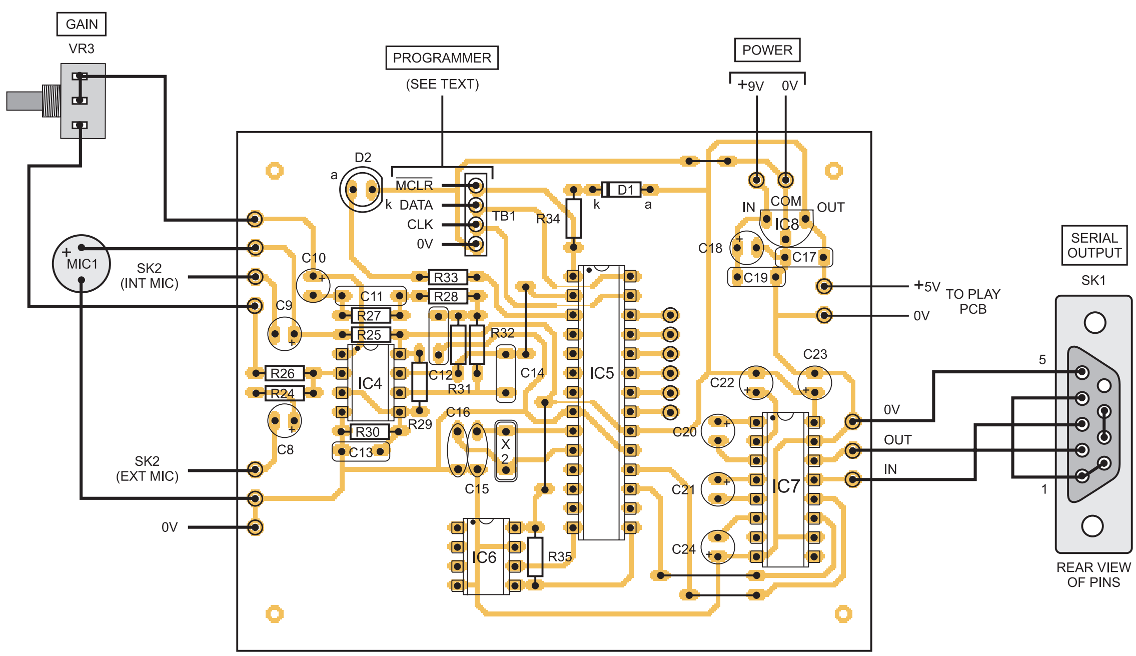
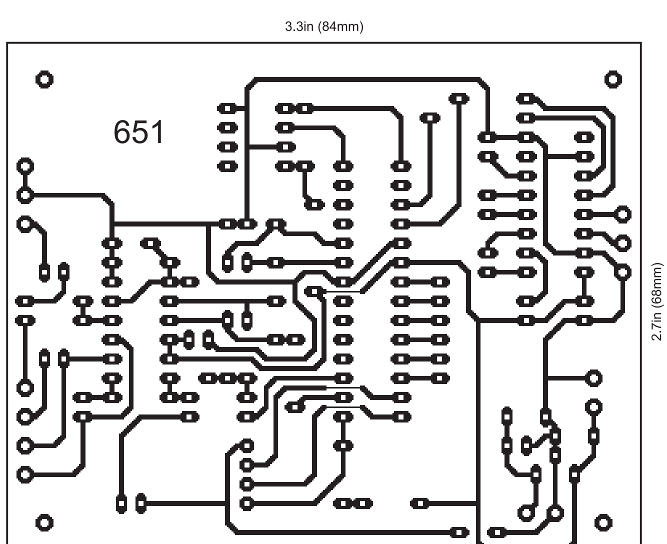


Fig.5: Playback printed circuit board component layout and full-size copper track master





RECORDING CIRCUIT BOARD

Fig.6: Printed circuit board component layout, interwiring details and full-size copper foil master for the Record board

in Fig.3 and Fig.4 are needed for both versions. The PCBs are available from the *EPE PCB Service*, codes 650 (Playback) and 651 (Record).

Assemble the PCBs in order of ascending component size, commencing with the few on-board wire links. Use sockets for the DIL (dual-in-line) ICs and observe the correct polarity of the electrolytic capacitors and all semiconductors. Do not insert the DIL ICs until the correctness of the power lines, and all component positionings and orientations, have been double-checked.

Recheck the power lines after inserting all DIL ICs. Always switch off before correcting any fault.

Because any spoken message required depends on individual needs, you must program your own PICs via suitable PIC programming software and hardware. The source code was written in the author's *TK3* software. It is believed to be suitable for all MPASM-compatible programmers.

A case is not required for the circuit as described here.

PC program

The VB6 PC program has been written with two main screen areas. The first allows all the supplied recorded phoneme waveforms to be displayed. An example of it is shown in Fig.7.

A group of 64 buttons at the top of the screen allows the individual phoneme waveforms to be selected and displayed (although the Pause buttons have no display associated with them). The phoneme shown in Fig.7 is that for the letter 'N', as used in the word *anchor*. Hover the mouse cursor over any button for brief details of its use to appear as a message box.

Below the buttons are shown the code numbers allocated to each phoneme. These are the codes originally used with the SP0256 speech chip mentioned erlier.

For each phoneme waveform displayed, details of the number of bytes it uses and the minimum and maximum voltage values of the waveform are shown.

The Creating Phonemes button tells you that this can be done through the Edit Screen. But for the moment, the main screen can be used to send the supplied phonemes to the serial EEPROM on the Record PCB.

Insert the serial EEPROM into the socket on the Record PCB. With the Record PCB connected to the PC via a suitable serial cable (as used with standard modems) and the PIC units powered, click the Send EEPROM button.

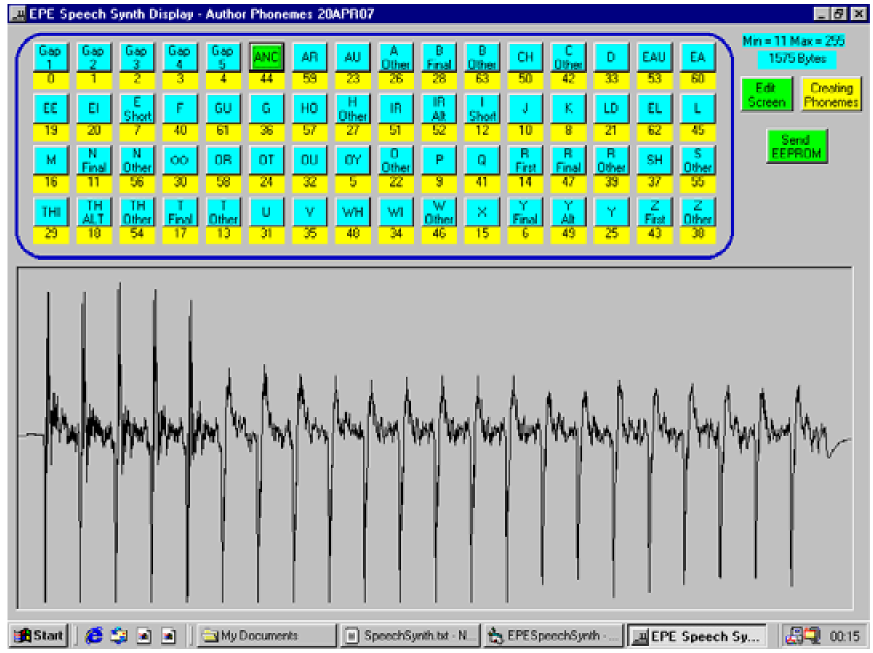


Fig.7: Main PC screen example. The phoneme shown is that for the letter 'N', as used in the word *anchor*

This causes the complete set of supplied phonemes to be sent to the serial EEPROM. Once done, switch off the power, and transfer the EEPROM to the Playback PCB, where it can now be used with any speech message you wish to play (more on this later).

With the EEPROM now installed for Playback, switch on. The unit now plays back the message initially supplied with the software. Adjust preset VR3 until the voice tone (frequency) sounds right to your ear.

Recording phonemes

When recording your own phonemes, click the button for the one required. This allocates a specific name to the file that can then be created. If you choose the wrong button, simply select the one you really want.

With the Record PCB connected to the PC via the serial cable, click the Get Data button. This triggers the PIC to now accept audio data from the preamp on that board. The LED comes on when you start speaking, at which point you then immediately record the sound of the phoneme you selected.

The sampled data is output to the PC which stores it. Both PIC and PC then wait until you wish to record the next phoneme in the same way. Having recorded a phoneme, its waveform can be examined by pressing the Show Orig Waveform button.

Set the recording level so that the waveform nearly covers the maximum height of the display area, without clipping distortion. The phoneme may be re-recorded if you wish by the same process as before.

Having recorded a satisfactory waveform its front and end sections may be edited. With the waveform shown on the Edit Screen, move the red and green sliders and their associated marker lines to embrace any excess length of waveform that has no variation, ie about midway amplitude without deflection. Then click the Delete button to delete the marked section.

Only the start and end sections should be trimmed. Do not select any central portion.

A new file is then created, into which the remaining waveform is stored on disk. Having stored the data, the screen then reloads the data in the new file and shows the complete length of waveform as it now is. The other end, or the same end again, can then be trimmed. You may start again if you wish by recalling the original waveform via its button. The modified waveform may be viewed at any time by selecting a phoneme and clicking the Show Mod Waveform button.

Compiling

Having recorded and edited all your own phonemes, they can then be compiled to a single file. To do so, click the CONC (concatenate) button. There follows a brief assembly procedure in which you end up with two files, **UserAllphons.txt** and **UserEEPaddresses01.txt**.

The screen tells you the length of the former file – ensure that it does not exceed the maximum 65535 bytes allowed. If it does, you will need to further trim the phonemes until the file is less than the maximum length.

This file can then be sent to the serial EEPROM chip, in the same way as with Author Phonemes. The second file needs to be assembled into the PIC program for Playback.

Open the **SpeechPlayxx.asm** file (where 'xx' is the current version number) through your PIC programming software. Near the top of that file are the statements:

```
; PHONEME ADDRESSES

include "AuthorPhonemeAddresses.inc"

;include "UserPhonemeAddresses.inc"
```

Put a semicolon colon (;) in front of the Author line and remove the semicolon from the User line. Save the asm file, recompile as a hex file and send that to the PIC. That's all there is to creating your own phonemes.

Speech messages

Initially, the **SpeechPlayxx.asm** file calls in a message used in the prototype, called in as **TESTMSG01.inc** (as commanded at the end of the asm file). This simply tells you that 'Today is Tuesday' (irrespective of the true day of the week!), constantly repeating it until the power is switched off. You can create you own message and use it in place of the author's.

TESTMSG01.inc consists of the following data statements (prefixed by the indented 'DE', followed by a value):

```
DE 15             ; 0 number of
                    values needed
DE 13  ;  'T'     ; 1
DE 15  ;  'O'     ; 2
DE 33  ;  'D'     ; 3
DE 20  ;  'Y'     ; 4
DE 1   ;  ' '     ; 5
DE 12  ;  'I'     ; 6
DE 43  ;  'S'     ; 7
DE 1   ;  ' '     ; 8
DE 13  ;  'T'     ; 9
DE 31  ;  'U'     ; 10
DE 43  ;  'S'     ; 11
DE 33  ;  'D'     ; 12
DE 20  ;  'A'     ; 13
DE 1   ;  ' '     ; 14
DE 1   ;  ' '     ; 15
```

The first value gives the number of bytes that the PIC software has to process to play the complete statement. The remaining values are the numbers allocated to the phonemes in question (a complete list of which can be found towards the head of the **SpeechPlayxx.asm** file. The value of 1 calls one of the pause lengths into play to allow a short 'breathing space' between words.

It will be apparent that this message is nearly the same as if written in correct English; but note the differences. The reason will be obvious when you study the phoneme list and the usages in terms of pronunciation. You could certainly try spelling it all correctly, and you'll hear how different the words sound.

The choice of the correct phonemes requires practice and experiment to obtain the sounds that you find to be correct – it's partly subjective, and depends on the speech dialect and pronunciation with which you are most familiar. More later.

As the test program is written, direct access to the speech statement is immediately made. In your own program you could arrange the code so that messages are triggered at particular points within the code. They can also be arranged to be activated by an external source, triggering PIC input RA2.

You could also have several short messages stored within the Data EEPROM space available with the chosen PIC (256 bytes in a PIC16F628), triggering them, as required, from different parts of the program, or in respect of a counter incremented when RA2 is triggered. The scope is large.

Tone and amplitude

The use of varying tone (frequency) and amplitude to give emphasis to different parts of a sentence, as in normal spoken language, is an area ripe for experimentation. Six variants have been made possible with the supplied software:

Raise frequency
Lower frequency
Normal frequency
Raise amplitude
Lower amplitude
Normal amplitude

The frequency/amplitude values can be changed by the user, not just the basic values triggered by the command values. Details of the procedure are in the .asm file itself and it's best if you study those rather than have it explained here. Note that choosing a corrective value causes that value to be used by all subesequent phonomes until it is changed. The TESTMSG10.inc file supplied gives examples of all six variants. The method by which the author uses the variants can also be changed. It is up to you.

Spelling guidance

Guidance on re-spelling words to provide the required phoneme data in program statements is available through the Edit screen. Click on the Phoneme Use Guide button to access it.

Software

All the software for this design can be download free from the *EPE Downloads* site (access via **www.epemag.co.uk**).

Download (copy) all the files into a common folder 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 the PC and is run simply by double-clicking on its icon.

Occasionally, readers have had difficulty with the serial communication aspect of the EXEs. The author of the serial control program says that this can be cured by installing the entire *EPE* Serial software from our downloads site at

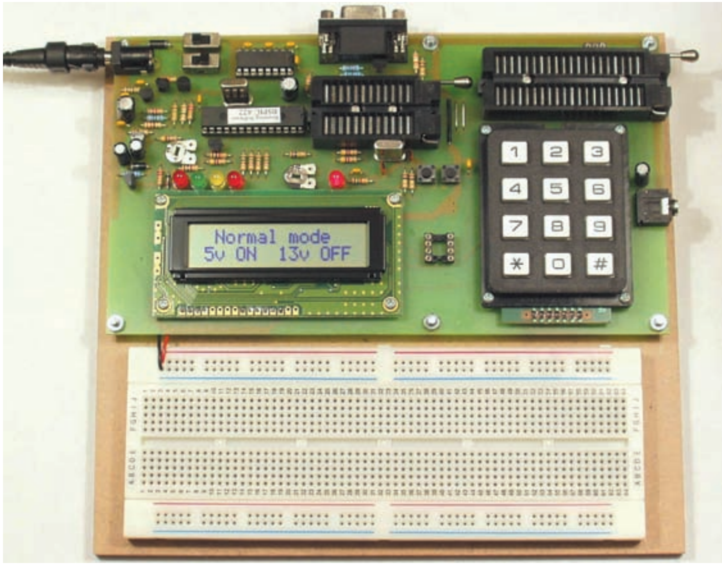
ftp://ftp.epemag.wimborne.co.uk/pub/PICS/SerialOCX/">ftp://ftp.epemag.wimborne.co.uk/pub/PICS/SerialOCX/.

Download all the serial files into a temporary folder, make sure you have *no* other applications running (including Virus checkers, email clients, Visual Basic etc) and run the SETUP.EXE and follow the prompts. This will install a copy of the OCX and all its correct sub-components and correctly install and register them. He confirms that he's tested the OCX software on Windows 98, ME, XP and 2000.

Most readers should not find this process necessary.

Enjoy the vocal opportunities offered by this whole design! ***EPE***

Learn About Microcontrollers



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Experimenting with PIC Microcontrollers

This book introduces PIC programming by jumping straight in with four easy experiments. The first is explained over ten and a half pages assuming no starting knowledge of PICs. Then having gained some experience we study the basic principles of PIC programming, learn about the 8 bit timer, how to drive the liquid crystal display, create a real time clock, experiment with the watchdog timer, sleep mode, beeps and music, including a rendition of Beethoven's *Fur Elise*. Then there are two projects to work through, using a PIC as a sinewave generator, and monitoring the power taken by domestic appliances. Then we adapt the experiments to use the PIC16F877 family, PIC16F84 and PIC18F2321. In the space of 24 experiments, two projects and 56 exercises we work through from absolute beginner to experienced engineer level using the most up to date PICs.

Experimenting with PIC C

The second book starts with an easy to understand explanation of how to write simple PIC programmes in C. Then we begin with four easy experiments to learn about loops. We use the 8/16 bit timers, write text and variables to the LCD, use the keypad, produce a siren sound, a freezer thaw warning device, measure temperatures, drive white LEDs, control motors, switch mains voltages, and experiment with serial communication.

Web site:- www.brunningsoftware.co.uk

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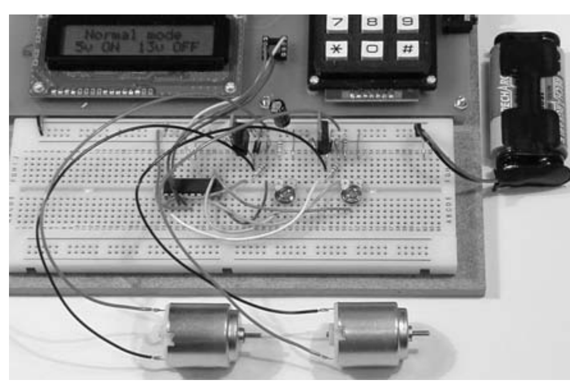
Both training courses need either a free serial port on your PC or a USB to COM adapter (full details on website). All software referred to in this advertisement will operate within Windows XP, NT, 2000 or later.

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



White LED and Motors

Our PIC training system uses a very practical approach. Towards the end of the second book circuits need to be built on the plugboard. The 5 volt supply which is already wired to the plugboard has a current limit setting which ensures that even the most severe wiring errors will not be a fire hazard and are very unlikely to damage PICs or other ICs.

We use a PIC16F627A as a freezer thaw monitor, as a step up switching regulator to drive 3 ultra bright white LEDs, and to control the speed of a DC motor with maximum torque still available. A kit of parts can be purchased (£30) to build the circuits using the white LEDs and the two motors. See our web site for details.

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PIC N' MIX

MIKE HIBBETT

Our periodic column for your PIC programming enlightenment

Displaying Menus

This month we look at a more advanced programming problem – providing for input and output to our pet project from keys and an LCD, or perhaps over a serial port interface. In some cases this is quite simple and can be implemented with a few lines of code, but when the interaction required between a user and the device gets more involved (perhaps you want to offer a multitude of user-selectable features) then the problem becomes more complex and a certain amount of advanced planning is required to get it right.

Many microcontroller equipped projects demand some kind of user interface – a means of changing the way the device operates, viewing information etc. It's often the reason why we add a microcontroller to a design, so that we can make changes 'on the fly', rather than have to re-wire the circuit.

LCD feedback

In modern times an LCD has become the default route for providing feedback to a user. As their use in consumer products has exploded, LCD modules have become very cheap – a two line by sixteen character display module can be purchased for as little as £5.

A decade or so ago designers would have provided a serial port interface for interaction with a device, requiring the connection of a PC running a 'terminal emulation' program such as **hyperterm**, which emulates a physical terminal display unit popular in the early days of computing. Even today, a serial port interface still has its uses, especially if you want to provide a means of transferring data between the device and a PC. The removal of serial ports from modern PCs is making this more difficult, and over the next few years we will see a gradual progression from serial ports to USB interfaces – a subject that has been covered to some extent by *EPE*, and that will no doubt feature in many future articles.

For now, however, both LCD displays and serial interfaces remain a very useful means of providing interaction with our microcontroller equipped projects – and it can be very easy to do, if we design it right from the beginning.

The technique that we will discuss here will work equally well for LCD or serial port implementations. The problems are exactly the same – how do you provide a series of menus, allow for user input and handle key presses without interfering with the main operation of the device?

Typical problems

Let's start by considering some of the problems associated with presenting information to a user. Typically, a program will run in what is known as a *main loop* – a series of operations in a list that return back to a starting point and continue forever. We design our routines so that they execute quickly enough to operate correctly. For example, in a hypothetical heater controller, your 'main loop' might look like this:

```
reset:
  call init_hw

loop:
  call read_temp
  btfss temp_level, 0
  call heater_off
  btfsc temp_level, 0
  call heater_on
  goto loop
```

we rely on *read_temp*, *heater_off* and *heater_on* being quick and deterministic (ie, taking a known range of possible execution times) to ensure that our program will be able to control the temperature, and not overheat. For programs that require no user intervention this is usually quite easy. When we add routines to provide user intervention, such as changing the desired temperature, things get rather more complicated. We must provide for input from the user without interrupting the critical operation of the program.

User interaction is generally a slow process. The simple program above, running on a processor equipped with a 10MHz crystal, could quite easily run that loop at a rate of tens of microseconds. Responding to user interaction via a keypad or serial port, however, could require tens of seconds – a million times slower! Changes of that order of magnitude to the operation of the main loop could completely disrupt what you want to do, so we have to take care with the design of the user interface software.

The second problem is to do with the complexity of implementing the menu software itself. The 'logic' behind handling multiple key presses in different screens or menus can cause the software to explode into a long, difficult to read and maintain jumble if not properly defined. Even when using a high level language like C.

Goals

The goal for a good menu design is becoming clear:

1. Keep the code for each menu option isolated from the other code
2. Separate the software that displays the menus from the actual menu specific code
3. Do not duplicate code that handles key presses in each menu
4. Minimise the interference between the act of displaying a menu and the 'real' application

Goals one to three are related, and goal four is very hard to get right.

Before we start designing the code, we need to decide on the number of keys and type of display to use, as this will have a minor effect on the design. The two line by sixteen character alphanumeric LCD panel is a popular and low cost display, so we will use that in our example. For the keys, you have to consider what type of information you will be entering.

If your menu system is simple, perhaps only displaying information or providing the ability to select options from a fixed list, then you can probably get by with just two buttons: one to scroll through the list, and one to 'select'. If you are providing options that require numeric data to be entered, then the classic 'cursor' interface of 'up, down, left, right, and action' buttons

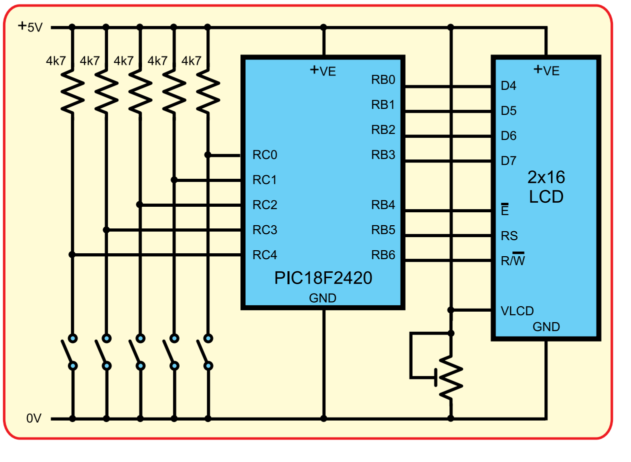

Fig.1 Example circuit

will be more appropriate. For our example, we will use the latter combination of five keys since this is a more interesting combination to demonstrate in software.

The example circuit is shown in Fig.1, on which all the software that we create for this month's article will run. It's a very simple circuit: we use the internal oscillator (an on-chip resistor and capacitor) which we set to run at 8MHz. The choice of port pins for the connection of the LCD is very important, as will be seen later. We have chosen the PIC18F2420 device because we can use it with the free Microchip C compiler, allowing us to demonstrate programs written in both C and assembler.

Now let's take a look at two designs for handling menus, one very simple (that will be fine in a few example cases) and another, more complicated design that will suit a much wider range of applications, and also represents the 'best practice' approach.

Simple design

An example where a simple display solution will work could be an electronic lock. An LCD displays 'Door Locked', until a user presses a key. The display then shows 'Door Open', operates a solenoid unlocking the door, and then after a few seconds (giving someone time to pull the door open), it turns the solenoid off, and returns the display to 'Door Locked'. The flowchart design for this is shown in Fig.2. (If you are confused by the use of flowcharts, refer to last month's *Pic N'Mix* article on the subject.)

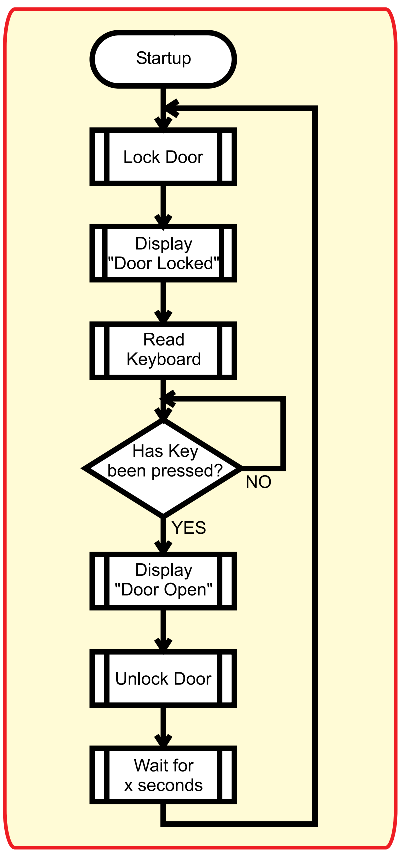

Fig.2 Simple design

This simple example has no special timing requirements, other than the delay for a few seconds while the door is left unlocked. It is quite acceptable to have the program loop continuously waiting for a keypress as it has nothing else to do. The program for this is quite unexceptional, and is shown in **list1.asm**. (This file and all other source code examples mentioned in this article can be found on the *EPE* website in the Pic N'Mix section of the Downloads page.) The exact equivalent program written in C can be found in **list1.c**.

It's interesting to note that while we had to write the assembler routines for driving the LCD, in the C program we didn't have to – the C library files supplied by Microchip include routines to drive LCDs. This is one of the great things about using a high level language – so many of the 'utility' functions we might want to use have already been written for us. If you have installed the free Microchip C compiler, look at the **MPLAB-C18-Libraries.pdf** file, located in the **c:\mcc18\doc** directory, to see the full list of functions provided. If you read this document you will notice that the library routines for driving an LCD expect the display to be wired to specific ports, as we have used on our example circuit – hence the original choice of pins!

In this article we are not interested in the mechanics of writing to the LCD – these are fixed by the design on the LCD hardware, and can be found by examining the example code – instead it is how we design our application to use them. So let's now look at the more complex example, which is the main purpose of this article.

More complex design

Consider an application like a temperature controller. First, it reads the current temperature (presumably from a temperature sensor connected to an analogue input on the processor). If the temperature is above a set 'upper limit', it turns the heater off. If the temperature is below a set 'lower limit', it turns the heater back on. The program must loop round this process very quickly to ensure that the temperature does not rise too high or fall too low. The design for this is shown in Fig.3.

Now, what happens when we want to add an LCD display and keyboard to the project to allow the user to view the current temperature and change the upper and lower limits? If we use the previous design idea, when the program halts while the user is changing a limit setting, the temperature could go dangerously high or low. That's obviously not what we want!

We can deal with this problem by designing the menu code so that it responds to key presses one at a time. Every time a key is pressed, the display menu function is called, which handles just that one keypress, and then returns. The display menu function 'remembers' what state it is in (ie, it remembers what keys have been pressed before). This kind of functionality in a program is called a *State Machine*, and can be a very powerful way to deal with such problems.

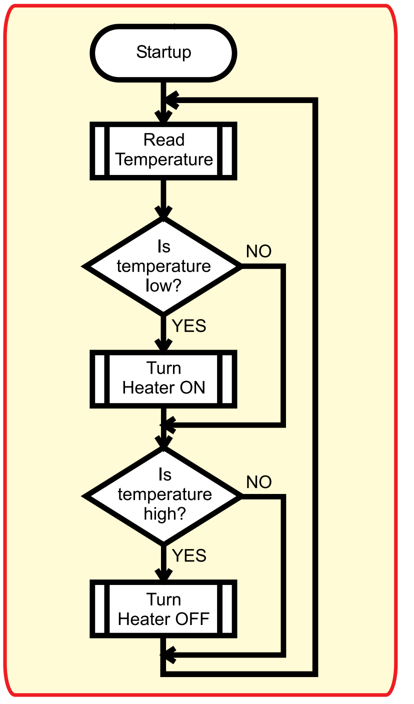

Fig.3 Initial temperature control design

State machines

State machines have some very useful features: they are easy to design, they are simple to code (especially in a high level language), and they can operate very quickly. They rely on the use of a variable, initialised to a known value at start-up, which tracks the state through successive calls to the code. The state changes only when one of a number of pre-defined events occur. These events (which could be interrupts, key presses, timeouts etc) are converted to an 'event number' that is unique for the type of event. This event number is used by the state machine to look up the corresponding code that will be executed.

The translation of the state machine found in Fig.4 and Fig.5 to actual code is shown in the source file **menu.c** (also available on the website). You will see that this routine takes as an input a variable called **eventType**, which is used to indicate what event has happened: **startup** or **keypress**. The **startup** event is an artifical event created for the purpose of 'telling' the menu system to set itself up. You can see from Fig.4 and Fig.5 how different input events will cause the menu display state machine to go through different states.

At each event, indicated by the arrow-headed lines, a small piece of code is executed. You may notice that some events do not cause a change of state – for example, the UPKEY and DOWNKEY events shown at the bottom of the State Machine. That's quite normal, and in this case the code associated with the event simply increments a variable and updates the display.

The 'brains' of the state machine software – and this is where its elegance lies – is not actually in software. It's in the array variable called **states** at the top of the file. This array holds one entry for each state that the state machine can be in, and each entry contains a list of pointers to functions, one for each possible event. *Pointers*, in the C programming language, can be a very difficult concept to understand, but it isn't necessary to understand them to use them.

State machines find uses in all kinds of software, including the TCP/IP protocol that powers the Internet.

By implementing these small functions, one for each event that can occur in a state, the design of the program can be very easy to see. The array variable defines how the program works, the function pointers specified in the array variable provide the work, and the state machine itself – **menuStates** in this case – is so generic in operation that you could re-use it anywhere.

The number of events that your state machine should respond to is up to you; if you add more keys, the number goes up, and you might want to have more than one timer signal to handle different events (such as a 10s timer for timing out on no

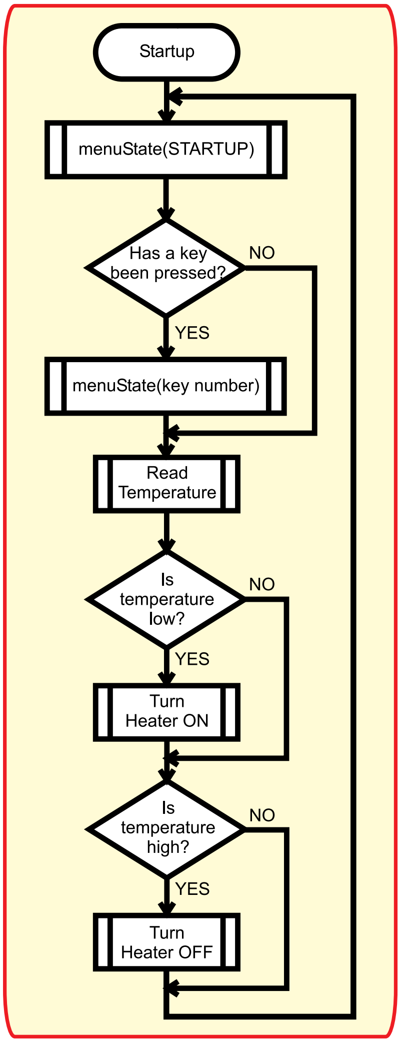

Fig. 4 Final design flowchart

keypress, and a 1s timer for toggling information shown on the display). If you add an extra event signal, then you add an extra column to the menuStates array variable. You will not want to have all events handled by every possible state in your code, and this is dealt with, as shown in **menu.c**, by having a 'NULL' entry in the array.

The array variable, while quite easy to read, removes all the complexity of conditional branches and loops in your code. For larger, more complex designs, it can also run faster as the lookup table approach takes less time to reach the code that needs to be run, rather than skipping down a series of if statements or branch instructions.

This has been a very quick introduction to the use of state machines for helping with displaying menus, and while a complex subject to get to grips with, they do help make the task of writing software easier. We will look at other uses for state machines in a later article.

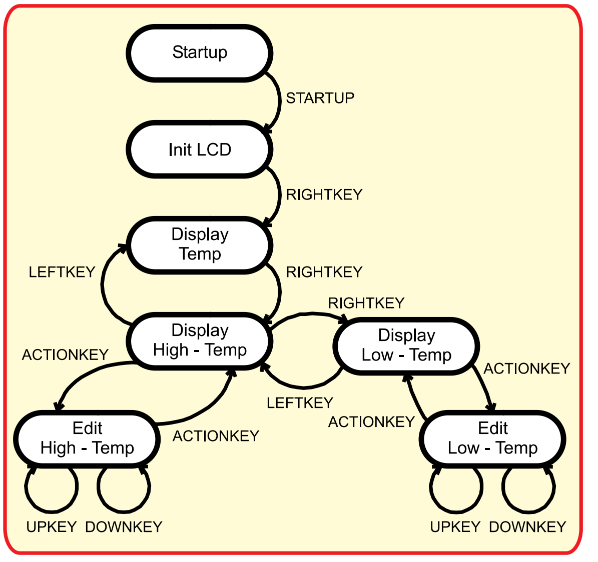

Fig.5 Display menu state machine

More randomness

Reader Ed Grens had an interesting spin on the 'Random Number Generator' brain teaser from a few months back. Ed says:

I have used 'random' numbers a lot, and the Monte Carlo method is almost entirely on mainframes and PCs and have had cause to examine the performence of a few alternatives. Pseudo-Random generators (in software) can give good overall distribution of 'random' numbers over an interval, but when the sequence of large samples of such numbers is examined it is (almost) always non-random.

Naturally occurring random noise in many systems, including the atmosphere, has been used as a truly random number source. The noise in reverse-biased semiconductor devices at small currents is a good such source, and a Zener diode is a convenient device, able to provide about 20mV p-p random output at about 20µA current.

The key is to use a low-noise driver with very high output impedance. The LTC1340 varactor driver is such a driver, providing about 20µA at 9.2V with supply and input voltages both at 5V. The Zener noise is amplified by a high-gain-bandwith-product, low-noise op amp and converted to hi/lo (1/0) output with a high-speed comparator. The reference voltage to the comparator is adjusted to give equal numbers of 1s and 0s. This output is then latched and clocked into the MCU or PC.

Thanks for that Ed.

Brain teaser

We'll finish this month with another brain teaser.

PIC microcontrollers can operate at a wide range of clock frequencies and the more observant of you may have noticed that most (if not all) of them can operate down to DC – ie, the clock signal can stop altogether without damaging the processor. (Older processors based on NMOS technology such as the 6502 would be permanently damaged if that happened, as the author experienced to his cost!) *EPE* have never published a design which took advantage of this facility (it was used in the original *EPE PIC Tutorial* a few years ago) but it can be quite useful. Can you think of any examples where it might?

Submissions by email to **mike.hibbett@gmail.com** or in writing to *EPE*.

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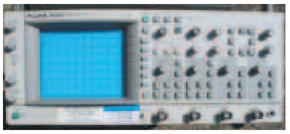

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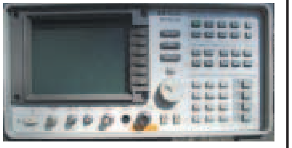

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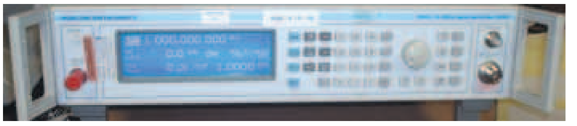

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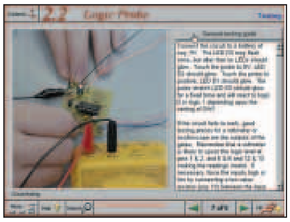

Logic Probe testing

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.

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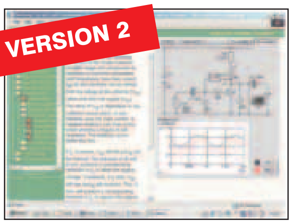
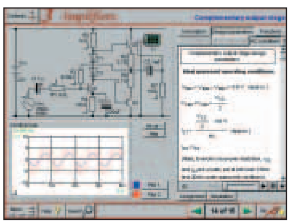


Circuit simulation screen

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

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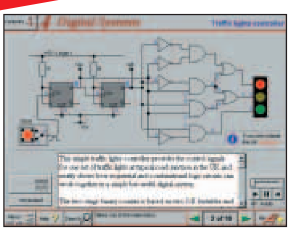
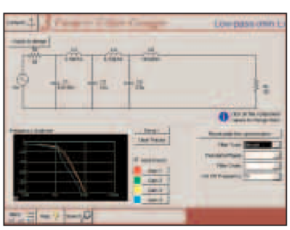


Virtual laboratory – Traffic Lights

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

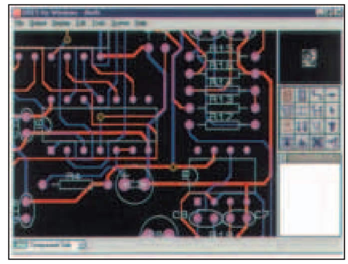
ANALOGUE FILTERS



Filter synthesis

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

ELECTRONICS CAD PACK



PCB Layout

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

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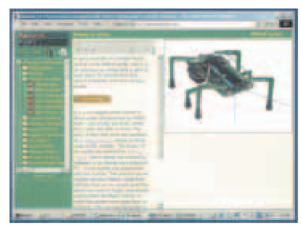

Case study of the Milford Instruments Spider

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.

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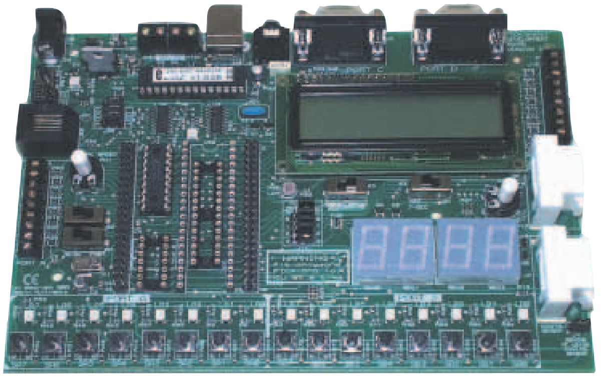

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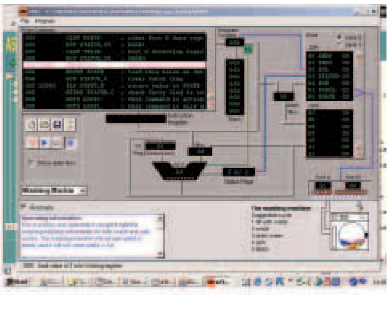
(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

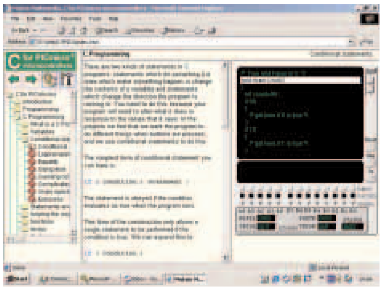


'C' FOR 16 Series PICmicro VERSION 4

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



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

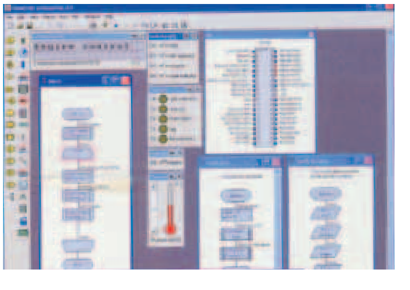
FLOWCODE FOR PICmicro V3

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A Powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and l.c.d.'s. The use of macros allows you to control these 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 ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols ● Full on-screen simulation allows debugging and speeds up the development process.

● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● New features in Version 3 include 16-bit arithmetic, strings and string manipulation, improved graphical user interface and printing, support for 18 series devices, pulse width modulation, I2C, new ADC component etc. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



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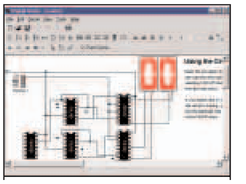

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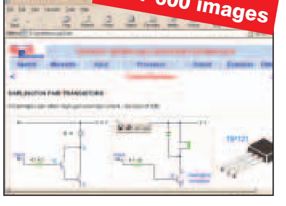

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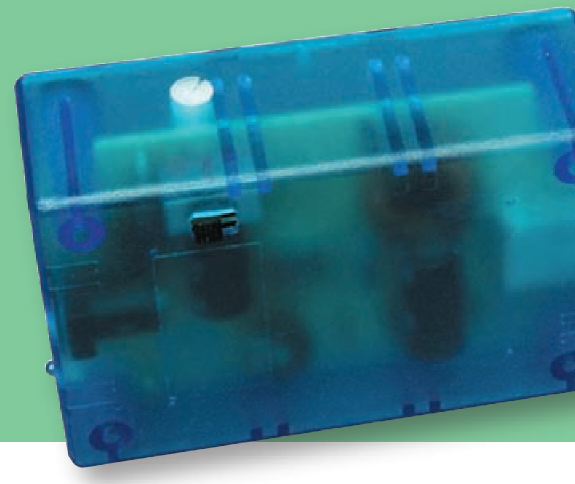
For the chance to win one of these boards, log on to: **www.microchipcomp.com/epepicdemmc** and enter your details into the online entry form.

Charge your iPOD without connecting it to a computer!

Build a charger for your or MP3 player

By JOHN CLARKE

This Charger can be used to charge your iPOD or MP3 player without connecting to your computer's USB port. It can be powered using a DC plugpack or from 12V DC in your car and it can also be used to power any accessory normally run from a USB port.



USING THE USB PORT on your computer to charge your iPOD or MP3 player's batteries is not always practical. What if you do not have a computer available at the time or if you do not want to power up a computer just for charging? Or what if you are travelling?

Chargers for iPODs and MP3 players are available but you need separate models for charging at home and in the car. This charger can be used virtually anywhere.

While we call the unit a charger, it really is nothing more than a 5V supply that has a USB outlet. The actual charging circuit is incorporated within the iPOD or MP3 player itself, which only requires a 5V supply.

As well as charging, this supply can run USB-powered accessories such as reading lights, fans and chargers, particularly for mobile phones.

The supply is housed in a small plastic case with a DC input socket at one end and a USB type 'A' outlet at the other end, for connecting to an iPOD or MP3 player when charging. An LED shows when power is available at the USB socket.

Maximum current output is 660mA, more than adequate to run any USB-powered accessory. (The specification for the computer USB 2.0 port requires the USB port to deliver up to 500mA at an output voltage between 5.25V and 4.375V).

Circuit details

The circuit is based around an MC34063 switchmode regulator. This has high efficiency so that there is very little heat produced inside the box, even when delivering its maximum output current. The circuit is more complicated than if we used a 7805 3-terminal regulator but since the input voltage could be 15V DC or more, the voltage dissipation in such a regulator could be 5W or more at 500mA. and 5W is far too much for a 7805, even with quite a large heatsink.

Hence, we have taken the switchmode approach. This is illustrated in Fig.1(a) and involves a switch (S1), inductor L1, diode D1 and capacitor C1. When the switch is closed, current flows through inductor L1 into the load. The current (Path 1) slowly builds up from zero to the peak value, as shown in Fig.1(b).

When this peak current is reached, the switch opens and current from the inductor flows through diode D1 to discharge the inductor energy into the load. This current path is shown as Path 2. Capacitor C1 is included to act as a reservoir of power to smooth out the voltage produced across the load.

The output voltage is dependent on the load and the ratio of time that switch 1 is closed to when it is open. It is also dependent on the

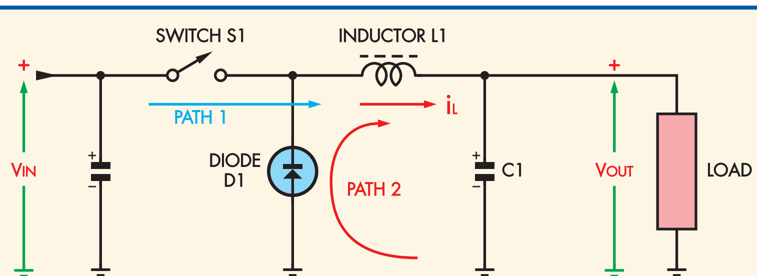


Fig.1(a): the basic scheme for a switchmode power supply. Voltage regulation is achieved by rapidly switching S1.

iPOD

peak current through L1 and the input voltage. This type of circuit can be very efficient because voltage control is achieved by rapidly switching the input. The small amount of power dissipated is mainly due to voltage losses in the switching device and diode D1.

Fig.2 shows the full supply circuit, which is based on an MC34063 switchmode controller IC. Its internal schematic is shown in Fig.3. The switching function of S1 [in Fig.1(a)] is provided by the internal transistor (Q1). The internal oscillator sets the switching period, while the 'Ipeak sense' limits the current flowing in inductor L1 by controlling the on-time for transistor Q1. The 1.25V reference and comparator provide a feedback arrangement to monitor and control the output voltage.

Power from the DC socket passes through diode D2 and slide switch S1 to IC1. D2 protects against reverse polarity and the adjacent Transient Voltage

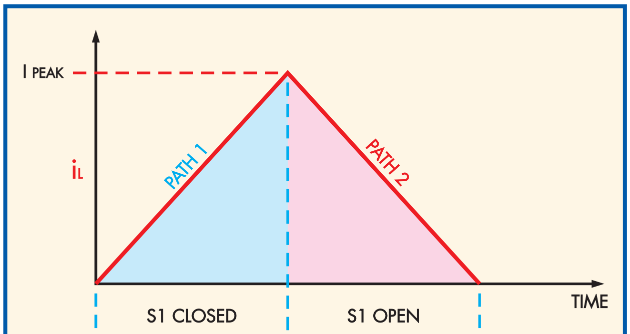


Fig.1(b): this diagram shows the current through L1 when S1 is closed (blue) and opened (red).

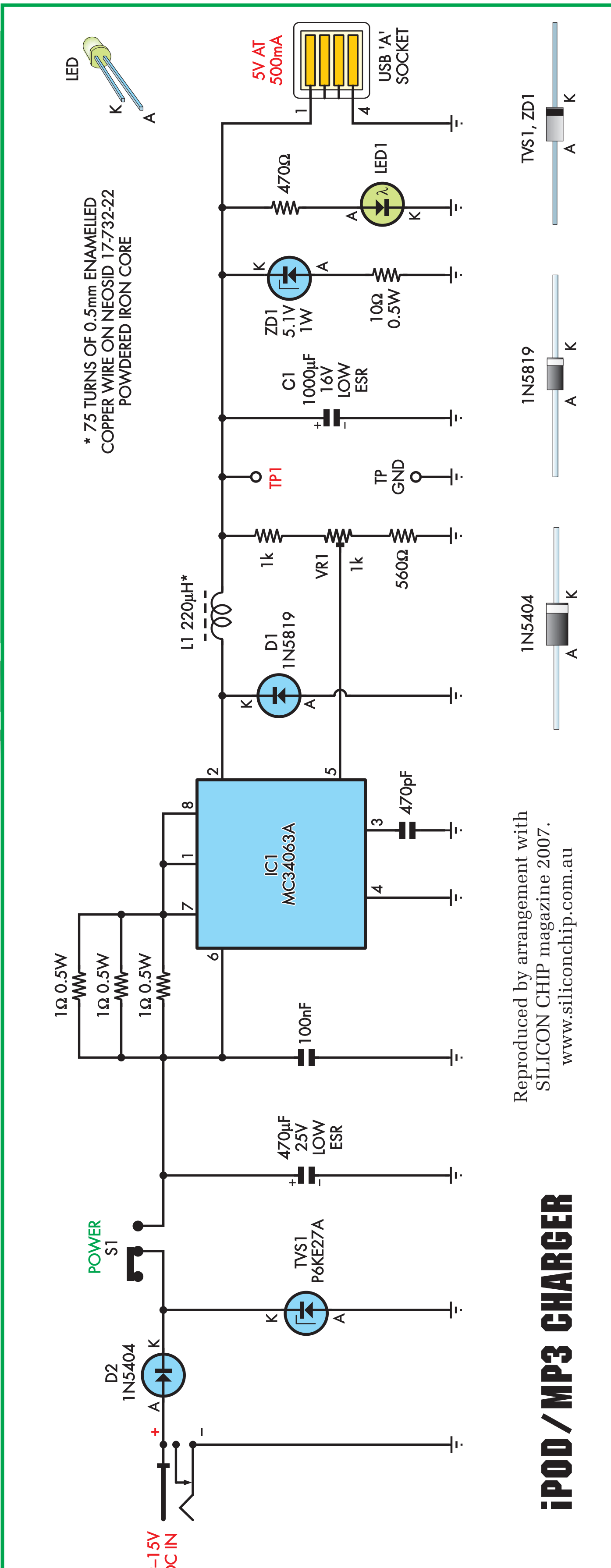


Fig.2: the complete circuit is based on a dedicated MC34063 switchmode controller IC.

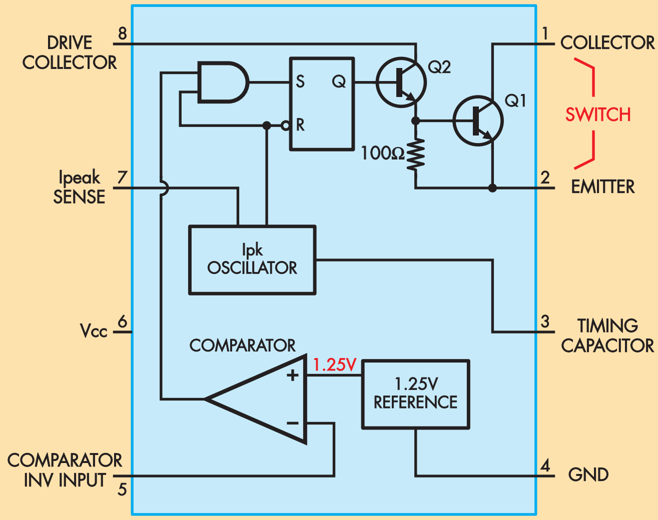


Fig.3: inside an MC34063 switchmode controller IC. The internal oscillator sets the switching period, while transistor Q1 does the switching.

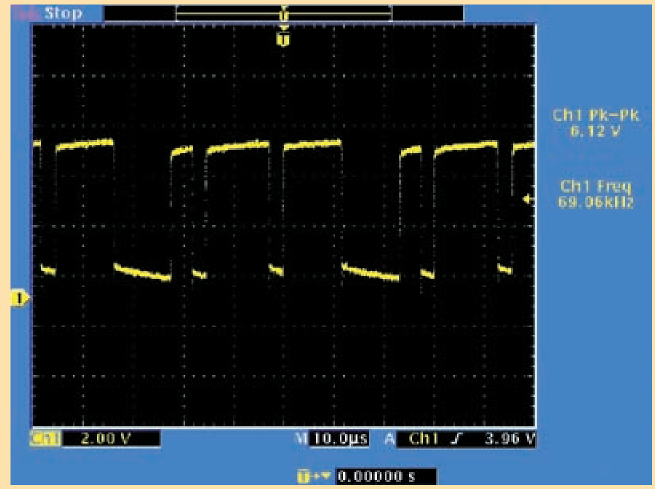


Fig.4: this switching waveform was measured across the output with an 8Ω resistive load, resulting in a current of 625mA. Note how the switching shows signs of 'hunting', as the circuit constantly maintains a 5V output.

Suppressor (TVS1) clamps any fast spikes which may be riding on the input supply. Further filtering is provided by a 470µF low-ESR (Effective Series Resistance) capacitor.

As previously described, current is switched to L1 using the internal transistor in IC1. In operation, the three paralleled 1Ω resistors between pins 6 and 7 monitor the current through L1. When the current reaches 1A, pin 7 becomes 300mV lower than pin 6 and the internal transistor switches off. The energy stored in L1 is then dumped into capacitor C1 via Schottky diode D1.

The resulting output voltage is filtered using a 1000µF low-ESR capacitor.

Output voltage control

Pin 5 of IC1 monitors the output via a voltage divider consisting of a 1kΩ resistor, trimpot VR1 and a 560Ω resistor to ground. VR1 sets the output voltage to 5V.

Zener diode ZD1 and the 10Ω resistor are included to catch any output overshoot voltages which can occur if the output load is suddenly reduced. As explained, the switching of L1 controls output regulation. If the load is suddenly reduced, the only way IC1 can stop any voltage rise is to prevent any switching of power to L1 and let capacitor C1 drop back to 5V. So, to prevent voltage overshoot, ZD1 begins to conduct when the voltage reaches 5.1V, with the current through it limited by its series 10Ω resistor.

In normal circumstances, when the output voltage is correctly set to 5V, ZD1 will not conduct unless the voltage rises momentarily. However, if VR1 is set so that the output voltage is higher than 5V, ZD1 conducts continuously. Because of this, the range of adjustment for VR1 has been deliberately restricted to limit the output to be no more than 6.5V, under worst-case conditions.

This worst-case setting occurs when VR1 is set fully clockwise (towards the 560Ω resistor) and when VR1 is 20% high in value and the reference for IC1 is at its maximum at 1.32V (typically, IC1's reference is 1.25V but this could be anywhere within the range of 1.18V to 1.32V).

With 6.5V at the output, there will be 140mA through ZD1 and the 10Ω resistor. Dissipation in ZD1 will be 0.7W (below its 1W rating), while dissipation in the 10Ω 0.5W resistor will be 0.2W. When VR1 is set correctly, the output is protected against producing transients above 5V.

Should the output become shorted, the fault current will be limited to a safe value at or below 120mA, as set by the paralleled current sense resistors.

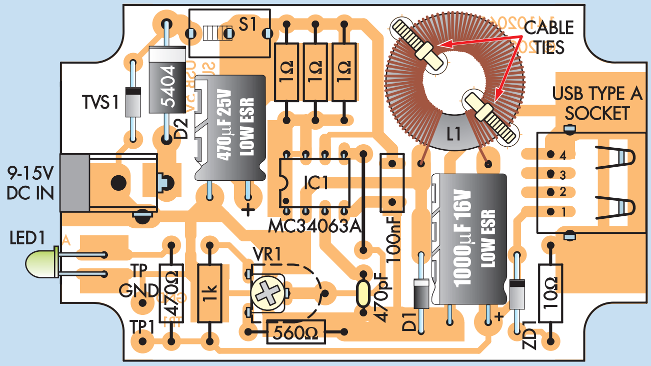
Specifications

Output voltage	5V
Output current	660mA maximum for 5V out
Input voltage range	9.5V to 15V DC
Input current requirement	500mA for 9V in, 350mA for >12V input
Input current with output shorted	120mA at 9V in, 80mA at 15V in
Output ripple	14mV (from no load to 660mA)
Load regulation	25mV (from no load to 660mA)
Line regulation	20mV change at full load from 9 to 18V input
No load input current	20mA

Construction

All the components for the charger are mounted on a PC board coded 648 (available from the *EPE PCB Service*) and measuring 79 × 47mm. This board is mounted upside down in a small plastic case measuring 83 × 54 × 31mm.The screw covers for the lid then serve as rubber feet.

Begin construction by checking the PC board for breaks or shorts between the copper tracks. Repair these as necessary. That done, make sure the holes



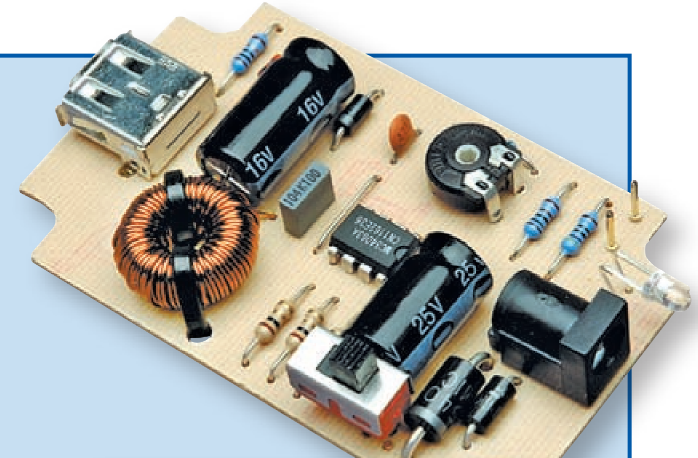


Fig.5: install the parts on the PC board as shown here. Inductor L1 is secured using cable ties.

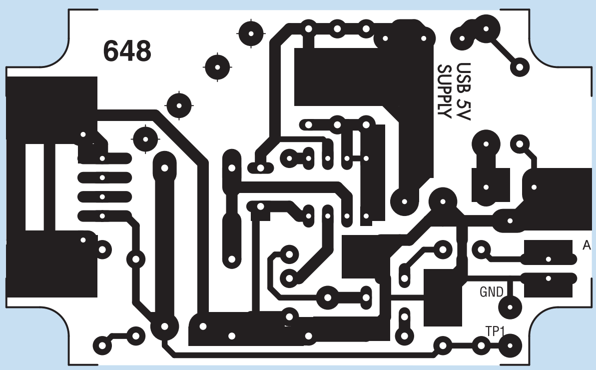
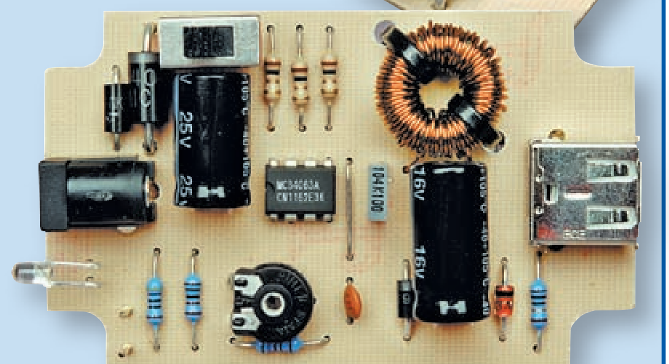


Fig.6: the full-size etching pattern for the PC board.



Take care to ensure that all polarised parts (ie, the IC, diodes and electrolytic capacitors) are correctly oriented when building the PC board.

are the correct size for each component and check that the PC board clips neatly into the integral side pillars in the specified box.

The component overlay for the PC board is shown in Fig.5. First, insert and solder the resistors, links and trimpot. You should check the resistor values with a digital multimeter. Make sure IC1 is mounted with the orientation shown.

The two electrolytic capacitors are mounted on their side to allow clearance in the box; make sure they are mounted with the correct polarity. LED1 is mounted with cranked leads so that it can poke through a hole in the side of the case. Again, take care with its polarity.

There are four diodes on the PC board, including the Zeners and TVS. Make sure you insert the correct ones in each position and with the correct orientation. Once they are in, insert and solder in the two PC stakes followed by slide switch S1. The latter is mounted so that the top of its body is 10mm above the PC board surface.

Inductor L1 is wound on a powdered iron toroid with 0.5mm enamelled copper wire. Wind on 75 turns in two layers spaced evenly around the core. The wire ends must be scraped clean of enamel and tinned, before soldering.

Alternatively, if the wire is coated with red enamel, this can normally be melted off with the tip of your soldering iron. The toroid is secured to the PC board with two cable ties. These pass through holes in the PC board.

Fig.7 shows the drilling details for the case. You have to drill holes for the DC socket and LED in one end, the switch at the top and the USB socket in the other end of the box. Mark these out and drill and file as necessary.

Testing

Initially wind VR1 fully anticlockwise. That done, set your multimeter to read DC volts and connect it between terminals TP1 and GND. Apply power to the input, switch on and adjust VR1 so that the voltage is 5V.

Table 2: Capacitor Codes

Value	μF Code	EIA Code	IEC Code
100nF	0.1μF	104	100nF
470pF	NA	471	470p

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	1kΩ	brown black red brown	brown black black brown brown
❏	1	560Ω	green blue brown brown	green blue black black brown
❏	1	470Ω	yellow violet brown brown	yellow violet black black brown
❏	1	10Ω	brown black black brown	brown black black gold brown
❏	3	1Ω	brown black gold gold	NA

Parts List

1 PC board, code 648, available from the *EPE PCB Service*, size 79 x 47mm
1 UB5 transparent blue plastic case, size 83 x 54 x 31mm
1 12V DC plugpack fitted with a 2.5mm DC plug and rated at 350mA minimum
1 fused cigarette lighter socket lead with 2.5mm DC plug
1 SPDT slide switch (S1)
1 USB PC-mount 'A' socket
1 PC-mount 2.5mm DC socket
1 powdered-iron toroidal core, measuring 14.8 x 8 x 6.35mm (Neosid 17-732-22, or equivalent)
1 2m length of 0.5mm enamelled copper wire
1 50mm length of 0.7mm tinned copper wire
1 M3 x 12mm countersunk screw
1 M3 tapped x 12mm Nylon spacer
2 100mm cable ties
2 PC stakes
1 1kΩ horizontal trimpot (VR1)

Semiconductors
1 MC34063A switchmode controller (IC1)
1 1N5819 1A Schottky diode (D1)
1 1N5404 3A diode (D2)
1 P6KE27A 600W transient voltage suppression diode (27V) (TVS1)
1 5.1V 1W Zener diode (ZD1)
1 3mm green LED (LED1)

Capacitors
1 1000µF 16V low-ESR PC electrolytic (C1)
1 470µF 25V low-ESR PC electrolytic
1 100nF MKT polyester
1 470pF miniature ceramic

Resistors (0.25W, 1%)
1 1kΩ
1 560Ω
1 470Ω
1 10Ω 1/2W
3 1Ω 1/2W 10%

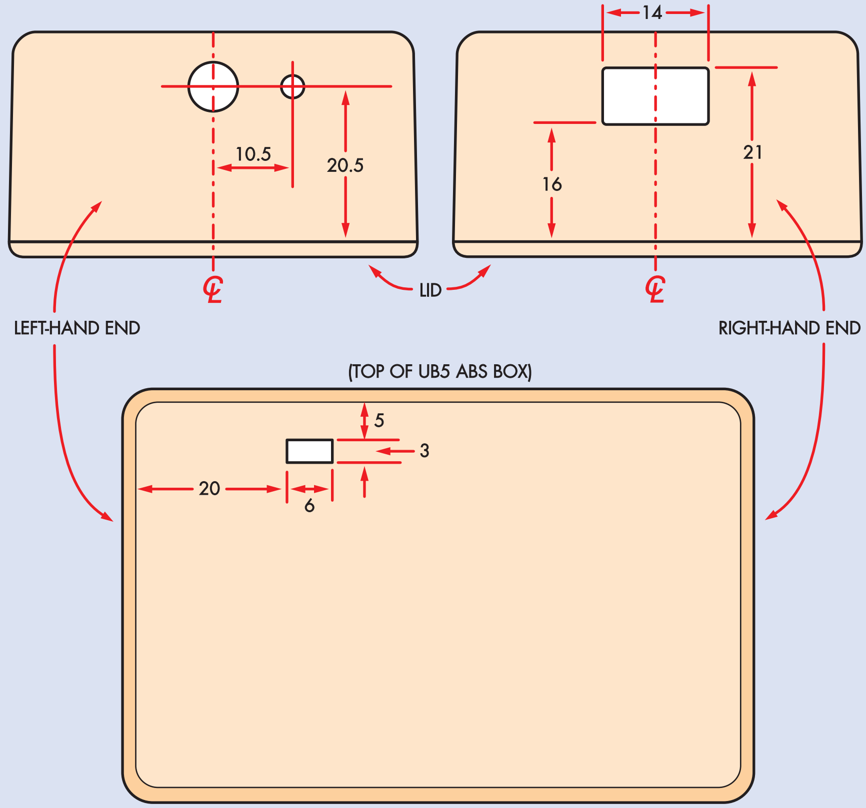
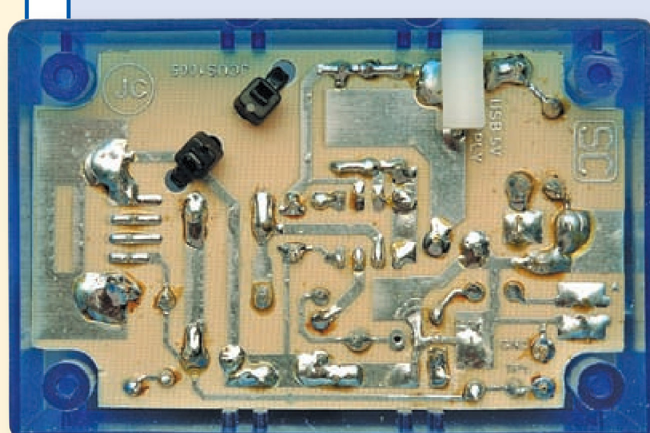


Fig.7: here are the drilling details for the plastic case. The square cutouts are made by drilling small holes around the inside perimeter, knocking out the centre pieces and filing to shape.



The PC board is clipped upside down into the bottom of the case and is secured using an M3 tapped Nylon spacer. This spacer ensures that the board doesn't move when the slide switch is operated.

This can generally be set to within 20mV of 5V (ie, 4.98V to 5.02V) using the trimpot.

Check that LED1 lights. If it doesn't, check that it is the right way around. If there is still no power indication, use a multimeter to check for voltage at pin 6 of IC1 and for a similar voltage at pins 1, 7 and 8. If there is no voltage here, perhaps the DC socket plug has the wrong polarity. The plug should have the positive to the centre hole and the negative to the outer case.

When testing is complete, the PC board can be clipped into the case, making sure the LED protrudes from its hole in the side of the case. The section of PC board directly below the switch will need supporting so it is not pushed out of position when the slide switch is operated. We used an M3 tapped Nylon spacer in the side of the case to support the PC board and this is secured using an M3 screw.

To do this, hold the spacer tightly against the PC board directly below the switch and mark out the position of the hole for the screw. The transparent box makes positioning of this hole easy. Now drill out the hole and secure the spacer. Finally, fit the lid and insert the rubber feet into the screw holes.

EPE

Footnote: *iPod* is a trademark of Apple Computer, Inc.

Protecting Your Designs and Copyright

Sara Ludlam of Ludlams Solictors is a specialist Intellectual Property lawyer. In this article, specially written for *EPE* readers, Sara explains how best to protect your design ideas from copyright infringement or theft.

Are you being copied? Can you stop copycats? If so how?

ONE of our readers, a consultant electronics engineer, recently asked about his rights in relation to a manufacturer whom he alleged had "ripped off his design work". The query raises lots of legal questions in the area known as Intellectual Property law (copyright, design rights, patents, trade marks etc., known collectively as 'IP law') – an area of law which is often misunderstood. Our reader kindly agreed that his experience could be used in this article to illustrate IP rights, and what can and cannot be done to protect IP rights.

The query was passed on to me, an English IP lawyer, and for some of the more technical aspects of this article I have relied on the expertise of *EPE*'s On-line Editor, Alan Winstanley.

Budding ideas

Many budding inventors have ideas that they think might be patentable or worth protecting in some other way. Electronics manufacturers and designers these days are involved not only with hardware design (eg circuitry and printed circuit board layouts etc.) but also the associated software, often involving the development of microcontroller source codes that are embedded into controller chips (creating firmware). So what sort of protection is available to individuals or companies seeking to prevent their idea from being pirated by anyone else?

The first thing I should say, since this is a magazine about electronics, is that most *software* programs in the UK *cannot* be protected by patents. It is a controversial issue in the UK. It is not the case in all countries, as some do allow patent law to protect software programs. This article will only deal with the rights available in the UK. However, many countries are signatories to various international treaties which allow IP rights to be treated and protected in a similar manner, worldwide. There are some variations, so if you are not a British citizen then you would need to check your IP rights with a local lawyer.

A patently good idea

Patents give you a 20 year monopoly right in an invention, but it can only be obtained if your invention falls within what is acceptable as an 'invention'. There is a list of what cannot be protected by patent law in the UK in the Patents Act 1976, and you can also find lots of useful information about it at the UK Intellectual Property Office website **www.ipo.gov.uk** . (Google has launched a beta Google Patents Search engine at **www.google.com/patents** indexing about seven million US-based patents issued by the United States Patent and Trademark Office or USPTO).

Most new software does *not* contribute what has been described as a 'technical effect' to the body of knowledge already in the world. It cannot therefore be patented. If you are unsure, you should ask your local patent attorney, but *do not tell anyone* else about your new software or invention. If you tell people about your invention without requiring them to sign a confidentiality or Non-Disclosure Agreement (NDA) first, it is considered to be 'public' knowledge and patent law will not protect it.

Patents are generally considered to be one of the best forms of IP protection available, but there are downsides. Patents are published and can be accessed by anyone, as Google has shown. They can be quite expensive to register and if you want to register the invention in more than one country they become very expensive. Renewal fees are also payable. As the maximum life of a patent is 20 years, once your time is up anyone can use your invention by following the published patent specification.

Copyright

Copyright is the main form of protection for software in the UK. Unlike patent rights, though, copyright is an automatic right in the UK. It exists automatically on the creation of a new work, without the need for registration. (This is not the case in all countries and it is recommended that in the USA you should register any copyright works at the Copyright Registry.)

The lack of registration can cause a problem if there is an argument about when you wrote the software and if you really are the first author or creator of the work. It is, therefore, strongly recommended that you always post yourself a copy of the original work (or the earliest copy you have) and date and sign it. Do not then open the envelope, but keep it somewhere safe in case your authorship or the date of creation is ever questioned.

The duration of copyright protection depends on what type of copyright work you have created. If the copyright work is a literary work, the protection expires at the end of the period of 70 years from the end of the calendar year in which the author dies, subject to certain legislative variations. If your copyright work is computer generated, copyright expires at the end of the period of 50 years from the end of the calendar year in which the work was made. If the work is a joint work or another type of work then other rules apply.

If someone designs a circuit and draws it out by hand, or with a computer-aided package that work is protected by copyright if it is a novel circuit. If someone else takes the same circuit diagram and redraws it so it looks different then that constitutes copyright infringement. But you may need to have evidence that your copyright work had been copied. If the electrical circuit is the same, the idea is the same, but the circuit looks different then you would need to show that the infringer had worked from your original.

Design rights

The third area of IP law which might be relevant to an electronics or software engineer is that of design right. There are two types of design right in the UK: those which can be registered and those which cannot.

Design rights protect original, non-commonplace designs of the shape or configuration of products. Design right is not a monopoly right, unlike patent rights, but instead it is *a right to prevent copying*.

A typical case

The above is a very simple summary to draw the distinction between various aspects of Intellectual Property rights. A specific case involving an *EPE* reader is discussed next.

Our reader spoke of having his "design work ripped off". He provided some samples of his electronics work to a manufacturer when tendering for a job. He did not get the contract, but later discovered that the manufacturer was producing an identical circuit board to the circuit board he had supplied as a sample, and they were incorporating it into their machinery. It looked like – and appeared to do – what his prototype did.

Jurisdiction

My first question was to ask where the reader resided. I knew he was Irish but did not know if he was from the Republic or from Northern Ireland. The answer was Northern Ireland. If he had been from the Republic of Ireland I would have had to refer him to a local lawyer, despite the similarities in IP law in both jurisdictions. As it was, I was able to advise him on IP law but could not act in relation to any court proceedings because the law in the United Kingdom varies depending on where you are. (England and Wales share common jurisdiction, but Scotland and Northern Ireland are separate and covered by their own legal systems.)

Thereafter, my advice was that if the reader had created an original work then it may be protected by copyright and/or design right. It is important to note that if there had been the possibility of patent protection, this right would have been lost when the work was shown to the manufacturer concerned.

Who owns copyright?

So, who owns the copyright in the work? Copyright *cannot* be transferred to another without a *written document* assigning such rights, and such a document must refer to consideration having been given for the transfer, and the document *must* be signed by the assignor. This means that even if you have been paid for your design work, *the copyright does not belong to the party that commissioned the work* unless you have said so in writing and signed such a document.

This point is a common misconception. It would seem logical that if you paid a third party to, say, write some bespoke software for you, or design a new machine, then once you had paid that software programmer or designer, you would own the copyright in that work. This is not the case.

You own the copy of the work you may have been given further to payment or as otherwise agreed. You may also have certain rights to reproduce that work and use it in various situations. But such reproduction rights and right to use the work is limited in scope unless you are the copyright owner in that work, having taken a written assignment of copyright from the creator of the work. If you have not, then you are using the work under a licence. You do not own the copyright in that work.

The licence might be express, if you have agreed terms. For example, the licence might state that you can only reproduce the work for your employees' use, and use it in the UK. Or the licence may be implied where there is no formal agreement, and the law would have to infer the terms of that licence from the way in which the parties have behaved. For example, how much was paid for the work, and has the copyright owner controlled further uses of the work?

Our reader did not sign a document transferring any IP rights to the manufacturer. He is, therefore, still the owner of any original copyright in that work.

He was not paid for his work developing the circuit board prototype. Therefore, any implied licence which the manufacturer may have had to keep the prototype and use it, would be limited to examination and consideration only.

Our reader made it clear to the manufacturer that it was not entitled to use the prototype to develop it further and any such work must be done by the reader himself. But if the reader fails to take steps to stop the manufacturer from reproducing the prototype, then the manufacturer's implied licence will include the right to reproduce it.

Remember that copyright does not need to be registered, as I have explained above, but it does need to be protected if you are to maintain it. So the reader would need to prove that he is the author/ creator of the work *and show that he is the first person to design that particular circuit board*. If there are no records of creation, this can be a difficult process, so do bear in mind that you should keep rough drafts and prototypes when developing new work, as evidence of your creativity and originality.

Also, be aware that the first owner of a copyright work will be the creator/author unless the work *is created in the course of employment*. In such an instance the work and copyright in the work is automatically the property of the *employer*. The reader confirmed that he was self-employed and therefore he was the owner of any copyright in the circuit board.

Is it an original work?

Then our reader explained that an engineer working for the manufacturer had provided him with certain parameters around which his work needed to fit, and he gave the reader a specification. Our reader had to use these specifications and parameters to create his circuit board.

Obviously, any elements of the work created by the reader which replicate a third party's work will not be protected by copyright, as they will not be original works. However, if our reader's work is all original, albeit designed to fit around other circuitry, it will have copyright protection. (Such 'must fit' criteria may however exempt the work from attracting design right protection, which I cover below.)

The reader went on to explain that his own prototype was created further to a design brief from the manufacturer which required certain components to fit into an existing system.

If the specification provided by the manufacturer had been incorporated into the final design of our reader's circuit board design, it may be held that the final work is a 'joint' work and as such the manufacturer and the reader have joint rights of copyright in it. This would be an issue decided on the evidence, and whether the work of one party could be extricated and used independently of the work provided by the other.

Is there evidence of copying?

Unlike patents, but similarly to design rights, copyright is not a monopoly right. Copyright will only allow the copyright owner the right to stop a third party from copying his/her rights. If the third party has created the same or a similar work from scratch, without reference to your work, then you cannot prevent their use of such a work. So any evidence of copying by the manufacturer will be useful.

In our example, the reader possessed such evidence because he had incorporated certain personal identifiers into the circuit board. These were not necessary for the circuit board to work but had been copied by the manufacturer. Such evidence is excellent in any claim for copyright infringement. (In written works, authors sometimes incorporate such deliberate mistakes for protection. If these are reproduced in a copy by a third party they act as direct evidence of copying and can help settle a claim for infringement very quickly!)

The reader was also suspicious because he claimed the manufacturer did not have much expertise in this particular area and the electronics engineer from the manufacturer with whom he had met had little experience with working with engine electrics. Our reader had provided answers to questions which suggested that the manufacturer was developing the prototype without his authority. The use of email in this context is fabulous because if you keep copies of your emails, they provide great evidence.

No design rights

The reader originally claimed that his "design had been ripped off". Use of the word 'design' is not the same in a legal context as it is in everyday speech. English law defines 'design' as any aspect of the shape or configuration (whether internal or external) of the whole or part of an article.

It also defines what Design Right does not subsist in and the list is as follows:

(a) A method or principle of construction;

(b) Features of shape or configuration of an article which enable the article to be connected to, or placed in, around or against, another article so that either article may perform its function, or are dependent upon the appearance of another article of which the article is intended by the designer to form an integral part;

(c) Surface decoration.

Unlike copyright, a Design Right is owned by the party *that commissioned the work.*

The reader did not provide enough information for me to establish whether there was any Design Right protection available for his circuit board, but insofar as there was a requirement that the board 'must fit' another system, and it was a commissioned work, it seemed unlikely that the reader had any such rights.

Costs

The legal cost of a copyright or design right infringement claim will depend on the experience of your lawyers. The more experienced the lawyer, the more efficiently the matter will be conducted, the better the quality of advice you will get, and the more likely you are to settle the matter on commercial terms or win a court case.

Another client a few years ago took advice on a claim for copyright infringement from his local solicitors who did not have the relevant expertise. As a result of that advice, he did not settle the claim and ended up in the High Court as a defendant. If you are party to court proceedings there is no way out unless you settle, and settlement always involves payment of legal costs. When this client finally came to me, we had the case transferred to the County Court because the value of the claim in damages was very small and it was not therefore an appropriate matter to be heard before the High Court; ultimately we had the matter struck out. The client had still spent an arguably unnecessary two years in management time, stress and legal fees. Experts may seem to be more expensive in the short term, but are always better value in the long run.

Damages and notices

You are normally entitled to recover damages for unauthorised use by a third party of your copyright or design right work. (This is subject to the caveat covered below re. use of notices). 'Damages' is the value placed on the harm done to you by the unauthorised third party use of your work. It is assessed either by an account of the profits made by the third party having used your work, or by the amount you have lost by such unauthorised activity.

It is important if you are the owner of IP rights in a work that you tell the world about it by using 'notices'. In relation to copyright, the notice is the well known symbol ©. Next to this symbol you should put the name of the copyright owner, either an individual or a company, and the date.

If your work has design right protection available to it then a further notice should be published on the work or its packaging: 'Design Rights owned by [...]. [Date]'

The reason why I say you should always tell the world that the work they are looking at is a copyright or design right protected work is because of 'damages'. If a third party uses your work without your authority, and there is no copyright or design right notice on it, they may be able to successfully argue that damages are not appropriate because their use of your work was 'innocent'.

If it is shown that at the time of the infringement the defendant did not know *and had no reason to believe* that design right or copyright subsisted in the work to which the action relates, the claimant is not entitled to damages against that defendant. So, by using notices you are removing any opportunity for an infringer to avoid paying you damages.

Hopefully, my general advice above will help designers to understand the differences between different aspects of their Intellectual Property (IP) rights. If you have any queries arising out of intellectual property rights then the Intellectual Property Office (IPO) website is very helpful for general information and expert bespoke advice for your jurisdiction is crucial if you have a particular problem. ***EPE***

Sara Ludlam has successfully handled a number of high profile cases on behalf of major UK brands. Ludlams provides specialist legal advice in the field of copyright, trade marks, design rights, patents, software agreements, licensing agreements, IP litigation, franchising and related areas. Contact details are at: **www.ludlams.co.uk**

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INTERFACE

Robert Penfold

VISUAL BASIC 6 – IS IT TIME TO MOVE ON?

AS REGULAR readers of *Interface* will know, the software featured in these articles is usually written using Visual BASIC 6, which is now a rather dated version of the Visual BASIC programming language. However, it is what could reasonably be deemed the last true version of this programming language, since it was subjected to massive and fundamental changes when the first .NET version was produced.

Programs for PC hardware projects that were easily handled using Visual BASIC 6 became much more awkward to write with later versions. The current versions of Visual BASIC seem to be aimed at those producing large and complex pieces of software, and they are less well suited to producing programs for PC projects, many of which require simple software that can be written in a few minutes using Visual BASIC 6.

Using Visual BASIC 6 is becoming problematic, and this is a situation that is likely to become steadily worse with the passage of time. It suffers the inevitable troubles associated with ageing software.

While it is not officially obsolete, it is clear that it is no longer fully supported by Microsoft. It will run under the Windows Vista operating system, but only after a fashion. Long-term use with Windows Vista would probably result in a few major difficulties arising. Fortunately, programs written using Visual Basic 6 generally seem to have good compatibility with the Windows Vista operating system, but success with every program is not guaranteed.

Moving on

Of course, it is not essential to remain faithful to Visual BASIC 6, and it is possible to move on to other programming languages. The obvious move is to a current version of Visual BASIC, and there are two main choices for those that opt for this route. The obvious next step is to try Visual BASIC 2005 Express Edition, which effectively replaces the standard version of this programming language, and is available as a free download. Visit the following web address for more details: **http://msdn2.microsoft.com/en-us/express/aa718406.aspx**

Unusually for a free program, the licence conditions are not particularly restrictive, and actually seem to be more accommodating than those of the standard versions of previous Visual BASIC languages. You are free to use and distribute any programs written using this software, with no significant restrictions.

Visual BASIC 2005 Express Edition has been featured in previous *Interface* articles, and it will not, therefore, be considered any further here. However, it is fundamentally the same as the commercial versions, so it is a good idea to try the free version before spending a substantial amount of money on one of the commercial products.

Visual studio

The free Express versions of the Microsoft programming languages are available as separate downloads. As far as can be ascertained, the commercial versions are no longer sold as individual products, and do not exist as separate entities. Instead, you have to buy Visual Studio 2005, which includes Visual BASIC, Visual C++, and Visual C#. One slight problem with this is that the standard version of Visual Studio 2005 is about three times the price that used to be charged for the standard version of Visual Basic 6.

Admittedly, it gives the option of trying the other main Microsoft programming languages, and in some respects it is more like the Professional version of Visual BASIC 6. For example, the licensing conditions are less restrictive than for the standard version of Visual BASIC 6. Even so, it is a shame that there is no low-cost, fully supported, and reasonably full version of Visual BASIC 2005 available.

When the program is run for the first time it is necessary to select the normal programming environment, which basically just means choosing the programming language that will be used for most projects. The other programming languages are still available when launching the program on subsequent occasions, and it is just a matter of choosing the appropriate one when choosing the type of project that will be produced. Things look much the same as the Express version once into the program, with the main panel showing the latest news about Visual studio.

Things also look much the same as the Express version when a new project is started (Fig.1), with a form in the main panel, a Toolbox in the column on the left, and a Properties panel in the right-hand column. It works with **Inpout32.dll** utilizing the same method that is used for the Express version, and discussed in previous *Interface* articles. The basic scheme of things is to make **Inpout32.dll** available to the system by placing it in the C:\Windows\system32 directory, and then to add a module to the project so that it is able to recognise the new commands.

The module is added by going to the Project menu and selecting the Add Module option. A pop-up window is then used to provide a name for the new module, or the default can be accepted. The following code is then entered for the module:

```
Option Strict Off
Option Explicit On
Module inpout

Public Declare Function Inp Lib "inpout32.dll" Alias "Inp32" (ByVal PortAddress As Short) As Short
Public Declare Sub Out Lib "inpout32.dll" Alias "Out32" (ByVal PortAddress As Short, ByVal Value As Short)
End Module
```

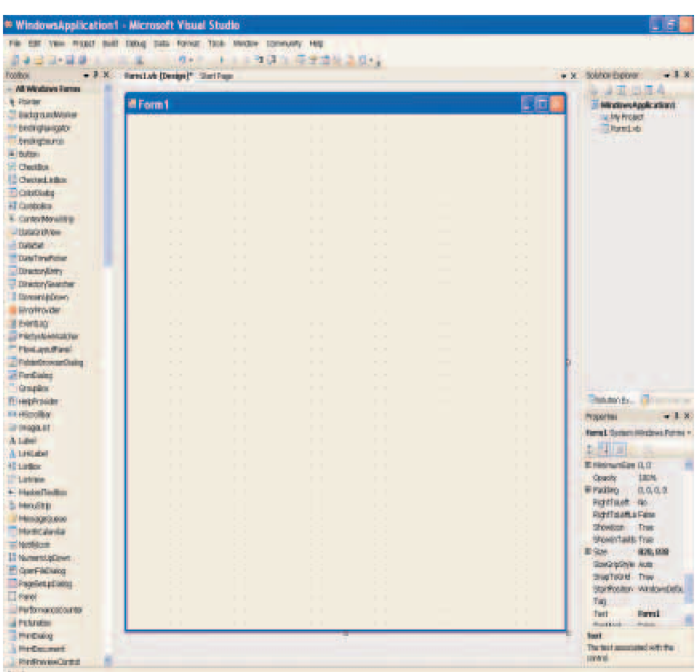


Fig.1. As one would probably expect, Visual BASIC 2005 Professional has a basic setup that is essentially the same as that of the Express version. The form has a Toolbox of components to its left and the Properties window in the right-hand column

The INP and OUT commands should then work correctly, and if everything is all right, the usual hint text will appear when you are entering an INP or OUT instruction. The hint text will not appear if something is not quite as it should be, and the word INP or OUT will then be underlined to show that it has not been recognised. The most likely cause of this problem is the **Inpout32.dll** file either being absent or not being where the program expects to find it.

The module can be saved by right-clicking its tab and selecting the Save option from the pop-up menu. It will be saved under its current name with a 'vb' extension being added automatically.

In order to use the Inp and Out commands in the future it is just a matter of starting a new project and then adding the module to it. With an existing module this is done by selecting Add Existing Item from the Project menu, and using the file browser to find and open the correct module file. Do not use the Open File option in the File menu, as this will load the module's file, but it will not be used in the desired fashion.

Drawing on experience

One respect in which Visual BASIC 2005 Express Edition falls well short of the capabilities of Visual BASIC 6 is in the graphics department. Using graphics with the Express version of Visual BASIC has been covered in previous *Interface* articles. Experience with the previous version of Visual Studio suggested that the 2005 version was unlikely to be much better, and this is certainly the case. In their standard forms, Visual BASIC 2005 Standard and Professional Editions do not appear to offer any more than the Express version.

The usual components such as buttons, scrollbars, and labels are present, and there are instructions that permit simple graphic elements to be drawn onto a form. Unfortunately, there are no components that are comparable to the Line and Shape components of Visual BASIC 6. These enable shapes and lines to be dragged onto a form, 'fine tuned', and then, if necessary they can be controlled by the program. Among other things, this makes it very easy to implement analogue displays such as bargraphs and virtual panel meters.

Although there are no Shape or Line components included as standard, they are available as free add-ons in the form of Microsoft Visual Basic 2005 Power Packs 2.0. This software can be downloaded via the following address, which also includes some basic information about using these components:

http://msdn2.microsoft.com/en-gb/vbasic/bb735936.aspx

Having downloaded the program file, it is just a matter of running it to install the new components, which will then automatically appear in the Toolbox when Visual BASIC is run. There are actually three Shape components. These are the LineShape, OvalShape, and RectangularShape components. The OvalShape component actually produces circles and ellipses, while the other two do exactly as their names suggest. Fig.2 shows a form with examples of all three types of shape component.

While the new Shape components are not exactly the same as their Visual BASIC 6 counterparts, they are very similar, and can be used in much the same way. One difference is that their co-ordinate system is not the high resolution type of Visual BASIC 6, but a much lower resolution type that appears to be based on screen pixels.

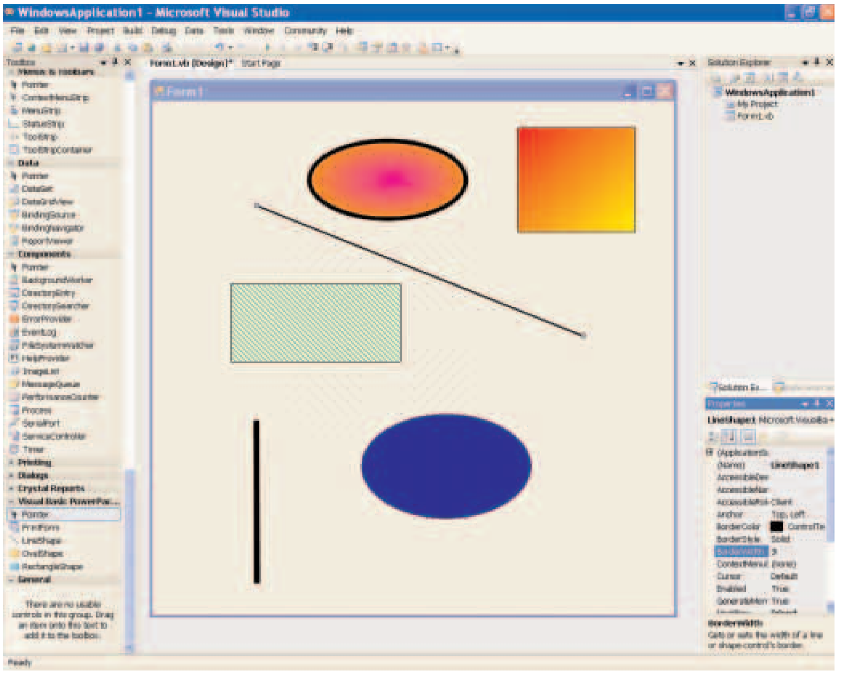


Fig.2. Some lines and shapes produced with the aid of the add-on Shape components. The RectangularShape and OvalShape components can have a range of fill types, including a choice of gradient types

This is probably something that is enforced by a change in the general co-ordinate system of the newer versions of Visual BASIC. The co-ordinates of the shapes can be altered using program commands, so it is easy to implement bargraphs and virtual panel meters. Fig.3 shows a dummy virtual meter that is controlled by the horizontal scrollbar, rather than readings from a port, but it could be made to respond to values from a port without any difficulty.

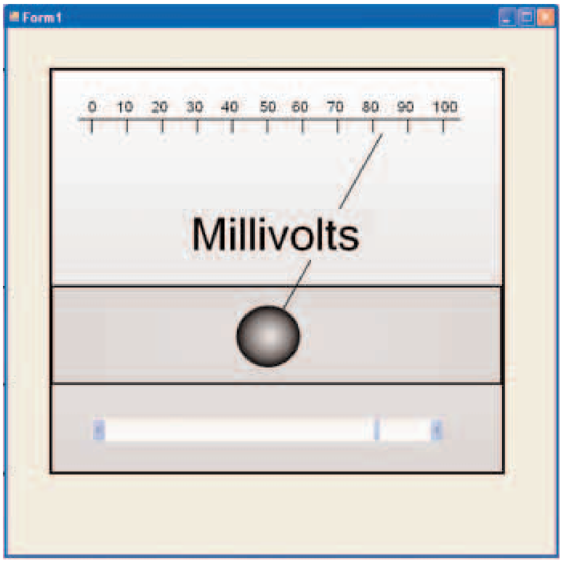


Fig.3. A virtual panel meter produced using the Shape components. It is controlled by the horizontal scrollbar, but could just as easily be made to respond to readings from an input port

Visual BASIC 2005 Express Edition would be greatly improved by the addition of these components, but as far as can be ascertain, this is not possible. The Power Packs 2 file can be downloaded and installed, but the additional components do not appear in the Toolbox when Visual BASIC is run.

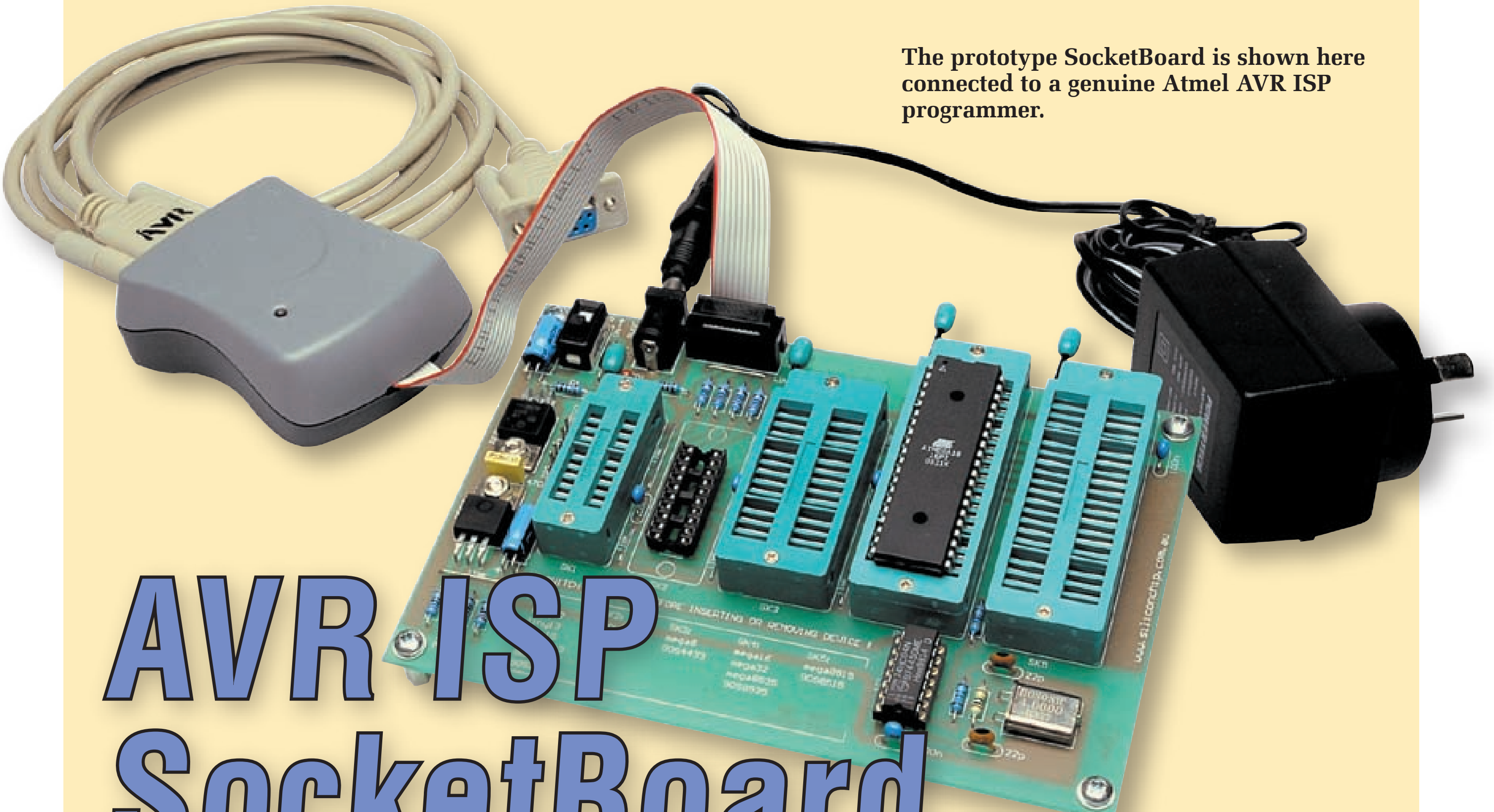
Finally

All versions of Visual BASIC 2005 are supplied with a serial port component as standard. This might not seem to be of great importance since ordinary RS232C serial ports are now obsolete and have not been a standard feature of new PCs for some time. However, some USB input/output boards are installed in the computer as ordinary COM serial ports, and can then be accessed as if they were genuine serial ports. Once the drivers have been installed it should be possible to use Visual BASIC 2005 with USB boards of this type without the need for any software add-ons.

The Standard and Professional editions of Visual BASIC 2005 can certainly act as a good substitute for Visual BASIC 6, but only with the aid of some add-on components if the full graphics potential of Visual BASIC 6 is required. Users moving from Visual BASIC 6 to one of the 2005 versions should bear in mind that numerous changes to the language are evident when using the newer versions. It can take a while to get used to these changes, making it tough going when first making the switch, and possibly for some time afterwards.

AVR ISP SocketBoard

By PETER SMITH



The prototype SocketBoard is shown here connected to a genuine Atmel AVR ISP programmer.

Teamed with an AVR in-system programmer, this board enables you to programme Atmel microcontrollers on the spot – without an expensive production programmer or development system. It supports just about all dual-in-line AVR micros and includes over-current protection.

MOST ATMEL AVR microcontrollers can be programmed via their in-built serial programming interfaces (SPI). This method is ideal for in-situ programming, such as might be used in manufacturing or for firmware development or field upgrades.

In this scenario, the micro remains in its socket on the application board and a low-cost in-system programmer (ISP) is plugged into a dedicated programming header. In other words, the microcontroller does not have to be removed from its socket and plugged into a parallel programmer each time a firmware update is required.

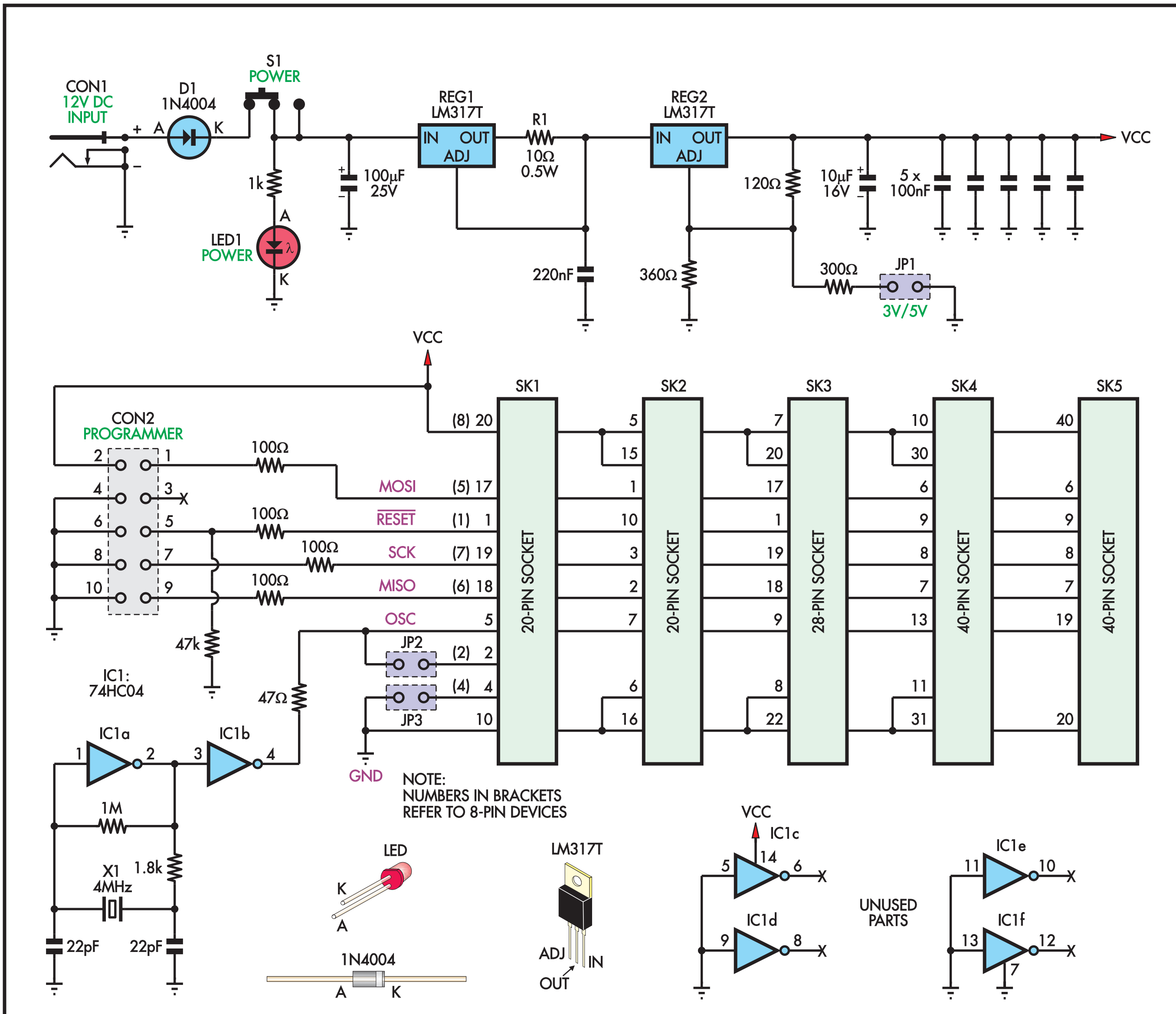
However, in some cases it is desirable to programme a microcontroller stand-alone, such as when the application board is unavailable or doesn't include an ISP (or JTAG) header. A low-cost method of stand-alone programming might also be useful where a batch of chips is needed for a small prototype run and the cost of a commercial parallel programmer is prohibitive.

This is where the AVR ISP SocketBoard comes in. It provides the minimum of functions necessary to support in-system programming, including a regulated power supply, clock source and microcontroller IC socket. Just connect your in-system programmer to a PC, plug its ISP cable into the SocketBoard's on-board header and add a DC plugpack. You're then ready to start programming!

Programming sockets

As you can see from the photos, the SocketBoard contains five programming sockets. Why so many? Well, we've provided one programming socket for each group of micros with common SPI pinouts. This allowed us to eliminate the switching logic that would have been required if we'd used just a single, 40-pin socket, so greatly simplifying design and construction.

We expect that many constructors will install just one or two programming sockets (depending on their requirements), to keep costs as low as possible. The overlay diagram (Fig.2) lists specific device types and the sockets (SK1 to SK5) that support them. For example, to program the ATMega16, socket SK4 must be installed.



JUMPER	IN	OUT
JP1	3V SUPPLY	5V SUPPLY (DEFAULT)
JP2 & JP3	8-PIN DEVICE IN SK1	20-PIN DEVICE IN SK1

Fig.1: the SocketBoard consists of a current-limited power supply, oscillator, ISP header and a series of programming sockets. This simple configuration supports most dual-in-line packaged AVR micros. Surface-mounted equivalents can be accommodated by using commercial DIL adapters.

For cases where quantities of chips need to be programmed, the board will accept standard zero insertion force (ZIF) sockets as well. There is absolutely no need to install ZIF sockets (as shown in our photos) for occasional programming; this would simply be expensive overkill.

The unit can be powered from a 12V DC 150mA (or higher) unregulated plugpack, which also powers the ISP programmer when it's plugged into the on-board header.

Operation

As mentioned, the SocketBoard provides the minimum of functions necessary to support in-system programming. As stated, this includes a series of programming sockets to accommodate the different types of AVR micros, a regulated power supply, and a clock source.

The power supply is based around two series-connected LM317 adjustable positive regulators (see Fig.1). The first regulator acts as a current limiter. In normal operation, it performs no function. However, should the current through R1 increase to a level where about 1.25V is dropped across it, REG1 begins to reduce the voltage at its OUT terminal. In effect, REG1 then acts as a constant current source, limiting output current to a maximum of 125mA.

In normal operation, the complete setup consumes an average of about 20 to 40mA, depending on the type of in-system programmer connected. The remaining capacity (85 to 105mA) leaves a comfortable margin, which in most cases is still low enough to preserve any micro that might be accidentally reversed in a socket. It also

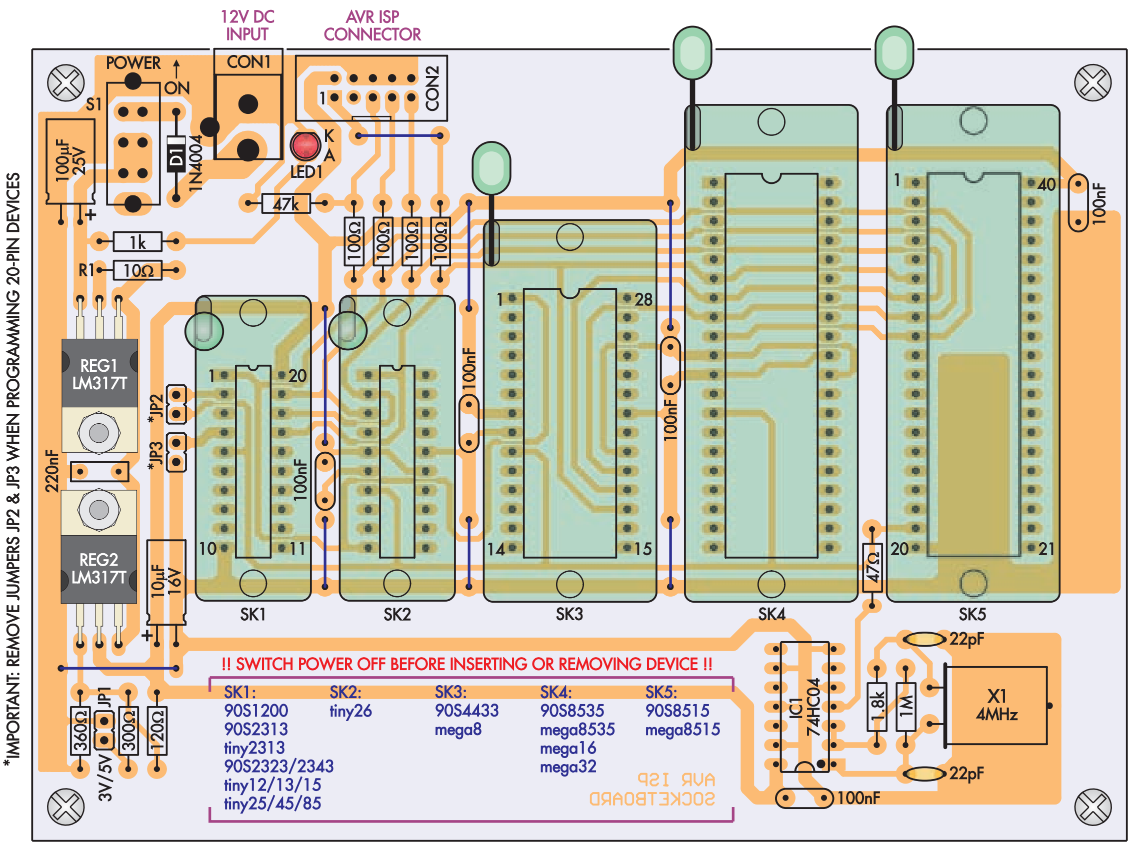


Fig.2: follow this diagram closely during assembly. Take particular care with the orientation of the electrolytic capacitors, D1, LED1 and IC1. Also, be sure to install the 10-pin header (CON2) with the keyway facing towards the programming sockets. Note that although we show ZIF sockets in five positions, most constructors will require only one or two for high-volume programming.

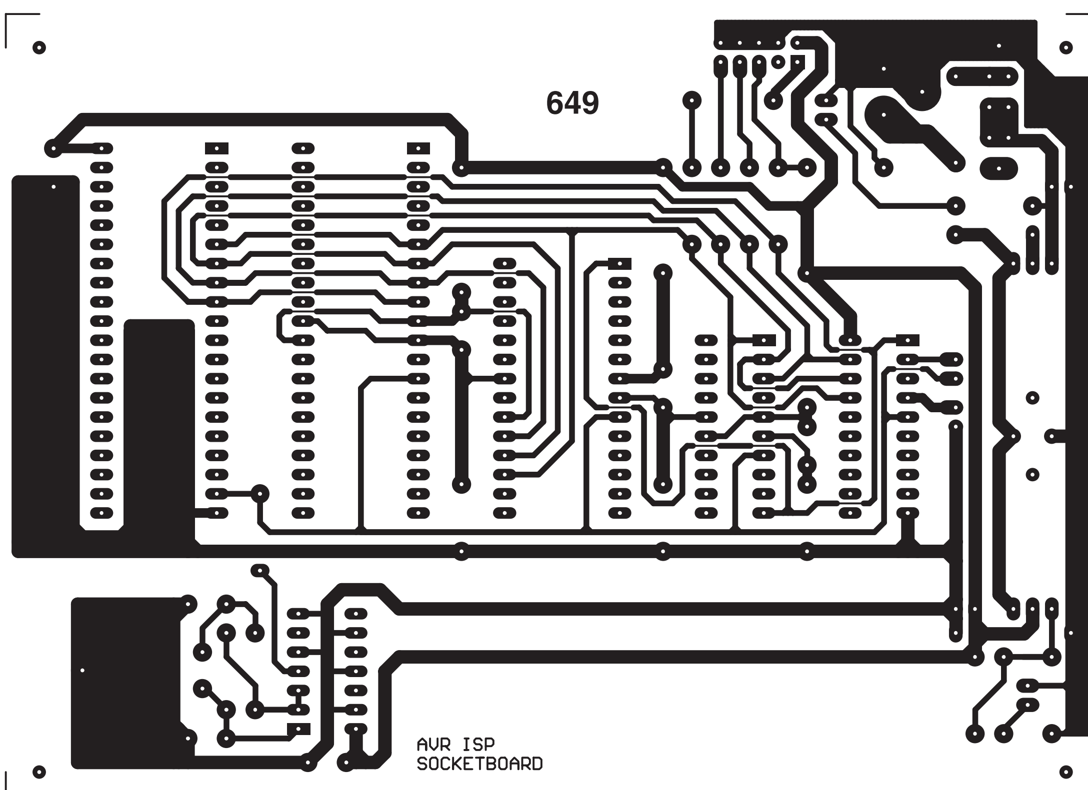
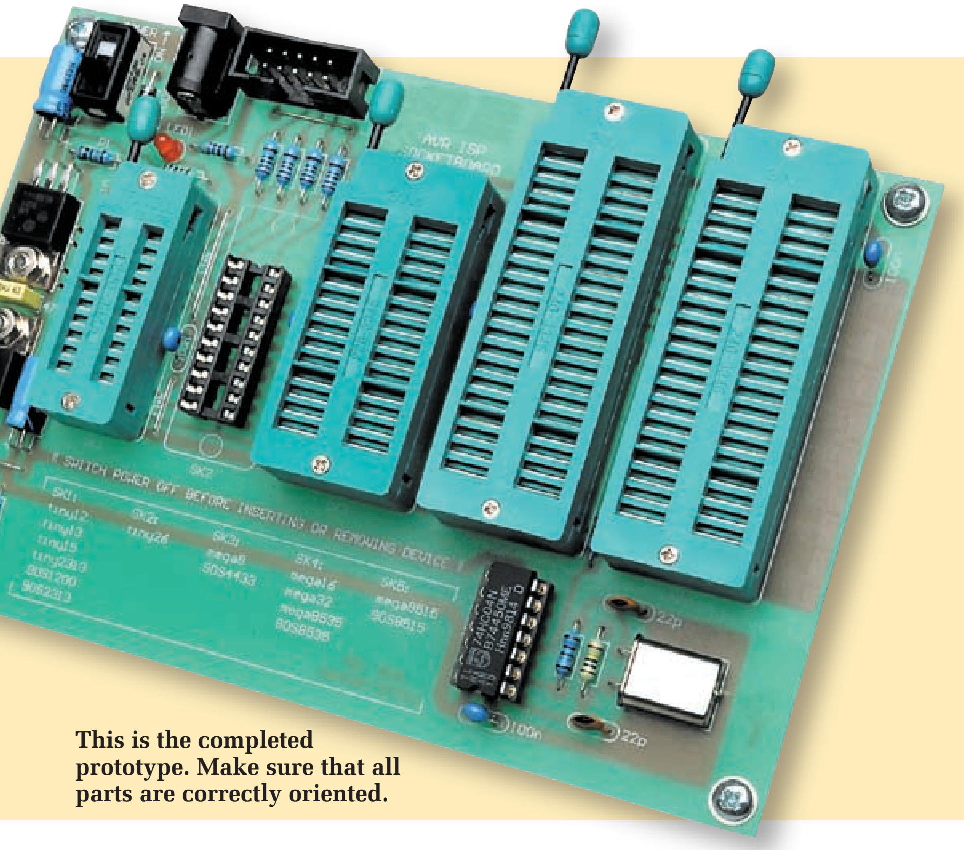


Fig.3: the full-size etching pattern for the PC board. It can also be downloaded from the *EPE* website.



This is the completed prototype. Make sure that all parts are correctly oriented.

Suitable Programmers

This project has been tested with two programmer variants, as follows:

- **AVR ISP Serial Programmer**, as described in the October 2002 issue of *Silicon Chip*. This programmer connects to your PC's serial port. It's available as a kit from Jaycar Electronics (Cat. KC-5340).
- **AVR ISP Programmer.** This genuine Atmel item is supplied preassembled and again, it connects to your PC via a free serial port.

protects other components if an internally short-circuited micro is plugged into a socket.

The second regulator (REG2) is configured as a conventional voltage regulator. Without JP1 installed, it produces +5V to power the system. Installing JP1 reduces this to +3V. Some constructors may find this lower voltage useful for verifying the memory in micros that are destined for 3V systems.

As well as power, AVR micros require a clock source for their internal programming circuits to operate. This is provided by a Pierce oscillator, which is composed of a 4MHz crystal (X1), two resistors and one gate of a 74HC04 hex inverter (IC1a). A second gate (IC1b) buffers the clock signal before it is applied to all of the programming sockets. A 47Ω resistor provides series termination and current limiting.

All that now remains to be described is the ISP interface. This is extremely simple indeed, as it consists only of a 10-pin DIL header (CON2) and five resistors. The four 100Ω series resistors act as peak current limiters, in case the ISP cable or a chip is accidentally inserted with power applied. These also help to protect the programmer if a faulty micro is inserted in a socket.

The remaining resistor (47kΩ) pulls down the interface's RESET line, so that the micro is held in the reset state if a programmer is not connected or is non-functional.

Assembly

Using the overlay diagram (Fig.2) as a guide, install all the low-profile components first, starting with the wire links and resistors. There are seven links in total, all of which can be fashioned from 0.7mm tinned copper wire or similar.

Follow with all of the capacitors, noting that the leads of the 10µF and 100µF units must be bent at right angles before installation. Before bending the leads, check that you have the positive leads oriented correctly.

The crystal (X1) also mounts horizontally, so bend its leads about 2 to 3mm from the can before installation. Once in place, a short length of tinned copper wire should be soldered to the top of the can and the pad directly below to secure it in position.

Diode D1, LED1, header CON2 and the 14-pin socket for IC1 can now go in. All of these items are polarised, so make sure that they're installed the right way around. Don't plug the 74HC04 into its socket just yet, though; it's a good idea to test the power supply first (see below).

All of the remaining items can now be installed, leaving the five programming sockets (SK1 to SK5) until last.

The two LM317 regulators (REG1 and REG2) should be attached to the PC board using M3 × 6mm screws, nuts and flat washers. As shown, their leads must be bent at right angles before installation. Be sure to tighten the screw and nut before soldering the leads, otherwise damage to the regulator package or PC board may result.

The three 2-pin headers (JP1 to JP3) can be cut down from a longer section using a sharp knife. Check that each header is sitting square on the PC board surface before soldering.

Finally, install just the programming sockets (SK1 to SK5) that you require. For casual use, low-cost IC sockets can be installed in any or all of the indicated positions. Alternatively, ZIF type sockets can be fitted to any positions that are expected to be high usage – it's up to you.

Testing

Connect a 12V DC source to the DC socket (CON1), noting that the centre pin is the positive input. If the power connections are accidentally reversed, nothing bad will happen as a series diode (D1) provides polarity protection.

Now apply power by sliding switch S1's actuator towards the edge of the

Parts List

1 PC board coded 649, available from the *EPE PCB Service*, size 145 x 105mm
1 4MHz crystal (HC49 package) (X1)
1 DPDT PC-mount slide switch (S1)
1 10-pin dual-row shrouded (boxed) PC-mount header
1 2.1mm PC-mount DC socket (CON1)
2 20-pin IC sockets (SK1, SK2)
1 28-pin IC socket (SK3)
2 40-pin IC sockets (SK4, SK5)
1 6-pin 2.54mm (0.1-inch) SIL header strip (for JP1 to JP3) – see text
3 jumper shunts
6 M3 x 6mm pan head screws
2 M3 x 6mm nuts and washers
4 M3 x 10mm tapped spacers
160mm (approx.) 0.7mm tinned copper wire (for links)
Note 1: if desired, small stick-on feet can be used in place of the tapped spacers.

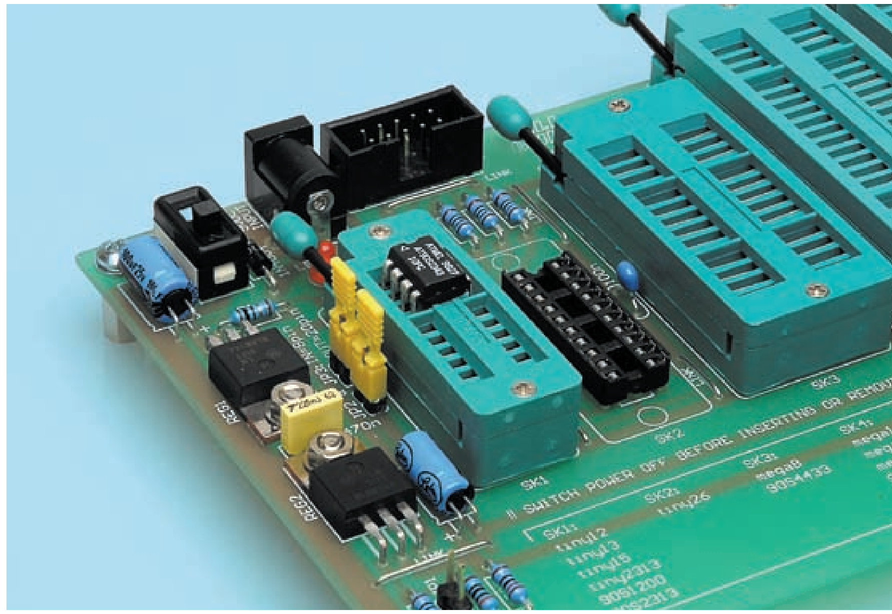
Semiconductors
1 74HC04 hex inverter (IC1)
2 LM317T adjustable voltage regulators (REG1, REG2)
1 1N4004 diode (D1)
1 3mm high-brightness red LED (LED1)

Capacitors
1 100µF 25V PC electrolytic
1 10µF 16V PC electrolytic
1 220nF 50V MKT polyester
5 100nF 50V monolithic (multi-layer) ceramic
2 22pF 50V ceramic disc

Resistors (0.25W, 1% metal film)

1 1MΩ	1 300Ω
1 47kΩ	1 120Ω
1 1.8kΩ	4 100Ω
1 1kΩ	1 47Ω
1 360Ω	1 10Ω 0.5W

Note 2: See text regarding the IC sockets required



8-pin devices are programmed in the first 20-pin socket (SK1). Here's how they're inserted, with pin 1 in the same position as for 20-pin devices. Note that jumper shunts must be installed on JP2 and JP3 when programming 8-pin devices.

board. The power LED should light immediately. If it doesn't, either the power connections are reversed or there is an assembly error. Carefully recheck the board against the overlay diagram and look for dry or missed solder joints.

Next, use your multimeter to measure the voltage between pins 7 and 14 of IC1's socket. Expect a reading of 5V ±5%. Temporarily insert a jumper shunt on JP1 and measure the voltage again. This time, you should get the lower reading of 3V ±5%. When done, remove the jumper, as in the majority of applications, a 5V supply is preferred for programming.

If the power supply checks out, switch off and insert IC1 into its socket. Naturally, the position of the notched (pin 1) end of this IC must match that of the IC socket.

Using it

It doesn't take a lot of grey matter to use the SocketBoard. Simply switch power off, plug your in-system programmer into the AVR ISP connector (CON2), and insert the microcontroller to be programmed into the designated socket. After switching on, the micro can be programmed following the instructions supplied with your ISP.

Important: always switch the power off before inserting or removing a microcontroller from its programming socket.

Note that 8-pin micros present a special case. Instead of a separate socket, all 8-pin devices are programmed in the first 20-pin socket (SK1). In addition, jumper shunts must be installed on JP2 and JP3 to route signals to the correct places for these diminutive devices.

After programming an 8-pin device, the two jumper shunts (JP2 and JP3) should be removed if you also intend to program 20-pin devices in the same socket. This ensures that there is no possibility of damage to the larger devices.

If a faulty micro is inserted in a socket or if a working device is inserted backwards, the current-limit function will swing into action. In most cases, the current passed through the part should not be destructive – if the problem is noticed right away and power is switched off immediately! ***EPE***

Warning!

Programming the 'reset disable' fuse present on some smaller AVR devices disables the RESET input, with the side effect of preventing further programming via the SPI port. In other words, you'll no longer be able to use your in-system programmer to erase, read, write or verify the affected part.

To restore SPI access, the device must be erased on a parallel programmer, high-voltage serial programmer or JTAG programmer, depending on the device in question. Do not experiment with fuse settings unless you know exactly what they do!

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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★ LETTER OF THE MONTH ★

Flowcharts

Dear EPE,

Your correspondence with Edward Chase in the August issue reminded me of my experience with flowcharts. In the olden days, the flowchart was about the only design and documentation tool available, and some managers regarded them as the 'bee's knees'.

Early in my career, I encountered a manager who ruthlessly required all junior programmers to prepare flowcharts and insisted that we were not allowed to write even a single line of our program until he had reviewed and approved our flowchart(s). Although this policy seemed draconian at the time, it taught me much:

* Nothing, not even a waste of time, is a total waste of time

* If the program is so simple that a flowchart can describe it, it is so simple that it describes itself, and other descriptions are superfluous

* If the program is so complicated that some aid would be useful, it is so complicated that a flowchart is inadequate

* It is a huge chore to keep the flowchart and the program together. Even in modern times, with modern word processors like Word, the flowchart and the program will almost always be maintained as separate files, and the file containing the flowchart risks being lost or becoming obsolete

* Managers can't read flowcharts anyway.

Most programmers 'think' in the language in which they program. I remember an interview of the great polymath, Jacob Bronowski. He had a very complicated life, moving from Israel, to Germany, to England. He reported that he did arithmetic in Hebrew, algebra in German, and calculus in English.

Programmers are similar. When programming a PIC, I really do think in terms of 'movf' and 'addwf' and 'movwf', rather than in terms of 'a = b + c', and certainly not in terms of boxes with lines joining them. I am reasonably certain that other programmers do too.

To cope with my problem manager, I learnt a trick from my more experienced colleagues. We would write our programs more or less secretly, and once they were written, we'd rewrite them as flowcharts to show to our manager. Sadly, this confirmed his belief that flowcharts were wonderful. Once he had approved our flowcharts, we appeared to write our programs almost instantly.

Modern design and documentation tools are much better than flowcharts. The most versatile is the pseudo language. Most programmers invent their own. For historical reasons, I write in a pseudo-Pascal; I'm sure modern programmers write in pseudo-C.

Another tool, borrowed from our commercial colleagues, is the decision table. This is surprisingly useful for real time applications, and has two important benefits. First, forgotten cases become conspicuous, like a missing tooth. Second, it is easy to follow the advice of Kernighan and Plauger, 'First get it right; worry about making it fast or efficient only if that is necessary, and do that only after you are confident that it is right.'

If we ignore efficiency, it is easy to design a correct table and to be confident that it is correct. Once the table has been designed, it is easy to shuffle the rows about to spot the most efficient way to implement it.

Even in real-time programming, if the answer is wrong, it doesn't matter how quickly our wonderful program achieved it.

Keith Anderson, Kingston, Tasmania

Thank you Keith for another valuable insight from you.

What Energy Saving?

Dear EPE,

I have been reading (and not just in *EPE*) some of the slightly desperate sounding measures that are proposed to save a few watts of power usage here and there. But in some cases I am completely at a loss to see where the energy is saved.

Measures such as using low-energy lamps, and switching equipment off instead of into a standby mode, seem to be aimed at the domestic user. In spite of the impressive figures generated by quoting the national or global sum, the actual energy saved from these measures will be close to zero, except possibly in summer.

Why? Well, by far the greatest part of domestic energy use goes into intentionally heating the house, but it should be remembered that all the other energy used (except for light lost through the windows) also finishes up as heat.

Usually the house heating will be thermostatically controlled. But a consequence of this is that, if the unintentional heating is reduced, the real heating system will just work that bit harder to make up the deficiency!

So by all means buy expensive lamps and switch off unused equipment if it makes you feel virtuous. But then listen to see if you can hear your boiler coming on more often to compensate! Where is the saving?

Tony Jaques (Tony, G3PTD), Stretford, Manchester, by email

Thanks Tony, I can't see a flaw in what you say. Can anyone?

Calibration

Thirty years ago, when I worked as chief calibration engineer, I obtained a precision voltmeter from Solatron. It could measure a volt down to seven decimal places and was so accurate that it showed there was no such thing as a standard volt to measure. Even the so-called chemical standard cells showed fluctuations due to tiny temperature changes.

With hindsight, we all should have realised that no way can you measure anything that accurately with DC amps using 1% tolerance resistors, especially as they change with age as well. They thought that all you had to do was to introduce a numerical offset and it would stay magically accurate for years.

Funny thing was, the men from the ministry believed every word of it. As it was, if you declared it as the firm's primary standard then the ministry would want it to be kept in a glass case and never used, yet on one calibration job alone it saved 14 hours work.

Even now you can buy a digital voltmeter for £10 in the market which is sold as 10 times more accurate than an Avo 8. The norm was that calibration test gear had to be 10 times as accurate as the gear under test and there was nothing on the market at any price that could do it.

George Chatley, via email

That's interesting George. I can't believe that the typical hobbyist is ever going to require such acute accuracy – or are they?

ADE7756AN IC

Dear EPE,

If it would be helpful to any future constructors of the *Energy Meter* project (May '07), I now have a spare supply of the ADE7756AN ICs at £4 each, UK post inclusive. If any reader would like one, then please email me at: **jmbaldwin 2005@yah oo.co.uk**.

John Baldwin, via email

Thanks John, your kind offer is now publicised!

12V Car Battery Chargers

I recently made the following comment on the EPE Chat Zone *(via* **www.epemag.co.uk***). Some of the resulting replies follow:*

I've just been trying to buy a 12V battery charger for my car. In the distant past I've built my own but for the last 30 years or so have been using one I inherited, with a meter to show the charging current, something which I find useful to observe.

I have failed to find a similar modern one. Those from Halfords either have no visible current monitoring and just show whether the battery is charging or not, or have a digital display and at a horrendous price.

Does anyone know of a source for such chargers with an analogue meter needle? Max current about 5 amps.

philwarn: I suggest you buy a cheap 5 to 6 amp 12 volt charger and use a cheap analogue/digital multimeter to monitor the current. I also suggest you browse eBay.

zeitghost: A moving iron ammeter will give a more realistic reading for the charging current (square law and all that). Maplin did a 5A or 10A one. A true rms digital meter would do the same thing.

vlf: A high current 12V lamp bulb in series would be much cheaper... gives dim light at full charge, and medium to bright on low charge, or constant brightness for a duff battery.

john_becker: Thanks all – I had hoped/expected I could go into a local car spares shop and get what I wanted, but apart from Halfords and a local shop, I don't know anyone else, but wondered if other known-name sources might be around.

I'm very surprised that no-one seems to want an analogue meter version now. They used to be the only thing available – many, many years ago. Yes, a meter in series would do the trick I guess. Just a bulb is also a workable idea.

Another odd thing is that car spares shops around here used to be quite numerous, but all there seems to be now is one in rather a 'back-water' area, apart from Halfords. Has car maintenance as a hobby gone the way of so many things?

zeitghost: Yup – died the death – about all you can do these days is replace the oil, oil filter and air filter. Everything else is largely unfixable without special tools, or worse, special software. Ho hum.

One of my electric windows just failed and the loom has about 15 wires in it. The motor itself has two relays and a microcontroller, plus a Hall sensor to count revolutions and monitor current. Probably a snip at £100!

gordon: John, not sure what your budget is but Argos have one for £30.

I also agree that fixing modern cars is not as easy as it once was, everything seems to be shoehorned in. I think most modern cars tell the mechanic what is wrong via the onboard computer!

Gordon also quoted a full URL, but it's too long to repeat here – browse the Argos site at ***www.argos.co.uk****. When I browsed it, the charger was what I wanted, with analogue meter. I went into my local Argos and bought one from stock. It's a very nice one. Thank you Gordon.*

MPLab Mistake

First off, may I say I really look forward to receiving *EPE* every month.

In your Sept 2007 edition and Mike Hibbett's article *Using MPLAB*, I think there is a mistake. On page 39 the line above the 3rd last paragraph reads: **'MPLIB utils.lib random.o delays.o'**

To create a library you should include the **/c** (create) switch. So, therefore, I think this line should read:

MPLIB /c utils.lib random.o delays.o.

If you try it you will see what I mean. Another handy switch is the **/t** switch. This displays the names of the object modules contained in a library file. So to see what is in utils.lib you type:

mplib /t utils.lib

Peter Barrett MIEAust,
via email

Mike Hibbett replied to Peter:

Well spotted, thanks. The **/c** was left off by mistake.

Thanks also for pointing out the tip about displaying the contents of libraries. If you run MPLIB without any command line options, it will display several other interesting options too, which the more adventurous might like to investigate.

Mike Hibbett,
via email

MPLab ORG

Dear EPE,

I have been reading with interest Mike Hibbett's recent series on *Using MPLAB* and I have also been reading the *PIC Tutorial V2*. There is something I do not understand. In the *PIC Tutorial* Listing 1 it shows ORG 0, 4 and 5 but in the MPLAB Fig.1 it does not show anything about ORG 0, 4 and 5. How does the software work without these. Does MPLAB put this in automatically?

Pepe Rush,
via email

Mike Hibbett replies:

Well spotted Pepe. The example code does not include an ORG 0 statement because the assembler defaults to zero. It's not MPLAB doing this, but the assembler program that MPLAB uses 'under the hood'.

It's probably a good idea to put the ORG statement in though, because it shows your original intention more clearly. Thanks for drawing our attention to the point.

Mike Hibbett,
via email

Loud Bangs and Memories

I believe the picture on the Editorial page of the Sept '07 issue shows the DC-DC converter module from a PCI 10Mbps network card. Wow, how that picture took me back. I've seen these go bang many times as, probably 17 years ago I used to repair network cards (they were expensive at the time).

I've had a DC-DC converter explode immediately after fitting it brand new from the manufacturer's shipping tube; the entire 'lid' of the package was removed and some rather large, sharp lumps of encapsulation embedded themselves in the plasterboard ceiling. The end result was a free tube of replacement parts from the manufacturer, and the habit now of turning away from a board when it's powered up and a healthy understanding of what parts should and probably should not be encapsulated.

I don't encapsulate anything unless it's absolutely necessary and even then only after careful consideration. Electrolytic and tantalum capacitors being my main concerns, I try to arrange for the tops of capacitors to be exposed wherever possible so that any malfunction that results in pressure build up can be vented without causing loud bangs and flying debris.

Thanks for making me remember my age and keep up the good work with the mag, I've been reading it in all its various forms for over 20 years now and I still look forward to seeing what's in next month's issue.

Clint Sharp,
via email

Thanks Clint. Horrifying what can happen with some faults if one is not aware of the possibilities.

Sinclair ZX81

Martin(?) recently emailed Alan Winstanley seeking his soldering guidance and enclosing a photo of a PCB for Alan to examine:

I am building a Sinclair ZX81 from detailed instructions which don't seem to indicate two separate solder joints for each component. That said, the board does have tracks on both sides and what would be the point in that unless they were supposed to be soldered on both sides? Some joints seem to be soldered and some don't! It seems to be crucial to me. What do you think?

Alan replied to Martin:

It's an old board from an era where double-sided PCBs were more primitive – they would not want you to insert a resistor from the top, through a solder pad, if it wasn't meant to connect to the track on top, because otherwise there would be a risk of the component lead shorting the track on top (e.g. the bottom ends of some resistors should IMHO be soldered to the large copper track on top. They're almost shorting to it anyway.)

The solder through-holes are big compared with modern PCBs, and so in that case the answer is actually 'yes' – they have left so much space to make it possible for molten solder to pass through and join both sides together in a solid well of solder.

It is better still to add small amounts of solder on top just to help the process along. Just a quick dab with the iron. I have seen this form of construction many times. All the 'empty' solder pads you see are vias, connecting through to tracks on the other side of the board. If you can fix a wobbly 16k RAM pack you may be on to a winner!

Alan Winstanley
via email

Maglev Systems

Dear EPE,

I have enjoyed your magazine now for some years and find it helpful in all aspects! For some time I have had an interest in Linear Induction Power, primarily maglev systems. I have all Professor Braithwaite's notes from 1947, when British Railways were running initial tests.

The Professor's notes give details of three model versions to build. While I am happy to build a model based on his notes, my problem is lack of knowledge as regards the control structure to run a model. As an amateur model engineer, I am more conversant with live steam railways. Is there any reader who could point me in the right diection to build a test model? I do not have access to a computer.

R.D. Mitchell,
Gt. Yarmouth, Suffolk.

Anyone who can help please write to Readout.

Net Work

Alan Winstanley

Keeping your word

One of the author's perennial grumbles is the way in which Microsoft Word has become the market's wordprocessor by default, pre-installed into many personal computer systems as part of Microsoft Office as if no alternative is available. The writer has blissful memories of typing early manuscripts for this magazine on a 1992 pre-Internet 486 PC using the wonderful Lotus Ami Pro word processor, a very elegant software package that was ultimately subsumed into IBM as Lotus Smartsuite.

The arrival of the Internet meant that new online features were integrated into successive releases of word processing packages – which is why (annoyingly) Word converts web addresses into clickable hyperlinks, and why Word offers to save documents as HTML web pages full of enough source code to make many web designers shudder.

This month's *Net Work* points the way for those looking at the thorny problem of free and paid-for Word and Office software upgrades, helping to fix any document compatibility problems along the way.

Today's upgraders face some agonising questions, the most important one being the choice of operating system. Some battle-hardened IT consultants still eschew Windows Vista in favour of XP, due to the headaches of software compatibility and the lack of hardware drivers. Some enthusiasts and experimenters may favour Linux and some will marvel at the latest Intel-based Apple Mac OS systems that can run Windows XP seamlessly using Parallels Desktop for Mac software (see **www.parallels.com**).

Looking at commercial word processing packages first, the writer admits to having persevered with Microsoft Word 2000 for far too long. It has become long in the tooth, offers too many options that make it counter productive, not to mention being clunky and downright annoying at times. However, it's familiar and it works. Obviously, the pressure is always on to upgrade, which brings problems of steep learning curves, as well as ensuring compatibility with legacy documents and files generated by one's peers.

This latter problem was highlighted recently when handling Word documents created with Microsoft's latest package. Word 2007 is very different from its predecessors and is the result of enormous usability research plus a focus on XML integration. There seems to be no dispute that the heavyweight Microsoft Office 2007 is the ultimate iteration of this powerful software. One problem though is that Word 2003 and earlier versions do not recognise native Word 2007 files, because Word 2007 saves files in its XML-based .docx format by default. For most readers, it is not worth upgrading just to open newer 2007 filetypes.

All is not lost though, and a search on the Internet reveals resources that help users handle this increasing problem. First, Word 2007 users should enable 'Compatibility mode' (q.v.) and export their work as the older .doc format instead of the new .docx (XML) filetype. More details of compatibility are blogged by the Microsoft Office Team at **http://tinyurl.com/3bnweu** – scroll down to click through to read Part 2.

OpenOffice.org is a completely free downloadable software suite containing a word processor, spreadsheet, graphics package and equations editor

Owners of previous versions of Word can also install the free Microsoft Office Compatibility Pack, and the place to go is **http://support.microsoft.com/kb/924074**. In difficult cases, one solution is to export files in a basic common format such as RTF (Rich Text Format), which will at least preserve the text and basic style. This is especially so when handling Microsoft Works .wps documents.

A free trial of Office 2007 is available from **http://office.microsoft.com/**. Microsoft Word 2007 costs about £160 ($320) alone, and Office tips the scales at some £370 ($740). Upgrade and home/student prices are available and it is absolutely essential to shop around, Googling for the best price.

Some wordy alternatives

Looking at alternative word processing packages, the veteran Word Perfect word processor is alive and kicking as part of a modernised Corel Office X3 (ie version 13) package (see **www.corel.com**), with home and office suites available from £50 ($99). This may well suit readers wanting a commercially-supported product but without the industry-strength or cost of Office 2007.

Die-hard Lotus Ami Pro fans might consider IBM Lotus Smartsuite Millennium Edition 9.8 for about £190. Details are listed on **www.ibm.com**. It includes Word Pro ('for today's Internet-centered world') though it does not claim to be Vista compatible. Lotus Smartsuite is increasingly a legacy product that still enjoys a following, but examine the datasheets very closely before committing to buy.

Sun Microsystems offers the very popular StarOffice suite, incorporating StarOffice Writer, Calc spreadsheet, Draw graphics and Impress presentations. Singapore Airlines offers StarOffice onboard for its business customers. StarOffice 8 is a fully featured suite at a remarkably low cost (£35/$69.95) and may be just the thing for the non-demanding casual user. Linux and Solaris versions are also produced. Download a trial from **www.sun.com/staroffice**.

If cost is an issue, then OpenOffice (or more correctly, OpenOffice.org), is an open source product founded on Sun's StarOffice that is a completely free download from **http://www.openoffice.org**. Wikipedia offers interesting background reading about its evolution at **http://tinyurl.com/uwmsx**. It is standards-compliant open source software, and claims to offer compatibility with major office suites; technical readers may also enjoy its 'Math' equation editor package. You can install OpenOffice.org on as many PCs as you wish, give it away, send it to friends and use it for any purpose, without worrying about the cost of licences.

Working with the Open Source community is very different from dealing with commercial enterprises: there is a spirit of friendliness and helpfulness, and an eagerness to share ideas and help fellow users, but without the corporate focus. Provided you can accept this unpolished community approach to using software, OpenOffice.org might be the perfect solution for many *EPE* readers who do not need the latest and greatest in office programs – and who enjoy writing equations! You can email me at: **alan@epemag.demon.co.uk**

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.

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Robotics

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. Then explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Details building and programming instructions provided, including numerous step-by-step photographs.

288 pages – large format **Order code BP901** **£14.99**

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision Command System

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using Lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

298 pages **Order code BP902** **£14.99**

ANDROIDS, ROBOTS AND ANIMATRONS – Second Edition – John Iovine

Build your own working robot or android using both off-the-shelf and workshop constructed materials and devices. Computer control gives these robots and androids two types of artificial intelligence (an expert system and a neural network). A lifelike android hand can be built and programmed to function doing repetitive tasks. A fully animated robot or android can also be built and programmed to perform a wide variety of functions.

The contents include an Overview of State-of-the-Art Robots; Robotic Locomotion; Motors and Power Controllers; All Types of Sensors; Tilt; Bump; Road and Wall Detection; Light; Speech and Sound Recognition; Robotic Intelligence (Expert Type) Using a Single-Board Computer Programmed in BASIC; Robotic Intelligence (Neutral Type) Using Simple Neural Networks (Insect Intelligence); Making a Lifelike Android Hand; A Computer-Controlled Robotic Insect Programmed in BASIC; Telepresence Robots With Actual Arcade and Virtual Reality Applications; A Computer-Controlled Robotic Arm; Animated Robots and Androids; Real-World Robotic Applications.

224 pages **Order code MGH1** **£16.99**

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The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order to your door. Full ordering details are given on the last book

For a further selection of books see the next two issues of *EPE*.

Radio

BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages **Order code NE30** **£20.00**

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.

92 pages **Order code BP304** **£4.45**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages **Order code BP257** **£5.49**

Computers and Computing

THE INTERNET FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s. Uses only clear and easy-to-understand language. Larger type size for easy reading. Provides basic knowledge to give you confidence to join the local computer class.

This book explains how to use your PC on the Internet and covers amongst other things: Choosing and setting up your computer for the Internet. Getting connected to the Internet. Sending and receiving emails, photographs, etc., so that you can keep in touch with family and friends all over the world. Searching for and saving information on any subject. On-line shopping and home banking. Setting up your own simple web site.

228 pages **Order code BP600** **£8.99**

BUILD YOUR OWN PC – Fourth Edition
Morris Rosenthal

More and more people are building their own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a state-of-the-art computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. The author goes 'under the hood" and shows step-by-step how to create a Pentium 4 computer or an Athlon 64 or Athlon 64FX, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows XP. The few existing books on this subject, although badly outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

224 pages – large format **Order code MGH2** **£16.99**

THE PIC MICROCONTROLLER
YOUR PERSONAL INTRODUCTORY COURSE – THIRD EDITION John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised third edition covers the popular reprogrammable Flash PICs: 16F54/16F84 as well as the 12F508 and 12F675.

270 pages **Order code NE36** **£18.50**

FREE CD-ROM

PROGRAMMING 16-BIT PIC MICROCONTROLLERS IN C – Learning to Fly the PIC24 Lucio Di Jasio (Application Segments Manager, Microchip, USA)

A Microchip insider tells all on the newest, most powerful PICs ever! Focuses on examples and exercises that show how to solve common, real-world design problems quickly. Includes handy checklists to help readers perform the most common programming and debugging tasks. FREE CD-ROM includes source code in C, the Microchip C30 compliler, and MPLAB SIM software, so that readers gain practical, hands-on programming experience.

Until recently, PICs didn't have the speed and memory necessary for use in designs such as video- and audio-enabled devices. All that has changed with the introduction of the first-ever 16-bit PIC family, the PIC24. This new guide teaches readers everything they need to know about the architecture of these new chips, how to program them, how to test them and how to debug them. Lucio's common-sense, practical, hands-on approach starts out with basic functions and guides the reader step-by-step through even the most sophisticated programming scenarios.

Experienced PIC users and newcomers alike will benefit from the text's many thorough examples, which demonstrate how to nimbly side-step common obstacles and take full advantage of all the new features.

496 pages + CD-ROM **Order code NE45** **£32.50**

NEWNES PC TROUBLESHOOTING POCKET BOOK – THIRD EDITION
Howard Anderson, Mike Tooley

All the essential data for PC fault-finding and upgrading. This book provides a concise and compact reference that describes, in a clear and straightforward manner, the principles and practice of fault-finding and upgrading PCs and peripherals. The book is aimed at anyone who is involved with the installation, configuration, maintenance, upgrading, repair or support of PC systems. It also provides non-technical users with sufficient background information, charts and checklists to enable the diagnosis of faults and help to carry out simple modifications and repairs. In order to reflect rapid changes in computer technology (both hardware and software) this new edition has been completely revised.

256 pages **Order code NE41** **£20.50**

Theory and Reference

ELECTRONIC CIRCUITS – FUNDAMENTALS & APPLICATIONS
Third Edition
Mike Tooley

A comprehensive reference text and practical electronics handbook in one volume – at an affordable price!
New chapter on PIC microcontrollers – the most popular chip family for use in project work by hobbyists and in colleges and universities.
New companion website: spreadsheet design tools to simplify circuit calculations; circuit models and templates to enable virtual simulation; a bank of on-line questions for lecturers to set as assignments, and on-line self-test multiple choice questions for each chapter with automatic marking, to enable students to continually monitor their progress and understanding.
The book's content is matched to the latest pre-degree level courses, making this an invaluable reference for all study levels, and its broad coverage is combined with practical case studies, based in real-world engineering contexts throughout the text.
The unique combination of a comprehensive reference text, incorporating a primary focus on practical applications, ensures this text will prove a vital guide for students and also for industry-based engineers, who are either new to the field of electronics, or who wish to refresh their knowledge.

400 pages **Order code NE43** **£24.95**

BEBOP TO THE BOOLEAN BOOGIE
Second Edition
Clive (Max) Maxfield

BOOK PLUS CD-ROM

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. Comes with a free CD-ROM which contains an eBook version with full text search plus bonus chapter – An Illustrated History of Electronics and Computing.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

500 pages **Order code BEB1** **£27.50**

BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

CD-ROM

This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!

Over 800 pages in Adobe Acrobat format

CD-ROM **Order code BEB2 CD-ROM** **£21.95**

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**

STARTING ELECTRONICS, THIRD EDITION
KEITH BRINDLEY

A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.

A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.

Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages **Order code NE42** **£11.50**

THE AMATEUR SCIENTIST
CD-ROM – VERSION 2

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.*

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The most complete resource ever assembled for hobbyists, and professionals looking for novel solutions to research problems. Includes extensive Science Software Library with even more science tools. Suitable for Mac, Windows, Linux or UNIX. 32MB RAM minimum, Netscape 4.0 or higher or Internet Explorer 4.0 or higher. *Over 1,000 projects*

CD-ROM **Order code AS1 CD-ROM** **£19.95**

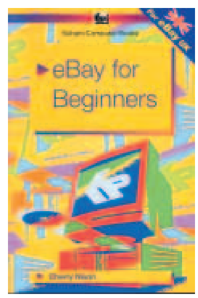
eBAY FOR BEGINNERS
Cherry Nixon

There are two kinds of people, those who are trading on eBay and the rest who are missing out. Though eBay has been embraced by entrepreneurs all over the world, it remains the peoples' site and offers the largest market for the smallest fee.

eBay presents an opportunity for everyone, the trick is to master it. This book shows you how to start trading on eBay UK. It also offers advice on getting organised and tips to put you ahead.

The book has been developed from Cherry's popular hands-on course "Buying and Selling on eBay for Technological Simpletons". In addition to fully explaining eBay and how to trade on it there are sections on Paypal, producing pictures of your sale items, fees and accounts, safety and security, including what to do when things go wrong and what protection is provided.

178 pages **Order code BP551** **£8.99**



Music, Audio and Video

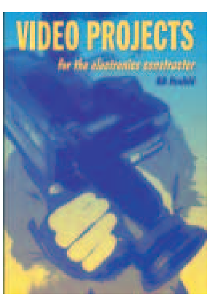
MAKING MUSIC WITH YOUR COMPUTER
Stephen Bennett

Nearly everyone with musical aspirations also has a computer. This same computer can double as a high quality recording studio capable of producing professional recordings. This book tells you what software and hardware you will need to get the best results.

You'll learn about recording techniques, software and effects, mixing, mastering and CD production.

Suitable for PC and Mac users, the book is full of tips, "how to do" topics and illustrations. It's the perfect answer to the question "How do I use my computer to produce my own CD?"

92 pages **Order code PC120** **£10.95**



QUICK GUIDE TO MP3 AND DIGITAL MUSIC
Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

How to play MP3s on your computer; How to use MP3s with handheld MP3 players; Where to find MP3s on the Web; How MP3s work; How to tune into Internet radio stations; How to create your own MP3s; How to record your own CDs from MP3 files; Other digital audio music formats.

Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

60 pages **Order code PC119** **£7.45**

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, push-button fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** ~~£10.95~~ **£5.45**

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Data and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

88 pages **Order code BP299** **£5.49**

DIGITAL LOGIC GATES AND FLIP-FLOPS
Ian R. Sinclair
This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.
Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.
No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explaination of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£9.95**

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold
This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages **Order code BP332** **£5.45**

MICROCONTROLLER COOKBOOK
Mike James
The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages **Order code NE26** **£23.50**

RADIO BYGONES

We also carry a selection of books aimed at readers of *EPE*'s sister magazine on vintage radio *Radio Bygones.* These books include Jonathan Hill's excellent *Radio Radio,* a comprehensive book with hundreds of photos depicting the development of the British wireless set up to the late 1960s.

The four volumes of our own *Wireless For the Warrior* by Louis Meulstee are also available. These are a technical history of radio communication equipment in the British Army and clandestine equipment from pre-war through to the 1960s.

For details see the shop on our UK web site at **www.epemag.co.uk** or contact us for a list of *Radio Bygones* books.

Project Building & Testing

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**

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold
Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages **Order code BP371** **£5.45**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

DISCOVERING PICS
W.D.Phillips

BOOK PLUS CDROM PLUS 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 l.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**

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PCB SERVICE

Printed circuit boards for most recent *EPE* constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. Double-sided boards are NOT plated through hole and will require 'vias' and some components soldering both sides. All prices include VAT and postage and packing. Add £1 per board for *airmail* outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Tel: 01202 873872; Fax 01202 874562;Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag.wimborne.co.uk/shopdoor.htm.** Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only). NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.**
Back numbers or photocopies of articles are available if required – see the *Back Issues* page for details. We do not supply kits or components for our projects.

Please check price and availability in the latest issue. A large number of older boards are listed on, and can be ordered from, our website.

Boards can only be supplied on a payment with order basis.

PROJECT TITLE		Order Code	Cost
'Smart' Slave Flash	APR '06	560	£6.18
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– Main Board		564	£8.56
– Charger Board		565	£6.66
Omni Pendulum		566	£6.34
Smart Card Reader/Programmer	MAY '06	567	£7.61
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★Giant LED Message Display – Master		594	£5.55
– Slave		595	£6.50
Lapel Microphone Adaptor	DEC '06	593	£6.18
RGB To Component Video Converter (double sided)		596	£12.69
USB Power Injector		597	£5.87
★Mind Trainer		598	£6.50
Balanced Microphone Preamp	JAN '07	599	£6.82
High-Efficiency Power Supply for 1W Star LEDs		600	£6.19
Jumping Spider		601	£5.71
★Programmable Robot	FEB '07	602	£6.50
Courtesy Light Delay		603	£5.87
★Deep Cycle Battery Charger			
Power Board		604 }	
Control Board		605 } set	£11.10
Display Board		606 }	
★PIC Digital Geiger Counter (double sided)		607	£12.53
IR Remote Checker	MAR '07	608	£6.35
★SMS Controller		609	£7.93
★Lap Counter For Swimming Pools		610	£7.14
★PIC Polyphonium – Main Board		611	£8.25
PIC Polyphonium – LED Display Interface	APR '07	612	£7.13
Students' Amp – Amplifier		613	£6.02
– PSU		614	£6.02
Star Power		615	£6.50

PROJECT TITLE		Order Code	Cost
Bass Extender	MAY '07	618	£5.87
Caravan Lights Check		619	£6.18
★Energy Meter – Main Board	JUN '07	616 } pair	£9.83
– Display Board		617	
3V to 9V Converter (PCB plus TL499A IC)		620 + chip	£7.53
Bat Sonar		621	£6.03
MiniCal 5V Meter Calibration Standard	JUL '07	622	£6.82
Lead-Acid Battery Zapper		623	£6.50
Video Reading Aid		624	£6.50
Digi-Flash Slave		625	£5.55
TwinTen Stereo Amplifier	AUG '07	626	£9.83
Printer Port Hardware Simulator		627	£6.66
★RFID Security Module		628	£6.02
★V2 PC Scope – Control Board		629	£7.13
Analogue Board		630	£6.50
★Flexitimer – Main Board	SEPT '07	631	£7.29
– Display Board 1		632	£7.29
– Display Board 2		633	£7.29
– Display Board 3		634	£7.29
Pocket Tens Unit		635	£6.35
★Simple Seismograph	OCT '07	636	£6.66
★V8 Doorbell			
– Main Board		637 } pair	£11.42
– Display Board		638	
★Standby Power Saver			
– Transmitter		639	£6.34
– Receiver		640 } pair	£6.97
– PSU		641	
Vehicle Voltage Monitor	NOV '07	642	£6.34
★USB Electrocardiograph		643	£7.61
★Inductance & Q-Factor Meter		644	£7.93
Experimenter's Audio System – Main Board		645 } pair	£7.61
– PSU		646	
★Teach-In '08 – Master Control Board		647	£7.93
iPod or MP3 Player Charger	DEC '07	648	£5.87
AVR ISP Socketboard		649	£7.61
★PIC Speech Synthesiser – Playback		650	£6.03
– Record		651	£6.66

EPE SOFTWARE

★ All software programs for *EPE* Projects marked with an asterisk, and others previously published, can be downloaded *free* from our Downloads site, accessible via our home page at: **www.epemag.co.uk.**

PCB MASTERS

PCB masters for boards published from the March '06 issue onwards can also be downloaded from our UK website (**www.epemag.co.uk**); go to the 'Downloads' section.

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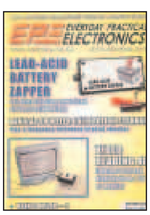
The No 1 UK Magazine for Electronics Technology & Computer Projects

VOLUME 36 INDEX

JANUARY 2007 TO DECEMBER 2007

CONSTRUCTIONAL PROJECTS



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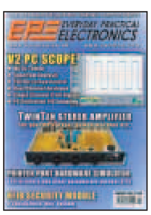

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V2 PC SCOPE

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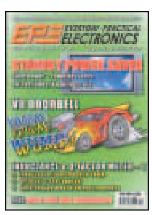

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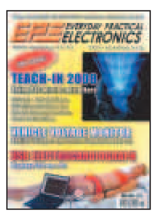

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EVERYDAY PRACTICAL ELECTRONICS

NEXT MONTH

PIC CARILLON

Want to be a bell ringer? This design produces bell-like sounds, using the multiple harmonics of sinewaves to give the tonality expected from bells, complete with the decay of each note played. A simple monophonic unit is described but additional channels can be added allowing multiple notes. The unit can be interfaced to the *PIC Polyphonium* (April & May '07), allowing musical scores to be composed and played.

PHONE/FAX MISSED CALL ALERT

This device detects an incoming call on your phone or fax, lights an LED and latches on a relay, which you can use to switch on a lamp or horn in another room or your garage etc.

SERIAL I/O CONTROLLER & ANALOGUE SAMPLER

Looking for an easy-to-drive I/O controller? This unit connects to the serial port of your PC and can be programmed to switch relays, in response to voltage, resistance, temperature and digital inputs. It also includes comprehensive system timers to control the relays and you can set the system up to operate as a PLC-style controller.

JANUARY '08 ISSUE ON SALE DECEMBER 13

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For Editorial address and phone numbers see page 7

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