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EVERYDAY

PRACTICAL ELECTRONICS

OCTOBER 2005

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PLUS

BACK TO BASICS - 7

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World Radio History

Colour CCTV camera, 8mm lens, 12vdc200m a 582X628 Res 380 lines Automatic aperture lens Mirror function PAL Back Light Comp MLR, 100x40x40mm ref EE2 £75.90

Built in Audio .15lux CCD camera 12vdc 200ma 480 lines s/n ratio >48 db 1v P-P output 110x60x50mm ref EE1 £108.90

Metal CCTV camera housings for internal or external use. Made from aluminium and plastic they are suitable for mounting body cameras in.Available in two sizes 1- 100x70x170mm and 2- 100x70x280mm Ref EE6 £22 EE7 £26 Multi position brackets Ref EE8 £8.80

Excellent quality multi purpose TV/ TFT screen, works as just a LCD colour monitor with any of our CCTV cameras or as a conventional TV ideal for use in boats and caravans 49.75mhz-91.75mhz VHF channels 1-5, 168.25mhz-222.75mhz VHF channels 6-12, 471.25mhz-869.75mhz, Cable channels 112.325mhz-166.75mhz Z1-Z7, Cable channels 224.25mhz-446.75mhz Z8-Z35 5" colour screen,Audio output 150mW,Connections, external aerial, earphone jack, audio/video input,12vdc or mains, Accessories supplied Power supply Remote control Cigar lead power supply Headphone Stand/bracket. 5" model £139 Ref EE9,

Self cocking pistol plcr002 crossbow with metal body.· Selfcocking for precise string alignment Aluminium alloy construction High tec fibre glass limbs Automatic safety catch Supplied with three bolts Track style for greater accuracy Adjustable rear sight 50lb draw weight 150ft sec velocity Break action 17" string 30m range £23.84 Ref PLCR002

Fully cased **IR light source** suitable for CCTV applications. The unit measures 10x10x150mm, is mains operated and contains 54 infra red LEDs. Designed to mount on a standard CCTV camera bracket. The unit also contains a daylight sensor that will only activate the infra red lamp when the light level drops below a preset level. The infrared lamp is suitable for indoor or exterior use, typical useage would be to provide additional IR illumination for CCTV cameras. £53.90 ref EE11

Colour CCTV Camera measures 60x45mm and has a built in light level detector and 12 IR leds .2 lux 12 IR leds 12vdc Bracket Easy connect leads £75.90 Ref EE15

A high quality external colour CCTV camera with built in Infra red LEDs measuring 60x60x60mm Easy connect leads colour Waterproof PAL 1/4" CCD542x588 pixels 420 lines .05 lux 3.6mm F2 78 deg lens 12vdc 400ma Built in light level sensor. £108.90 Ref EE13

A small colour CCTV camera just 35x28x30mm Supplied with bracket, easy connect leads. Built in audio. Colour 380 line res, PAL 0.2 lux +18db sensitivity Effective pixels 628x582 6-12vdc Power 200mw £39.60 Ref EE16

Peltier module. Each module is supplied with a comprehensive 18 page Peltier design manual featuring circuit designs, design information etc etc. The Peltier manual is also available separately Maximum watts 56.2 40x40mm Imax 5.5A Vmax 16.7 Tmax (c-dry N2) 72 £32.95 (inc manual) REF PELT1, just manual £4.40 ref PELT2

COMPAQ 1000mA 12vdc power supplies, new and boxed. 2 metre lead DC power plug 2.4mmx10mm £5.25 each, 25+ £3.50 100+£2.50

3km Long range video and audio link complete with transmitter, receiver, 12.5m cables with pre fitted connectors and aerials. Acheive up to 3km. Cameras not included Ideal for stables, remote buildings etc. Mains power required £299

Complete wireless CCTV sytem with video. Kit comprises pinhole colour camera with simple battery connection and a receiver with video output. 380 lines colour 2.4ghz 3lux 6-12vdc manual tuning Available in two versions, pinhole and standard.£79 (pinhole) Ref EE17, £86.90 (standard) Ref EE18

GASTON SEALED LEAD ACID BATTERIES

1.3AH 12V @ £5.50 GT1213
3.4AH 12V @ £8.80 GT1234
7AH 12V @ £8.80 GT127
17AH 12V @ £19.80 GT1217

All new and boxed, bargain prices. Good quality sealed lead acid batteries

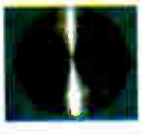
1.2ghz wireless receiver Fully cased audio and video 1.2ghz wirelessreceiver 190x140x30mm metal case, 4 channel, 12vdc Adjustable time delay, 4s, 8s, 12s, 16s. £49.50 Ref EE20

The smallest PMR446 radios currently available (54x87x37mm). These tiny handheld PMR radios look great, user friendly & packed with features including VOX, Scan & Dual Watch. Priced at £59.99 PER PAIR they are excellent value for money. Our new favourite PMR radios! Standby: - 35 hours Includes:- 2 x Radios, 2x Belt Clips & 2 x Carry Strap £59.95 Ref ALAN1 Or supplied with 2 sets of rechargeable batteries and two mains chargers £93.49 Ref Alan2

The TENS mini Microprocessors offer six types of automatic programme for shoulder pain, back/neck pain, aching joints, Rheumatic pain, migraines headaches, sports injuries, period pain. In fact all over body treatment. Will not interfere with existing medication. Not suitable for anyone with a heart pacemaker. Batteries supplied. £21.95 Ref TEN327 Spare pack of electrodes £6.59 Ref TEN327X

Dummy CCTV cameras These motorised cameras will work either on 2 **AA** batteries or with a standard DC adapter (not supplied) They have a built in movement detector that will activate the camera if movement is detected causing the camera to 'pan' Good deterrent. Camera measures 20cm high, supplied with fixing screws. Camera also has a flashing red led. £10.95 Ref CAMERAB

INFRA RED FILM 6" square piece of flexible infra red film that will only allow IR light through Perfect for converting ordinary torches, lights, headlights etc to infrared output using standard light bulbs Easily cut to shape. 6" square £16.50 ref IRF2 or a 12" sq for £34.07 IRF2A



THE TIDE CLOCK These clocks indicate the state of the tide,Most areas in the world have two high tides and two low tides a day, so the tide clock has been specially designed to rotate twice each lunar day (every 12 hours and 25 minutes) giving you a quick and easy indication of high and low water. The Quartz tide clock will always stay calibrated to the moon. £23.10 REF TIDEC

LINEAR ACCTUATORS 12-36VDC BUILT IN ADJUSTABLE LIMIT SWITCHES POWDER COATED 18" THROW UP TO 1,000 LB THRUST (400LB RECOMMENDED LOAD) SUPPLIED WITH MOUNTING BRACKETS DESIGNED FOR OUTDOOR USE These brackets originally made for moving very large satellite dishes are possibly more suitable for closing gates, mechanical machinery, robot wars etc. Our first sale was to a company building solar panels that track the sun! Two sizes available, 12" and 18" throw. £32.95 REF ACT12,

Samarium magnets are 57mm x 20mm and have a hole (5/16th UNF) in the centre and a magnetic strength of 2.2 gauss. We have tested these on a steel beam running through the offices and found that they will take more than 170lbs (77kgs) in weight before being pulled off. With keeper. £21.95 REF MAG77

New transmitter, receiver and camera kit. £69.00

Kit contains four channel switchable camera with built in audio, six IR leds and transmitter, four channel switchable receiver, 2 power supplies, cables, connectors and mounting bracket. £69.00 Wireless Transmitter Black and white camera (75x50x55mm) Builtin 4 channel transmitter (switchable) Audio built in 6 IR Leds Bracket/ stand Power supply 30 m range **Wireless Receiver** 4 channel (switchable) Audio/video leads and scart adapter Power supply and Manual £69.00 ref COP24

This miniature **Stirling Cycle Engine** measures 7" x 4-1/4" and comes complete with built-in alcohol burner. Red flywheel and chassis mounted on a green base, these all-metal beauties silently running at speeds in excess of 1,000 RPM attract attention and create awe wherever displayed. This model comes completely assembled and ready to run. £106.70 REF SOL1

High-power modules using 125mm square multi crystal silicon solar cells with bypass diode Anti reflection coating and BSF structure to improve cell conversion efficiency: 14%. Using white tempered glass, EVA resin, and a weatherproof film along with an aluminum frame for extended outdoor use. system Lead wire with waterproof connector. 80 watt 12v 500x1200 £315.17, 123w 12vdc 1499x662x46 £482.90
165 w 24v 1575x826x46mm £652.30

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Ultra-compact, lightweight, easy to use and comfortable to hold, the new NVMT is unique for a night scope in offering a tactile, suregrip plastic bodyshell and, for extra protection/grip, partial rubber armouring. Currently the top of the range model, the NVMT G2+ features a 'commercial' grade" Gen 2+ Image Intensifier Tube (IIT). The NVMT has a built-in, powerful Infrared (IR) Illuminator for use in very low light/total darkness. Power for the scope and IR is provided by 1 x 3V Lithium CR123A battery (not supplied). A green LED next to the viewfinder indicates when the Image Intensifier Tube is switched on while a red LED indicates when the IR Illuminator is switched on.Type Gen Weight Size Lens Mag 2x, Weight 400g, 125x82x35mm angle of view 30 deg, built in infra red, rang 3 - 400m, supplied with batteries £849 ref COB24023.

55 - 200 WATT INFRA RED TORCHS

Search guard 1 infrared torch Plastic bodied waterproof infrared rechargeable lamp. 100mm diameter lens, 200mm body length. 55 watt bulb, 1,000,000 candle power (used as an indication of relative power) Supplied complete with a 12v car lighter socket lead/charger and a 240v mains plug in charger. £49 REF sguard 1. Also available, 70watt @ £59, 100 watt @ £79, 200watt @ £99.

AIR RIFLES FROM £24.70

B2 AIR RIFLE Available In .177 and .22• 19" Tapered Rifled Barrel• Adjustable Rear Sight• Full Length Wooden Stock• Overall Length 43" approx Barrel Locking Lever • Also available in CARBINE Grooved for Telescopic Sight model with 14" barrel - no front sight for use with scope. Weight approximately 6lbs Extremely Powerful .22 £28.90, .177 £24.70, pellets (500) £2.55, sights 4x20 £6.80. 4x28 £15.32 Other models available up to £250 www.airpistol.co.uk

12V SOLAR PANELS AND REGULATORS
9 WATT £58.75
15 WATT £84.25
22 WATT £126.70
Regulator up to 60 watt £21.25
Regulators up to 135 watt £38.25

The combination of multi-crystal cells and a high-reliability module structure make this series of solar panels the ideal solar module. For large-scale power generation hundreds or even thousands of modules can be connected in series to meet the desired electric power requirements. They have a high output, and highly efficient, extremely reliable and designed for ease of maintenance. Separate positive negative junction boxes and dual by-pass diodes are a few examples of some of its outstanding features. Supplied with an 8 metre cable. Perfect for caravans, boats, etc. Toughened glass.

LOCK PICK SETS 16, 32 AND 60 PIECE SETS

This set is deluxe in every way! It includes a nice assortment of balls, rakes, hooks, diamonds, two double ended picks, a broken key extractor, and three tension wrenches. And just how do you top off a set like this? Package it in a top grain leather zippered case. Part: LP005 - Price £45.00

This 32 piece set includes a variety of hooks, rakes, diamonds, balls, extractors, tension tools ... and comes housed in a zippered top grain leather case. If you like choices, go for this one! Part: LP006 - Price £65.00

If your wants run toward the biggest pick set you can find, here it is. This sixty piece set includes an array of hooks, rakes, diamonds, balls, broken key extractors, tension wrenches, and even includes a warded pick set! And the zippered case is made, of course, of the finest top grain leather. First Class! Part: LP007 - Price £99.00

Mamod steam roller, supplied with fuel and everything you need (apart from water and a match!) £85 REF 1312 more models at www.mamodspares.co.uk

Mamod steam roller, supplied with fuel and everything you need (apart from water and a match!) £130 REF 1318 more models at www.mamodspares.co.uk

PEANUT RIDER STIRLING ENGINE This all metal, black and brass engine with red flywheel is mounted on a solid hardwood platform, comes complete with an alcohol fuel cell, extra wick, allen wrenches, and Owner's Manual.Specifications: Base is 5-1/4" x 5-1/4", 4" width x 9" height, 3/4" stroke, 3-1/2" flywheel £141.90

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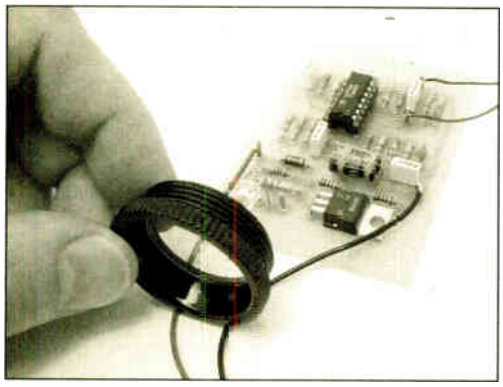

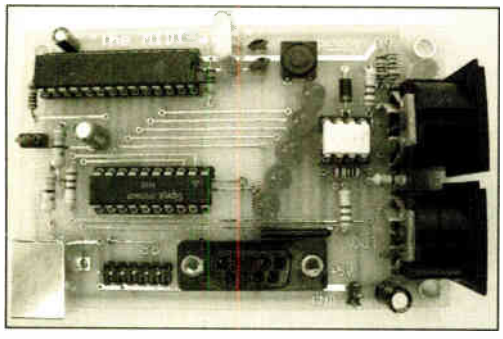

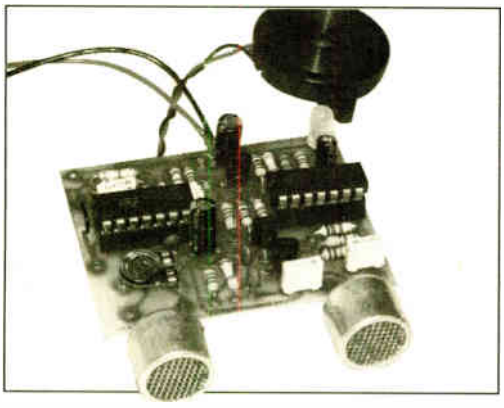

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Fun project; the sound comes from WAV files stored in EEPROM

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USB the easy way with a PIC18F2455 microcontroller

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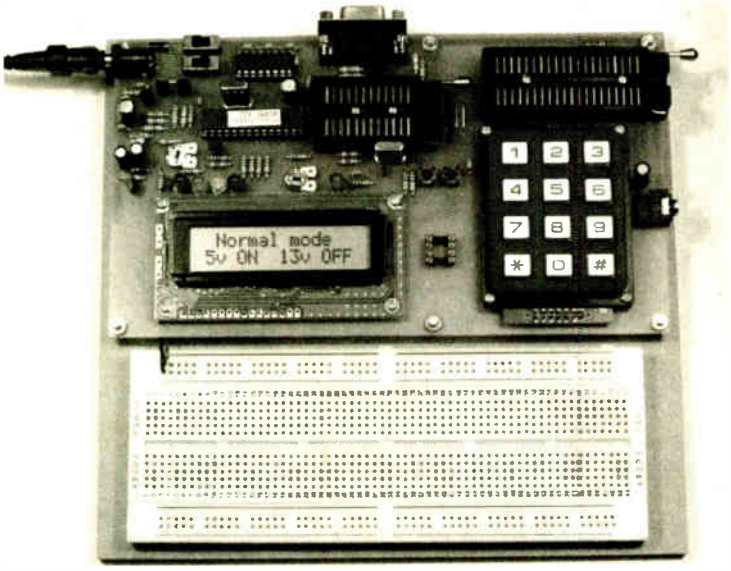
World Radio History

Learn About Microcontrollers



PIC Training & Development System

The best place to start learning about microcontrollers is the PIC16F84 with its simple easy to understand internal structure. Then continue on using the more sophisticated PIC16F877 family.

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

Our PIC training course consists of our mid range PIC programmer, a 298 page book teaching the fundamentals of PIC programming in assembly language, a 274 page book introducing the C programming language for PICs, and a suite of programmes to run on a PC. The module is an advanced design using a 28 pin PIC16F870 to handle the timing, programming and voltage switching requirements. Two ZIF sockets and an 8 pin socket allow most mid range 8, 18, 28 and 40 pin PICs to be programmed. The plugboard is wired with a 5 volt supply. The programming is performed at 5 volts, verified with 2 volts or 3 volts applied and verified again with 5.5 volts applied to ensure that the PIC is programmed correctly over its full operating voltage. UK orders include a plugtop power supply.

Universal mid range PIC programmer module
+ Book Experimenting with PIC Microcontrollers
+ Book Experimenting with PIC C
+ PIC assembler and C compiler software suite
+ PIC16F84 and PIC16F870 test PICs. £159.00
(Postage & insurance UK £10, Europe £15, Rest of world £25)

Which Language to Learn

Everyone should start programming PICs using assembly language. That is the only way to fully understand what happens. Then there are good arguments in some applications to change over to using a high level language, but, BASIC or C? At the beginning BASIC is easy to learn while C can seen very strange, but the weakness of BASIC comes from its ease of use, while the power of C lurks in its strangeness. Once the early stages are past programmes are easier to write in C than in BASIC.

Experimenting with PIC Microcontrollers

This book introduces PIC assembly language programming using the PIC16F84, and is the best way to get started for anyone who is new to PIC programming. We begin with four easy experiments, the first of which is explained over ten and a half pages assuming no starting knowledge of PICs. Then having gained some practical experience we study the basic principles of PIC programming, learn about the 8 bit timer, how to drive the liquid crystal display, create a real time clock, experiment with the watchdog timer, sleep mode, beeps and music, including a rendition of Beethoven's *Fur Elise*. Finally there are two projects to work through, using the PIC16F84 as a sinewave generator and investigating using the PIC16F88 (from the PIC16F877 family) to monitor the power taken by domestic appliances. In the space of 24 experiments, two projects and 56 exercises the book works through from absolute beginner to experienced engineer level.

PIC C Language

The second book *Experimenting with PIC C* starts with an easy to understand explanation of how to write simple PIC programmes in C. The first few programmes are written for a PIC16F84 to keep continuity with the first book *Experimenting with PIC Microcontrollers*. Then we see how to use the same C programmes with the PIC16F627 and the PIC16F877 family.

We study how to create programme loops using C, we experiment with the IF statement, use the 8 bit and 16 bit timers, write text, integer and floating point variables to the liquid crystal display, and use the keypad to enter numbers.

Then its time for 25 pages of pure study, which takes us much deeper into C than is directly useful with PICs as we know them - we are studying for the future as well as the present. We are not expected to understand everything that is presented in these 25 pages, the idea is to begin the learning curve for a deep understanding of C.

In chapter 9 we use C to programme the PIC to produce a siren sound and in the following chapter we create the circuit and software for a freezer thaw warning device. Through the last four chapters we experiment with using the PIC to measure temperature, create a torch light with white LEDs, control the speed of one then two motors, study how to use a PIC to switch mains voltages, and finally experiment with serial communication using the PIC's USART.

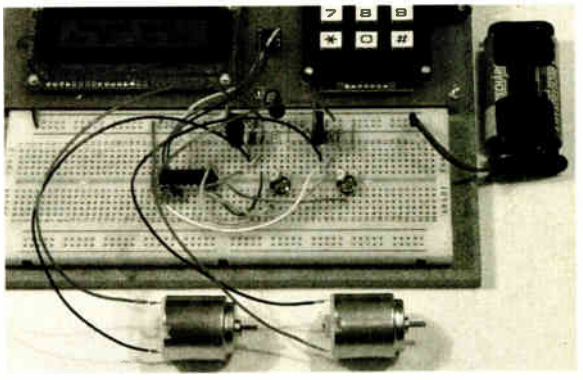
Some of the programmes towards the end of *Experimenting with PIC C* are shown in assembler and C to enable the process to be fully explained, and in the torch light experiments, due to the fast switching speed, the programmes are written only in assembler.

As you work through this book you will be pleasantly surprised how C makes light work of calculations and how easy it is to display the answers.

Ordering Information

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

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



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 PIC16F627 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.

Web site:- www.brunningsoftware.co.uk

Mail order address:

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World Radio History

NEXT MONTH

TEACH-IN 2006

Are you starting electronics for the first time? Or perhaps you are a little more experienced but have missed out on some aspects of electronics? Do you wonder about how circuits work and what really goes on inside them? Do you want to be able to design and build your own circuits and get them to work first time? Are you a student or thinking about gaining a formal qualification in electronics? If the answer to any one or more of these questions is "yes" then our Teach-In 2006 *series is going to be just right for you!*

We won't assume that you have any previous knowledge, and while we will include the relevant theory, we won't bore you with a lot of mathematics. Each part includes a number of Practical Investigations providing you with an opportunity to prove why real circuits work. And with each part there will be a short multiple choice Quiz on-line for you to enter.

A Final Test will also be available on-line, successful completion of which will lead to the award of a personalised EPE Teach-In Certificate, *something that will provide you with lasting formal recognition of your success.*

List of Topics

- *Units, Multiples and Sub-multiples. Atoms, Electrons and Electric Current. Periodic Table. Introducing Resistors, Batteries, Switches. Current, Voltage and Resistance. Potential Difference. Ohm's Law.*
- *Circuit Diagrams. Series and Parallel Circuits. Circuit Construction Techniques. Basic Measurements – The Multimeter. More Circuit Theory. Power and Energy. Voltage Divider. Current Divider.*
- *Charge and Capacitance. Introducing Capacitors and Inductors. Magnetism and Inductance.*
- *Introducing Transformers and Semiconductors. Diodes. Rectifiers. Power Supplies.*
- *Introducing Transistors. Basic Concepts of Amplifiers. Gain and Frequency Response. Single and Multi-stage Amplifiers. Coupling.*
- *Test and Measurement. Waveforms. The Oscilloscope. Signal Sources and Signal Generators. Optoelectronics. Introducing Light Emitting Diodes.*
- *Digital Electronics. Introducing Logic Circuits.*
- *Introducing Microprocessors and PICs. Programming. Interfacing. Typical Applications.*
- *Analogue Electronics. Introducing Operational Amplifiers. Inverting, Non-inverting and Differential Amplifiers. Filters. Comparators. Typical Applications.*
- *Radio and Communications. Tuned Circuits. Modulation and Demodulation. Transmitters and Receivers. Aerials. Introducing Quartz Crystals. Typical Applications. Radio Constructional Project.*

CAMERA WATCH MK2

The publication of the first EPE Speed Camera Watch *project in Jan '05 generated a lot of interest and many suggestions for enhancements. Camera Watch Mk2 addresses those suggestions.*

It uses GPS signals to locate speed cameras. It can store up to 10,000 camera positions and can scan them all within one second. An l.c.d. provides the visual feedback and enables the display of additional GPS related information.

As requested, an RS232 PC interface has been added. The unit's database can now be extracted, uploaded to the internet and shared with other users.

You can also download other user's databases and merge them with your own. A special web site has been set up for this option.

Significantly, too, the ability to set an acoustic warning for exceeding preset speeds (30, 40, 50, 60 and 70 mph) has also been added.

PIC CHROMATONE

You've all experienced Sound-to-Light displays – haven't you – discos, parties, raves, etc? But what about Light-to-Sound? Bet that's probably a new one to you – but not any longer if you read next month's light-controlled musical novelty!

Light-to-sound? Well it's just a matter of turning thoughts on their head a bit. Given the infinite variety of colour tones around us, all we do is to electronically sense what colours they are and produce frequency tones specific to them.

It must be said, though, the resulting design is a gimmick. But it's a fun gimmick, and should provide much musical entertainment!

EVERYDAY PRACTICAL ELECTRONICS

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PIC & ATMEL Programmers

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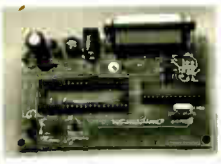
Programmer Accessories:
40-pin Wide ZIF socket (ZIF40W) £15.00
18VDC Power supply (PSU010) £19.95
Leads: Parallel (LDC136) £4.95 / Serial (LDC441) £4.95 / USB (LDC644) £2.95

NEW! USB 'Flash' PIC Programmer

USB PIC programmer for most 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows Software. ZIF Socket and USB Plug A-B lead not incl.
Kit Order Code: 3128KT – **£34.95**
Assembled Order Code: AS3128 – **£39.95**

"PICALL" ISP PIC Programmer



"PICALL" will program virtually all 8 to 40 pin *serial-mode** AND *parallel-mode* (PIC16C5x family)* Programmed PIC micro controllers. Free fully functional software. Blank chip auto detect for super fast bulk programming. Parallel port connection. Supply: 16-18V dc.
Assembled Order Code: AS3117 – **£24.95**

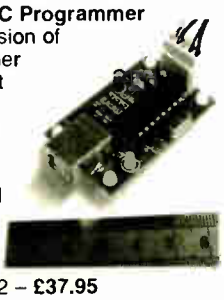
ATMEL 89xxx Programmer

Uses serial port and any standard terminal comms program. 4 LEDs display the status. ZIF sockets not included. Supply: 16VDC.
Kit Order Code: 3123KT – **£29.95**

NEW! USB & Serial Port PIC Programmer

USB/Serial connection. Header cable for ICSP. Free Windows software. See website for PICs supported. ZIF Socket and USB Plug A-B lead extra. 18VDC.
Kit Order Code: 3149KT – **£34.95**
Assembled Order Code: AS3149 – **£49.95**

USB Flash ICSP PIC Programmer



Fully assembled version of our 3128 USB Flasher PIC Programmer but WITHOUT the programming socket. It just has 5-pin ICSP header (GND, VCC, CLK, DAT, VPP) and cable. No external PSU required. Free Windows software.
Order Code: AS3182 – **£37.95**

ABC Maxi AVR Development Board

The ABC Maxi board has an open architecture design based on Atmel's AVR AT90S8535 RISC microcontroller and is ideal for developing new designs.
Features:
8Kb of In-System Programmable Flash (1000 write/erase cycles) • 512 bytes internal SRAM • 512 bytes EEPROM • 8 analogue inputs (range 0-5V) • 4 Opto-isolated Inputs (I/Os are bi-directional with internal pull-up resistors) • Output buffers can sink 20mA current (direct l.e.d. drive) • 4 x 12A open drain MOSFET outputs • RS485 network connector • 2-16 LCD Connector • 3·5mm Speaker Phone Jack • Supply: 9-12VDC.
The ABC Maxi STARTER PACK includes one assembled Maxi Board, parallel and serial cables, and Windows software CD-ROM featuring an Assembler, BASIC compiler and in-system programmer.
Order Code ABCMAXISP – **£89.95**
The ABC Maxi boards only can also be purchased separately at £69.95 each.

Controllers & Loggers

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

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 TXs can be learned by one Rx (kit includes one Tx but more available separately). 4 indicator LEDs.
Rx: PCB 77x85mm, 12VDC/6mA (standby).
Two & Ten Channel versions also available.
Kit Order Code: 3180KIT – **£39.95**
Assembled Order Code: AS3180 – **£47.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 38x38mm. Powered by PC. Includes one DS1820 sensor and four header cables.
Kit Order Code: 3145KT – **£16.95**
Assembled Order Code: AS3145 – **£23.95**
Additional DS1820 Sensors – **£3.95 each**

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

NEW! DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12VDC.
Kit Order Code: 3140KT – **£39.95**
Assembled Order Code: AS3140 – **£59.95**

Serial Port Isolated I/O Module

Computer controlled 8-channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130 x 100 x 30mm. Power: 12VDC/500mA.
Kit Order Code: 3108KT – **£49.95**
Assembled Order Code: AS3108 – **£59.95**

Infra-red RC 12-Channel Relay Board

Control 12 on-board relays with included infra-red remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12VDC/0·5A.
Kit Order Code: 3142KT – **£39.95**
Assembled Order Code: AS3142 – **£49.95**

PC Data Acquisition & Control Unit

Monitor and log a mixture of analogue and digital inputs and control external devices via the analogue and digital outputs. Monitor pressure, temperature, light intensity, weight, switch state, movement, relays, etc. with the apropriate sensors (not supplied). Data can be processed, stored and the results used to control devices such as motors, sirens, relays, servo motors (up to 11) and two stepper motors.

Features
- 11 Analogue Inputs – 0·5V, 10 bit (5mV/step)
- 16 Digital Inputs – 20V max. Protection 1K in series, 5·1V Zener
- 1 Analogue Output – 0-2·5V or 0-10V. 8 bit (20mV/step)
- 8 Digital Outputs – Open collector, 500mA, 33V max
- Custom box (140 x 110 x 35mm) with printed front & rear panels
- Windows software utilities (3·1 to XP) and programming examples
- Supply: 12V DC (Order Code PSU203)

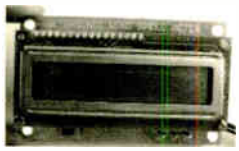
Kit Order Code: 3093KT – **£64.95**
Assembled Order Code: AS3093 – **£94.95**

World Radio History

Hot New Kits This Summer!

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

NEW! EPE Ultrasonic Wind Speed Meter



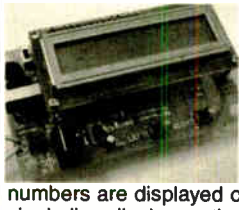
Solid-state design wind speed meter (anemometer) that uses ultrasonic techniques and has no moving parts and does not need calibrating. It is intended for sports-type activities, such as track events, sailing, hang-gliding, kites and model aircraft flying, to name but a few. It can even be used to monitor conditions in your garden. The probe is pointed in the direction from which the wind is blowing and the speed is displayed on an LCD display.

Specifications

- Units of display: metres per second, feet per second, kilometres per hour and miles per hour
- Resolution: Nearest tenth of a metre
- Range: Zero to 50mph approx.

Based on the project published in Everyday Practical Electronics, Jan 2003. We have made a few minor design changes (see web site for full details). Power: 9VDC (PP3 battery or Order Code PSU345).
Main PCB: 50 x 83mm.
Kit Order Code: 3168KT – **£34.95**

NEW! Audio DTMF Decoder and Display



Detects DTMF tones via an on-board electret microphone or direct from the phone lines through the onboard audio transformer. The numbers are displayed on a 16-character, single line display as they are received. Up to 32 numbers can be displayed by scrolling the display left and right. There is also a serial output for sending the detected tones to a PC via the serial port. The unit will not detect numbers dialled using pulse dialling. Circuit is microcontroller based.
Supply: 9-12V DC (Order Code PSU345).
Main PCB: 55 x 95mm.
Kit Order Code: 3153KT – **£17.95**
Assembled Order Code: AS3153 – **£29.95**

NEW! EPE PIC Controlled LED Flasher

This versatile PIC-based LED or filament bulb flasher can be used to flash from 1 to 160 LEDs. The user arranges the LEDs in any pattern they wish. The kit comes with 8 superbright red LEDs and 8 green LEDs. Based on the Versatile PIC Flasher by Steve Challinor, *EPE* Magazine Dec '02. See website for full details. Board Supply: 9-12V DC. LED supply: 9-45V DC (depending on number of LED used). PCB: 43 x 54mm.
Kit Order Code: 3169KT – **£11.95**

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

FM Bugs & Transmitters

Our extensive range goes from discreet surveillance bugs to powerful FM broadcast transmitters. Here are a few examples. All can be received on a standard FM radio and have adjustable transmitting frequency.

MMTX' Micro-Miniature 9V FM Room Bug

Our best selling bug! Good performance. Just 25 x 15mm. Sold to detective agencies worldwide. Small enough to hide just about anywhere. Operates at the 'less busy' top end of the commercial FM waveband and also up into the more private Air band. Range: 500m. Supply: PP3 battery.
Kit Order Code: 3051KT – **£8.95**
Assembled Order Code: AS3051 – **£14.95**

HPTX' High Power FM Room Bug

Our most powerful room bug. Very Impressive performance. Clear and stable output signal thanks to the extra circuitry employed. Range: 1000m @ 9V. Supply: 6-12V DC (9V PP3 battery clip suppied). 70 x 15mm.
Kit Order Code: 3032KT – **£9.95**
Assembled Order Code: AS3032 – **£17.95**

MTTX' Miniature Telephone Transmitter

Attach anywhere along phone line. Tune a radio into the signal and hear exactly what both parties are saying. Transmits only when phone is used. Clear, stable signal. Powered from phone line so completely maintenance free once installed. Requires no aerial wire – uses phone line as antenna. Suitable for any phone system worldwide. Range: 300m. 20 x 45mm.
Kit Order Code: 3016KT – **£7.95**
Assembled Order Code: AS3016 – **£13.95**

3 Watt FM Transmitter

Small, powerful FM transmitter. Audio preamp stage and three RF stages deliver 3 watts of RF power. Can be used with the electret microphone supplied or any line level audio source (e.g. CD or tape OUT, mixer, sound card, etc). Aerial can be an open dipole or Ground Plane. Ideal project for the novice wishing to get started in the fascinating world of FM broadcasting. 45 x 145mm.
Kit Order Code: 1028KT – **£23.95**
Assembled Order Code: AS1028 – **£31.95**

25 Watt FM Transmitter

Four transistor based stages with a Philips BLY89 (or equivalent) in the final stage. Delivers a mighty 25 Watts of RF power. Accepts any line level audio source (input sensitivity is adjustable). Antenna can be an open dipole, ground plane, 5/8, J, or YAGI configuration. Supply 12-14V DC, 5A. Supplied fully assembled and aligned – just connect the aerial, power and audio input. 70 x 220mm.
Order Code: AS1031 – **£134.95**

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3143KT – 10W Stereo Amplifier £10.95
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FARNELL B30/20 30V 20A Variable No Meters £110
FARNELL B30/10 30V 10A Variable No Meters £55
FARNELL LT30-1 0-30V 0-1A Twice £75
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THURLBY TS3021S 0-30V 0-2A LCD £65
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(*Some projects are copyright)

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The latest MAGENTA DESIGN – highly stable & sensitive – with I.C. control of all timing functions and advanced pulse separation techniques.

- High stability drift cancelling
- Easy to build & use
- No ground effect, works in seawater

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- Efficient quartz controlled microcontroller pulse generation.
- Full kit with headphones & all hardware

KIT 847 .....£63.95

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- NEW PCB DESIGN
- 8MHz 68000 16-BIT BUS
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- 2 SERIAL PORTS
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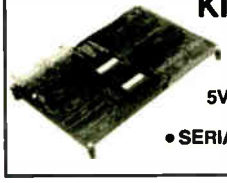

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- SIMPLE TO BUILD
- HIGH POWER OUTPUT
- AUDIO & VISUAL MONITORING
- SWEPT FREQUENCY

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Kit includes case, P.C.B., coupling coil and all components.
High coil current ensures maximum effect. L.E.D. monitor.

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

MICRO PEsT SCARER

Our latest design – The ultimate scarer for the garden. Uses special microchip to give random delay and pulse time. Easy to build reliable circuit. Keeps pets/pests away from newly sown areas, play areas, etc. uses power source from 9 to 24 volts.

- **RANDOM PULSES**
- **HIGH POWER**
- **DUAL OPTION**

Plug-in power supply £4.99

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

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

KIT 856.....£28.00

★ TENS UNIT ★

DUAL OUTPUT TENS UNIT

As featured in March '97 issue.

Set of 4 spare electrodes £6.50

Magenta have prepared a FULL KIT for this. excellent new project. All components, PCB, hardware and electrodes are included.
Designed for simple assembly and testing and providing high level dual output drive.

KIT 866. . Full kit including four electrodes £32.90

1000V & 500V INSULATION TESTER

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

KIT 848.....£32.95

EPE TEACH-IN 2000

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

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

SPACEWRITER

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

KIT 849 .....£16.99

12V EPROM ERASER

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

KIT 790 .....£29.90

SUPER BAT DETECTOR

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

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

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

MOSFET MkII VARIABLE BENCH POWER SUPPLY 0-25V 2·5A

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

Kit No. 845 .....£64.95

ULTRASONIC PEsT SCARER

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

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

KIT 812.....£15.00

SIMPLE PIC PROGRAMMER

KIT 857... £12.99

Includes PIC16F84 chip disk, lead, plug, p.c.b., all components and instructions

Extra 16F84 chips £3.84
Power Supply £3.99

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PIC LCD DISPLAY DRIVER

16 Character x 2 Line display, pcb, programmed PIC16F84, software disk and all components to experiment with standard intelligent alphanumeric displays. Includes full PIC source code which can be changed to match your application.

- Learn how to drive the display and write your own code.
- Ideal development base for meters, calculators, counters, timers — just waiting for your application!
- **Top quality display** with industry standard driver, data and instructions

KIT 860.....£19.99

PIC STEPPING MOTOR DRIVER

PCB with components and PIC16F84 programmed with demonstration software to drive any 4 phase unipolar motor up to 24 Volts at 1 Amp. **Kit includes 100 Step Hybrid Stepping Motor** Full software source code supplied on disc.

Use this project to develop your own applications. PCB allows 'simple PIC programmer' 'SEND' software to be used to reprogram chip.

KIT 863.....£18.99

8 CHANNEL DATA LOGGER

From Aug/Sept.'99 *EPE*. Featuring 8 analogue inputs and serial data transfer to PC. Magenta redesigned PCB - LCD plugs directly onto board. Use as Data Logger or as a test bed for developing other PIC16F877 projects. Kit includes lcd, progd. chip, PCB, Case, all parts and 8 x 256k EEPROMs

KIT 877.....£49.95

PIC16F84 MAINS POWER CONTROLLER & 4 CHANNEL LIGHT CHASER / DIMMER

- Zero Volt Switching
- Opto-Isolated 5 Amp **HARD FIRED** TRIACS
- 12 Way keypad Control
- With program source code disk.
- Chase Speed and dimming potentiometer controls.
- Reprogram for other applications

KIT 855.....£39.95

PIC TUTOR 1 — *EPE* MARCH APRIL MAY '98 PIC16F84 STARTER SERIES

The original PIC16F84 series by John Becker. Magenta's Tutor board has individual switches and leds on all portA and PortB lines, plus connectors for optional 4 digit seven segment led display, and 16 x 2 intelligent lcd. Written for newcomers to PICs this series. Disk has over 20 tutorial programs. Connect to a PC parallel port, send, run, and experiment by modifying test programs - Then Write and Program your Own

KIT 870... £27.95, Built...£42.95

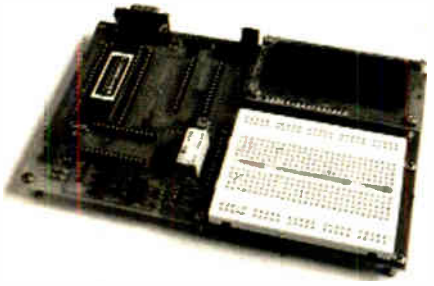
16x2 LCD..£7.99. LED display..£6.99. 12VPSU..£3.99

SUPER PIC PROGRAMMER

Magenta's original parallel port programmer. Runs with downloaded WINDOWS 95 - XP software. Use standard Microchip .HEX files. Read/Prog/Verify wide range of 18,28,and 40 pin PICs. Including 16F84/876/877, 627/8, (Inc. 'A' versions) + 16xx OTPs.

KIT 862... £29.99 Power Supply £3.99

ICEBREAKER



PIC Real Time In-Circuit Emulator

- ICEbreaker uses PIC16F877 in-circuit debugger.
- Links to standard PC **Serial** port (lead supplied).
- Windows (95 to XP) Software included
- Works with MPASM assembler

16 x 2 LCD display, Breadboard, Relay, I/O devices and patch leads.

Featured in *EPE* **Mar'00** Ideal for beginners & experienced users.

Programs can be written, downloaded, and then tested by single-stepping, running to breakpoints, or free run at up to 20Mhz.

Full emulation means that all ports respond immediately - reading and driving external hardware.

Features include: Run; set Breakpoint; View & change registers, EEPROM, and program memory; load program; 'watch window registers.

KIT 900...£34.99 **With serial lead & software disk, PCB, Breadboard, PIC16F877, LCD, all components and patch leads.**

POWER SUPPLY - **£3.99** STEPPING MOTOR 100 Step **£9.99**

20W Amp. Module

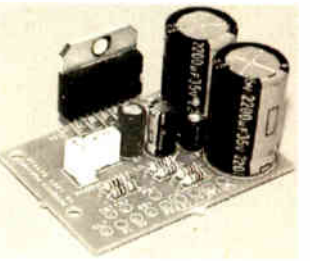
EPE May '05 -- Superb Magenta Stereo/Mono Module

Wide bandwidth Low distortion 11W /channel Stereo 20W Mono True (rms) Real Power

Short Circuit & Overheat Protected. Needs 8 to 18V supply.

Stable Reliable design

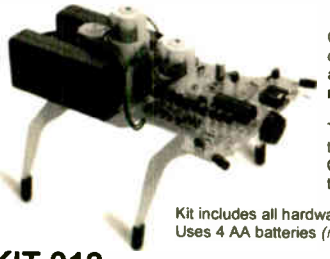
Latest Technology IC with local feedback gives very high performance.



KIT 914 (all parts & heatsink for stereo or mono) **£11.90**

Magenta BrainiBorg

A super walking programmable robot with eyes that sense obstacles and daylight: **BrainiBorg** comes with superb PC software CD *(WIN95+ & XP)* and can be programmed to walk and respond to light and obstacles on any smooth surface.



CD contains illustrated constructional details, operating principles, circuits and a superb **Educational Programming Tutorial.**

Test routines give real-time 'scope traces of sensor and motor signals. Connects to PC via **SERIAL** port with the lead supplied.

Kit includes all hardware, components, 3 motor/gearboxes. Uses 4 AA batteries *(not supplied).* *An Ideal Present!*

KIT 912 Complete Kit with CD rom & serial lead **£49.99**

KIT 913 As 912 but built & tested circuit board **£58.95**

EPE PIC Tutorial

***EPE* Apr/May/Jun '03 and PIC Resources CD**

- Follow John Becker's excellent PIC toolkit 3 series.
- Magenta Designed Toolkit 3 board with printed component layout, green solder mask, places for 8,18, 28 (wide and slim), and 40 pin PICs. and Magenta extras.
- 16 x 2 LCD, PIC chip all components and sockets included.

KIT 880 (with 16F84) **£34.99,** built & tested **£49.99**

KIT 880 (with 16F877) **£39.99,** built & tested **£55.99**

EPE TEACH-IN 2004

THE LATEST NOV 03 SERIES

All parts to follow this new Educational Electronics Course. Inc. Breadboard, and wire, as listed on p752 Nov. Issue.

KIT 920.....£29.99

Additional Parts as listed in 'misc.' Section (less RF modules, Lock, and Motor/g.box)

Reprints: £1.00 per part.

KIT921.....£12.99

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- Full kit with ALL hardware and electronics.
- As featured in *EPE* Feb '03 (KIT 910)
- Seeks light, beeps, and avoids obstacles
- Spins and reverses when "cornered"
- Uses 8 pin PIC chip
- ALSO KIT 911 - As 910 *PLUS* programmable from PC serial port leads and software CD included.

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Starting Out

Teaching electronics or design and technology? A student studying electronics or design and technology? A newcomer to electronics? Generally interested in electronics and want to learn more? Like to brush up on your electronics theory? Then our new ten part *Teach-In* series is sure to be of interest to you – or someone you might know. It starts next month and you will find more details about it on page 667.

We think the on-line monthly test and end of series on-line test and certificate are a first for *EPE*. Our *Teach-In* courses are always popular and, as this one has been written by Mike Tooley, who is well known for his many books and articles and who edited our *Electronics Service Manual*, it will no doubt be very well received. Mike has over 30 years experience in teaching electronics at all levels and has an easy-going writing style that helps to get the subject across in a readily understandable form.

Don't miss the start of the series next month. With cut backs by high street newsagents you may find issues are sold out quickly. We suggest you place an order with your newsagent or take out a subscription and save money – see page 716.

Cameras Again!

Next month also sees the publication of a Mk2 *Speed Camera Watch*. The original vesion, published in the January issue, aroused a great deal of interest and the Mk2 version has been greatly enhanced. One of the major changes – suggested by readers – has been to add an audible speed warning. This makes it easy to keep to the speed limit without constantly checking the speedo. So when you come off the motorway into a 30mph area it will help to make sure you adjust your speed accordingly. The memory has also been enlarged to hold up to 10,000 camera or black spot coordinates so, hopefully, it will cover everywhere you want to go, and keep you within the law.

Mike Kenward

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Constructional Project

Halloween Howler

Mike Hibbett

Halloween's coming – why not give your "trick or treat" visitors a scare?!

PICTURE a pumpkin head, eyes lighting up red and emitting an eerie howl when someone walks past it!

Although intended to help generate a bit of fun over Halloween, this project also serves to demonstrate just how easy (and cheap) it can be to output audio in an electronics project. The sound comes from a pre-recorded computer "WAV" file stored in a small non-volatile memory. WAV files can be downloaded from the internet, extracted from music CDs and even recorded by yourself on a PC using software supplied with most operating systems.

The circuit can be configured into one of two modes of operation: Halloween Howler, which includes a light sensor to detect moving objects, and a generic three-input design that allows one of three stored sound samples to be played when an input is asserted. This second setup provides a more general purpose sound generator that can have a number of uses. Only minor component changes are required for the different setups, which are described later.

WAV File Format

WAV files are one of the simplest formats used for storing sounds on a PC and are typically used for short sound clips. They are not a very efficient format. For example, a CD quality four minute music track requires about 42MB. An MP3 format file would require a tenth of that, but also requires complex encoding and decoding algorithms to record and play back.

A WAV file consists of a small header section which defines how the content has been recorded followed by the data itself. When a sound source is recorded, for example from the microphone on your PC, there are two factors that will determine the quality and size of the file: the number of data bits used per sample, and the rate at which samples are taken.

Values of four, eight and 16 are typical for the number bits per sample, while the sample rate varies typically from 8000 to 44000 samples per second. The sample rate determines the maximum frequency that you can record and must be at least twice that of the highest frequency to be sampled.

For reasons that will become clear later, the WAV files used in this design are encoded at 11025 samples per second, with an 8-bit resolution per sample. This provides an acceptable quality sound output without requiring enormous and expensive memory storage. WAV files are easy to create in this format on a PC, and existing higher quality sound files can be easily re-encoded to this format.

Digital-to-Analogue Conversion

The heart of this project is the circuit which converts the digital representation of the sound, stored in the WAV file, into an analogue signal. In other words, it is a digital-to-analogue converter (DAC). DACs are not just used for creating audio, they are used in PC video cards to create the analogue video signals. and they find many other uses in embedded control systems.

There are a number of ways to implement a DAC. Some of the more common methods that can be used in a hobby project are:

Pulse Width Modulation: Many microcontrollers provide an option to control a pulse-width modulated (p.w.m.) peripheral, such as a motor for example. The p.w.m. control is generally run at least three times the sample rate, and the output signal is connected to an RC (resistor/capacitor) filter to produce an averaged analogue signal. The nice feature is that it requires just a single output pin, and is a good option if you have a spare p.w.m. on your micro.

On chip DAC: Some high performance microcontrollers have a DAC peripheral built in, with a resolution of eight to 16 bits. These are the easiest to use.

Dedicated DAC: These implement all the electronics into a single chip, such as the Analog Devices DAC08 for example.

Discrete R2R DAC: This technique uses an array of resistors connected to a parallel port on the microcontroller. This is cheap, easy to route on a p.c.b. and very effective. It is also very easy to drive in software.

Single bit DAC: Uses a single output port pin to drive an RC circuit, at high speed. However, the sound file needs to be encoded in a special way and the encoder must "model" the characteristics of the RC circuit. It's quite complex and hard to understand but very easy to implement if you have a fast enough microcontroller.

Digital Potentiometer: These devices can readily be used as 8-bit (or greater) DACs, the "wiper" output providing an analogue voltage in respect of a input digital value.

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Chosen R2R DAC

For this project the simplest and cheapest method is used, the discrete R2R DAC. By carefully examining the I/O (input/output) port requirements (memory interface, DAC output pins, trigger input pins) a search of the Microchip database showed that the PIC16F628 was ideal for the purpose. It is small, cheap and every available pin can be used, so nothing is wasted! In the Howler there is plenty of free code space for adding extra features later on should you wish to.

The trick behind making an R2R DAC work lies in being able to drive all the output pins simultaneously. Delays in setting some outputs will result in unacceptable distortion in the audio signal. That limits the number of bits (and therefore the DAC resolution) – we can drive at most eight bits simultaneously, so eight bits it is then!

The next issue to deal with is the sample rate. CD quality audio is sampled at 44kHz: there are two problems with that rate. First we would not be able to read data from memory fast enough, and secondly we would quickly run out of storage space. The industry-standard rate of 11025Hz was chosen as a fair compromise.

As it is a standard encoding rate, so we can use existing PC tools to create our sound sources, it allows us to store almost six seconds of sound, and we can read data from a serial EEPROM (electrically erasable programmable read-only memory) at this rate. The sound's quality isn't bad either. In theory it would be possible to run at a sample rate of 22050Hz, but with just three seconds of recorded sound. Feel free to tinker!

Circuit Description

There are two configurations that can be used for the Halloween Howler. They both use the same circuit, which is shown in Fig.1, with a few minor changes. We first describe the Halloween setup and explain the changes required for the second setup later.

The circuit is based around a PIC16F628 microcontroller, IC5, that reads a standard Windows WAV file stored in a serial EEPROM, IC2. The eight bits of data that represent each sound sample are output on PIC PORTB, to which the R2R DAC is connected.

Capacitor C4 provides some initial filtering, and as this signal is quite high impedance it is buffered by an op.amp, IC3a. Op.amp IC3b acts as both a low pass filter (C5 and R25) and attenuator to provide the correct drive to a small audio power amplifier, IC4. The low pass filter removes the high frequency artifacts caused by the signal switching at the sample rate.

The audio amplifier based around IC4 uses the device's application sheet design and produces about 350mW, more than enough to drive a small 4Ω or 8Ω loudspeaker connected to jumper connector TB8. Potentiometer VR1 provides a volume control.

Light emitting diodes D1 and D2 are standard 5mm red l.e.d.s that illuminate when the sound is triggered, simulating glowing red eyes. Any l.e.d.s will do, so

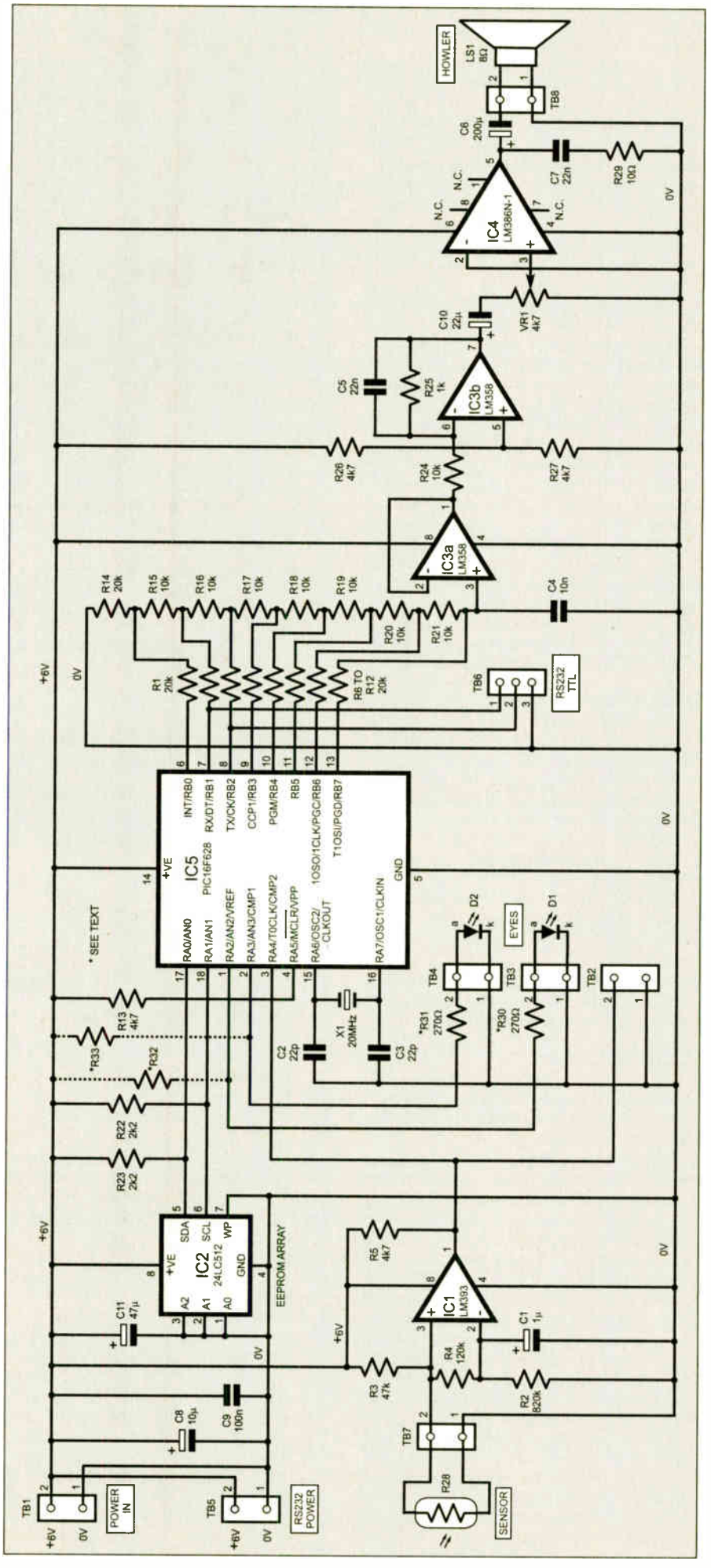

Fig.1. Complete circuit diagram for the Halloween Howler

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long as the PIC's drive capability of 25mA per pin is not exceeded.

The sound output is triggered by a sudden rise in light level on a light dependent resistor (l.d.r.), R28, connected to TB7. Op.amp IC1 is configured as a comparator into which the l.d.r. is fed. Capacitor C1 and resistor R2 provide a bias to the comparator's reference input so that gradual changes in light level, such as sunrise or clouds passing over the moon, do not trigger the sound output. The sensitivity of the circuit is largely determined by resistor R4; reduce this to increase the sensitivity.

The circuit is triggered by a sudden *rise* in light level – the idea being that as someone approaches the pumpkin the light level falls, then as they go past, the circuit triggers. So the pumpkin wakes up behind them, adding to the scary effect!

Serial EEPROM IC2 holds the WAV file sound data, of up to 64KB, about six seconds. A PC can be connected via RS232 interface on TB5 and TB6 using a suitable level shifter circuit as shown later in Fig.3.

The serial EEPROM also holds data which defines how the p.c.b. is configured. The sound file and the configuration information are downloaded using a simple PC program, **dlwav.exe**.

The board is powered at 6V, supplied by four 1·5V batteries connected via TB1.

Alternative Setup

The PIC software supports a second mode of operation, using three input signals to trigger one of three stored WAV files. In this configuration the light detection circuitry and l.e.d.s D1 and D2 are removed (but not their jumper headers, TB7, TB3 and TB4, respectively.

Other circuit changes are:

R30, R31 replaced by wire links
R32, R33 values changed to 4k7
IC1, R2, R3, R4, C1 not fitted

The three new trigger inputs are connected to TB2, TB3 and TB4. A low level input will trigger the sound.

Construction

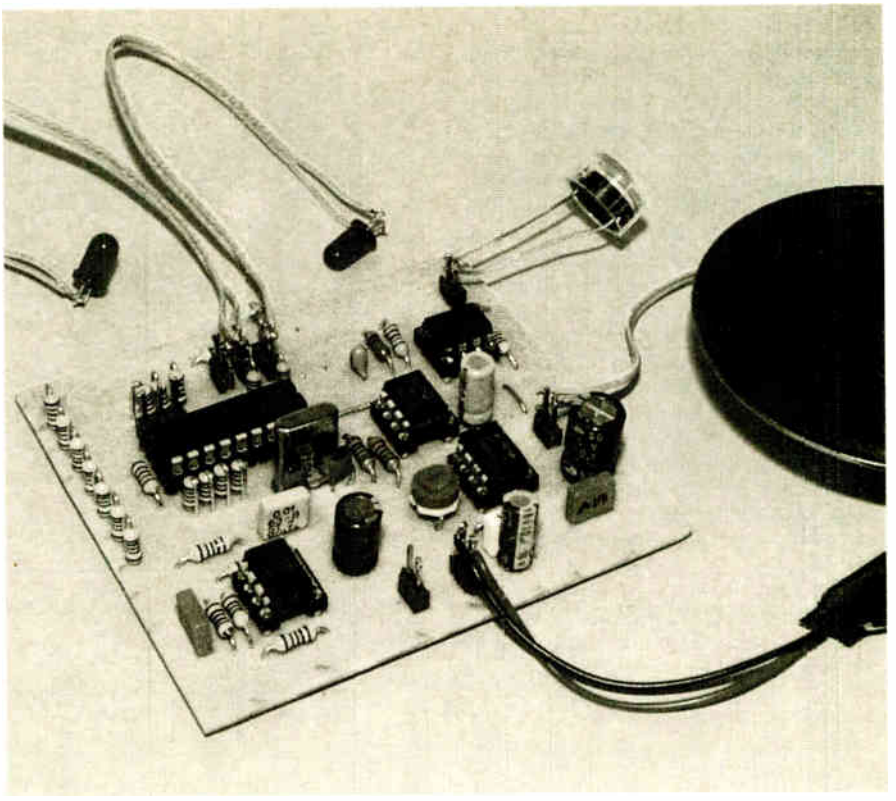
Printed circuit board component and track layout details are shown in Fig.2. This board is available from the *EPE PCB Service*, code 535.

Solder the two wire links first, then i.c. sockets and jumper header pins (terminal pins may be used instead of the latter), followed by the remaining components. Before fitting the i.c.s, apply power and check that the (nominally) 6V supply voltage is reaching the correct i.c. socket pins. Remove power and fit the i.c.s, observing normal static precautions when handling them.

Wire up l.e.d.s D1 and D2 via TB3 and TB4, connect a speaker via TB8 and connect the light sensor l.d.r. to TB7. The l.d.r. is not polarity sensitive and can be fitted either way round.

If you are programming your own PIC it must be programmed with the Osc HS, power-up timer and watchdog options enabled in the Config bits.

Download your WAV file to the board, then power the board up again. Quickly move your hand over the l.d.r.; The "eyes" l.e.d.s will illuminate while the sound is



Finished prototype with the off-board components attached ready for the pumpkin

COMPONENTS

Approx. Cost Guidance Only **£20**

excl speaker, batts & interface

Resistors

R1, R6 to R12,R14	20k 1% (11 off)	
R2	820k	
R3	47k	See SHOP TALK
R4	120k	
R5, R13, R26, R27	4k7 (4 off)	
R15 to R21, R24	10k 1% (8 off)	
R22, R23	2k2 (2 off)	
R25	1k	
R28	ORP12 l.d.r.	
R29	10Ω	
R30, R31	270Ω see text (2 off)	
R32, R33	4k7 or not fitted (see text) (2 off)	

All 0·25W 5% carbon film unless stated

Potentiometer

VR1	4k7 min. preset

Capacitors

C1	1μ radial elect. 25V
C2, C3	22p ceramic disc, 2·5mm pitch (2 off)
C4	10n ceramic disc, 5mm pitch
C5, C7	22n ceramic disc, 5mm pitch (2 off)
C6	220μ radial elect. 16V
C8	10μ radial elect. 16V
C9	100n ceramic disc, 5mm pitch
C10	22μ radial elect. 63V
C11	47μ radial elect. 10V
C12 to C16	1μ radial elect. 25V (optional – see text) (5 off)

Semiconductors

D1, D2	5mm red l.e.d., (2 off)
IC1	LM393 dual op.amp
IC2	24LC512 serial EEPROM
IC3	LM358 dual op.amp
IC4	LM386N-1 audio power amp
IC5	PIC16F628-20 microcontroller, pre-programmed (see text)
IC6	MAX232 RS232 converter (optional – see text)

Miscellaneous

TB1 to TB10	jumper header or 1mm terminal pins (see text)
SK1	9-pin D-type connector, female (optional - see text)
LS1	8Ω min. speaker
X1	20MHz Crystal

Printed circuit board, available from the *EPE PCB Service*, code 535; 8-pin d.i.l. socket (4 off); 16-pin d.i.l. socket (see text); 18-pin d.i.l. socket; stripboard (optional – see text); pumpkin!; connecting, solder, etc.

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being played. Adjust volume potentiometer VR1 for an appropriate sound level.

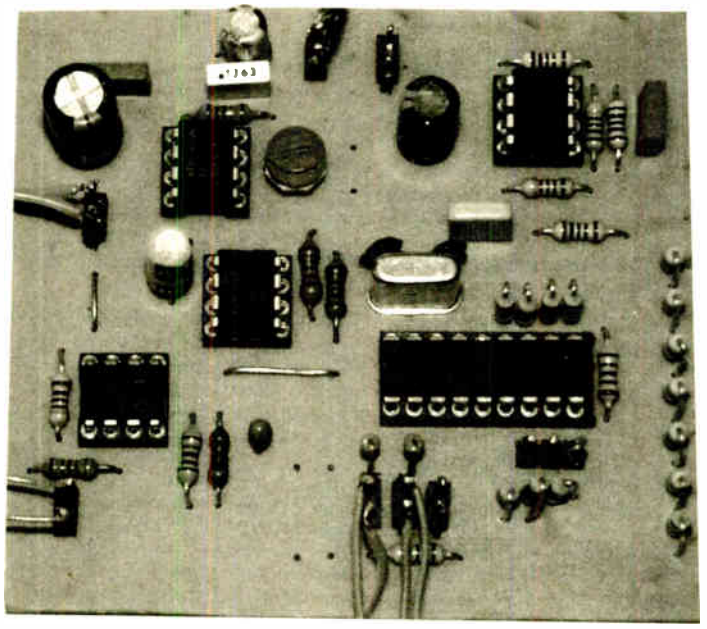
You can download WAV files to the board any number of times; The EEPROM can be written to over 100,000 times so you are unlikely to wear it out!

Pumpkin Head

Once you are happy with the setup you can install it into a pumpkin. It's best to place the p.c.b. and speaker inside a sealed plastic bag since the inside of a pumpkin remains damp for many weeks.

Position the light sensing l.d.r. in the "mouth" and the l.e.d.s close to the holes cut for the "eyes". Covering the eye holes with red crepe paper helps to diffuse the light and adds to the scary effect.

Positioning the pumpkin requires a little thought, since it must be pointing to a light source (such as a porch lamp). It must be positioned so that the light is interrupted when someone approaches. A little experimentation may be required, and the value of resistor R4 adjusted if necessary.



Completed Howler prototype circuit board. Note resistors R33 and R32 do not apper on this board and the author has used header pins for the wiring take-off terminals

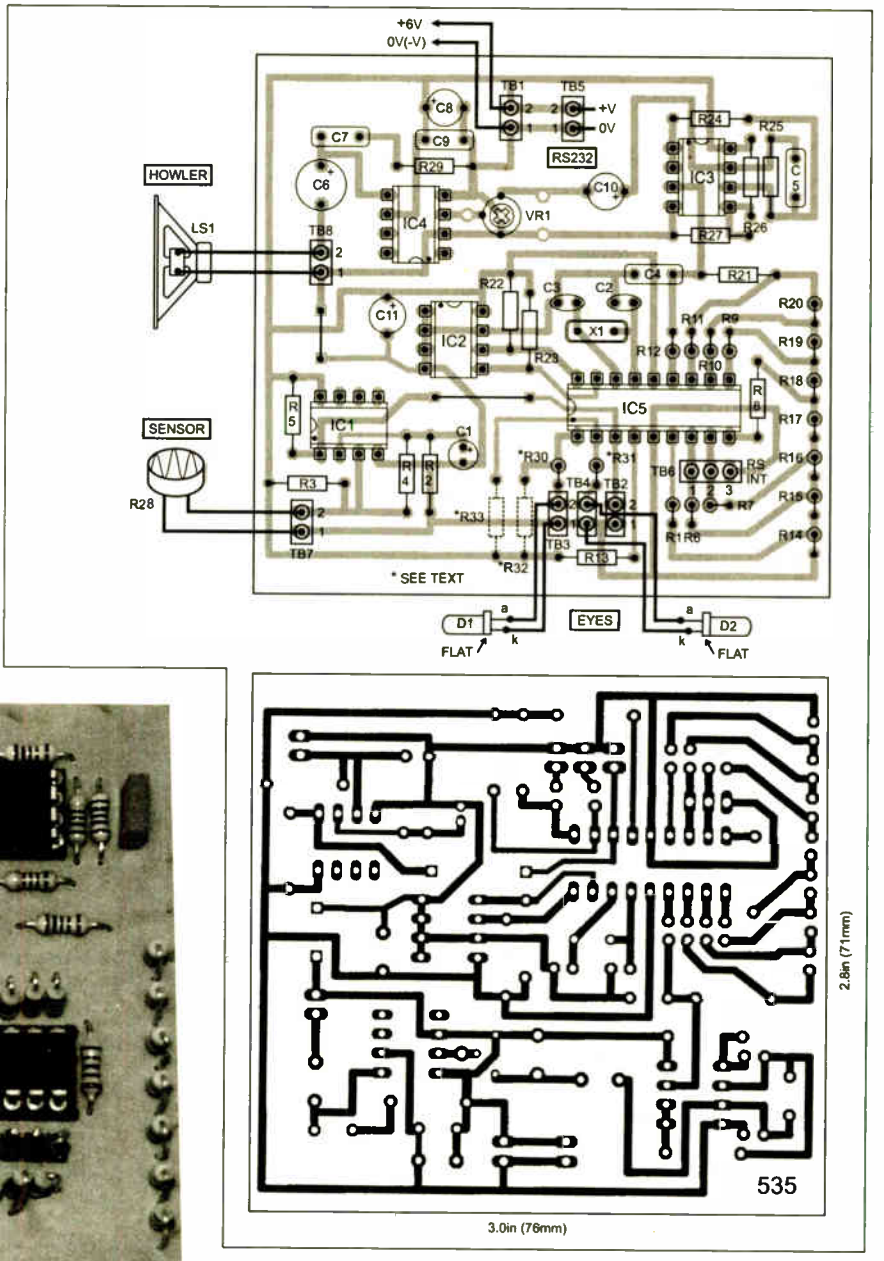


Fig.2. Printed circuit board topside component layout, off-board wiring details and full-size underside copper foil master pattern for the Haloween Howler

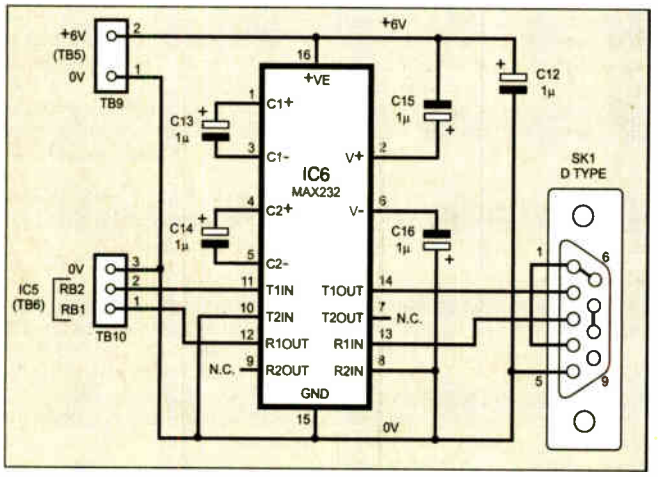


Fig.3. Suggested circuit diagram for a suitable RS232 Interface using the Maxim MAX232 chip. This circuit and accompanying board has not been tested with the Howler

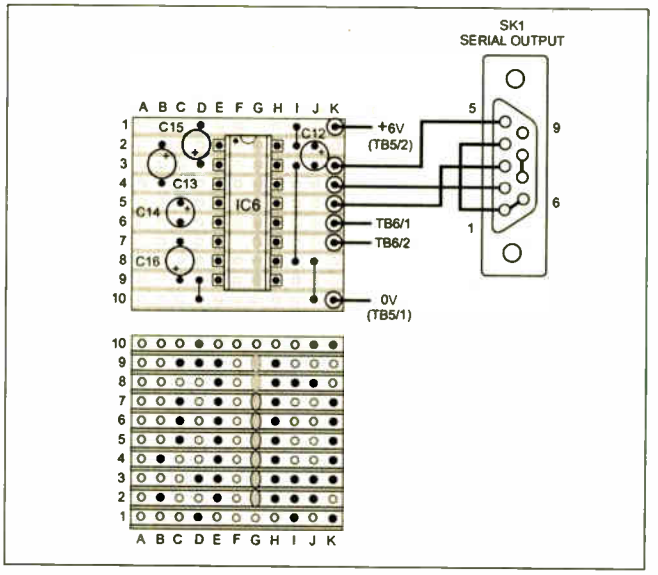


Fig.4. Stripboard component layout and wiring details for the suggested RS232 Interface circuit

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The final effect on visitors is priceless, and worth the effort!

Sound Downloading

The WAV file files can be downloaded from the *EPE* website (see later). The program consists of **dlwav.exe** and **cp30fwm.dll**. Copy these files to a directory on your PC (any name you want) and then run the **dlwav.exe** program.

An example of the program window is shown in Fig.5. First select the appropriate COM port, then click on the p.c.b. configuration that you will be using. If you choose the second option then two further input boxes will appear for additional sound files. Type in the names of the sound files you want to use, or click on the browse button to find them using Explorer.

Download Interface

When you are ready to download the files to the board, connect an RS232 interface circuit to the PC and p.c.b. If you do not have such an interface, the circuit shown in Fig.3 can be assembled on stripboard. A suggested layout is shown in Fig.4, but has not been tested with the prototype.

Click the Download button in (as in Fig.5). After a few seconds the program should indicate it is waiting for the p.c.b. to respond. Apply power to the p.c.b. After a few seconds the **dlwav** screen should indicate the download progress. Downloading takes approximately 90 seconds. When it has finished, remove power from the p.c.b. and disconnect the cables.

The program will check that the sound files are of the correct format. They must be stored in 11025Hz, 8-bit Mono mode format. Microsoft's Sound Recorder application can re-sample audio files to the correct format. If you open a WAV file in Sound Recorder and select the **File->Save As** option you can click on the Change button in the dialog and select the correct format. If the sound sample is too long it will be truncated by the **dlwav** program, although you can also use the Sound Recorder application to trim the file to the length you want.

Suitable sounds can be easily found on the Internet and resampled to the correct format if necessary. A search via **www.google.com** for "Halloween sounds" resulted in plenty of interesting options! If you choose to record your own sounds make sure that you record at a high level using a decent microphone. Low volume sound samples will not playback well. The author found a cheap "Studio Microphone" quite acceptable.

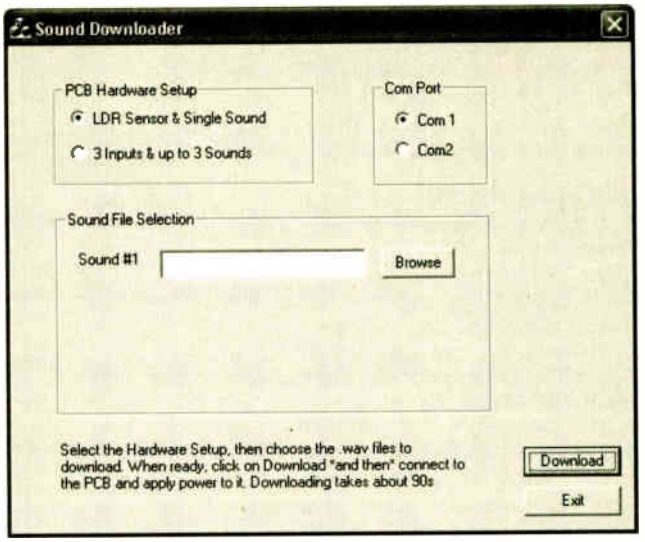

Fig.5. Screenshot of the download application window

Resources

Software, including source code files, for this design can be downloaded *free* from the *EPE* Downloads site, accessible via the home page at **www.epemag.co.uk**. It is held in the PICs folder, under Halloween.

This month's *Shop Talk* provides information about obtaining pre-programmed PICs and component buying advice. □

SHOP TALK with David Barrington

Halloween Howler

No real "howlers" appeared when casting an eye down the components list for the *Halloween Howler* project. The LM op.amps and auidio power amp i.c.s. should be widely available from our components advetisers.

For those readers who intend to program their own PICs, it should be pointed out that its the 20MHz version of the PIC16F628-20 that is required. This is usually identified by the -20 after the main type number.

The MAX232 RS232 serial interface i.c. is one of the most favoured devices and readers should have no trouble in obtaining one from most of our components advertisers. For more technical details you could log-on to **www.maxim-i.c.com**.

Some readers may experience difficulty in locating the 24LC512 serial EEPROM. This is currently listed by **Maplin** ***(☎ 0870 429 6000*** or ***www.maplin.co.uk)***, code N31BH. The serial EEPROM holds the WAV file sound data, up to 64KB, about six seconds.

Standard 5mm red l.e.d.s are used to simulate the "glowing eyes". Almost any l.e.d. will do here, so long as the PIC's drive capability of 25mA per pin is *not* exceeded.

For those readers unable to program their own PICs, ready programmed PIC16F628-20 microcontrollers can be purchased from **Magenta Electronics** ***(☎ 02083 565435*** or ***www.magenta2000.co.uk)*** for the inclusive price of £4.90 each (overseas add £1 for p&p). The sound file and the configuration information can be downloaded *free* from the *EPE* Downloads site, accesible via the home page at **www.epemag.co.uk**. It is held in the PICs folder under Halloween.

The Howler printed circuit board is available from the *EPE PCB Service*, code 535 (see page 733). Don't forget to seal the completed p.c.b. and miniature speaker inside a plastic bag; the inside of a pumpkin remains very moist for many weeks.

PIC-Basedf USB Interface

The most surprising aspect when checking through the availability of components for the *PIC-Based USB Interface* was the s.i.l. resistor array. Component suppliers carried plenty of stocks of these resistor arrays but none at the 680 ohms specified in the article. However, a 680 ohms 5-way commoned s.i.l. resistor module was found listed by Farnell ***(☎ 0870 1200 100*** or ***www.farnellinone.co.uk)***, code 476-330.

The Darlington output opto-isolator type 6N139 is currently stocked by **Rapid Electronics** ***(☎ 01206 751166*** or ***www.rapidelectronics.co.uk)***, code 58-0602. Readers should have no difficulty purchasing the MAX232 RS232 serial interface chip, this is one of the more popular devices.

For the USB type-B socket you could approach **ESR Components** ***(☎ 0191 251 4363*** or ***www.esr.co.uk)***, who carry a large range of PC connectrors. Also try **Jaycar** *(see back cover)*, code PS-092 or **Jameco** ***(www.jameco.com)***, code 230957.

The PIC18F2455 is one of the new USB-enabled flash memory microcontrollers and for those readers unable to program their own PICs, pre-programmed PIC18F2455s can be purchased from **Magenta Electronics** ***(☎ 02083 565435*** or ***www.magenta2000.co.uk)*** for the inclusive price of £10 each (overseas add £1 for p&p). The software, including source code files, is available for *free* download via the Downloads link on our UK website at **www.epemag.co.uk**.

The printed circuit board is available from the *EPE PCB Service*, code 536, (see page 733).

Photic Phone

The IRF610 *n*-channel power MOSFET called for in the *Photic Phone* project does not appear to be in favour with our components advertisers. However, it is listed by **Farnell** ***(☎ 0870 1200 100*** or ***www.farnellinone.co.uk)***, code 354-430 and **RS Components** ***(☎ 01536 44079*** or ***rswww.com)*** code 139-833.

The author specified a 500 ohm resistor for the ultrabright l.e.d., but as 510 ohms is the preferred value and it is shown as this in the circuit diagram. The Siemens SFH203 photodiode was purchased (*credit card only*) from **RS** (see above), code 195-681.

The Phone printed circuit boards are available as a pair from the *EPE PCB Service*, codes 531 and 532. As to the lens option, we leave that to readers own ingenuity. A toy telescope or binoculars perhaps.

Back to Basics – Parking Radar/Telephone Switch

We do not expect readers to encounter any buying problems when shopping for parts for the *Parking Radar* or *Telephone Switch*, this month's *Back To Basics* projects. The relay used with the *Telephone Switch board* will, of course, need to be selected to suit the ratings of the appliance being controlled.

The 40kHz ultrasonic transmitter and receiver transducers, used in the *Parking Radar*, are normally sold in pairs. As an idea it might be worth investigating a combined single transmitter/receiver transducer from **Jaycar** (*see back cover*), code AU-5550. We have no idea as to the pinout arrangement for this device.

The two printed circuit boards are available from the *EPE PCB Service*, codes 533 (Radar) and 534 (Tele) – see page 733.

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World Radio History

News . . .

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

ALL SYSTEMS ARE GO!

From movies to betting, the sky's the limit reports Barry Fox

LOVE it or hate it, Rupert Murdoch's satellite station *BSkyB* just keeps going from strength to strength. Murdoch's son James is now CEO and running the show.

At a recent meeting held to update city analysts, Chief Financial Officer Jeremy Darroch described the company as being in "robust health" and reported 12% subscriber growth over the last year, with 11% revenue growth.

Churn, subscribers who stop paying, averages 10.3% per year. Despite this, Sky now has 7·78 million paying subscribers with home dishes. Average revenue from each subscriber is now £384. "We expect 8m subscribers by the end of this year and 10m by end of the decade" says Murdoch. "We have 0·89m Sky+ PVR users with 1m expected in the next few weeks." Asked whether Sky's 10 million target is dependent on the UK government's analogue switch off plans, Murdoch admitted: "Of course there is some connection – the (government) switch off plan does not have a lot of clarity."

Revenue from Sky's interactive TV betting is rising by 40% a year with more growth expected following liberalisation of the UK laws. People can now lose even more money they cannot afford from the privacy of their homes. To protect children the electronic programme guide is being redesigned, with the option to remove all adult material from the menu and control the replay of Sky+ recordings.

An intriguing new service will be launched before the end of year that will let five million top-tier subscribers who also have a broadband connection use it to download movies and sports to a PC, or laptop "to watch on a train".

"We shall start by offering a few hundred movies on demand" says Murdoch. No details of the cost or technology are yet available. But Sky confirms that the PC will need to download a software application and very small print on a slide shown by Murdoch showed *Spiderman 2* using a file of 500MB – almost certainly with MPEG-4 compression instead of MPEG-2, as currently used by Sky and Freeview. Sky has already confirmed that its HDTV service, due for launch early next year, will use MPEG-4.

"The move from MPEG-2 to MPEG-4 will have to happen" says Murdoch. He also confirms that Sky and Microsoft are partners in DRM, the Digital Rights Management that controls how and when downloads can be viewed.

Question Time

But many key questions on the new broadband service remain unanswered, most important how long the download will remain playable on a PC and what happens if a customer churns out. Murdoch's reply on this was very vague. "The DRM rights will depend on the window. They will vary with the title. There are no details yet. We will have details as we move forward".

The vagueness may be due to the fact that Sky is currently re-negotiating its movie contracts with three Hollywood studios.

Details also remain sketchy on the HDTV service now promised for 2006. There will be an additional charge for the receiver which will have one Ethernet and two USB ports and "greatly expanded hard drive" for the connection of peripherals and "a variety of new features"

"By 2007 CRT production will be discontinued – there will be 10 million HD Ready sets sold by end of the decade" says Murdoch. "By Christmas you will be able to buy a very good quality HD Ready screen for under £1000. It's going to be great. It's going to be a big story over the next five or six years".

Down To Earth

More immediate and down to earth Sky will soon launch a battery radio that works anywhere in the house or garden to receive the sound of satellite stations that can normally only be heard from a mains-powered receiver with fixed dish antenna. The Gnome comes in two halves, a transceiver that plugs into the back of an ordinary satellite receiver, and a pint-sized portable.

A wireless telemetry link at 433MHz lets the portable switch channels on the satellite receiver; an FM signal at 864MHz carries hi-fi stereo to the portable. Working range is around 30 metres; the likely cost around £100. The Gnome is being made for Sky by Global Communications of Essex.

Murdoch confirms the Gnome will also work with *Freesat*, Sky's free-to-air satellite radio and TV service.

When Murdoch was asked about recent concern over the life cycle of existing receivers and how long receiver boxes can be expected to last, and a comment by Sky's suppliers that they are not allowed to talk about planned life, he tried to reassure:

"Life cycle is not an issue – at this point. We don't see any deterioration. There is a lot of life in them yet... I looked again before this conference. If we did see something I would tell you".

ToothPIC Unveiled

At a recent London gathering FlexiPanel Ltd unvelied ToothPIC, a PIC microcontroller module with in-built Bluetooth and radio communications software libraries. The class-1 radio is FCC/CE certified and has 100m range with its integral antenna.

"ToothPIC offers you radio communications straight out of the box." said Richard Hoptroff, managing director of FlexiPanel. "No specialist knowledge of radio frequency design is required. Indeed, many remote control and data acquisition applications can use our off-the-shelf firmware, so the PIC doesn't even need to be programmed."

Based on the high-end PIC18LF6720 microcontroller, ToothPIC is supported by a large range of free software, from on-chip firmware solutions such as OpenTooth. which provides access control from a cellphone, to the user interface server, which allows it to create user interfaces on PCs, pocket PCs and high-end cellphones. Using Wireless Field Programming it can be reprogrammed from any Windows PC via Bluetooth, allowing OEMs to distribute product upgrades to their customers by email.

"We are really enthusiastic about the ToothPIC modules." says beta customer Marcel Jacomet, Lecturer at Bemer Fachhochschule, Switzerland, who uses them for teaching. "They are so simple to use and to download our own applications."

Utility functions are provided to take easy advantage of the ToothPIC peripherals, including real time clock, UART, 10-bit 12 channel A/D inputs and five p.w.m. outputs. The on-board power regulator accepts anything from 3V to 10V.

For more information on FlexiPanel's ToothPIC browse: **www.flexipanel.com.**

World Radio History

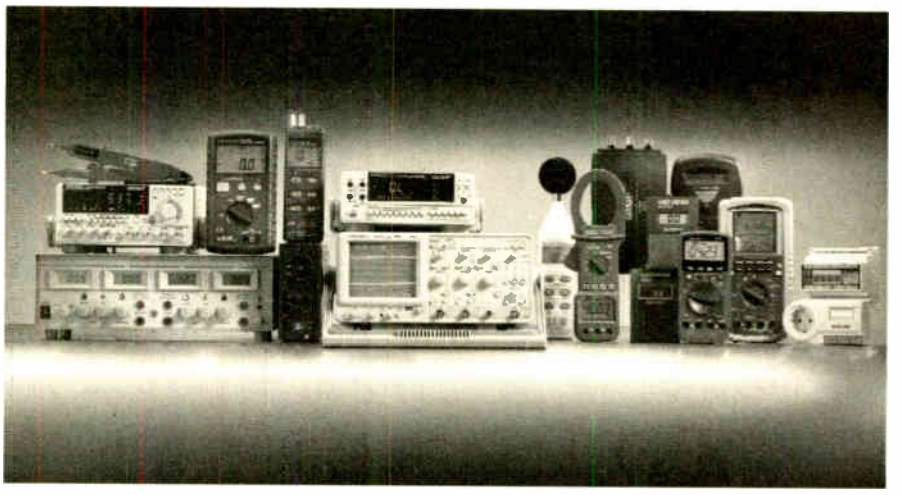
Conrad's One-Stop Shopping

FOLLOWING our welcome to Conrad Electronics last month, the company have filled us in with a bit more information about themselves:

Conrad has more than 80 years at the cutting edge of technology and says it leads the world in the supply of components. The Company began with providing components for kits for making radios in the 1920s, and then progressed in the 1930s to kits for making TVs. Components are now supplied for computers, multimedia, telephone, radio, and a multitude of home systems and electrical needs.

Conrad offers its products and services by catalogue, through retail branches and also via the Internet. Over 110 million products are shipped each year and products are supplied directly to customers in more than 150 countries worldwide. There are over 15,000 components on the website!

You can also subscribe online to the free regular Newsletter and stay informed about all the latest offers and exciting products.

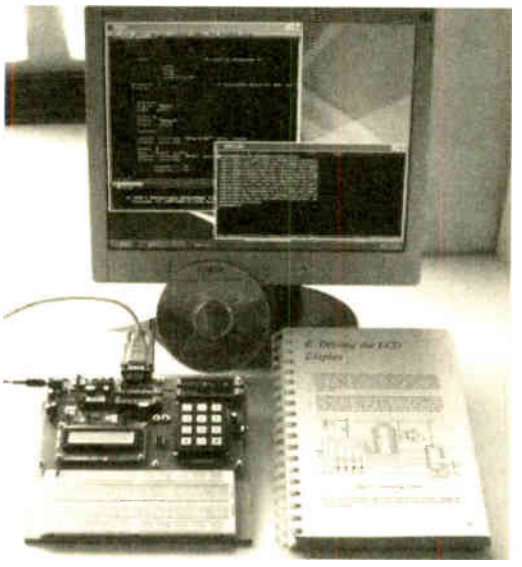


In Conrad's advert with us (see elsewhere in this issue), you can obtain a discount of 10% off orders valued at £30 or more. You'll also get the chance to win a Voltcraft Multimeter worth £139 in Conrad's Prize Draw!

For more information on Conrad browse: **www.conrad-direct.co.uk**.

Email:customerservice@conrad-direct.co.uk. or Tel 0870 732 3223.

Brunning Update Training



Brunning Software have just released a revised and updated version of their PIC Training and Development System. Peter Brunning believes that the practical approach is the natural way of learning so the theory is kept to a minimum. But he also believes that a newcomer can never become a proficient PIC programmer unless he or she has a grounding in the language of the processor.

The first of the two books included with the course gives a gentle start to PIC assembly language, while the second book teaches how to program PICs using the C language. The P801 PIC Training System works through from absolute beginner to experienced engineer level.

For £159 plus postage you get a programmer module which is also your experimental test bed, two books, CD with PIC assembler and C compiler, plugtop PSU (UK only) and PC serial COM lead.

For more information contact Brunning Software, 138 The Street, Little Clacton, Clacton-on-Sea, Essex C016 9LS.

Tel: 01255 862308. Web: **www.brunningsoftware.co.uk**.

PCB-POOL

The team at PCB-POOL have launched a number of new services. In their recent press release they say that they are Europe's largest on-line p.c.b. prototype supplier and are broadening their offering, promising a range which will suit every level of p.c.b. designer. The improvements will provide for reduced lead-times, and electrical testing as standard. The aim of the service is to pass on the cost saving benefits of prototype p.c.b. manufacture to the designer. Expensive tooling and photoplot charges have been eliminated.

The company has recognized the importance of receiving high quality p.c.b. prototypes, and all files are fully design-rule checked and validated by experienced CAM engineers. As an extra assurance for p.c.b. designers full electrical test is being offered on all four to six layer prototypes free of charge.

You can order pre-production quantities, working from a standard lead-time of eight working days. A fast turnaround service with a reduced lead-time of five working days is also available.

For further information visit: **www.pcb-pool.com**, *or free phone: 0800 3898560.*

Quote...Unquote

Dixons, one of the UK's leading retailers of consumer technology on the high street, has announced the launch of a Dixons-exclusive, Hitachi-branded Hi-Fi that the retailer believes will redefine the shape of future home entertainment systems.

OUT are tape decks, CD-only players, AM radios and other legacy technologies.

IN are a 40GB hard drive that stores 10,000 songs, a DAB radio, a DVD player that plays all CD formats, and high specification speakers. Other enhancements include front and rear USB ports to enable owners of MP3 players to plug and play or plug and go.

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TECHNO-TALK

MARK NELSON

USELESS AT THEIR JOB

Why cannot historians agree on even the key elements of recent electronic history? Mark Nelson investigates

YOU'D think that historians could at least do the job they're paid to do. As professionals, they of all people should be able to sort out who invented what and when.

"History is bunk," famously said the industrialist Henry Ford and from this you might infer he had a low opinion of historians. I could easily take offence at this remark, having a degree in economic and social history, but I feel bound to agree – up to a point. "Historians" manage to present multiple versions of what they present as facts, so it's not hard to criticise historians for failing to come up with a single, incontrovertible version of past events.

If only life were that simple! History exists to justify people's beliefs, as the conflicting versions of how any industrial or territorial dispute began will readily illustrate. And who invented radio – Marconi, Popov, Tesla or Nathan Stubblefield? It all depends whose side you are on!

Perception of Kilby

And in that vein I had to smile when I read Jack Kilby's obituary in the September issue of this magazine, where it stated that he was the inventor of the monolithic integrated circuit (i.c.). It may be received wisdom but it's a "fact" that's widely contested by alternative historians and it all boils down to what you call an integrated circuit.

By common consent an integrated circuit contains both active and passive electronic components, all "integrated" in a single package. Who first invented it, patented it or turned it into a practical device is a matter of debate:

Jack Kilby of Texas Instruments invented the i.c. in 1958, yet the patent was awarded the following year to Robert Noyce, co-founder of Fairchild Semiconductor Corporation. In the event, both pioneers shared the honours when the U.S. Academy of Engineering bestowed on them both the academy's Draper Award in 1978; in 1989 President George Bush (senior) awarded each $175,000.

So how come they both invented the i.c.? It depends on your definition. Kilby had the notion that all parts of an electronic circuit, not merely the transistor, could be made out of silicon on a single substrate. Creating the entire circuit in monolith i.c. form would make it smaller and much easier to produce. The idea appealed to his employers and in just over a month Kilby had built a working model.

This was in September 1958 and in February of the following year Texas Instruments filed a patent for their "Solid Circuit", which was shown publicly for the first time in March.

Rough Justice?

Ingenious as this Solid Circuit was, it could not in itself set the world alight with just one transistor on-board. Someone who realized this was Robert Noyce, who had independently thought along similar lines. Although he did not start until January 1959, his debut design was the first i.c. with more than one transistor.

Aware, too, of Kilby's work he delivered a patent application that stressed the unique characteristics of his own design along with details of its potential applications, something missing from Kilby's presentation. This paid off for him and it was he who was awarded the patent for the first integrated circuit while Kilby's submission was still being analysed. Was this rough justice? It's hard to tell.

Of course you cannot do much with such basic circuit elements and it fell to others to develop i.c.-type devices with practical applications. The microprocessor is one and in 1968 Los Angeles computer expert Gilbert Hyatt took the integrated circuit a step further by including in one place all the pieces necessary to operate a computer (except memory and interface).

His patent application for this microprocessor was submitted in 1970 and although three engineers from Intel Corporation created the first commercially viable microprocessor the following year, while Hyatt's paperwork was still being scrutinised, it was nevertheless Hyatt who was eventually credited with its invention by the U.S. Patent Office.

Ancient History

But this is by no means the end of the bickering and there are several other valid claimants for the credit of being father of the i.c. Radar scientist Geoffrey (G.W.) Dummer of Britain's Royal Aircraft Establishment had already outlined his ideas for integrated circuits in May 1952 and attempted to build a prototype in 1956.

His 1952 revelation was made at a conference in Washington D.C. when he explained how a solid block of material such as silicon could comprise separate layers that would act as the key components needed by electronic systems. He was thus the first person to publicise the concepts that Kilby and Noyce later brought to fruition.

Unfortunately for Dummer, his rudimentary integrated circuit of 1956 failed to persuade British investors willing to fund further research, losing an opportunity to create a multi-million pound industry.

If you broaden the definition of the i.c. to include thermionic technology, then the honours must fall to the Germans. For in 1926 the Loewe company's OE 333 radio receiver employed a valve that incorporated two audio amplifier stages plus a final amplifier, all in a single standard-size glass tube.

You can see photos of this 3NF valve on the Web at **www.jogis-roehrenbude.de/Roehren-Geschichtliches/Loewe-Roehren/Loewe.htm** and if you read German, you may care to download the period literature offered on this page.

Final Example

For my final example of disputed history, let's take a truly fundamental innovation of modern times, the printed circuit board or p.c.b. It's modern history after all, so determining the inventor must be a total no-brainer, but surprisingly not. A clue to the fact that it's perhaps not such a modern invention is its alternative and older name, the printed wiring board or PWB.

Because it was first exploited in earnest on the other side of the Atlantic, a notion grew up that the Americans invented the process to speed production of rugged military radios during World War II (p.c.b.s did not become commonplace in consumer electronics for another decade or more).

Then more diligent researchers named the inventor as Paul Eisler (1907-1995), an Austrian-born engineer who like many of his comrades came to Britain in the 1930s.

According to Eisler's own testimony, he first conceived the technique at his home around 1936, using small strips of copper foil fixed with varnish onto Bakelised paper (paper impregnated with phenolic resin to form a rigid but easily shattered board). In his book *My Life with the Printed Circuit*, he states that he employed his "first printed circuit invention in the form of a complete radio set that worked perfectly", as a credential when applying for a job with Plessey.

We can certainly credit Eisler with creating the first true printed circuit board but the idea was by no means new in 1936. A fascinating piece of research in the *Articles* section of **www.circuitree.com** reveals a patent of 1903 by Albert Parker Hanson, living in Berlin, for circuit boards using stamped copper tracks bonded adhesively to paraffined paper. The patent even illustrates double-sided and multilayer p.c.b.s – such modernity over 100 years ago!

World Radio History

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World Radio History

Constructional Project

PIC-Based USB Interface

Robert Lang

How to easily use USB to communicate with the new PIC18F2455 microcontroller

ARE you ready to jump on the Universal Serial Bus (USB) bandwagon? Maybe you have an existing embedded application you would like to update to use USB. Maybe you have a new PIC application you would like to develop to use USB. In this article we explore the basics of an easy way of getting data into and out of a PIC18F2455 microcontroller using its USB interface.

The design allows existing RS232 devices to be controlled by a Windows 2000/XP USB connection. In addition, l.e.d.s can be controlled over the USB. Although the design is simple, it illustrates the process of getting data into and out of the PIC over a USB connection. The "easy way" approach to USB makes maximum use of existing free software and Windows drivers.

Introduction to USB

The goals of the USB 2.0 development team were very lofty. They wanted to simplify, from the user's point of view, personal computer peripherals. They wanted a system that supported real time video, voice and audio data. They wanted a protocol that could handle isochronous data transfers and asynchronous messaging.

They wanted a standard interface that could quickly be used in products. They wanted new classes of devices that would expand the personal computer's capability, and they wanted backward compatibility with previous versions of USB.

The result is *Universal Serial Bus Specification, Revision 2*, a 650 page behemoth, that is available as a free download (see References, Ref.1, later). The USB specification contains almost anything you would want to know about USB, it is suggested that you start by reading Chapter 9 which discusses the USB device framework.

Chapter 9 includes device requests, descriptors and class definitions. USB allows peripherals to be plugged and unplugged without down-powering the computer. This process, called "enumeration", involves communicating with the peripheral to discover its identity and characteristics.

Information about the device is contained in descriptors that are transmitted to the host during enumeration. A unique address is assigned to each peripheral to be used for run-time transfers. The device is also assigned a configuration during the enumeration process.

Slave Protocol

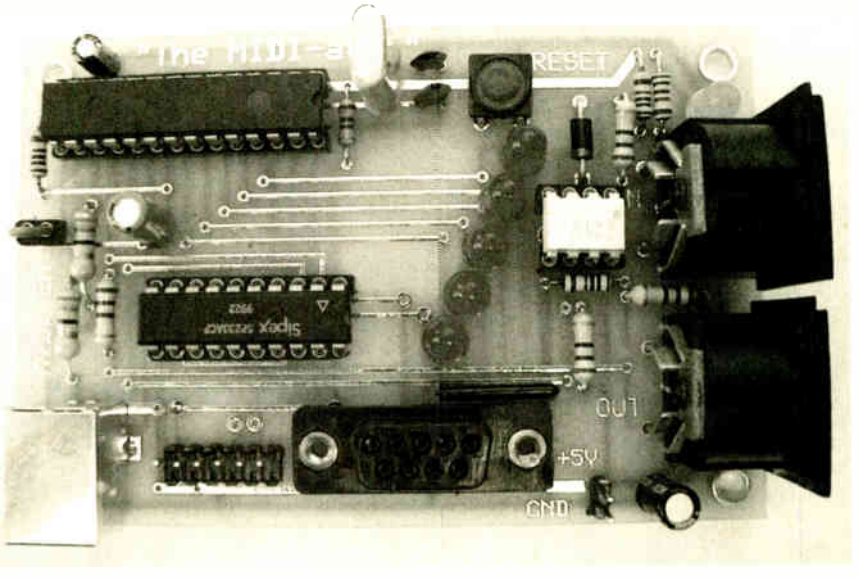
All USB peripherals are slaves that obey a defined protocol. They must react to request transactions sent from the host PC. For example, the peripheral must respond to control transactions that request detailed information about the device and its configuration. All USB devices support the requests and descriptor definitions described in Chapter 9.

In addition, devices may provide extended services that are characteristic of a group of devices. A class of devices, for example the Audio Device Class, is defined by a specific set of descriptors, requests and interface/endpoint usage. So you might find descriptors, request and interface usage relating to a volume control in the Audio Device Class but not in the Imaging Device Class.

Each USB device has two or more endpoints. An endpoint is a uniquely addressable portion of the USB device that is a sink or source of information that flows between the host and the device. One can think of an endpoint as a device buffer where data is placed to be transferred by the USB engine to or from the host. USB is a host-centric protocol so "IN" endpoints transfer data to the host from the USB device and "OUT" endpoints transfer data from the host to the USB device.

USB 2.0 supports four types of data transfer: Control, Interrupt, Isochronous and Bulk. Control transfers are typically used for command and status operations. They are essential and all enumeration functions are performed using control transfers. Interrupt transfers are typically non-periodic, small device "initiated" communication requiring bounded latency. An Interrupt request is queued by the device until the host polls the USB device.

Isochronous transfers occur continuously and periodically. They typically contain time sensitive information, such as an audio or video stream where a delay or retry would be unacceptable. However, if a



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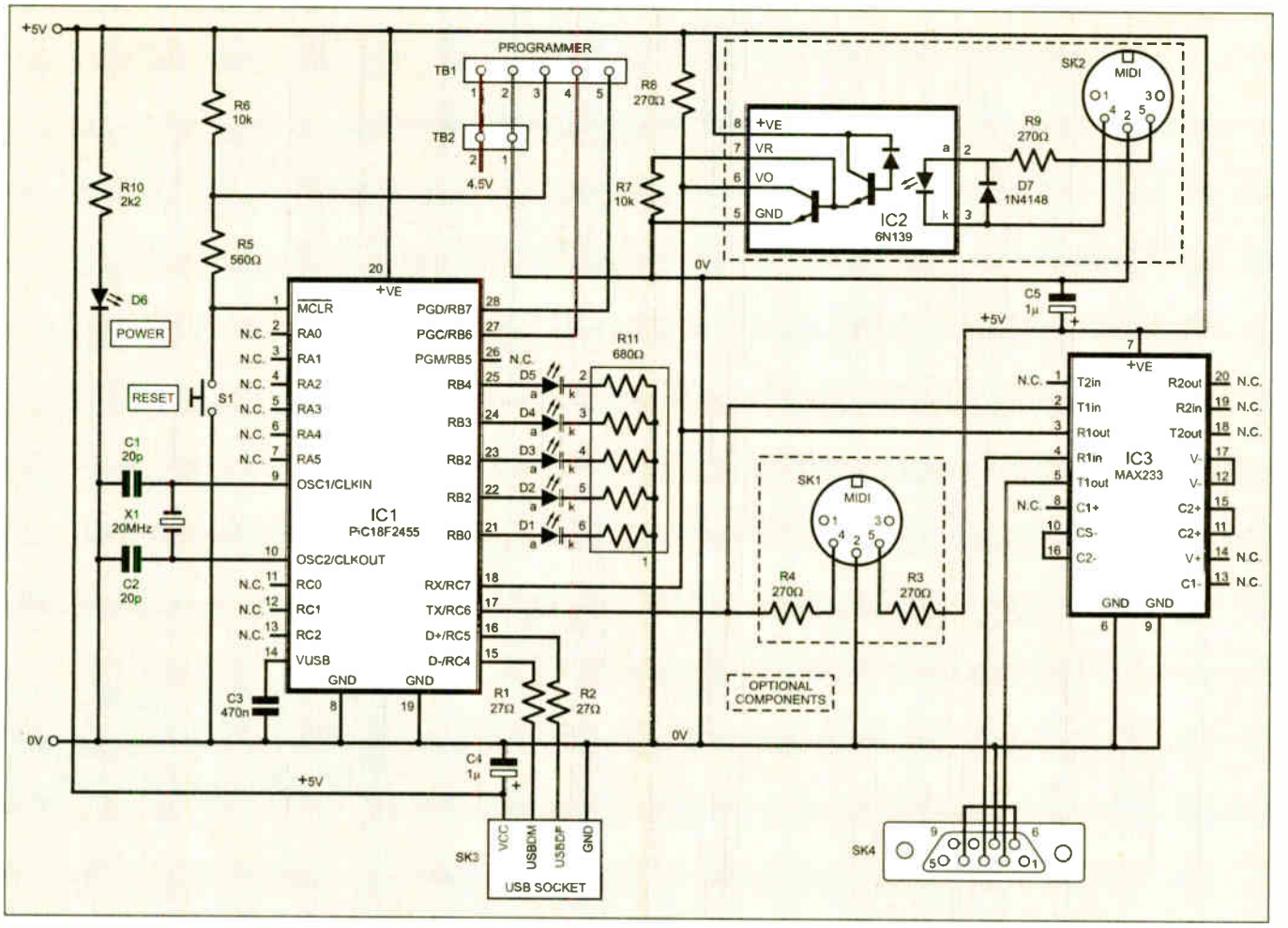

Fig.1. Complete circuit diagram for the PIC-Based USB Interface

packet or frame were to be dropped every now and again, it is less likely to be noticed by the listener/viewer.

Bulk transfers provide error correction on the data payload and error detection/re-transmission mechanisms, ensuring data is transmitted and received without error. Bulk transfers are the lowest priority and use spare un-allocated bandwidth on the bus after all other transactions have been allocated.

Class Definitions

A USB device class is a group of devices that has a common set of descriptors, requests and interface/endpoint usage. Some of the USB device classes that have been defined in the specifications include Audio Device Class, Imaging Device Class, Communication Device Class (CDC), Human Interface Device (HID) Class, Mass Storage Device Class, Printer Device Class and others. Some of the classes have subclasses such as the MIDI devices under the Audio Class.

If you can fit your device into a standard USB device class then you can leverage your software development efforts by using the standard device drivers written by the operating system developers.

With our "easy" approach to USB we make the device a Communication Device. A complete description of the communication device class is contained in *Universal Serial Bus Class Definitions for Communication Devices* (Ref.2). It is only 121 pages.

Putting the USB device into the Communication Device class has two advantages:

1. Microchip has written and freely distributes PIC software for the Communication Device class to emulate RS232 over a USB connection.

2. From the PC side, the USB device just looks like a COM port to the Windows software. This allows us to use existing Windows software like Hyperterminal to communicate with the device over the USB port.

PIC18F2455

The PIC18F2455 is one of the new USB-enabled flash memory microcontrollers from Microchip. It has 24K bytes of flash program memory that allow the user to store about 12 thousand 16-bit instructions which can be erased and reprogrammed electrically. The flash program memory supports 100,000 write/erase cycles and has a greater than 40-year data retention period.

This PIC has 2048 bytes of RAM data memory, and has many of the features users have come to expect from Microchip: a universal synchronous-asynchronous receiver/transmitter (USART), four timers, ten 10-bit ADC channels, and a master synchronous serial port (MSSP). The MSSP is useful for communicating with peripheral devices such as serial EEPROMS, and supports SPI and I²C protocols. The PIC18F2455 operates at clock speeds up to 48MHz.

The USB engine is V2.0 compliant and operates at low (1.5 million bits per sec) and full (12Mb/sec) speeds. The USB engine supports all types of data transfer and up to 32 endpoints. It has one kilobyte of RAM starting at 400h that is shared between the CPU and the USB engine. This shared memory can be configured for optimum use by the user. The first few locations are defined in **usbmap.c** and **usbmap.h** and are used for an endpoint (buffer) descriptor table consisting of: STAT, CNT and ADR.

There is one buffer descriptor table for each endpoint. STAT is the status register for the endpoint. Bit 7 determines who owns the buffer (CPU or USB engine) and who can write to it. CNT is the number of bytes in the buffer. ADR is the pointer to where the endpoint buffer starts in the 400h to 7FFh range.

Circuit Description

The circuit diagram for the PIC-Based USB Interface described here is fairly simple and is shown in Fig.1. We begin with the power supply. There is none – the device is powered by the USB bus!

There are a couple of critical components. One is C3, a 470nF capacitor connected to V_{USB} on the PIC18F2455. This is a filter capacitor and without it the PIC may not run at USB full speed. Since we are using power from the USB bus, we also need the 1µF capacitors, C4 and C5, to reduce the inrush current when the device is plugged into the USB bus.

World Radio History

When designing the circuit board, there were grand plans to make it also function as a USB MIDI interface. For that reason some additional components were added as outlined in Fig.1. The additional hardware needed for MIDI is very minimal – an optical isolator, IC2, on the input, some resistors and a couple of MIDI sockets. To get Windows to recognize the device as a MIDI interface, the PIC must be reprogrammed. The MIDI components are not needed for this project, but may be helpful to experienced readers who wish to add their own PIC code to make use of them.

The PIC18F2455 is the heart of the system. Use is made of its internal USB voltage regulator, USB transceiver and USB pull-up resistors. A 20MHz crystal (X1), in conjunction with capacitors C1 and C2, provides the clock signal. The 20MHz clock is increased to 48MHz inside the PIC.

The PIC handles all communications with the host over the USB bus and handles the two-way serial communication at 115,200 bits per second to the MAX233 RS232 driver/receiver, IC3. This device converts the 0V to 5V signals from the PIC to ±12V RS232 signals. The MAX233 generates the ±12V levels internally from the +5V supply line with no external components.

The output from IC3 is routed to socket SK4 where the RS232 cable is connected.

The five l.e.d.s (D1 to D5) are tied to the PIC's RB0 to RB4 pins and are used for status indicators as explained later. Pins RB6 and RB7 were used for in-circuit programming of the PIC during development of the software. The Reset switch, S1, connects the PIC's MCLR pin to the 0V line, causing the PIC to restart the program.

Construction

Component and track layout details for the printed circuit board are shown in Fig.2. This board is available from the *EPE PCB Service*, code 536. Start assembly by soldering in the link wires, using 22-gauge single-core wire. Next, solder the small components: diodes, resistors and capacitors. Add sockets for the PIC18F2455, MAX233 and the 20MHz crystal.

Now place a mounting screw under the USB socket position if you plan to use that hole to secure the board in a box. The screw cannot be accessed once the USB socket is installed. Alternatively, you may prefer to use the board without a box, in which case you could fix four stick-on rubber feet to it later.

Next mount the reset switch, and sockets SK3 and SK4.

Omit those components which are for the MIDI interface, unless you intend to write your own PIC software for it.

If you intend to program the PIC yourself using a programmer suited to the PIC18F2455, mount the programming connector, TB1, and test points TB2. Preprogrammed PICs and source code files are available as stated later.

Software Writing

Because Microchip wrote the CDC software in C, it was decided to write the remainder of the software in C as well. The C18 compiler is available for

COMPONENTS

See SHOP TALK page

Resistors

R1, R2	27Ω (2 off)
R3, R4, R8, R9	270Ω (4 off) (see text)
R5	560Ω
R6	10k
R7	10k (see text)
R10	2k2
R11	680Ω 5-way commoned resitor module

All 0.25W 5% carbon film unless stated

Capacitors

C1, C2	20p ceramic disc, 5mm pitch (2 off)
C3	470n ceramic disc 5mm pitch
C4, C5	1μ radial elect. 10V (2 off)

Semiconductors

D1 to D6	red l.e.d. (6 off)
D7	1N4148 signal diode (see text)
IC1	PIC18F2455 microcontroller, pre-programmed (see text)
IC2	6N139 opto-isolator (see text)
IC3	MAX233 RS232 interface

Miscellaneous

S1	min. s.p. push-to-make switch
SK1, SK2	5-pin DIN socket (2 off) (see text)
SK3	USB B connector, p.c.b. mounting
SK4	9-pin D-type connector (female)
X1	20MHz crystal
TB1	5-way terminal pin block
TB2	2-way terminal pin block

Printed circuit board, available from the *EPE PCB Service*, code 536; 20-pin d.i.l. socket; 28-pin d.i.l. socket; connecting wire; solder, etc.

Approx. Cost Guidance Only **£25** *excluding case*

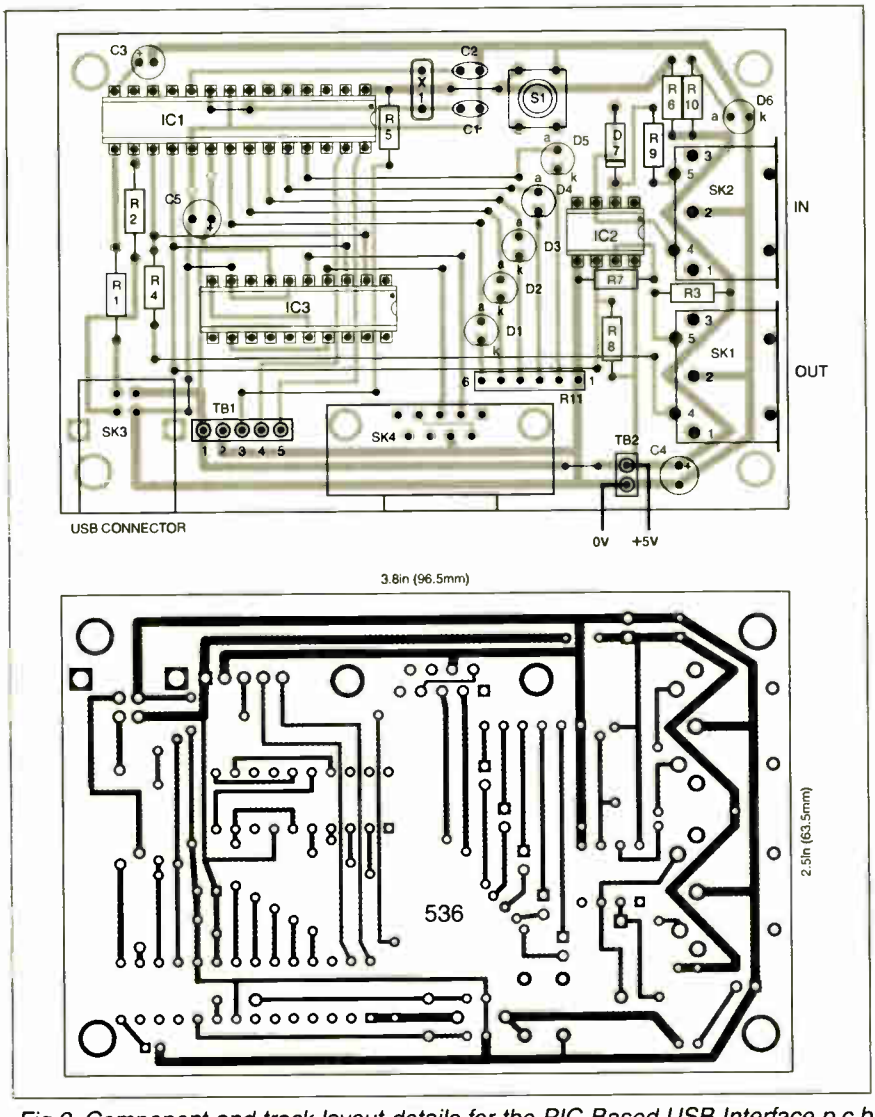

Fig.2. Component and track layout details for the PIC-Based USB Interface p.c.b.

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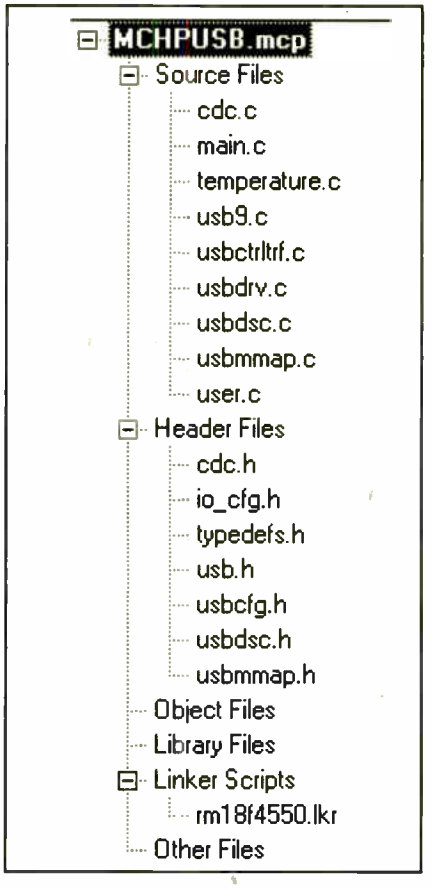

Fig.3. Files for the communication device class firmware

download from Microchip (see later) and is free for the first 60 days. After that time the compiler reverts to an un-optimized version. For that reason, the PIC software for this project was compiled with all optimization turned off.

Part of this design's software uses the CDC framework provided by Microchip, from whom it can be downloaded free. Additional information on the CDC framework can be found in Ref.3. When the MCHPUSB code is loaded into the C18 compiler the project files are as shown in Fig.3.

To compile the source code for this USB device, first delete the **temperature.c, user.c, usbcfg.h** and **main.c** files from the display. Then replace the **main.c** and **usbcfg.h** files with the ones supplied for this USB interface. Listing 1 shows the modified files installed in the project. If you are using a bootloader you can use the linker file supplied with the project, otherwise you should use the standard **18F2455.lkr** file.

The basic information about the device is contained in the device descriptor **device_dsc**, and configuration descriptor **cfg01** contained in file **usbdsc.c**. For example, the device descriptor, shown in Listing 2, tells the host that this is a CDC type device, and that the packet size for endpoint EP0 is eight bytes.

The vendor ID and product IDs are defined here. A vendor ID of 0x04D8 identifies this as a Microchip device. Normally the vendor ID and product ID are used to identify the operating system driver to be loaded when the device is plugged into the USB port.

Listing 1 Files For USB Device

```
[FILE_INFO]
file_000=system\usb\usbmmap.c
file_001=system\usb\usbdrv\usbdrv.c *
file_002=system\usb\usb9\usb9.c
file_003=autofiles\usbdsc.c
file_004=system\usb\usbctrltrf\usbctrltrf.c
file_005=system\usb\class\cdc\cdc.c
file_006=main.c *
file_007=system\usb\usbmmap.h
file_008=autofiles\usbcfg.h
file_009=system\usb\usb.h
file_010=system\typedefs.h
file_011=autofiles\usbdsc.h
file_012=system\usb\class\cdc\cdc.h
file_013=C:\mcc18\lkr\18f2455.lkr              * files modified
```

Listing 2 USB Device Descriptor

```
rom USB_DEV_DSC device_dsc=
{
    sizeof(USB_DEV_DSC),    // Size of this descriptor in bytes
    0x01,                   // DEVICE descriptor type=1
    0x0200,                 // USB Spec Release Number in BCD format=2.00
    0x02,                   // Class Code, 2=CDC device
    0x00,                   // Subclass code
    0x00,                   // Protocol code
    0x08,                   // Max packet size for EP0 =8, see usbcfg.h
    0x04D8,                 // Vendor ID
    0x000A,                 // Product ID: CDC RS-232 Emulation Demo
    0x0000,                 // Device release number in BCD format
    0x01,                   // Pointer to Manufacturer string descriptor
    0x02,                   // Pointer to Product string descriptor
    0x00,                   // Pointer to Device serial number string (none)
    0x01                    // Number of possible configurations
};
```

Descriptor Pointers

In addition, the device descriptor points to some string descriptors for the manufacturer and product. The **rom** in the **device_dsc** type statement means that this constant information will be stored in program memory, thus freeing up valuable RAM memory on the PIC18F2455 device.

The configuration descriptor, **cfg01**, defines the amount of power that the device can draw, 100mA. Two interfaces are defined in the configuration descriptor. The first interface (#0) has one endpoint (**EP02_IN**) which does 8-byte interrupt transfers. **EP02_IN** is polled by the host every 2ms. The second interface (#1) has two endpoints (**EP03_OUT** and **EP03_IN**) which do bulk data transfers. The data packet size is 64 bytes.

The string descriptors consist of a byte containing the size of the string descriptor, a byte containing the value "3" that identifies it as a string descriptor and a string containing the text in Unicode format. Microchip has cleverly performed the conversion to Unicode by declaring each character as a word type.

Variable Locations

The Microchip CDC framework software is general-purpose and automatically allocates the USB (400h-7FFh) region of memory. Because the framework does this automatically, it is not as clear where variables are located in memory, as is the case when using assembly language or allocating the variables manually.

The PIC18F2455 has rules as to how the memory must be allocated, which are defined in Ref.4. Table 1 shows the USB portion of the PIC18F2455 memory as allocated by the Microchip USB framework and the **main.c** program.

The framework provides several functions which are used to communicate over the USB:

- **mUSBUSARTIsTxTrfReady** determines if the USB engine is ready to accept a new string to transmit via USB
- **mUSBUSARTTxRam** writes a string of known length from data memory to USB
- **GetsUSBUSART** reads a string from the USB
- **mCDCGetRxLength** reports the length of the last string read from USB

Microchip advises that these functions should not be used in a blocking manner such as:

while (!mUSBUSARTIsTxTrfReady()).

Since the CDC framework is written to poll the USB data, there must be nothing in the software that will cause a significant delay in the polling.

Interrupts

Although the USB portion of the program does not use any interrupts, it became necessary to use interrupts to handle the RS232 serial interface. Interrupts are triggered when a character is received or a character can be transmitted.

It may be useful to follow along with the author's source code available from *EPE*. Received characters are loaded into 128-byte circular buffers (**serial_input_buffer** and **serial_output_buffer**) by the **usart_handler** interrupt routine. The routines **serial_receive** and **serial_send** are used to access the data in the buffers.

Indicators

A series of indicators has been implemented using the l.e.d.s. When the device is first powered up, all five l.e.d.s D1 to

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Table 1 USB RAM Memory Allocation

RAM Address (hex)	Value (hex)	Variable Name	Description	Function	MEMORY NAME
400	variable	ep0bo.Stat	Buffer Descriptor Status Register (See page 171-174 of Reference 3)	Buffer Descriptor Table (BDT) for Endpoint 0 Out	
401	08	ep0bo.Cnt	# of Bytes to be transmitted (before transmission) or bytes transmitted (after transmission).		
402	18	ep0bo.ADRL	Buffer Address Low Byte		
403	04	ep0bo.ADRH	Buffer Address High Byte		
404	variable	ep0bi.Stat	Buffer Descriptor Status Register (See page 171-174 of Reference 3)	Buffer Descriptor Table (BDT) for Endpoint 0 In	
405	08	ep0bi.Cnt	Buffer size in bytes (before receive) or # of bytes received (after receive).		
406	20	ep0bi.ADRL	Buffer Address Low Byte		
407	04	ep0bi.ADRH	Buffer Address High Byte		
408-413			unused for CDC application		
414	variable	ep2bi.Stat	Buffer Descriptor Status Register (See page 171-174 of Reference 3)	Buffer Descriptor Table (BDT) for Endpoint 2 In	USBRAM4
415	08	ep2bi.Cnt	# of Bytes to be transmitted (before transmission) or bytes transmitted (after transmission).		
416	00	ep2bi.ADRL	Buffer Address Low Byte		
417	05	ep2bi.ADRH	Buffer Address High Byte		
418	variable	ep3bo.Stat	Buffer Descriptor Status Register (See page 171-174 of Reference 3)	Buffer Descriptor Table (BDT) for Endpoint 3 Out	
419	40	ep3bo.Cnt	# of Bytes to be transmitted (before transmission) or bytes transmitted (after transmission).		
41A	08	ep3bo.ADRL	Buffer Address Low Byte		
41B	05	ep3bo.ADRH	Buffer Address High Byte		
41C	variable	ep3bi.Stat	Buffer Descriptor Status Register (See page 171-174 of Reference 3)	Buffer Descriptor Table (BDT) for Endpoint 3 In	
41D	40	ep3bi.Cnt	Buffer size in bytes (before receive) or # of bytes received (after receive).		
41E	48	ep3bi.ADRL	Buffer Address Low Byte		
41F	05	ep3bi.ADRH	Buffer Address High Byte		
420-427	...	SetupPkt[8]	8 bytes	Endpoint 0 Out Buffer	
428-42F	...	CtrlTrfData[8]	8 bytes	Endpoint 0 In Buffer	
500-507		cdc_notice[8]	8 bytes	Endpoint 2 In Buffer	USBRAM5
508-547	...	cdc_data_rx[64]	64 bytes	Endpoint 3 Out Buffer	
548-587	...	cdc_data_tx[64]	64 bytes	Endpoint 3 In Buffer	
700-77F	...	serial_input_buffer(128)	128 bytes		USBRAM7A
780-7FF	...	serial_output_buffer(128)	128 bytes		

D5 are flashed sequentially. This indicates that the device is programmed and that the clock is running. Next, the l.e.d.s are flashed as shown in Table 2 while the USB enumeration is done.

When the enumeration is successfully completed l.e.d.s D1 and D2 will flash alternately. During the first enumeration the operating system will ask for a device driver.

The user must point to the directory that contains the **mchpcdc.inf** file as shown in Fig.4. This file contains information that matches the product ID and vendor ID to the **usbser.sys** driver. The communication device class driver for Windows is called **usbser.sys** and is part of the Windows 2000/XP operating system.

The system will complain that the driver has not passed the Windows Logo testing, which is surprising since Microsoft wrote the driver, but continue the installation anyway. When the software installation is complete you will see Fig.5 on screen.

The flow of the main program is as follows. The **InitializeSystem** routine flashes the l.e.d.s to verify that the program is working, initialises the USB and initialises the USART to a transmission rate of 115,200 bits per second. The bit rate can be changed in the **IntializeUSART** routine.

Next the serial interrupts are enabled by the **EnableInterrupts** routine. All of the USB transmissions are handled by the **USBTasks** routine which is part of the CDC framework provided by Microchip. The **DataTransfer** routine displays the USB status on the l.e.d.s by calling the **BlinkUSBStatus** routine.

The **USB_to_USART_handler** handles the processing of received USB data and its transmission out via the RS232 connection. The **USART_to_USB_handler** does the receipt of incoming RS232 data and the queuing of the data for USB transmission. The **display_leds** routine is called by these

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last two routines to control the l.e.d.s based on the data received by the device.

Just to make it interesting, the receipt of certain characters toggle the l.e.d.s on and off. If a "0" is received, the logic showing the USB status in the l.e.d.s is turned off. Of course your imagination is the only limit to what can be done on the PIC once the USB data link is working.

There was some difficulty with getting the RS232 input to work. The first problem had to do with some variables, like **istart**, that were used in both the interrupt routine and the main routines. These variables needed to be declared as **volatile** to make sure both routines used the latest values.

A second problem had to do with the way the number of received bytes was calculated in the **serial_rxbytes routine**. This routine had to be modified to work with the C18 compiler. The C18 compiler was used to compile and link the C source into the **MCHPUSB.hex** file.

If you are programming your own PIC, make sure that your system works with the PIC18F2455 since the programming algorithm is different to that for many other PICs.

Hardware Testing

Before plugging the device into your computer's USB port, check its operation by applying a 5V power source to connector TB2. The first thing that should happen is that the l.e.d.s should flash sequentially. This means that the device is powered and programmed. The device should draw less than 55mA. If it does not, stop and check the circuit.

Do not plug the device into your USB port until you are sure your wiring is correct or you may damage the port. Some, but not all USB ports, have overload protection, so do not rely on it.

Table 2 LED Blink Codes

USB STATE	LED 1	LED2	LED 3	LED 4	LED 5
Detached State	off	off	off	off	off
Attached State	on	on	off	off	off
Powered State	on	off	off	off	off
Default State	off	on	off	off	off
Addressed State	blinking	off	off	off	off
Configured State	blinking	blinking	off	off	off
ASCII '0' received via USB or USART	LEDs toggled between Configured State and all off.				
ASCII '1' received via USB or USART	toggled	unchanged	unchanged	unchanged	unchanged
ASCII '2' received via USB or USART	unchanged	toggled	unchanged	unchanged	unchanged
ASCII '3' received via USB or USART	unchanged	unchanged	toggled	unchanged	unchanged
ASCII '4' received via USB or USART	unchanged	unchanged	unchanged	toggled	unchanged
ASCII '5' received via USB or USART	unchanged	unchanged	unchanged	unchanged	toggled

The next thing to do is to plug the device into the USB port and check that the device is properly enumerated (see earlier). This can be done using the **USBVIEW** program (see later). Fig.6 shows the output of the USBView program with the hardware and software of this article connected.

USBVIEW shows that the device has one configuration and a maximum control packet size of eight bytes. It operates at full speed and has three open pipes. The first

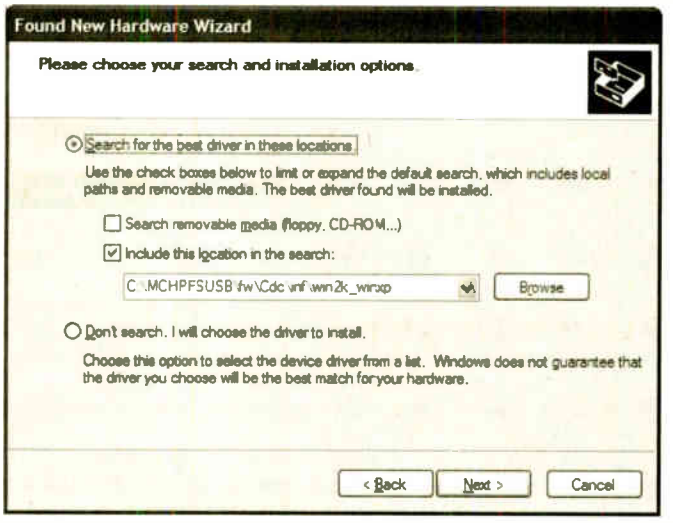

Fig.4. First device enumeration

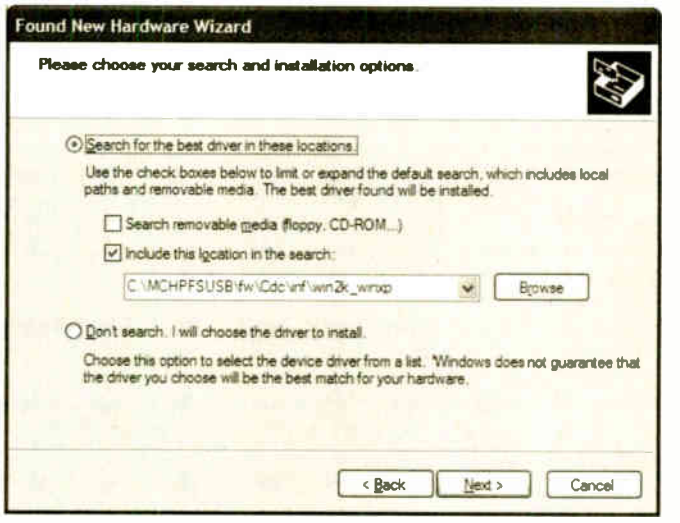

Fig.5. USBVIEW of installed device

Fig.5. Successful completion of Windows driver installation

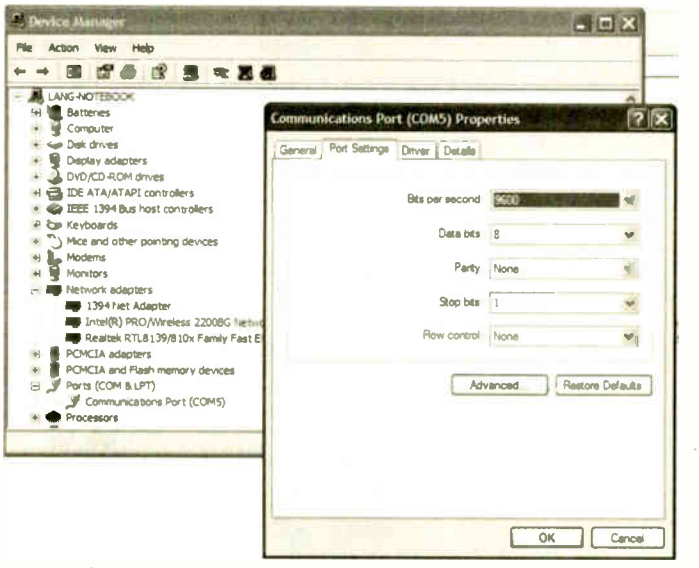

Fig.7. Device Manager view of installed device

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pipe uses interrupt data transfers and is for device-to-host data transfers (82) every 2ms and has a maximum packet size of eight bytes.

The second pipe uses bulk data transfers and is for host-to-device data transfers (03) and has a maximum packet size of 64 bytes. The third pipe uses bulk data transfers and is for device-to-host data transfers (83) and has a maximum packet size of 64 bytes. We can also look at the USB device using the XP device manager as shown in Fig.7.

It will be seen that the USB device looks like a standard Windows COM port (COM5). To Windows application programs, like Hyperterminal or a program you might write in Visual Basic or C, the device will look like a standard COM port and can be accessed as one.

Hyperterminal Test

The final test involves using the Hyperterminal (or other) terminal emulation program. Plug the USB device into a Windows 2000/XP PC running Hyperterminal, connect a loopback plug to the RS232 socket on the USB as shown in Fig.8. With this configuration the transfer of data into and out of the device can be observed.

RS232 data routed out of the device is sent back to it via the loopback plug. The data typed into Hyperterminal will also appear on the Hyperterminal screen after being sent to the USB device, sent out the RS232 connector, read back in the RS232 connector and transmitted via USB back to the host.

Although there are no data flow controls on the USART data, blocks of 15,000 characters have been sent and received successfully at 115,200 bits per second using this device.

One additional piece of information about using Windows programs like Hyperterminal with the USB device: if you unplug the USB device from the host computer with Hyperterminal running, when you plug the USB device back into the host, Hyperterminal will not be able to communicate with it.

The proper sequence, if you want to unplug the device and reconnect it, is to shutdown Hyperterminal before unplugging. This applies whether the USB is disconnected by unplugging or using its Reset switch (S1).

For the final test, remove the loopback plug. Now if you type a "0" in the Hyperterminal the flashing l.e.d.s should stop. Typing consecutive "1"s should turn on and off l.e.d. D1. Likewise "2, 3, 4, 5" should turn on and off l.e.d.s D2, D3, D4 and D5. Another "0" should set the l.e.d.s back to the USB status reporting mode.

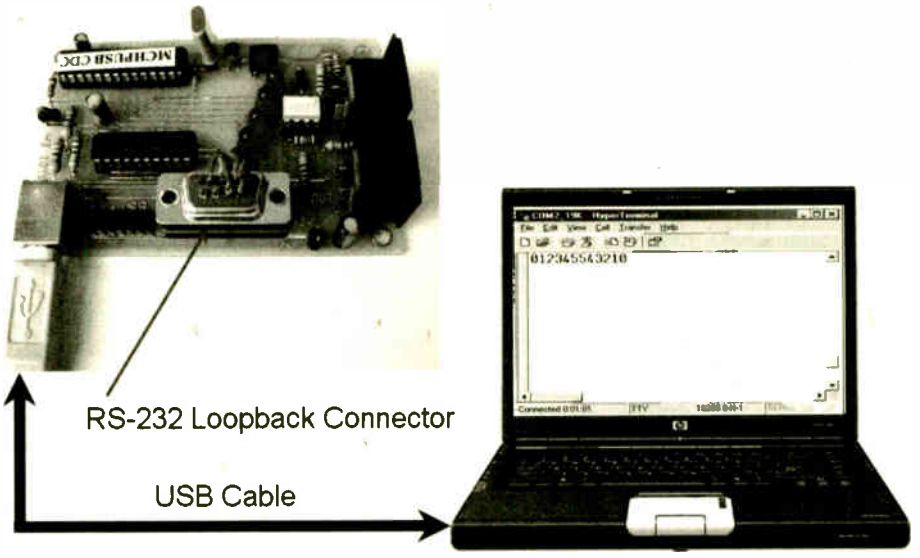

Fig.8. USB-RS232 Testing Configuration

Note that this logic is seen to work when the loopback is plugged in, but it will not be seen when the USB "0" takes the device out of USB status reporting mode – the "0" being echoed from the loopback plug puts it back into USB status reporting mode.

Conclusion

This is an interesting project which allows computers using the Windows 2000/XP operating system to communicate with a PIC microcontroller over the USB port. The device allows computers that do not have a COM serial port to use legacy devices.

This project also provides a practical introduction to USB, to CDC devices, to one of the new USB flash PICs and to the C18 compiler. As well as showing how l.e.d.s can be controlled via USB, it also provides the basics of getting data into and out of a PIC using USB, becoming the foundation of more complicated USB PIC projects.

Resources

Sourcecode is available for free download from our Downloads site, access via **www.epemag.co.uk**.

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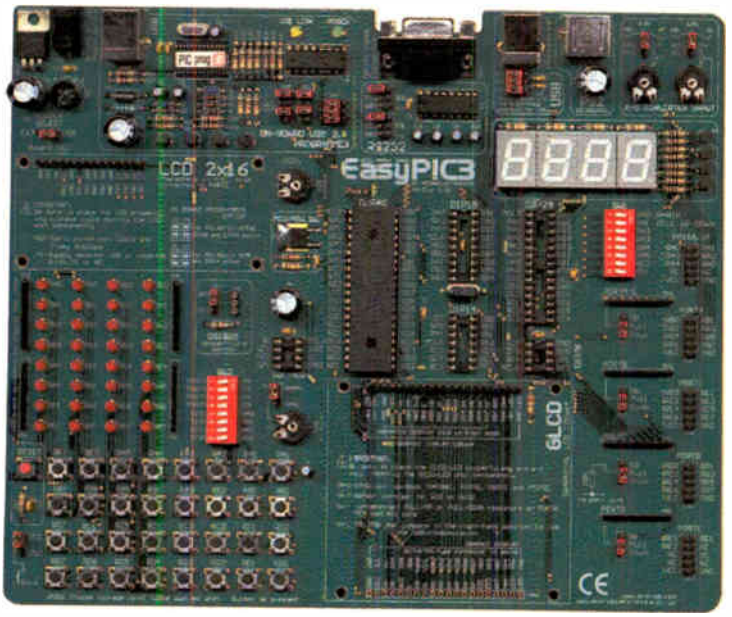

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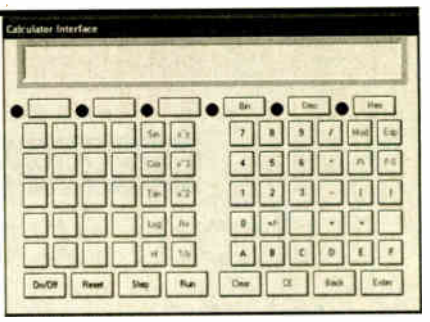

Clive "Max" Maxfield & Alvin Brown

Learn how computers do maths without making your brain ache!

WHEN you come to think about it, there are lots of "application-type" computer books along the lines of *Learn Prof. Cuthbert Dribble's Visual Programming V6.0 In 21 Days* (you often have only 21 days, because that's when version 7.0 of the software is going to come out). Sad to relate, however, there really aren't many tomes – outside of mega-complex University courses – that teach how computers actually work.

In order to address this sad state of affairs, the authors decided to pen their own humble offering. One point we considered is that it's a lot easier to learn how to do something if you actually have a specific project in mind.

For example, if someone simply hands you a plank of wood, a saw, a hammer and some nails, you might hang around for a while pondering just what to do. But if you are also presented with the plans for a simple bird table, then you can immediately leap into the fray with gusto and abandon.

Thus, we decided to base a book (details are given later) on the concept of a simple calculator called the DIY Calculator, The cunning part of all of this is that we created the DIY Calculator as a virtual machine that runs on your home computer. This article is a spin-off from the book and is designed to give a brief introduction as to how the DIY Calculator functions. In order to facilitate this, you can download a fully-functional copy of the DIY Calculator software from our website at **www.DIYCalculator** for free (you'll find instructions on how to download and install the calculator on the website).

Computers and Calculators

In its broadest sense, a computer is a device that can accept information from the outside world, process that information using logical and/or mathematical operations, make decisions based on the results of this processing, and – ultimately – return the processed information to the outside world in its new form.

The main elements forming a computer system are its central processing unit (CPU), its memory devices (ROM and RAM) that are used to store programs (sequences of instructions) and data, and its input/output (I/O) ports that are used to communicate with the outside world. The CPU is the "brain" of the computer, because this is where all of the number-crunching and decision-making is performed. Read-only memory (ROM) has its contents hard-coded as part of its construction; by comparison, in the case of random access memory (RAM), you can load new values into it and read these values back out again later.

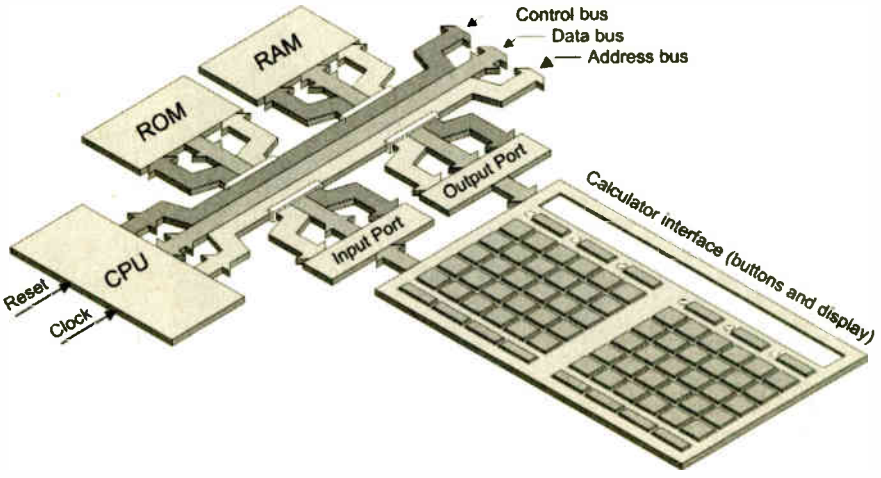

Fig.1. The main elements forming a computer-calculator.
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The term "bus" is used to refer to a group of signals that carry similar information and perform a common function. A computer actually makes use of three buses called the control bus, address bus, and data bus. The CPU uses its address bus to "point" to other components in the system; it uses the control bus to indicate whether it wishes to "talk" (output/write/transmit data) or "listen" (input/read/ receive data); and it uses the data bus to convey information back and forth between itself and the other components. Our virtual computer is equipped with a data bus that is eight bits wide and an address bus that is 16 bits wide. This allows the address bus to point to 2^{16} = 65,536 different memory locations, which are numbered from 0 to 65,535 in decimal; %0000000000000000 to %1111111111111111 in binary; or $0000 to $FFFF in hexadecimal, where the concepts of binary and hexadecimal are briefly introduced a little later in this article.

Once we've conceived the idea of a general-purpose computer, the next step is to think of something to do with it. In fact

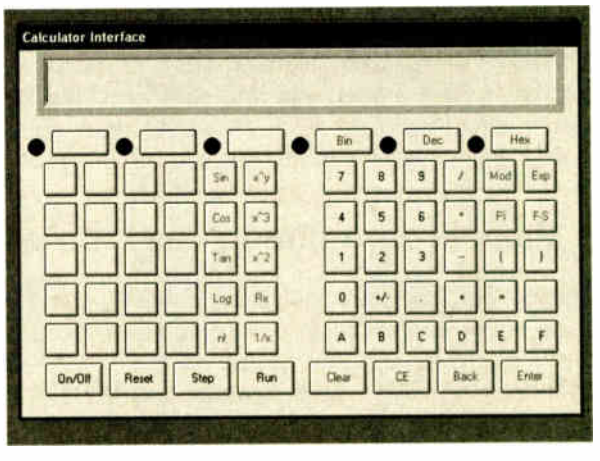

Fig.2. Screenshot of the DIY Calculator's interface

World Radio History

there are millions of tasks to which computers can be assigned, but the application we're interested in here is that of a simple calculator. So what does it take to coerce a computer to adopt the role of a calculator? Well, one thing we require is some form of user interface, which will allow us to present data to – and view results from – the computer (Fig.1).

The calculator's user interface primarily consists of buttons and some type of display. Each button has a unique binary code associated with it, and this code will be presented to the computer's input port whenever that button is pressed. Meanwhile, one of the computer's output ports can be used to drive the display portion of the interface.

A Simple Test Case

In order to provide a simple demonstration as to how the DIY Calculator works, download your free copy and install it as described on our website. Now use the **Start > Programs > DIY Calculator > DIY Calculator** command (or double-click the **DIY Calculator** icon on your desktop) to launch this little rapscallion, which should look something like the screenshot shown in Fig.2.

Click the **On/Off** button on the calculator interface to power it up and then click on some of the "0" through "9" buttons. Nothing happens, because we haven't loaded a program yet. In a moment we are going to create our own program, but just to provide a simple example, we've already provided a test case for you to play with as part of the download.

Use the **Tools > Assembler** command (or click the appropriate icon in the main window's tool bar) to launch an application called the assembler. Now use the assembler's **File > Open** command to open the file called **hello.asm** that you'll find in the **C:\DIY Calculator\Work** folder on your system.

This program is in a low-level computer programming language known as *assembly language*. Each computer has its own assembly language, but once you've learned one (especially one as simple as ours), this makes it much easier to learn others if you need to do so.

Now use the assembler's **File > Assemble** command. This takes our source program and assembles (translates) it into a new file called **hello.ram** that contains the raw instruction and data values that will be processed by our virtual CPU. The contents of this file are in a form called *machine code*, because this is the form that is actually executed by the computer (machine).

Listing 1: Program to read button codes and write to the main display

```
CLRCODE:  .EQU   $10          #  Code to clear main display
MAINDISP: .EQU   $F031        #  Output port to main display
KEYPAD:   .EQU   $F011        #  Input port from keypad

          .ORG   $4000        #  Set origin to address $4000
          LDA    CLRCODE      #  Load ACC with clear code
          STA    [MAINDISP]   #  Store ACC to main display

LOOP:     LDA    [KEYPAD]     #  Load ACC from the keypad
          CMPA   $0F          #  Compare accumulator to $0F
          JC     [LOOP]       #  Jump if C flag is set
          STA    [MAINDISP]   #  . . . else copy ACC to display
          JMP    [LOOP]       #  Jump to LOOP

          .END                #  End of the program
```

Value	Decimal	Binary	Hexadecimal
zero	0	%0000	$0
one	1	%0001	$1
two	2	%0010	$2
three	3	%0011	$3
four	4	%0100	$4
five	5	%0101	$5
six	6	%0110	$6
seven	7	%0111	$7
eight	8	%1000	$8
nine	9	%1001	$9
ten	10	%1010	$A
eleven	11	%1011	$B
twelve	12	%1100	$C
thirteen	13	%1101	$D
fourteen	14	%1110	$E
fifteen	15	%1111	$F

Fig.3. Binary and hexadecimal

Use the assembler's **File > Exit** command to dismiss this application. Next, use the **Memory > Load RAM** command to load the **hello.ram** file that you'll find in the **C:\DIY Calculator\Work** folder into the DIY Calculator's memory. Finally, click the **Run** button to execute this program and see the message "Hello World" appear on the calculator's main display.

Binary and Hexadecimal

In a moment we're going to create our own program, but before we start, we need to understand that computers store and manipulate data using the binary number system, which comprises just two digits: 0 and 1. One wire (or register bit/memory element) can be used to represent two distinct binary values: 0 or 1; two wires can represent four binary values: 00, 01, 10, and 11; three wires can represent eight binary values: 000, 001, 010, 011, 100, 101, 110, and 111; and so on. As our virtual computer has an 8-bit data bus, this can be used to represent 256 different binary values numbered from 0 to 255 in decimal or %00000000 to %11111111 in binary (where the "%" symbol is used to indicate a binary value).

The problem is that humans tend to find it difficult to think in terms of long strings of 0s or 1s. Thus, when working with computers, we tend to prefer the hexadecimal number system, which comprises 16 digits: 0 through 9 and A through F as shown in Fig.3.

In this case, we use "$" characters to indicate hexadecimal values. Each hexadecimal digit directly maps onto four binary digits (and vice versa of course). This explains why we noted earlier that our 16-bit address bus could be used to point to 2^{16} = 65,536 different memory locations, which are numbered from $0000 to $FFFF in hexadecimal.

The Accumulator (ACC) and Status Register (SR)

There are just a couple more things we need to know before we plunge headfirst into the fray. As illustrated in Fig.4, amongst other things, our CPU contains two 8-bit registers called the *accumulator (ACC)* and the *status register* (SR). (In this context, the term "register" refers to a group of memory elements, each of which can store a single binary digit.)

As its name implies, the accumulator is where the CPU gathers, or "accumulates", intermediate results. In the case of the status register, each of its bits is called a *status bit*, but they are also commonly referred to as *status flags* or *condition* codes, because they serve to signal (flag) that certain conditions have occurred. We will only concern ourselves with the carry (C) flag for the purposes of our example program.

Since we may sometimes wish to load the status register from (or store it to) the memory, it is usual to regard this register as being the same width as the data bus (eight bits in the case of our virtual system). However, our CPU employs only five status flags, which occupy the five least-significant bits of the status register. This means that the three most-significant bits of the register exist only in our imaginations, so their non-existent contents are, by definition, undefined.

The Program Itself

For the purposes of this article, we're going to create a simple program that first clears the calculator's main display, and then loops around waiting for us to click one or buttons on the keypad. If any of these buttons are part of the "0" through "9" or "A" through "F" set, we're going to display these value on the main display. In a moment we're going to enter our program as shown in Listing 1. But before we do that, let's walk through this code step-by-step.

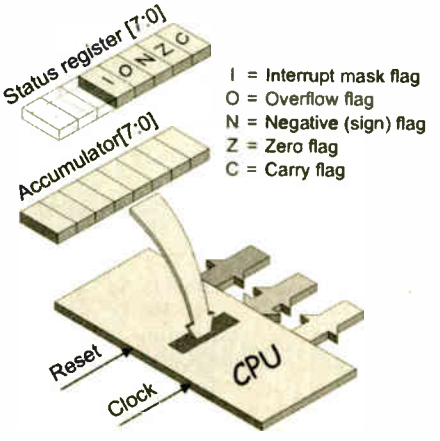

Fig.4. The accumulator (ACC) and status register (SR)

World Radio History

The first thing we do is to declare some constant labels and associated them with certain values using **.EQU** ("equate") commands. In the case of this program, the **CLRCODE** label is associated with a hexadecimal value of $10, which is a special code that will clear the calculator's main display. By comparison, the **MAINDISP** label is associated with the hexadecimal value $F031, which happens to be the address of the output port that drives the calculator's main display. Similarly, the **KEYPAD** label is associated with the hexadecimal value $F011, which is the address of the input port that is connected to the calculator's keypad. (Note that everything to the right of a "#" character is treated as a comment and is therefore ignored by the assembler.)

Following the **.EQU** commands we see a **.ORG** ("origin") statement, which we use to specify $4000 as being the start address in our program. (The reason we use $4000 is that this is the first address in the DIY Calculator's virtual RAM. When we come to run the program, the DIY Calculator will automatically start at this address.)

Next, we use a **LDA** ("load accumulator") instruction to load our special clear code into the accumulator, and then we use a **STA** ("store accumulator") instruction to copy this value to the main display, thereby clearing it.

Now we find ourselves at the **LOOP** address label, which is where we are going to wait for the user to click on a key. There are a couple of things we need to understand here. First, our virtual calculator's front panel contains an 8-bit register. By default, this register is loaded with a dummy value of $FF. When we click a button on the keypad, a code associated with that button is loaded into this register. When the CPU reads from the input port connected to the calculator's keypad, it actually reads the value out of this register. Furthermore, the act of performing this read automatically reloads the register with its default $FF value. Last but not least, the hexadecimal codes associated with the "0" through "9" and "A" through "F" keys are $00 through $09 and $0A through $0F, respectively (we'd have been extremely silly to make this work any other way).

When we arrive at the **LOOP** label, we use a **LDA** ("load accumulator") instruction to load the accumulator from the memory location pointed to by the **KEYPAD** label. As we previously noted, this is the address of the input port connected to the calculator's keypad. Next, we use a **CMPA** ("compare accumulator") instruction to compare the contents of the accumulator with a value of $0F.

If the value in the accumulator is larger, the carry (C) status flag will be loaded with 1; this means that the user clicked a button whose code is higher than $0F, which we don't wish to happen. Thus, if the user did click a button other than "0" though "9" or "A" through "F", the **JC** ("jump if carry") instruction will return the program to the **LOOP** label to await another key. Otherwise, we use a **STA** ("store accumulator") instruction to copy this key code to the main display, and then we use a **JMP** ("unconditional jump") instruction to return us to the **LOOP** label to await another key.

The final statement in the program is a **.END** that, not surprisingly, informs the assembler that its task here is completed.

Entering and Running the Program

Now we're really ready to rock and roll. If you haven't already done so, launch the DIY Calculator and invoke the assembler. (If you still have the assembler open from running the test case earlier, then use its **File > New** command to create a new source code file.)

Enter the program shown in Listing 1, use the assembler's **File > Save As** command to save this program with the name **mykeytest.asm**, and then use the assembler's **File > Assemble** command to translate your source program into a machine code equivalent called **mykeytest.ram** (if any errors are reported in the status bar at the bottom of the assembler window, debug them and re-assemble the program). Finally, use the assembler's **File > Exit** command to dismiss this application.

Click the **On/Off** button on the calculator interface to power it up. (Alternatively, if the calculator is still powered up from running the test case earlier, then use the main window's **Memory > Purge RAM** command to delete the old program from the calculator's memory.) Next, use the **Memory > Load RAM** command to load the **mykeytest.ram** file that you just created into the DIY Calculator's memory.

Now, click the **Run** button to execute this program and observe that the main display is cleared. The program is now looping around waiting for you to press a key. Try clicking several of the "0" to "9" and "A" to "F" keys and observe the corresponding characters appearing on the main display. Also try clicking some of the other keys (such as "=" and "+") and observe that – due to the way in which we created our program – these are discarded and do not appear on the display.

But Wait, There's More!

We've really only scratched the surface of what is possible with the DIY Calculator. For example, click the **Reset** button on the calculator's front panel. Make sure the main window fills your screen, and then use the **Display > CPU Registers, Display > Memory Walker**, and **Display > I/O Ports** commands to invoke these utilities. As each tool appears, drag it to a clear area on your screen (if you have enough room on your screen, you might also try launching the **Display > Message System** utility).

Now click the **Step** button on the calculator's front panel a few times and watch what happens in the various displays for each click. Next, click one of the number buttons – say the "6" key – and then click the **Step** button a couple more times, again watching the various displays for each click.

Note that you can use the main window's **Help > Contents** command to learn more about what these diagnostic tools do. And if you want to experiment a little further, a slightly more testing example program that uses the DIY Calculator to implement a simple pseudo-random number generator is described on the website.

Further Projects

The book, *How Computers Do Math*, is organized in an interesting way. First there are a series of chapters introducing fundamental concepts such as *Subroutines* and *Recursion*. Each chapter is then backed up by a suite of interactive laboratories, each of which details what the reader will lean and how long it will take (typically 20 to 40 minutes each), followed by step-by-step instructions that walk the reader through that lab.

For educators, the CD ROM accompanying the book includes all of the labs as Adobe Acrobat files that can be printed out and used as handouts. Also, all of the illustrations in the book are provided as PowerPoint slides that can be used as the basis for presentations.

The chapters and labs build on each other until, at the end, we have a four function calculator that can input numbers in decimal, convert them into 16-bit binary integers, perform addition, subtraction, multiplication, and division on these binary values, and then present the results from these calculations in decimal on the main display. But this is only a starting point. On the DIY Calculator's website, it is intended to develop this much further by introducing the concept of floating-point values, describing our own simple floating-point format, and then implementing binary floating-point versions of our input, output, and math subroutines. (We are also going to do the same for Binary Coded Decimal (BCD) – check the website for more details.)

And this is still just the beginning, because (in conjunction with schools, colleges, universities, and individual readers), we plan on creating subroutines (with associated documentation) to implement many more math functions. These will be provided on the website for folks to download and experiment with and – hopefully – to say "I can do better than that" and send in their own versions.

As yet another example of something that may interest educators, as a final year project at the beginning of 2005, a team of students at the University of Newcastle upon Tyne, created VHDL models of the DIY calculator and then implemented a physical version of the little scamp using a field-programmable gate array (FPGA) development board. (Details of this project, including the VHDL source files and the project notes, are available on our website.)

So there you have it. Now there is a way to learn about how computers work – and how they do math – that's actually fun and doesn't make your brain ache or your eyes water. We'd love to hear what you think about all of this, so please feel free to email us at **info@DIYCalculator.com** to share your thoughts and ideas.

The book, *How Computers Do Math* – John Wiley & Sons, ISBN 0471732788 – is scheduled to roll off the printing presses September 2005. Throughout *How Computers Do Math*, we introduce the way in which computers work and walk readers through the process of creating a simple four-function calculator program (add, subtract, multiply and divide) from the ground up. □

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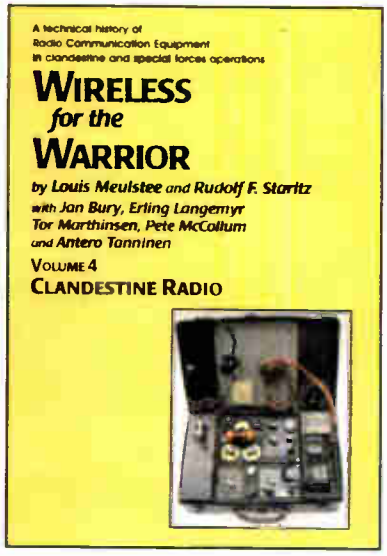
Volume 4
CLANDESTINE RADIO

A technical history of Radio Communication Equipment in clandestine and special forces operations



Volume 4 'Clandestine Radio' – not only 'spy' equipment but sets used by Special Forces, Partisans, Resistance, 'Stay Behind' organisations, Diplomatic Service, Australian Coast Watchers, RDF and intercept receivers, bugs and radar beacons. The information has been compiled through the collaboration of a vast number of collectors and enthusiasts around the world. Volume 4 includes information on more than 230 sets and ancillaries. It contains 692 pages in hardback format, and features over 850 photographs, 360 line drawings and 440 data tables.

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Volume 2 'Standard Sets for World War II' – provides information in detail of mass-produced Wireless Sets such as No.18, 19, 22 and 38. Additionally included are a number of post-war sets on which development had been started during World War II.

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Cybervox Light Interface – *Enlightened Extermination*

DALEK aficionados will know that when these diabolical creatures speak, a set of head mounted lights flash in sympathy with each spine-chilling word spoken. The circuit shown in Fig.1 is designed to be attached to the *EPE Cybervox* (July '05) and will flash filament lights whenever a word is spoken.

The voice signal is picked from the *Cybervox* board at connection point 19 (junction of C16 and the signal side of VR5). The signal is passed via capacitor C1 to an amplifier formed around an LM351 op.amp. The voltage gain of this amplifier is adjustable from about ×10 to ×1000. The gain level set by VR1 forces the output of the amplifier to swing between the supply rails (referred to as clipping) – a situation which is normally to be avoided.

In this application, however, these large voltage swings are usefully rectified by D1 and D2 and used to charge capacitor C4. As soon as the voltage across C4 reaches 0·6V, transistor TR1 conducts, turning on l.e.d. D3. Power transistor TR2 is used to switch more demanding loads such as filament lights and will only require a heatsink if more than two bulbs are wired in parallel.

Mike Boyden,
Binfield, Bracknell

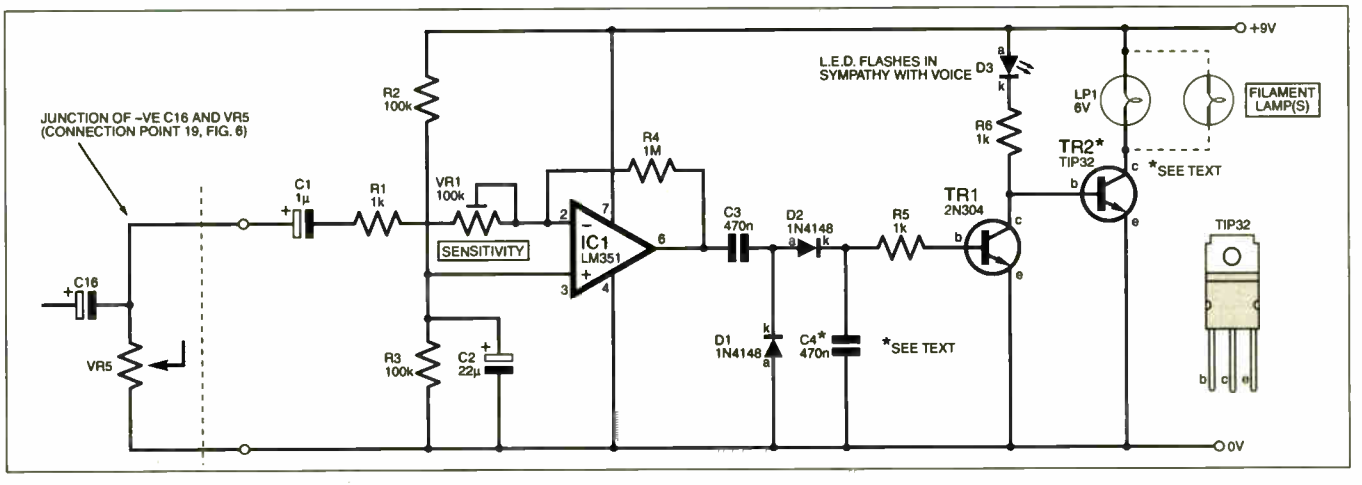


Fig.1. Circuit for the add-on Cybervox Light Interface for the EPE Cybervox *Dalek voice emulator project – July '05 issue*

World Radio History

Theremin Volume Control – *Waving Soundly*

IN the *EPE Theremin* (Oct '04), Robert Penfold commented that his method for volume control gave a somewhat abrupt variation. Fig.2 shows an alternative, which still adheres to the concept of using hand capacitance to change the volume, but has the advantage of a nice gradual action whilst still allowing a tremolo effect to be obtained by fluttering the hand or fingers.

The circuit is simple, easy to set up and has a low component count. As it was designed to be a direct replacement for Robert's volume control, it only requires a single supply of 9V, and it could well be useful in other applications.

The design is based on an ICM7556 dual timer, with one half functioning as an astable oscillator and driving the other, which is connected as a monostable pulse generator. The hand capacitance sensor is an aluminium plate, 18cm x 10cm as a rough match to hand size. This is mounted in the vertical plane and with the 10cm side vertical, and is situated at one side of the instrument case behind a 6mm thick sheet of MDF, which gives a convenient lower limit for hand proximity.

The plate is connected directly to the 7556, no isolating capacitor being needed. No specific timing capacitor is used either, and the inherent stray circuit capacitance gave a suitable frequency of about 25kHz with the 1·2MΩ timing resistor, R1. This arrangement maximises the hand capacitance effect, for greatest sensitivity.

In use, the monostable is adjusted by preset VR1 to have a period slightly shorter than that of the oscillator when a hand is not near the sensor plate, whereupon the output voltage is as shown in Fig.3a, changing to that in Fig.3b and then Fig.3c as the oscillator period progressively lengthens when a hand nears the plate.

This waveform is then inverted by a CA3140 op.amp, whereupon the time-averaged output voltage is low for the Fig.2a waveform and increases as a hand nears the sensor. Output averaging is performed by the R6, C4 filter, thus providing the steady voltage needed to supply control current to pin 5 of the original CA3080 gain-control amplifier (IC4).

The CA3140 was chosen not for its high input impedance but for its good slewrate characteristic and because its output bottoms at only a few millivolts above the negative rail, which is necessary to enable the CA3080 gain to be reduced to zero for total sound cut-off.

For optimum operation, it is important that VR1 is adjusted until zero sound is only just achieved and it is convenient therefore to have it as a front panel control. The Theremin note then becomes audible when a hand approaches within some 12cm to 15cm from the sensor plate.

If VR1 is turned much below the setting for zero sound output then the monostable period will exceed that of the astable oscillator. This means that it will only trigger on alternate cycles of the oscillator, resulting in an output waveform having about a 50:50 mark-space ratio and hence giving a considerable sound output in the absence of a hand near the sensor.

This is a useful characteristic, simplifying any setting-up work on the Theremin tone production circuitry and also obviating the need for l.e.d. indication of control circuit functioning.

Tony Read, Rugby

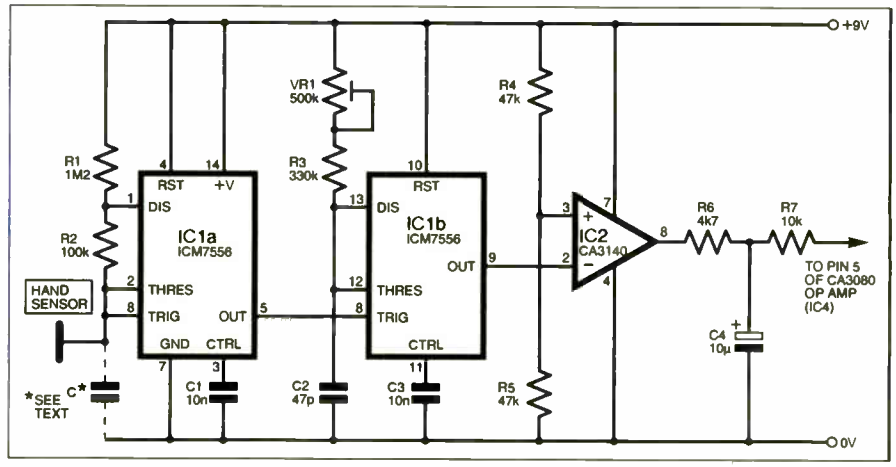


Fig.2. Theremin Volume Control circuit diagram

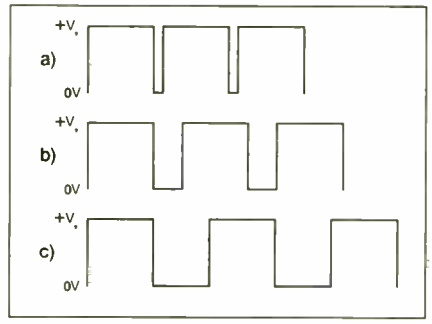


Fig.3. Monostable output waveform

Voltage Splitter – *Single Bias*

THE commonly used method to split a single supply is to use an op.amp and two resistors, as shown in Fig.4. Using an LM386 audio i.c. instead of the op.amp, the resistors are not required, see Fig.5. This saves on board space. Of 20 LM386s tried, 15 of them split the voltage to within 5%. The worst was 8·4%. This was sufficient for my application and would probably be so for most applications.

If more accurate splitting is required this can be done by connecting one or the other input to the negative rail via a 47kΩ pot (Fig.6). With most examples the split could be set precisely. With a 12V supply and loading only the one side with a 200Ω resistor (30mA) caused less than 0·5% change in the split (regulation). This is better performance than the op.amp solution can provide.

Op.amps are normally limited to 20mA of imbalance current. It is quite possible that other more robust audio amp i.c.s, such as the TDA2003, can be used if a more rigid split and a higher imbalance current is required. The LM386N-4 will handle 18V. The LM386N-1 has a quiescent current of 8mA at 12V. This should not be too onerous even for a battery application.

Neville Frewin,
Fontainebleu, South Africa

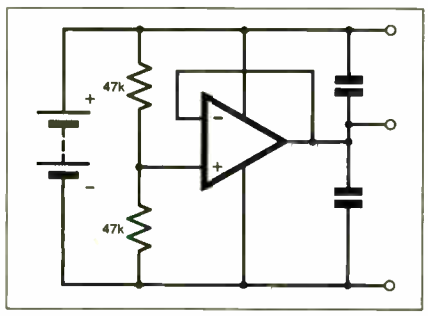


Fig.4. Splitter using an op.amp

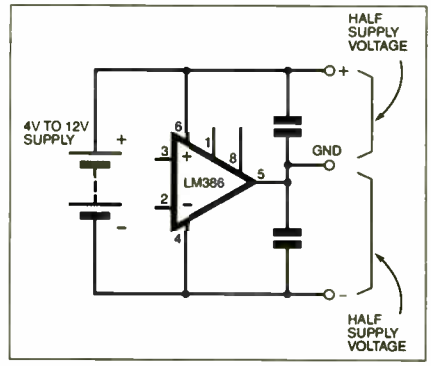


Fig.5. Splitter using an LM386

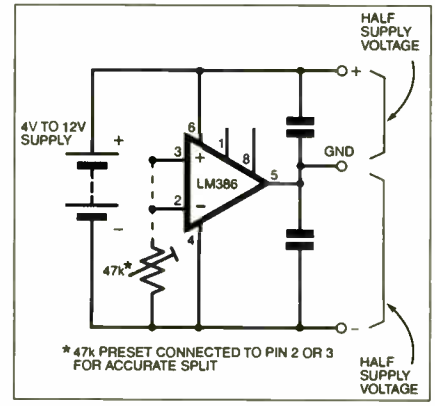


Fig.6. An LM386 splitter with trimmer

World Radio History

Pulsed Motor Speed Controller – *Over and Out*

THE circuit diagram shown in Fig. 7 was built to keep the speed of a motor constant with varying load conditions. It works by driving the motor with a train of 12V pulses, and varying the mark/space ratio of these pulses to control its speed. This method is reckoned to be more efficient than using a linear regulator because the series pass transistor dissipates much less power.

The speed of the motor is determined by measuring the voltage developed across it when no power pulse is being applied (this is effectively using the motor as a generator) and comparing its output voltage to a reference.

The 555 timer, IC1, is configured in its astable mode with capacitor C3 and resistor R8 determining the "output low" pulse width. This is of constant duration (about 7ms) and drives transistor TR1, via resistor R2, to feed a 12V power pulse to the motor M1.

The "output high" duration ("the dead time") is determined by the value of the timing capacitor charge current. This charge current is itself determined by the voltage developed across the motor when no power is being applied to it. This motor voltage is compared by comparator TR2 to a 4·7V reference voltage provided by Zener diode D2.

So, if the voltage across the motor is less than about 3·5V transistor TR2 conducts and turns on TR3, its collector current charging timing capacitor C3. Resistor R7 limits the maximum collector current of TR3 and so limits the minimum "dead time" of the power pulses.

Switch-On

At switch-on, the voltage developed across the motor between the power pulses is zero so transistors TR2 and TR3 both conduct heavily and timing capacitor C3's charge time is very short. As the motor accelerates to its target speed and its "generated" voltage increases, TR2 and TR3 both reduce their conduction, increasing the time it takes to charge C3 and so the "dead time" increases.

Eventually, an equilibrium is reached when the voltage generated across the motor is about the same as the reference voltage minus the voltages dropped across TR2's emitter-base junction and diode D1 junction. Diode D1 protects TR2's emitter-base junction from reverse bias during the 12V power pulse to the motor. During the power pulse both TR2 and TR3 are switched off so they have no effect on C3's discharge current.

Capacitor C1 reduces the voltage "spike" developed across the motor produced by its internal inductance when the 12V pulse ends, and is most important to protect transistor TR1. Capacitor C2 provides a "soft start" for the motor by making the reference voltage build up slowly on switch-on; it can be omitted or increased in value as desired.

If the circuit is unstable, for instance, the motor is continually starting and stopping, increase the value of resistor R4 to reduce the system gain until stability is achieved.

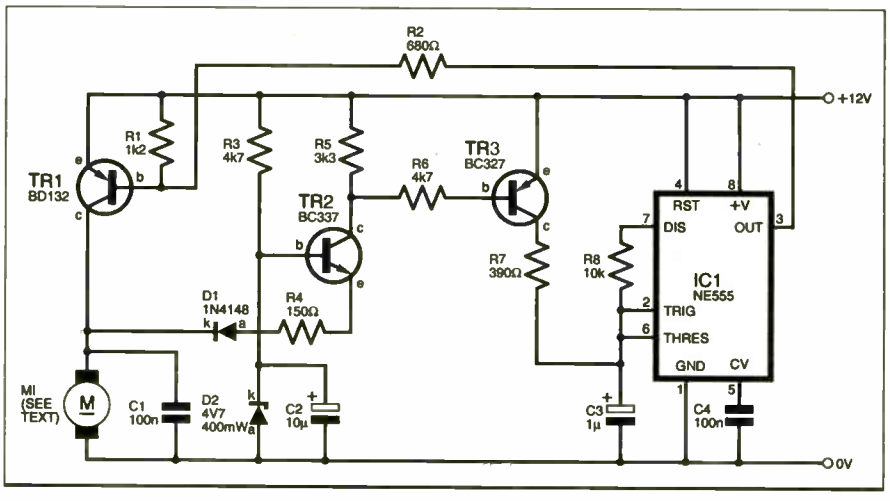
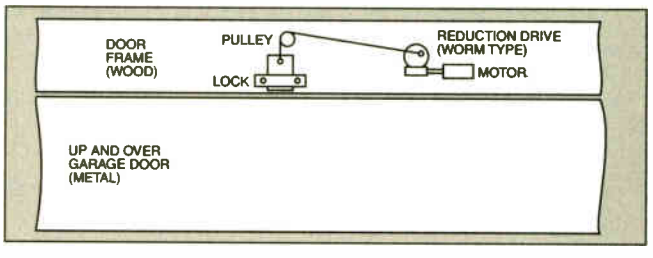


Fig.7. Circuit diagram for the Pulsed Motor Speed Controller

Fig.8. General set up of garage door lock from inside of garage



Up-and-Over Lock Out

I use the circuit with a motor and worm-type reduction drive salvaged from an old VCR (the cassette loading mechanism) to form part of a lock mechanism for an up-and-over garage door, see Fig.8. All I had to do was add a small bolt through the output gear so that I could fasten the drive cord to it.

The drive cord is "shock leader" for fishing lines – I do not know what that is used for but I know that it has a 45lb breaking strain rating, and its waterproof (the garage gets damp in the winter).

The lock plates are both 1/4in. aluminium and so rustproof and strong enough for the job. As can be seen from Fig.8, the motor lifts and lowers the lock plate thereby opening and closing the door lock.

In practice, it works fine from no load to stall, though it is a bit juddery at low load. If the judder is too great, reduce the value of capacitor C3. The motor has a stall current of about 600mA, and it should be ensured that the series pass transistor TR1 is still saturated under such conditions – reduce the value of resistor R2 if necessary to ensure that this is the case.

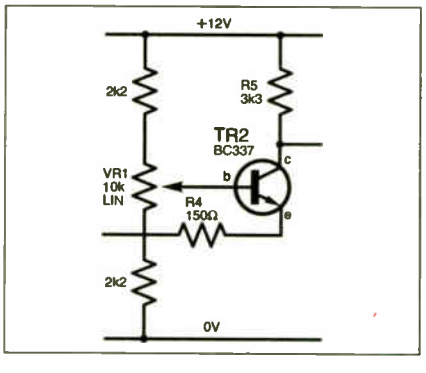


Fig.9. Alternative base bias arrangement for transistor TR2 to give variable speed

The circuit should work fine as a variable speed controller by varying the reference voltage on TR2's base (b), though judder may be encountered at low speeds and with low loads unless the timing capacitor C3 is reduced in value. Suitable circuit alterations for this are shown in Fig.9. It must be stressed that this circuit modification is untested.

Peter A. Tomlinson,
Hull, East Yorkshire.

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Net Work

Alan Winstanley

LAST month's *Net Work* column highlighted AuthSMTP (see **www.authsmtp.net**), a third party mail service that promises to solve most outgoing email problems. This can be a perfect solution for users having domain mail relaying problems, or other issues such as a regular ISP's mail server being blacklisted due to spam campaigns.

In use, AuthSMTP's service is holding up extremely well and has been entirely trouble free for the past three months, offering superior performance to the writer's broadband service provider, although the writer's Eudora E-mail software was problematic initially. A 14-day trial of AuthSMTP can be ordered online.

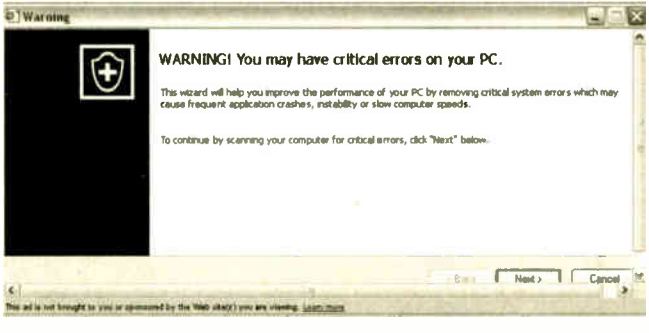
They're Spying On Us

This month we revisit the thorny topic of dealing with spyware and we take a look at some of the latest and most popular anti-spyware programs. Spyware is said to affect 90% of Windows PCs and can be dropped onto a computer in a number of ways. It may be included in some trial software, or it could originate from certain web pages or other computer files or downloads. Spyware programs reside on a host computer such as a PC and may be used to transmit credit card numbers or login details to a third party, or may have marketing-related purposes instead. They may hijack your web browser home page as well.

Some of the worst examples of spyware involve elements of "social engineering" which play mind-games by raising uncertainties in the minds of users and tricking them into clicking through to another web site. For example, a pop-up might appear that warns you that your PC has an infection (which it has: it's the pop-up itself); clicking through might take you to a cheap utility software.

In a recent example, the author became increasingly irked to find a pop-up advert appearing every time he visited eBay's web site. By using the free spyware removal tool Ad.Aware (highlighted in May 2005 *Net Work*, see **www.lavasoft.de**), some spyware was detected, but every time it was deleted by Ad Aware, the pop-up advertisement re-appeared. Only by using a whole armory of anti spyware tools was the problem eventually cured.

The pop-up was also deceptive, as it resembles an authentic dialogue box that encourages neophyte computer users to click a "Next" button. The only redeeming grace was the unobtrusive warning link along the bottom of the pop-up. A similar pop-up also appeared, this time with a logo for "Casale Media". This Internet marketing company claims to operate one of the world's largest online media marketing networks, with 140 million "unique users" per month.



Example of a spyware-generated pop-up

Not Us, Guv'nor

The eBay problem was eventually tracked down to "People On Page" spyware advertising. I asked Casale Media to comment on this form of persistent pop-up advertising. Casale assured me that they do not have the ability to target anyone's computer or put any software onto their machine.

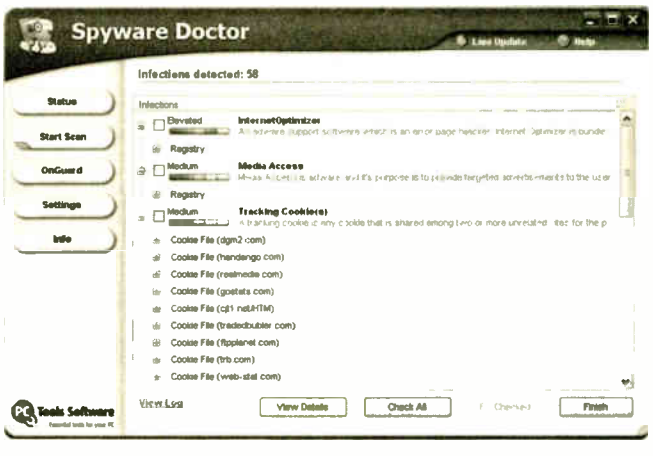
They added that they do not support pop-up advertisements and they specify that any site hosting adverts must only place pop-unders, and the amount of advertisements displayed to individual users is restricted to one per day. Casala blamed the persistent appearance of pop-ups on the presence of third party adware, as the Casale network only placed pop-unders – which appear after a short duration, underneath the main target web site.

The source of the People on Page spyware could not be pinpointed, and it proved troublesome to remove (it appeared to defeat AdAware SE), demonstrating the wisdom of using a range of spyware removal tools to hopefully cure any problems.

Large portal sites such as **www.download.com**, **www.shareware.com**, **www.snapfiles.com** and TUCOWS (The Ultimate Collection of Windows Software at **www.tucows.com**) are good places to start searching for utilities. Current anti-spyware contenders worth considering include: Paretologic's Xoftspy (**www.xoftspy.co.uk**, free download, $39.95 one-time fee for the full version), the excellent Spyware Doctor (**www.pctools.com** £19.95) and the ubiquitous Spybot Search and Destroy (donationware) from **www.safer-networking.org/en/download/**.

Webroot offers the acclaimed Spysweeper for $29.95 per year (free trial available from **www.webroot.com**). Other spyware tools to consider are Sunbelt Software's CounterSpy which has a 15 day trial and costs $19.95 per year. See **www.sunbelt-software.com/CounterSpy.cfm** for their take on Microsoft's own Anti Spyware tools, which is available in beta from Microsoft via **http://tinyurl.com/47cus**.

Next month, I'll be looking at ways of handling web site passwords and logins, without having to resort to memory or some dog-eared notebook (that you lost anyway). If you have any comments, suggestions or feedback please email them to the writer at **alan@epemag.demon.co.uk**



Just one of many anti spyware programs

World Radio History

PIC N' MIX

JOHN BECKER

Our periodic column for your PIC programming enlightenment

More on using a DS1267 dual digital potentiometer with a PIC

LAST month we examined the basics of using the DS1267 dual digital potentiometer chip. We now look at some further aspects of its use.

Stacked Configuration

The potentiometers can be connected in series as in Fig.5. This stacked configuration allows the user to double the end-to-end resistance and the number of steps from 256 to 512 (9-bit resolution).

The wiper output for the stacked pots is taken from the SOUT pin, which is the multiplexed output of the wiper of pot 0 (W0) or pot 1 (W1), as governed by the stack select bit (bit 0). If bit 0 = 0, the output to SOUT will be that of W0. If bit 0 = 1, the SOUT output will be from W1.

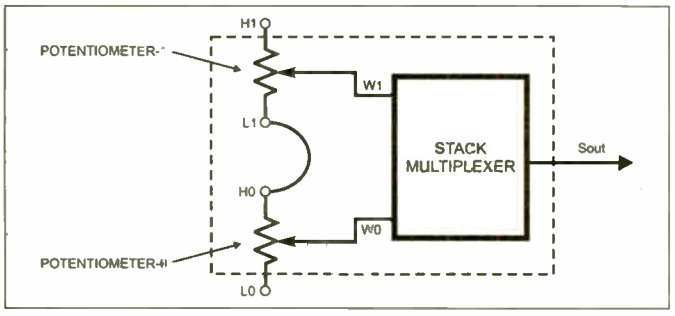


Fig.5. Stacking the pots

Cascade Operation

Multiple DS1267s can be daisy-chained as in Fig.6. As a data bit is entered into the shift register, a bit will appear at the COUT output. The stack select bit will always be the first out at the beginning of a transmission. The COUT pin is always active regardless of the state of RST. This allows the shift register to be read without changing its value.

The COUT output can be used to drive the DQ input of another DS1267. When connecting multiple devices together, the total number of bits transmitted must always be 17 times the number of DS1267s in the daisy-chain.

An optional feedback resistor of between 2k and 10k can be placed between the COUT terminal of the last device and the first DQ input. This allows the PIC to be read as well as written to, or to circulate data through the daisy-chain.

When reading data via the COUT pin and feedback resistor, the PIC must set its pin that controls the DQ line into a high-impedance (input) state. When RST is taken high, bit 17 is present on the final COUT pin, which is fed back to the first DQ input through the resistor. The first DQ pin's status can then be read by the PIC. By successive clocking of the CLK line, the register contents can be read and stored into PIC registers allocated by the user for the purpose.

When the CLK input is then taken from low to high, bit 17 is loaded into the first position of the DS1267 register, and bit 16 becomes present on final COUT and first DQ pins. After 17 bits (of 17 times the number of DS1267s in the daisy-chain), the data will have been shifted completely around and back to its original position. When RST is taken low to end data transfer, the same value as before the read occurred is loaded into the W0, W1 and stack select bit registers.

Cascading Demo

The demo code discussed last month simply illustrates the writing of data to a single DS1267. It can also be used with two or more DS1267s cascaded, as in Fig.7. The control code now requires pot values appropriate to each pot in the chain. These codes are sent in the same way as with one DS1267, but as a serial stream of 17 × the number of DS1267s (two in this case).

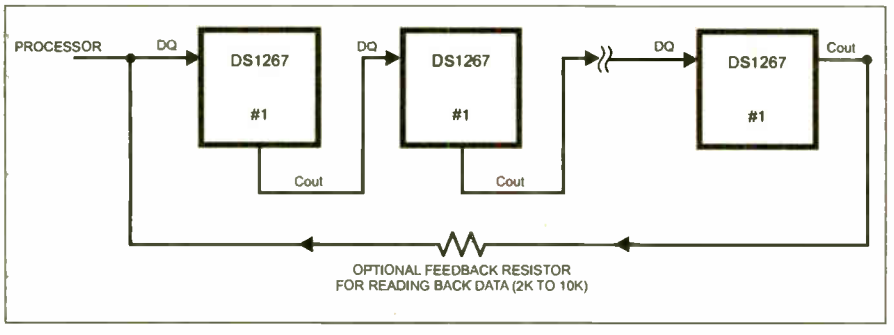


Fig.6. Daisy-chaining several DS1267 devices

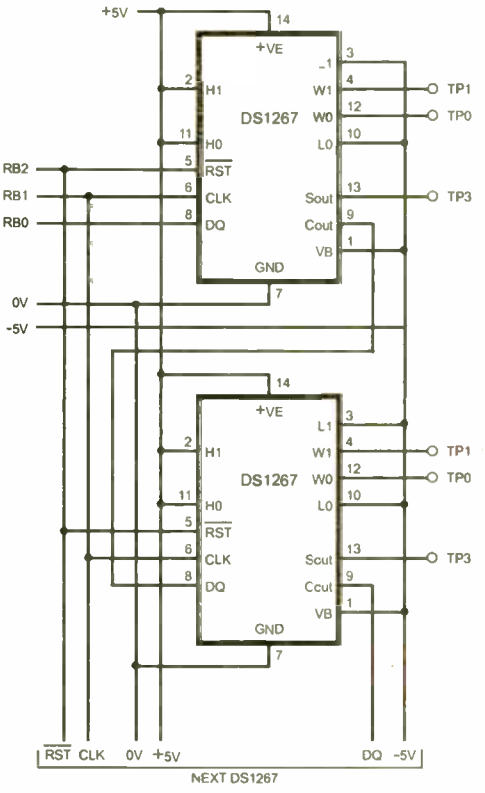


Fig.7. Cascading demo circuit

By deleting the **goto ENDPOT** command the demo sends data to both chips. Note though that as written the code sends the first data group to the second chip, and the second group to the first chip. The ramping rate for the second pot group is higher than for the first.

Practically Speaking

In reality, it will be unlikely that repetitive looped control of one or more DS1267s would be required, unless ramped waveforms at various frequencies and slope angles were required.

Instead, it is more likely the pot wiper values may only need to be changed periodically. For this the PIC would only set particular values into the POTVALx registers immediately prior to the sending routine being called (**call SETPOTS**). Then at the end of that routine, the **goto SETPOTS** command would be replaced by a single **return** command.

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Applications

The diagrams in Fig.8a and Fig.8b show two ways in which the DS1267 can be used in a circuit. In Fig.8b, the required pot is connected between the +5V and –5V lines. The wiper is then connected to the non-inverting input of a unity-gain (buffering) op.amp. The op.amp output can then be used to control some other aspect of the circuit.

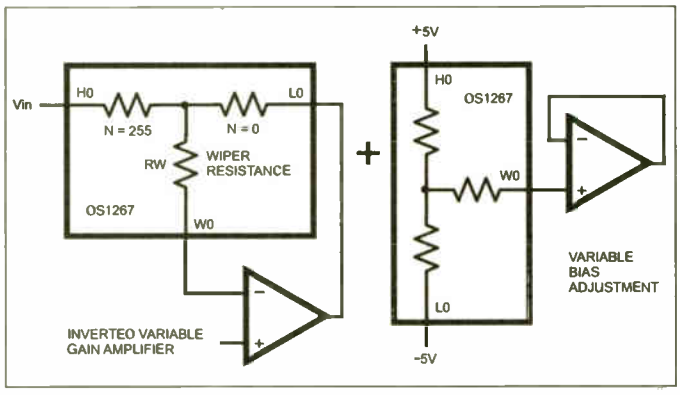

Fig.8. Using a DS1267 with an op.amp

Secondly, Fig.8a shows how the gain of an op.amp circuit can be amended by a DS1267 pot. The gain of the circuit is set by the relative resistance values at either side of the pot's wiper. A further implementation of this idea is shown in the full datasheet.

In a forthcoming *EPE* project, a DS1267 is used with a single op.amp to control not only the gain, but also the offset bias of the stage. In that application, the setting of the pots is performed via a PC coupled to the controlling PIC.

It should be noted that any op.amp used as above should be defined as a rail-to-rail device.

Data Readback

A use for reading back data from a DS1267 has so far not been imagined. But should you wish to do so, a loop similar to that in **SETPOTS** should be written, in which the PIC's data pin is set as an input. Three registers are then needed, one each for the pot data and one for the stack bit. The feedback resistor referred to earlier must be added. The process would then be along the lines of the logic in Table 2.

Table 2. Data Readback Logic

set RST high
read data (DQ) bit and store it as the stack bit
send clock high then low
read data bit
store it into bit 0 of PIC's first pot register
rotate that register left by one place
send clock high then low
repeat process eight times
repeat the last eight reads for the second pot register
set RST low
use the readback values as required

Meter Monitoring

If an oscilloscope is not available, the W0, W1 and SOUT waveforms can be monitored via a multimeter. This requires that a delay loop is put into the code, so that the analogue voltages at the three pins can be followed on the meter. As it stands, the demo code is clocked at too fast a rate for a meter.

Listing 2

```
DELAY:  decfsz COUNTER0,F
        goto DELAY
        decfsz COUNTER1,F
        goto DELAY
        return
```

Such a loop could consist of a routine such as that in Listing 2. This could be called by the command **call DELAY** immediately prior to the final command **goto SETPOTS**. This delay code would slow the wiper code changing routine by a factor of 256 × 256 = 65536. Other more sophisticated delay routines could be used instead, for example by using the PIC's timer to set the delay length.

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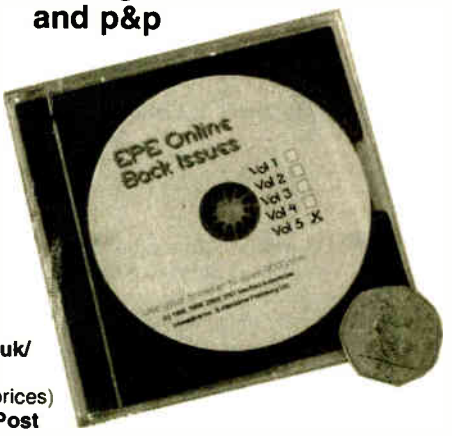

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World Radio History

Constructional Project

Photic Phone

Thomas Scarborough

Using a single ultrabright l.e.d., this simple low-cost, high security, optical voice link achieved a range of four metres, and 15 metres with a single lens

THIS project slices up the human voice into forty-thousand binary segments a second, transmits it over a light-beam, then re-integrates it at the other side. That is, it applies pulse width modulation (p.w.m.) to the voice, to create a binary transmission. This is far more advantageous than similar analogue circuits, which typically achieve a range of no more than a few metres.

The circuit presented here has a range approximately five times greater than similar analogue circuits. Without the use of lenses, the prototype Photic Phone achieved a range of four metres. With a single lens at the Transmitter, it achieved a range of 15 metres. In theory, therefore, with the use of two lenses, it should achieve a range of fifty metres using a single cheap, ultrabright l.e.d.

The problem with similar analogue circuits is that these depend on a light beam of continuously variable intensity. What happens in this case is that, over distance, the subtler nuances of the light beam are lost – and with them the intelligibility of the voice.

Transmitting a voice in binary form has the advantage of always transmitting at full intensity. This means that even the weakest nuances of a voice will reach the Receiver as strongly as the rest.

Lighting The Way

Besides being good fun, communicating via a light-beam may have certain advantages over other methods of transmission. It requires no wires, it needs no radio license, it is very cheap to implement, and it is all but impossible for anyone to eavesdrop on a transmission. Not only this, but the Photic Phone may also be used with fibre optic cable or a laser (at a price)!

It has at least one further, less obvious use. This is to detect pulsed, reflected light. In this case the circuit would require a few small modifications, in particular the addition of an oscillator to the Transmitter circuit, and a diode charge pump to the Receiver. Such a circuit should have a potential range of a few metres with lenses, and would detect , for example, persons walking past a window or approaching a door.

In Concept

While the Photic Phone has an unusually good "line-of-sight" range, it does have two limitations in particular which the constructor might wish to be aware of. First, it has a "tinny" sound which does not match the quality of the humble telephone. However, its sound quality is more than adequate for clear voice communication. Second, although it incorporates fairly effective filtering, there is likely to be an audible hum when it is used under a.c. lighting.

The seed for this project was sown with the original *Wind-Up Torch* (*EPE*, October 2000). In order to conserve power, the author pulsed the torch's light on the one hand, and gathered it with a lens on the other. It was then noted that a pulsed, focused ultrabright l.e.d. would easily light up objects 15 metres away.

The next impetus came as the author was developing the *Bat Detector* (*EPE*, March 2004). While contemplating the circuit diagram, it seemed obvious that it should be possible to transmit a modulated voice over a light-beam. This proved to be true, and a simple experiment achieved a short range.

The author also wondered just how simple such a circuit might potentially be. At first a direct analogue-to-binary conversion of the voice at the voice's natural frequency – around 300Hz – was tried.

Although this had the advantage of great simplicity, the clarity of transmission (or lack of it) was such that one could barely, if at all, make out what was being said. Female voices were more easy to discern than male – perhaps due to their higher frequency.

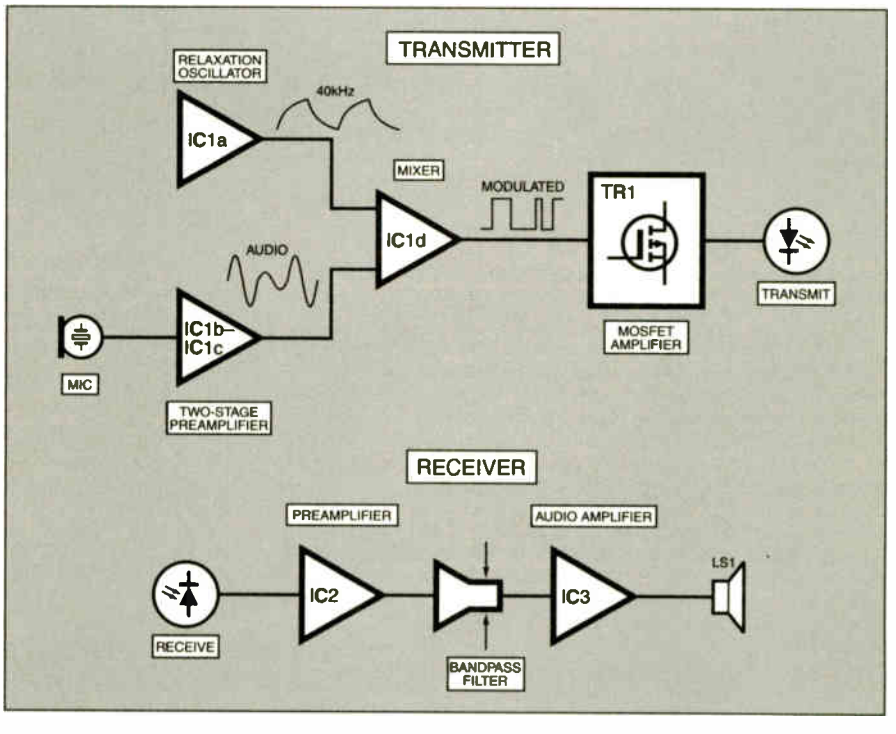


Fig.1. Block schematic diagram showing the general Transmitter and Receiver line-up that makes up the Photic Phone

World Radio History

Clarity further improved if compression was applied at the transmitter. However, this approach was obviously not destined for practical success.

The obvious way to go, it seemed, was p.w.m. (pulse width modulation). This is not the same as digital transmission, since the latter converts the voice into equally spaced 0s and 1s, usually in a mathematically encoded form. Nor is it the same as amplitude modulation (a.m.), which modulates the amplitude of a signal. Instead, p.w.m. chops up the voice into binary segments with varying mark-space ratios, which correlate directly to the voice.

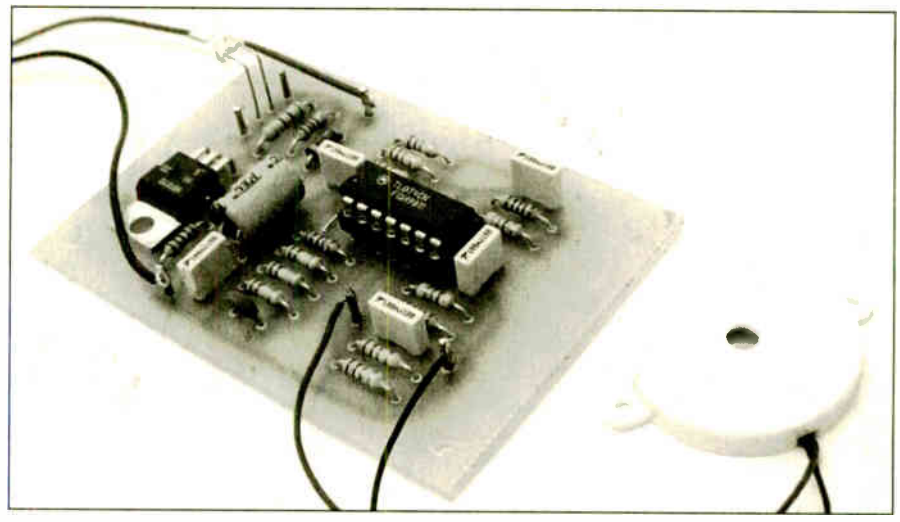
Fast Response

A breakdown of the Photic Phone system into the Transmitter and Receiver sections is shown in the block diagram Fig.1.

The next key question was how fast an ultrabright l.e.d. would be able to switch. The author found that many ultrabright l.e.d.s (although not white l.e.d.s) could switch at 100kHz. Therefore, to be on the safe side, a modulating frequency a little above 40kHz was chosen for the circuit.

Again, it was considered whether compression would be required at the transmitter. However, in practice this proved not to be necessary, on condition that one knows approximately how loudly to speak into the microphone. As shown, the piezo microphone needs to be held about 10cm from the mouth when speaking normally.

As it turned out, one of the most important requirements of the circuit was filtering. Firstly, a low-pass filter (482Hz) was required to reduce acoustic feedback. An early prototype produced acoustic feedback at 15 metres distance. This low-pass filter also doubles as demodulation or "decoding" for the modulated voice. Secondly, it was necessary to include a high-pass filter (175Hz) at the receiver end, to suppress the hum of a.c. lighting.



Completed prototype Transmitter circuit board. The passive piezoelectric sounder acts as the circuit's microphone

Note that since a power MOSFET (TR1) is used to switch the ultrabright l.e.d. D1, the light output of the Transmitter could easily be increased. A few ultrabright l.e.d.s could be used at once, or even the exceptionally bright Lumileds that are now available on the hobbyist market.

Transmitter Circuit

The full circuit diagram for the Transmitter stage of the Photic Phone is shown in Fig.2. Op.amp IC1a is configured as a relaxation oscillator, running at just over 40kHz. Notice that its output is taken from inverting input pin 2, instead of output pin 1. This is to obtain a rough approximation of a triangle wave for the modulating signal, which is presented to IC1d pin 13.

Next, a simple preamplifier, IC1b and IC1c, is employed to amplify the signal from a piezo microphone, MIC1. This is a cheap, disc type, piezo sounder, without an integral drive circuit.

The potential at IC1b non-inverting input pin 5 is lightly biased through resistors R1 and R2, and gain is set through resistors R7 and R10. The values of these two resistors may be increased for greater sensitivity, and vice versa. However, bear in mind that greater sensitivity means increased acoustic feedback, which is more problematic at shorter distances.

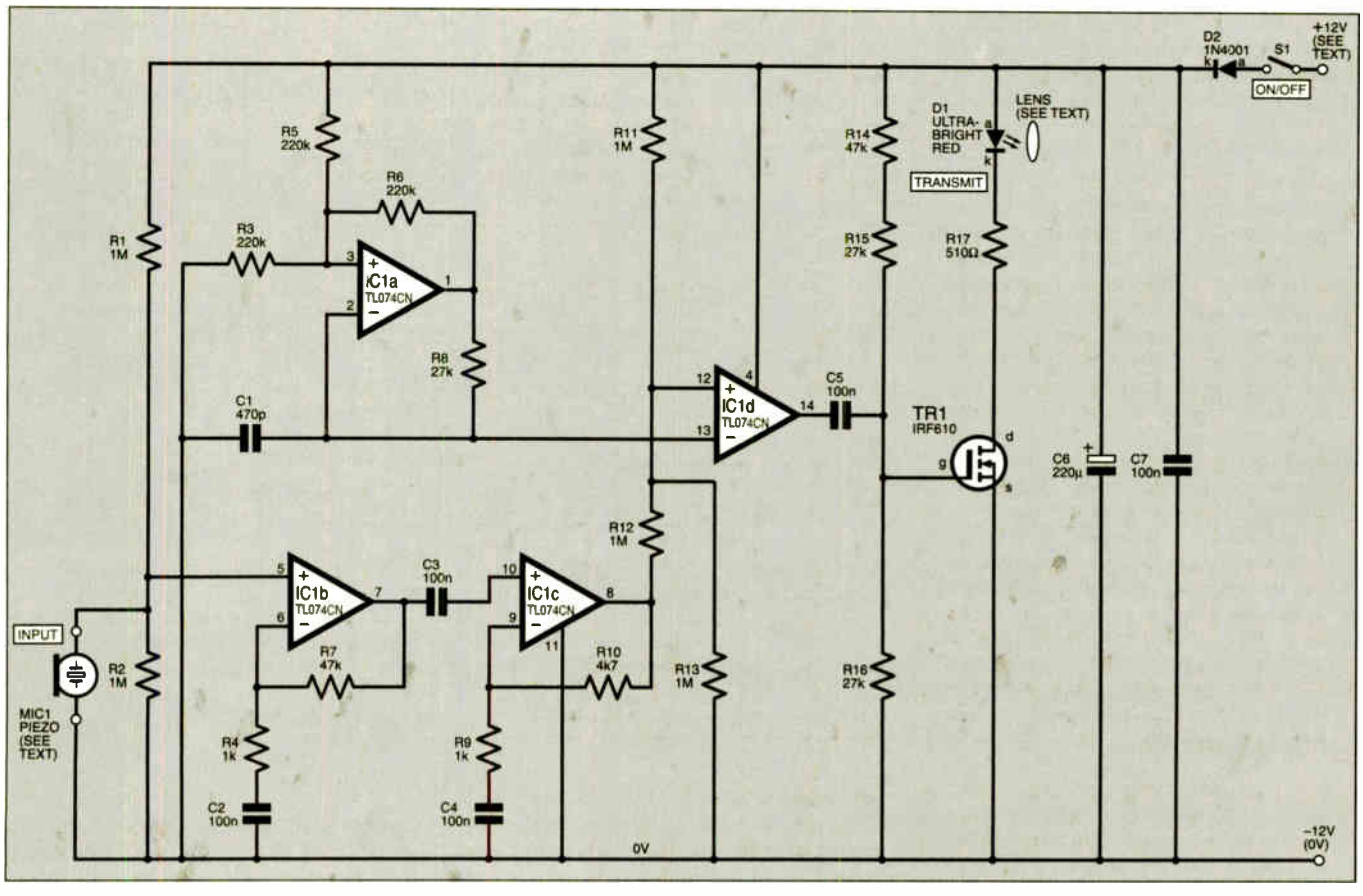


Fig.2. Complete circuit diagram, less power source, for the Photic Phone Transmitter

World Radio History

Resistors R11 to R13 are particularly important to the circuit, since these "contain" the signal at IC1d input pin 12 within one-third and two-thirds of the supply voltage. That is, the maximum amplitude of the preamplifier signal at IC1d input pin 12 matches the maximum amplitude of the modulating signal at IC1d input pin 13.

Lastly, the gate (g) of MOSFET TR1 is biased at its switching voltage through resistors R14 to R16, so that a modulated signal at IC1d output pin 14 causes the ultrabright "transmit" l.e.d. D1 to switch. If a different MOSFET is used, R14 to R16 may need to be adjusted so that the potential at TR1's gate (g) approximates the switching voltage. Bearing this in mind, most power MOSFETs may be used.

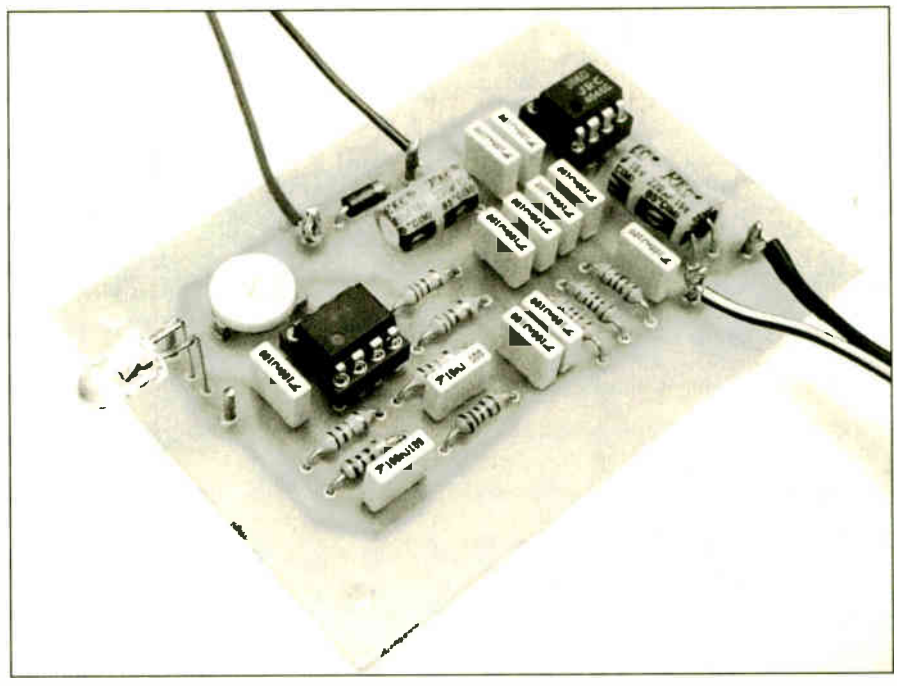
Receiver Circuit

The complete circuit diagram for the Receiver section is shown in Fig.3. This comprises a preamplifier, IC2, followed by a simple passive bandpass filter, and a 500mW r.m.s. audio amplifier i.c. IC3.

The "receive" photodiode D3 was taken from the author's spares box, but any sensitive photodiode or phototransistor may be used here, e.g. the Siemens SFH203. As a rough guide, the resistance of the author's photodiode fell below 10kΩ when situated 10cm from the "transmit" l.e.d. D1.

Resistor R18 may be modified to suit D3, and ideally the potential at the D3/R18 junction would be about half supply voltage when receiving. A light dependent resistor (l.d.r.) also worked here, but with much reduced sensitivity.

Of course, an infra-red diode could be used for D1, with a matching photodiode or phototransistor for D3. In this case, the Photic Phone would communicate invisibly. However, considering the difficulty of working with an invisible beam, the author would not wish to attempt this himself!



Component layout on the finished Receiver board

Light Signals

The potential at the junction between photodiode D3 and resistor R18 fluctuates rapidly as a light signal is received. This is fed to the non-inverting input (pin 3) of preamplifier IC2 by means of coupling capacitor C8. The preamplifier's non-inverting input (pin 2) is biased by means of resistors R19 and R20.

After this follow five passive filters, which make up a second-order low-pass filter (cut-off 482Hz), and a third-order high-pass filter (cut-off 173Hz), which form a bandpass filter when combined. This filter essentially permits the voice to pass, while filtering out both low frequency ripples caused by a.c. lighting, and the high frequency modulating signal. While active filters could have been used in this circuit, this would not have contributed to a simpler circuit, nor would it strictly have been necessary.

The fact that the high-pass filter is third-order, and its cut-off frequency relatively high, reveals that ripple from a.c. lighting was problematic during development of the circuit. While this filter does not completely eliminate hum, it greatly reduces it, particularly if photodiode D3 is placed in a black tube (see Fig.6). One could insert another high-pass filter if desired.

The author was unable to find the required 9·2 kilohm resistors for the filter,

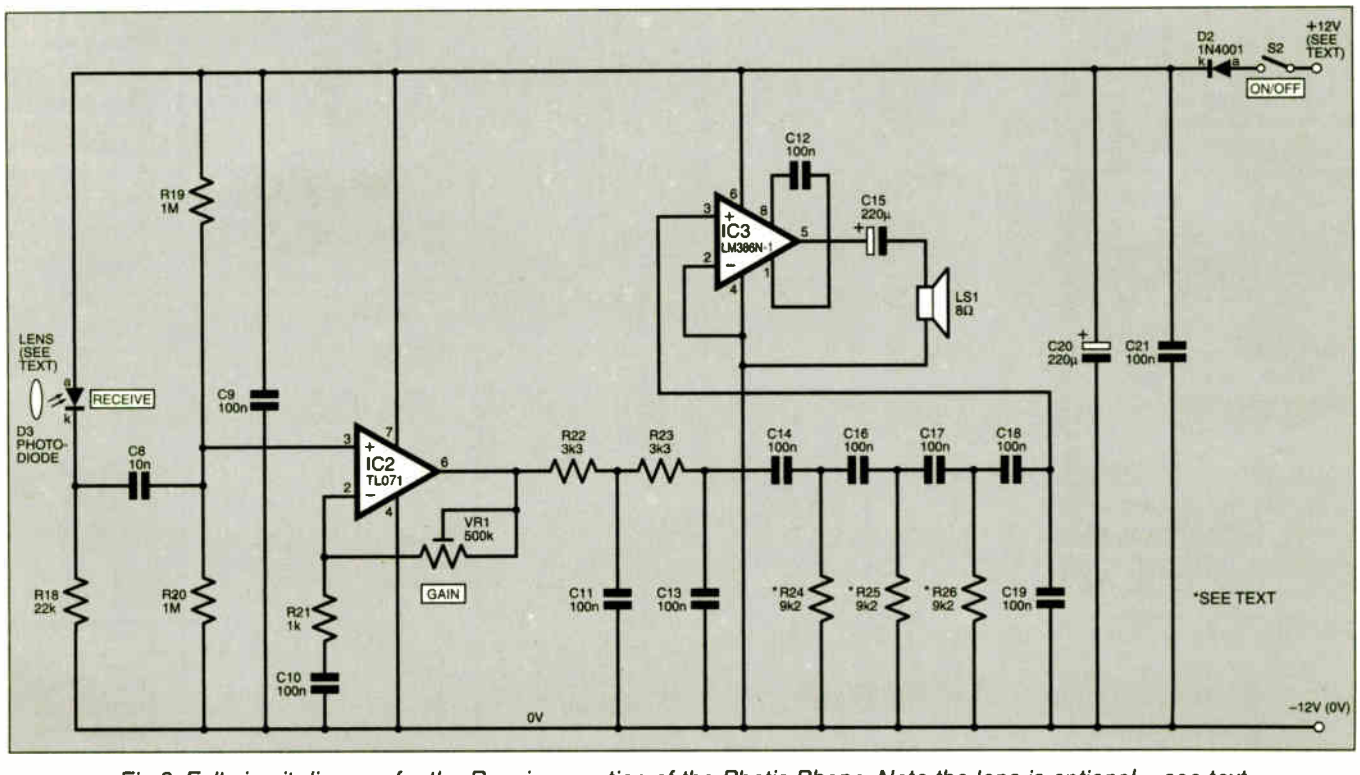


Fig.3. Full circuit diagram for the Receiver section of the Photic Phone. Note the lens is optional – see text

World Radio History

COMPONENTS

Approx. Cost Guidance Only **£18** excl case, lens and batts

See SHOP TALK page

Resistors

R1,R2, R11 to R13, R19,R20	1M (7 off)
R3, R5, R6	220k (3 off)
R4, R9, R21	1k (3 off)
R7, R14	47k (2 off)
R8, R15, R16	27k (3 off)
R10	4k7
R17	510Ω
R18	22k
R22,R23	3k3 (2 off)
R24 to R26	9k2 (10k and 100k in parallel) (3 off)

All 0.25W 5% carbon film

Potentiometers

VR1	500k enclosed round preset

Capacitors

C1	470p ceramic or polyester
C2 to C5, C7, C9 to C14, C16 to C19, C21	100n ceramic or polyester (16 off)
C6, C15, C20	220μ radial elect. 16V (3 off)
C8	10n ceramic or polyester

Semiconductors

D1	ultrabright red l.e.d. (see text)
D2, D4	1N4001 50V 1A rect. diode (2 off)
D3	sensitive photodiode or phototransistor (e.g. SFH203 – see text)
TR1	IRF610 n-channel power MOSFET
IC1	TL074CN quad j.f.e.t. op.amp
IC2	TL071 j.f.e.t. op.amp
IC3	LM386N-1 audio amplifier

Miscellaneous

MIC1	3V to 30V piezo sounder, without integral driver)
S1, S2	s.p.s.t. toggle or slider switch (2 off)
LS1	0·5W 8 ohm miniature loudspeaker
B1, B2	12V sealed lead-acid battery or 12V regulated power supply – see text (2 off)

Printed circuit boards available from the *EPE PCB Service*, codes 531(Trans.) and 532(Rec.); 8-pin d.i.l. socket (2 off); 14-pin d.i.l. socket; ABS plastic case, size and style to choice (see text); lenses (optional – see text); screened microphone cable (optional); cable ties; battery clip (2 off); solder pins (12 off); solder, etc.

however, an easy solution is to use 10 kilohm resistors and to wire 100kΩ resistors in parallel, which equals about 9·1 kilohms.

The cut-off frequency of the filters is calculated with the formula $f=2\pi CR$. The two low-pass filters comprise R22/C11 and R23/C13, while the three high-pass filters comprise resistors R24 to R26 and capacitors C14, C16 and C17.

Audio Amplifier

The audio signal amplifier, IC3, uses the popular LM386N-1 i.c., which puts out a respectable 0·5W r.m.s. into 8 ohms. Capacitor C19 is used as a final low-pass filter, recommended in data sheets (usually its value lies around 10nF), and C15 is a coupling capacitor for loudspeaker LS1.

To simplify design, the usual Zobel network at the output of IC3 was omitted. Capacitor C12 is used to boost the amplifier's gain, and this may be increased up to 10μF for increased gain, its positive terminal wired to pin 1 of IC3).

The current consumption of both Transmitter and Receiver is fairly high (about 15mA each), therefore two 12V sealed lead-acid batteries would be recommended, or two 12V regulated power supplies.

Construction

The printed circuit boards (p.c.b.s) for the Transmitter and Receiver both measure just 80mm (3·15in.) × 55mm (2·17in.) Instructions are given here for soldering both boards simultaneously.

The component layouts, off-board wiring and underside copper foil master patterns for the Transmitter and Receiver p.c.b.s for the Photic Phone are given in Fig.4 and Fig.5. These boards are available as a pair from the *EPE PCB Service*, codes 531(Trans.) and 532(Rec.)

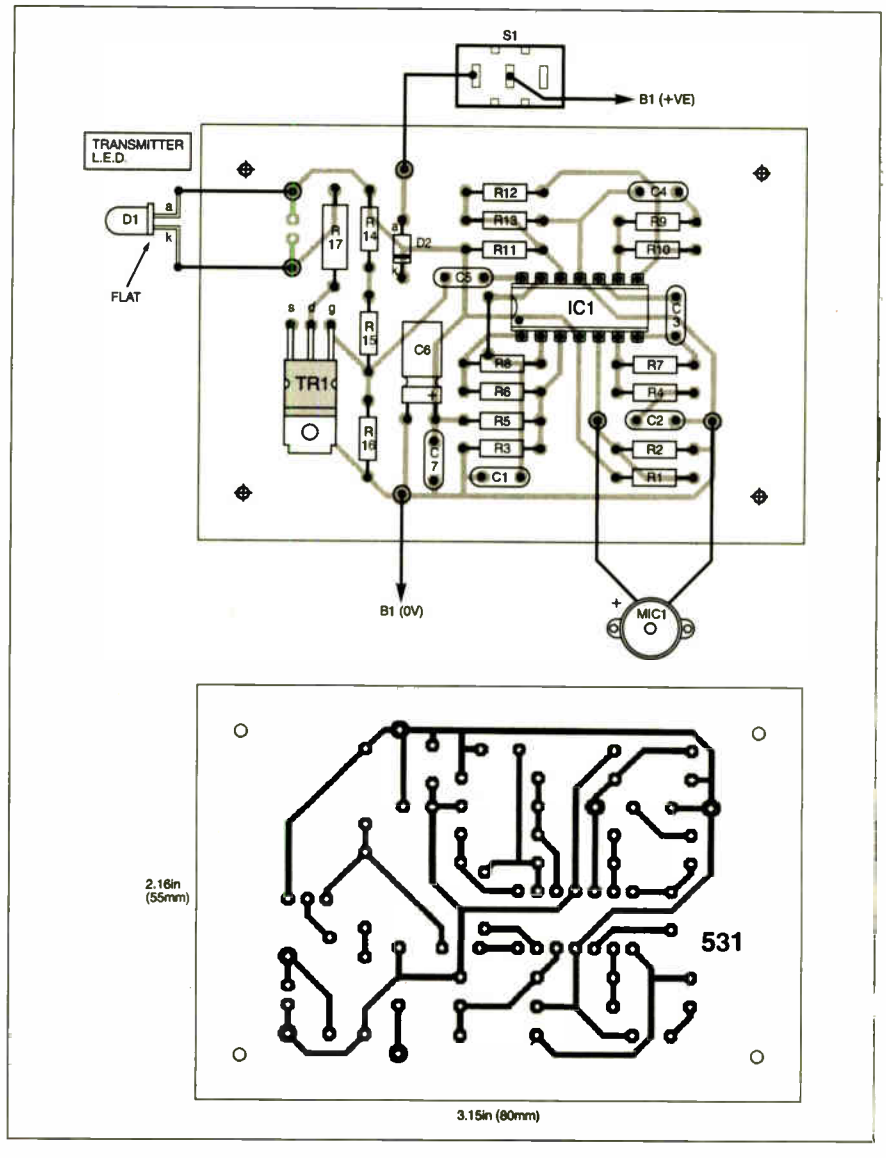


Fig.4. Transmitter printed circuit board component layout and wiring details

World Radio History

Since the two circuits amplify audio signals, and operate at a relatively high frequency, good solder joints need to be made throughout. All the components are fairly robust, and should not suffer from a good (though not excessive) application of solder. The integrated circuits should not be inserted in their dual-in-line (d.i.l.) sockets until circuit board construction has been completed and double checked for any component placement errors or bad soldering connections, including "bridged" copper tracks.

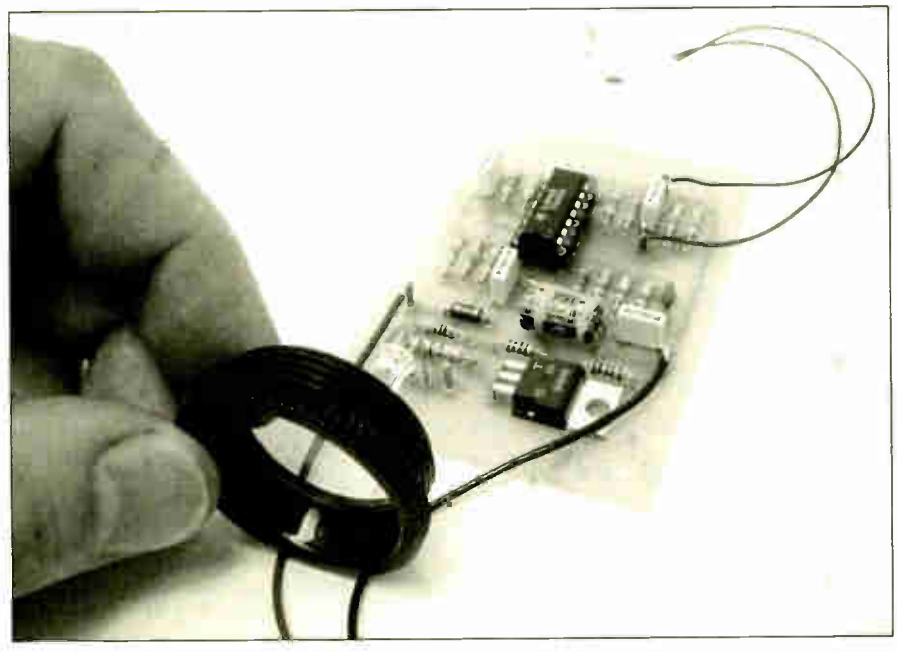
Working on each board in turn, begin construction by soldering the twelve solder pins, the three d.i.l. sockets, the twenty-six resistors and twenty-one capacitors (note the polarity of C6, C15 and C20). Solder preset potentiometer VR1, diodes D1 to D4 (D1 and D3 may be situated off-board for convenience), and transistor TR1.

Follow this by attaching the piezo microphone MIC1, loudspeaker LS1 and the two battery clips, observing the correct polarity, to the circuit boards as shown in Fig.4 and Fig.5. Finally, insert IC1 to IC3 in the d.i.l. sockets, observing their correct orientation.

Final Assembly

Suitable ABS plastic cases may be used for the Transmitter and Receiver, with the Transmitter being mounted on a tripod if desired. The piezo sounder/microphone MIC1 may be mounted in a separate, small ABS case, and wired to the p.c.b. by means of screened microphone cable to make a "CB-style" handheld microphone.

Lenses may be used with the Transmitter and Receiver as shown in Fig.6. and each should increase the range of the Photic Phone a few times over. Either add a single lens at the Transmitter (see photograph), or lenses at both the Transmitter and Receiver. The lenses are positioned so that the semiconductor chips within D1 and D3 are located precisely at the focal points of the lenses. A method for determining the approximate focal length of a lens is shown in Fig.6.



Experimenting with a lens in front of the Transmitter's ultrabright light emitting diode (l.e.d.) to check its operating range. With no lens it reached four metres and with it achieved a range of around 15 metres. The completed Receiver board is shown below left.

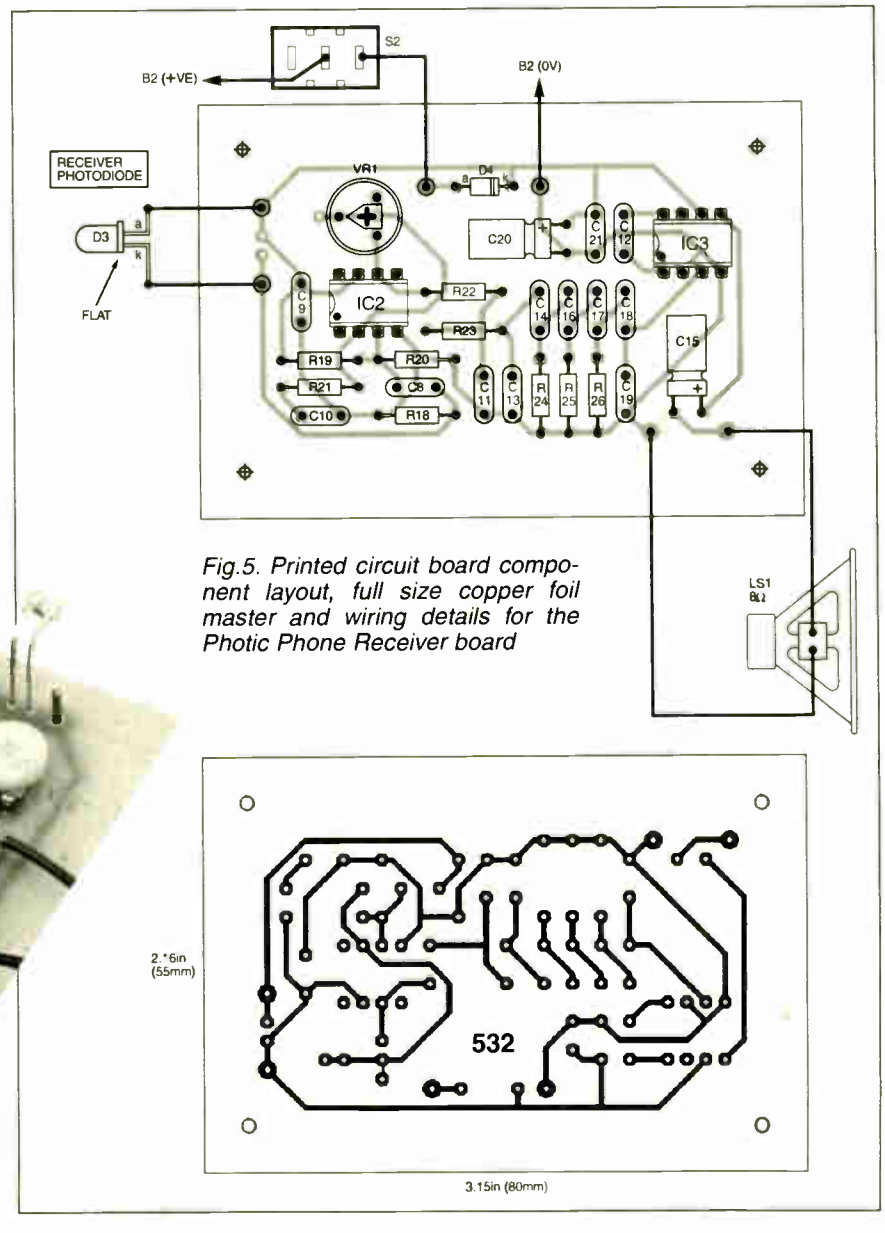
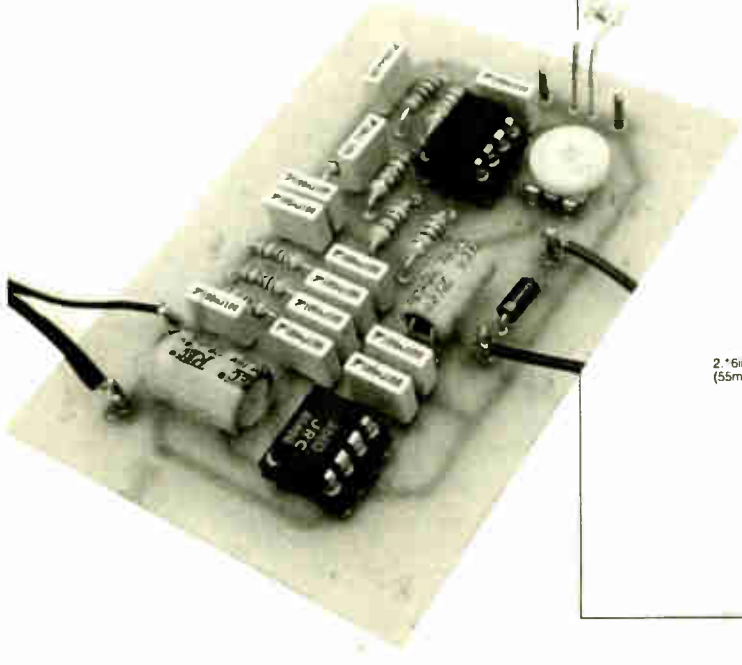


Fig.5. Printed circuit board component layout, full size copper foil master and wiring details for the Photic Phone Receiver board



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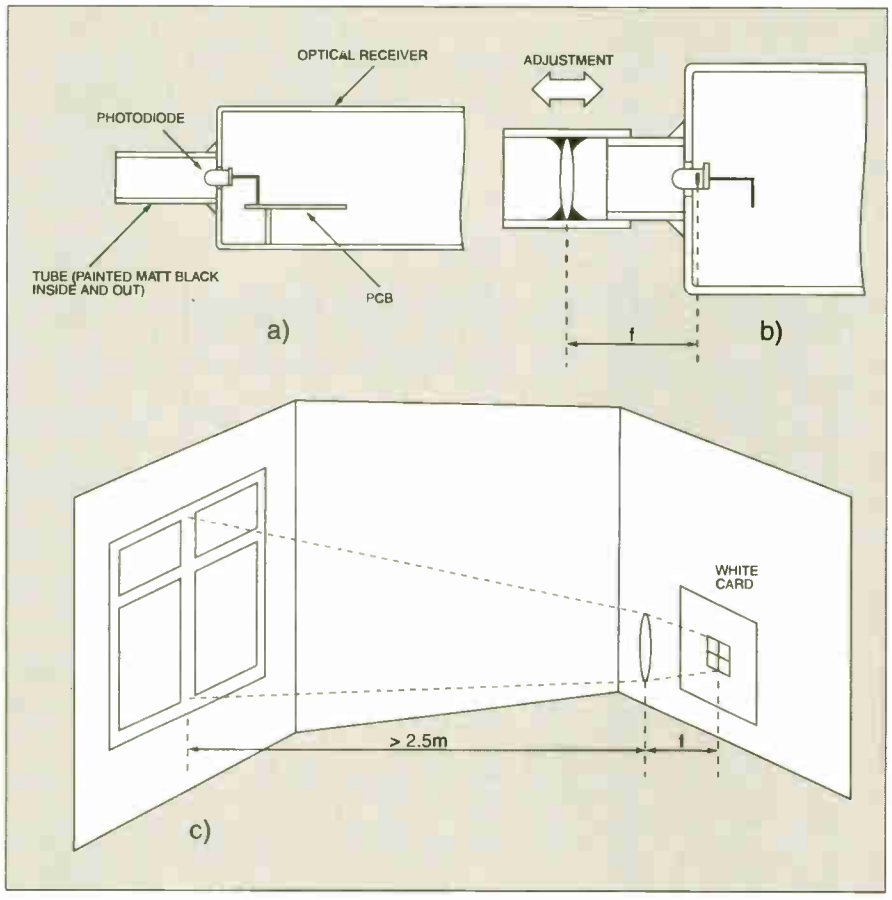

Fig.6. (a) Method of reducing mains lighting hum, (b) suggested adjustable lens mounting arrangement and (c) determining the approximate focal length of a lens

Setting Up and Use

Begin the setting up procedure by turning the Receiver's preset Gain control VR1 up (clockwise) about one-third. If the circuit is powered up under a.c. lighting, a soft hum should be heard. If the volume of the hum varies as you move your hand across photodiode D3, this is a likely indication that all is well with the Receiver.

Now place the Transmitter about one metre from the Receiver, with the ultrabright l.e.d. D1 pointing directly at photodiode D3. When you power up the Transmitter, D1 should immediately illuminate, and there may be a squeal in loudspeaker LS1 due to acoustic feedback.

If there is no acoustic feedback, tap microphone MIC1. The tap should be heard in the loudspeaker. In the case of acoustic feedback, back-off (turn anti-clockwise) preset VR1 slightly until the Receiver is silenced, then tap microphone MIC1. Again, the tap should be heard in the loudspeaker.

From here on, it is now merely a matter of "pushing the boundaries" by increasing the range, experimenting with the gain of the Receiver with preset VR1 (note that higher gain does not always translate to better performance), and by experimenting with lenses. It should be found that, with a single lens at the Transmitter, the Photic Phone should operate over 10 metres' distance with ease, and likely a good deal further.

Note that for two-way, "line-of-sight" communication you will require two sets of Photic Phones.

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Oscilloscope timebase	5ns/div to 50s/div	2ns/div to 50s/div	1ns/div to 50s/div
Timebase accuracy	50ppm	50ppm	50ppm
Spectrum ranges	0 to 25MHz	0 to 50MHz	0 to 100MHz
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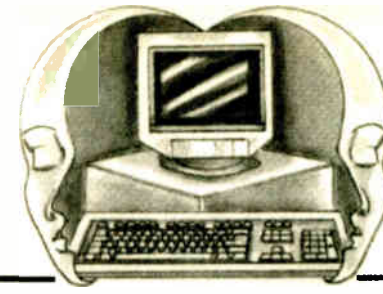
INTERFACE

Robert Penfold



USING A D/A CONVERTER IN A TRANSISTOR TESTER

IN the previous *Interface* article we considered the basics of using a digital to analogue converter to provide analogue to digital conversion. In particular, the use of this method in an "improved" transistor tester was considered. Most transistor testers use a fixed base current which produces a collector current that varies widely depending on the gain of the device.

The method outlined previously uses a "suck it and see" approach that steps-up the base current until a certain collector current is achieved. In other words, it uses a fixed collector current and a variable base current. This ensures that the gain reading is always taken at a reasonably high collector current where the test device will operate quite efficiently. This avoids having low gain but serviceable transistors being erroneously indicated as duds.

Transistor Tester Circuit

The circuit diagram for the transistor tester appears in Fig.1. The digital to analogue converter is based on an AD557JN chip (IC1), and this has been covered in recent *Interface* articles. It is an 8-bit converter that has an output voltage range of 0 to 2·55 volts, which equates to a resolution of 10 millivolts. In this application a voltage swing of 2·55 volts is adequate and it is not necessary to use any amplification. Some signal conditioning is required though, since it is actually a variable output current that is needed and not a variable voltage.

Of course, using a series resistor gives a simple but often effective form of voltage-to-current conversion, but in this case about 0·6 volts is needed before a significant current will start to flow. This is simply due to the fact that a silicon transistor has a forward threshold potential of about 0·6 volts. Once that threshold has been reached, large increases in the base current produce little increase in the base voltage.

One way around this problem is to simply adjust the mathematics of the software to take the forward threshold voltage into account. A slight drawback of this method is that it reduces the effective resolution of the system, with output values from 0 to 60 being left unused. The alternative used here is to process the output voltage of IC1 using a simple non-inverting buffer amplifier based on IC2. However, the inclusion of D1 in the negative feedback network adds about 0·6 volts to the output potential from IC1, nullifying the forward threshold voltage of test components.

NPN Testing

The base of a *npn* test device is driven from the output of IC2 via resistor R2. The collector load resistor for an *npn* test transistor is R3, and IC3 is used as the voltage comparator.

The Select In handshake input is used to monitor the output of IC3. R4 and R5 set the comparator's threshold voltage at half the supply potential, or 2·5 volts in other words. The base current is incremented until the collector voltage falls below this level, which occurs with a collector current of just over 20 milliamps.

This is high enough to ensure that any test device will operate efficiently, and realistic readings should even be obtained when testing power transistors. On the other hand, the test current is not so high that small signal transistors are in danger of being zapped.

The base current is a little over eight microamps per LSB, so multiplying the final value output to the converter by eight gives the base current in microamps. The current gain of a transistor is equal to its collector current divided by the base current, and with this design the collector current is 20 milliamps (20000 microamps).

Dividing 20000 by the final base current therefore gives the current gain of the test component. The mathematics can be simplified slightly, and dividing 2500 (20000/8 = 2500) by the final value sent to the converter gives the current gain of the test device.

PNP Testing

Some additional circuitry is needed in order to accommodate *pnp* test devices. The base current for a *pnp* test transistor is fed via R6 to a simple current mirror based on TR1 and TR2. The collector of TR2 drives the base of a *pnp* test device, and sinks a current that is approximately equal to the input current via R6. Resistor R7 acts as the collector load for *pnp* test components, and IC4 acts as the voltage comparator that detects the collector voltage going through the half-supply level. Its output is monitored by the printer port's Paper Out handshake line.

The connections to the two voltage comparators are such that their outputs go high when the 20 milliamp threshold current is exceeded. The software therefore has to increment the base current until a high logic level is detected from the relevant comparator. Rather than having *npn/pnp* switching, the interface has separate *npn* and *pnp* test sockets.

The circuit requires an accurate and stable +5V supply that can handle currents of up to 50 milliamps. The connections to the printer port are made using a piece of

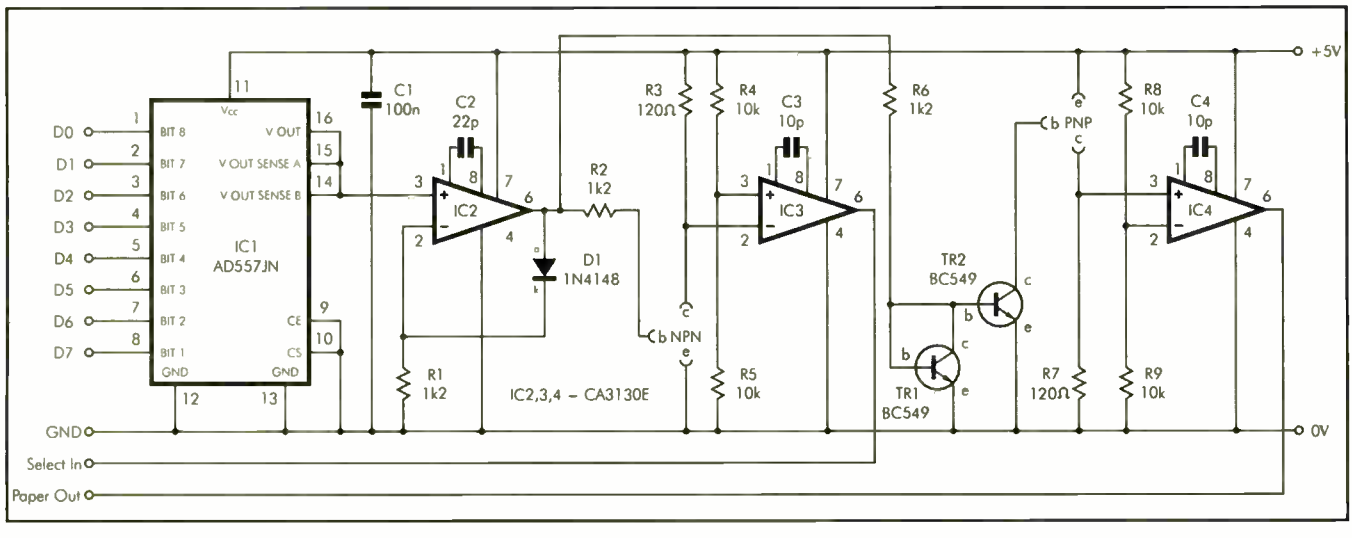


Fig.1. The circuit diagram for the Transistor Tester. Separate test sockets are used for npn *and* pnp *test transistors.*

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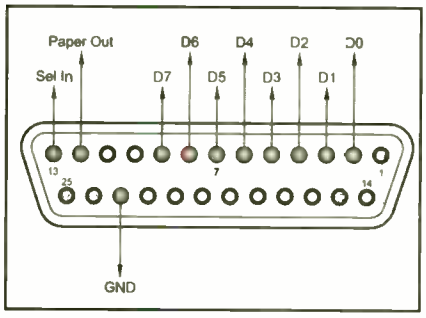

Fig.2. The 11 connections to the printer port are made via a 25-way D-type connector.

11-way ribbon cable that will probably have to be peeled from a 20-way cable. It is advisable to use a connecting cable that is no more than about two or three metres long. A 25-way male D connector is fitted at the PC end of the cable, and the correct method of connection is shown in Fig.2.

All four integrated circuits are MOS devices that require the usual anti-static handling precautions. Diode D1 can be any small signal silicon diode such as a 1N914 or 1N4148. For optimum accuracy with *pnp* test components the current gains of TR1 and TR2 should be reasonably well matched, so there is an advantage in using two components from the same gain group (e.g. BC549Cs).

Miniature 3-way DIN sockets are suitable for making the connections to most small transistors. It is necessary to make up a set of test leads to accommodate awkward transistors such as power types. The connections to power devices can be made by way of miniature crocodile clips or small spring-loaded test prods.

Software

The sample program for the transistor tester is an extension of the analogue to digital converter program described in the previous *Interface* article. The form has two labels (see Fig.3), one of which acts as the digital readout, while the other just provides a "Transistor Tester" heading. There are two command buttons, and operating the appropriate one takes a reading from an *npn* (Command1) or *pnp* (Command2) test transistor. The subroutine for the *npn* button is in Listing 1.

The routine is a For Next loop that outputs values from 1 to a maximum of 255 to the data lines of the printer port. The count is started at 1 rather than 0 in order to avoid errors later in the routine due to a division by zero.

Each time the value in variable "loopcount" is incremented, the corresponding current gain is calculated and displayed on the digital readout. However, the value is incremented so fast that only the final gain figure is actually displayed.

When bit 4 of the handshake input port (&H379) goes high, loopcount is set at 255 and the loop is brought to a halt. This line is placed at the end of the loop so that the display is left showing a valid reading.

If the measured current gain is less than 10, an If....Then instruction displays "OPEN" on the readout. This indicates that the test device is not exhibiting a significant amount of current gain and it has probably gone open circuit.

It is important that each test device is checked initially without the base terminal connected. This should result in "OPEN" being displayed, because only minute leakage currents will flow through a serviceable device with no base current applied. Obtaining any gain reading when no base current is applied indicates that the test component has an excessively high leakage current and is faulty.

A current gain reading of 2500 is intercepted by another If....Then instruction that displays "CLOSED" on the digital readout. Real-world transistors have current gains of no more than about 1000, and a gain of 2500 indicates that the test component has gone closed circuit. A faulty device in this state will provide a "CLOSED" reading with or without the base terminal connected.

The routine for testing *pnp* transistors is essentially the same as the one for checking *npn* devices. The only difference is that a masking value or 32 rather than 16 is used when testing the state of the handshake input line, so that the Paper Out line at bit 5 of the handshake input register is monitored.

Listing 1

```
Private Sub Command1_Click()

For loopcount = 1 To 255
Out &H378, loopcount
Currentgain = 2500 \ loopcount
Label1.Caption = Currentgain
If Currentgain = 9 Then
Label1.Caption = "OPEN"
If Currentgain = 2500 Then
Label1.Caption = "CLOSED"
If (Inp(&H379) And 16) = 16 Then
loopcount = 255
Next loopcount

End Sub
```

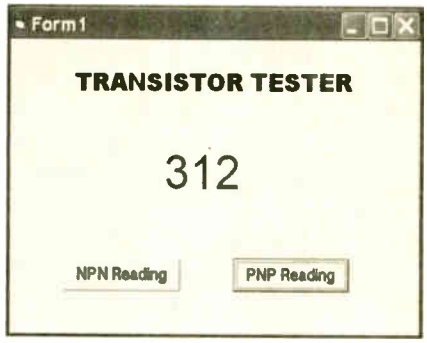

*Fig.3. The sample transistor tester program in action. Operating a button takes a reading for the appropriate type (*npn *or* pnp*) of transistor.*

Mods

A common display is used for *npn* and *pnp* devices, but it would obviously be a simple matter to add another label component and use that for *pnp* readings. With separate displays it would be possible to use the two loops with a timer component so that readings were updated (say) 20 or 30 times per second. The system functions properly with *npn* and *pnp* devices connected simultaneously, so it would then effectively provide separate *npn* and *pnp* testers.

It is possible to alter the collector current at which measurements are made, and it is just a matter of altering the values of resistors R2, R3, R6, and R7. Resistors R2 and R6 must have the same value, which has to be ten times higher than the value used for R3 and R7. The correct value for R3 and R7 is equal to 2·5 divided by the required test current (in amps). The circuit is unlikely to work well using test currents of more than about 30 milliamps, or much less than about one milliamp.

This system of gain measurement gives better resolution at low gains than at the other end of the range. This was deemed acceptable as it was primarily designed for checking low gain devices that tend to be problematic when tested using simple transistor testers.

Making R2 and R6 20 times higher in value than R3 and R7 would accommodate gains down to 20, and would give better resolution at high gains. Of course, the mathematics in the software would have to be adjusted to suit this change. The current gain would be equal to 5000 divided by the final value fed to the digital-to-analogue converter.

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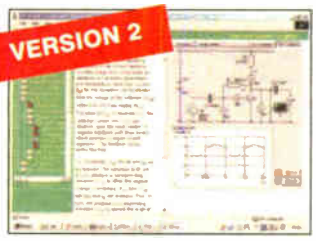

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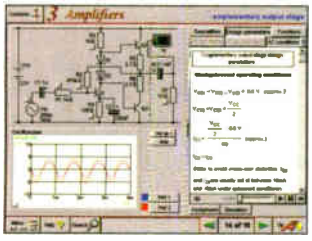

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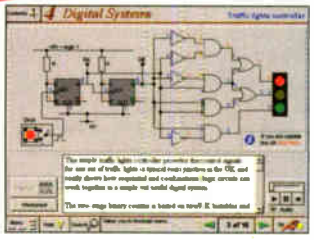

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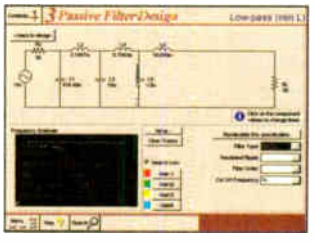

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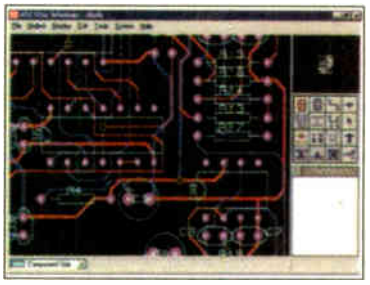

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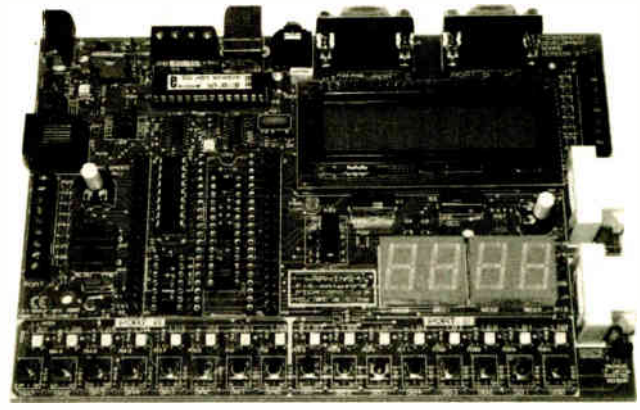

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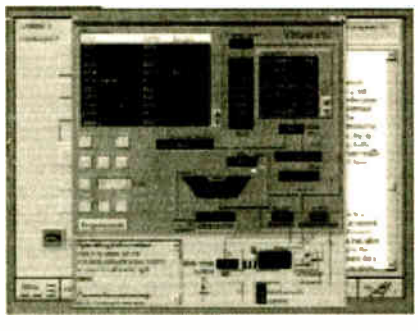

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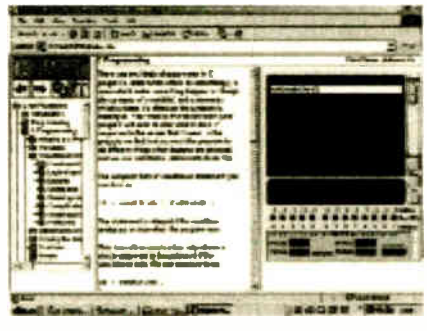

Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

FLOWCODE FOR PICmicro V2

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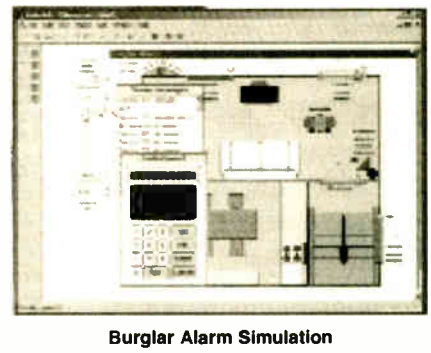

Burglar Alarm Simulation

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World Radio History

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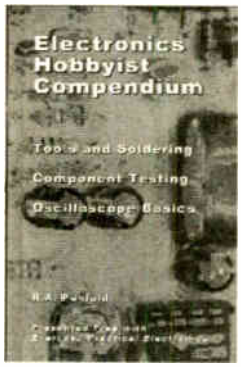

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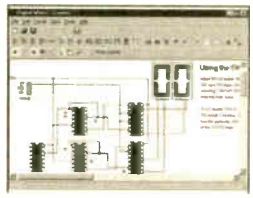

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Constructional Project

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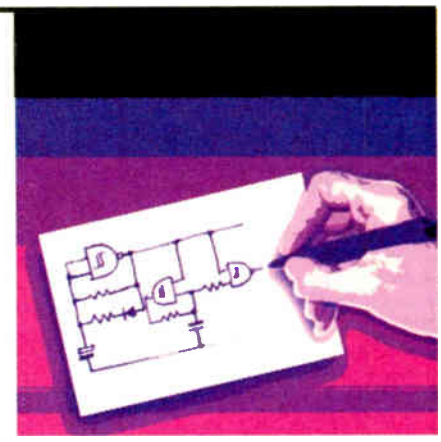

Bart Trepak

Part 7 – Parking Radar and Telephone Switch

Illustrates how useful circuits can be designed simply using CMOS logic devices as the active components

AMONG the many gimmicks fitted to modern top-of-the-range cars, a parking radar would rank as one of the more useful. Presented now is a little unit that is both inexpensive and easily fitted to any car (even an "old banger") and should help to prevent expensive mishaps!

The unit uses ultrasonics to determine the distance to an obstruction, the presence of which is indicated initially by an l.e.d. As the distance is reduced, a sounder emits a tone that rises in pitch to give a rough indication of the distance before impact!

As well as its intended use, this unit could also be suitable for a blind or partially sighted person to indicate the presence of obstacles in their path.

Basic Operation

All radars operate on more or less the same principle – a signal is transmitted which bounces back from the target to a receiver, which measures the time taken for the echo to return.

For long distance radar, radio frequency signals are used, but for short range applications (up to a few tens of metres) ultrasonics offer a simpler method. Despite the frequency being beyond the range of human hearing, the speed of the sound is still roughly 300m/sec, or 1m every 3ms.

This sort of time is easily resolved using ordinary components. Ultrasonic beams are also moderately directional (typically having a beam width of about 30°) so that only the object roughly in front of the transmitter should be detected.

The Parking Radar block diagram is shown in Fig.7.1. The master oscillator controls a 40kHz oscillator which drives an ultrasonic transmitter producing an ultrasonic beam directed at the target. The beam is reflected back, picked up by the ultrasonic receiver whose output signal is amplified. The resulting signal is used to set a bistable which has been previously reset at the start of the transmission.

The result is a pulsed output from the bistable. The duration of the pulses depends on the time between the transmission and its reception. Fig.7.2 illustrates the waveforms at various points in the circuit when the distance is large, medium and small. At very large distances (not shown) the reflected signal is too small to set the bistable and so the output remains low, while at decreasing distances, the output spends more and more time in the logic high state.

This p.w.m. (pulse width modulated) waveform is fed to a simple integrator which produces a d.c. voltage proportional to the distance from the target. This could be read on a suitably calibrated meter but here it is used to control a voltage controlled oscillator (VCO) which produces an audio tone increasing in pitch as the distance to the target is reduced.

The range obtainable from such a system is limited by four factors: the power

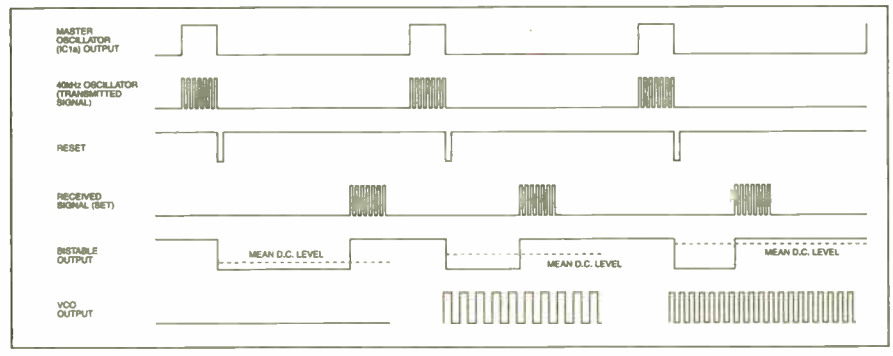

Fig.7.2. Waveforms at various points in the circuit when the "object" distance is large, medium and small

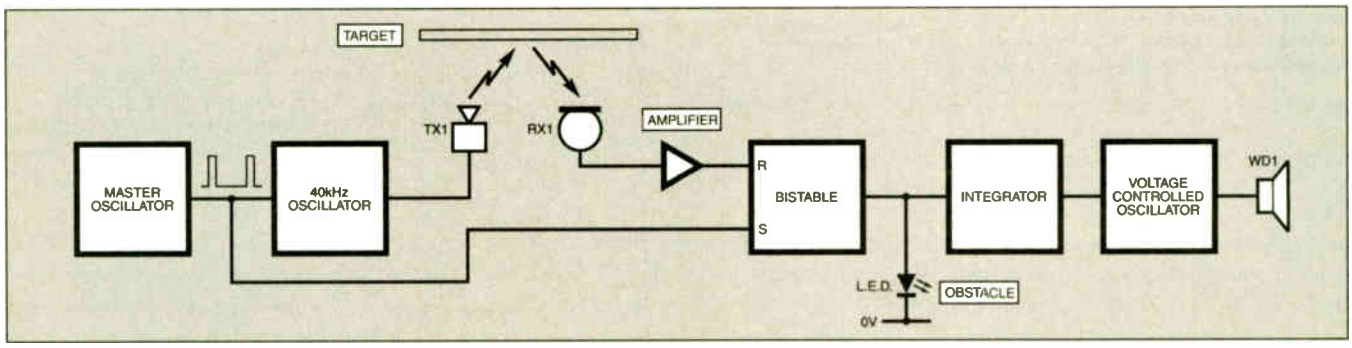

Fig.7.1. Block schematic diagram for the Parking Radar. The Ultrasonic Transmitter and Receiver transducers are labelled TX1 and RX1 respectively

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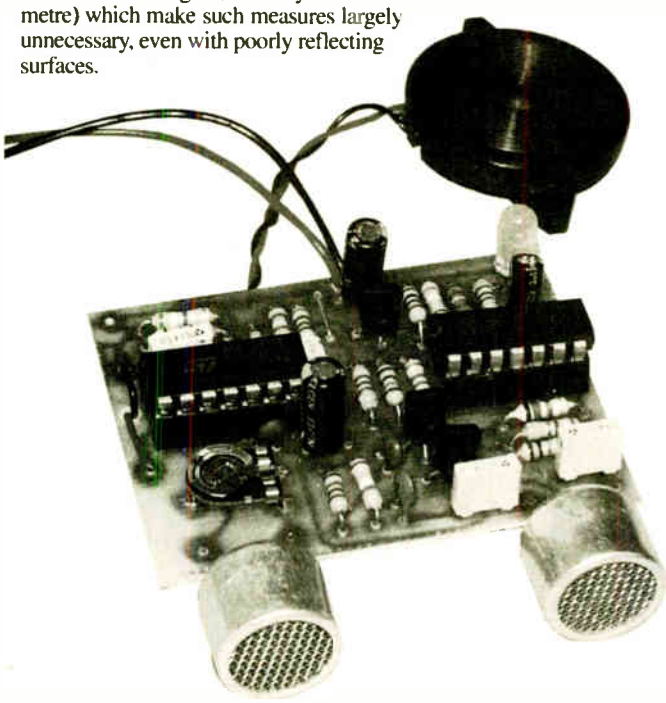
transmitted; the gain of the echo amplifier; target reflection efficiency; the direction in which the echo is reflected. This will obviously be different for large flat surfaces perpendicular to the beam than for irregular or angled surfaces which will tend to absorb or disperse the signal rather than reflect it towards the receiver.

Sophisticated ranging systems include a variable gain amplifier to amplify weak received signals more than strong ones to provide a constant amplitude return signal to get around these problems. Fortunately in this application, where a miss is as good as a mile, we are only interested in short ranges (normally less than one metre) which make such measures largely unnecessary, even with poorly reflecting surfaces.



Circuit Diagram

The complete circuit diagram for the Parking Radar is shown in Fig.7.3.

The master oscillator formed around Schmitt NAND gate IC1a produces short positive-going pulses of about 0.4ms duration every 4ms, as defined by components C1, R1, R2 and D1. When IC1a output pin 10 goes high, the oscillator built around IC1b is enabled and oscillates at a frequency of 40kHz, adjustable by preset VR1. IC1c inverts the output of IC1b, and transducer TX1 is driven in anti-phase by both gates for maximum power output.

When the output of IC1a goes low, it switches off the transmission. It also generates a pulse across capacitor C7, which triggers the bistable formed around IC2a and IC2b.

The echo signal reflected from the target is picked up by transducer RX1 and amplified by the circuit around transistors TR1 and TR2. The reset input of the bistable is held just above the logic threshold of the gate by the potential divider formed by resistors R8 and R9. Transistor TR2's collector (c) is coupled to this input via capacitor C8. The output of IC2a (and thus IC2c) is therefore a rectangular waveform which goes low when the transmitted signal ends and high when it is received after being reflected.

The distance range at which the amplified echo signal is large enough to reset the bistable is about one metre with the components shown, although this can be varied somewhat by altering the value of R9. At this range l.e.d. D2, which is controlled by the output from IC1c, begins to turn on giving an indication of the presence of an obstacle.

The output from IC2c also feeds into the integrator formed around R12 and C9. The voltage across C9 rises according to the time for which the output of IC2c is high. It increases as the range decreases.

A simple voltage controlled oscillator (VCO) is formed by IC1d and its associated components. As the voltage across C9 rises, transistor TR3 is turned on harder and passes a greater current, causing capacitor C10 to charge faster. When the voltage at the input of IC1d falls below the lower logic threshold, the output goes high, discharging C10 via D3 and R16.

Although the discharge time remains constant, the charge time falls and consequently the oscillation frequency rises with increased current flowing into the base (b) of TR3. This is reproduced by the piezo buzzer WD1 as a tone with a rising pitch. The frequency varies from low frequency clicks at a range of around 1m, to about 300Hz when the range has fallen to 5cm. Resistor

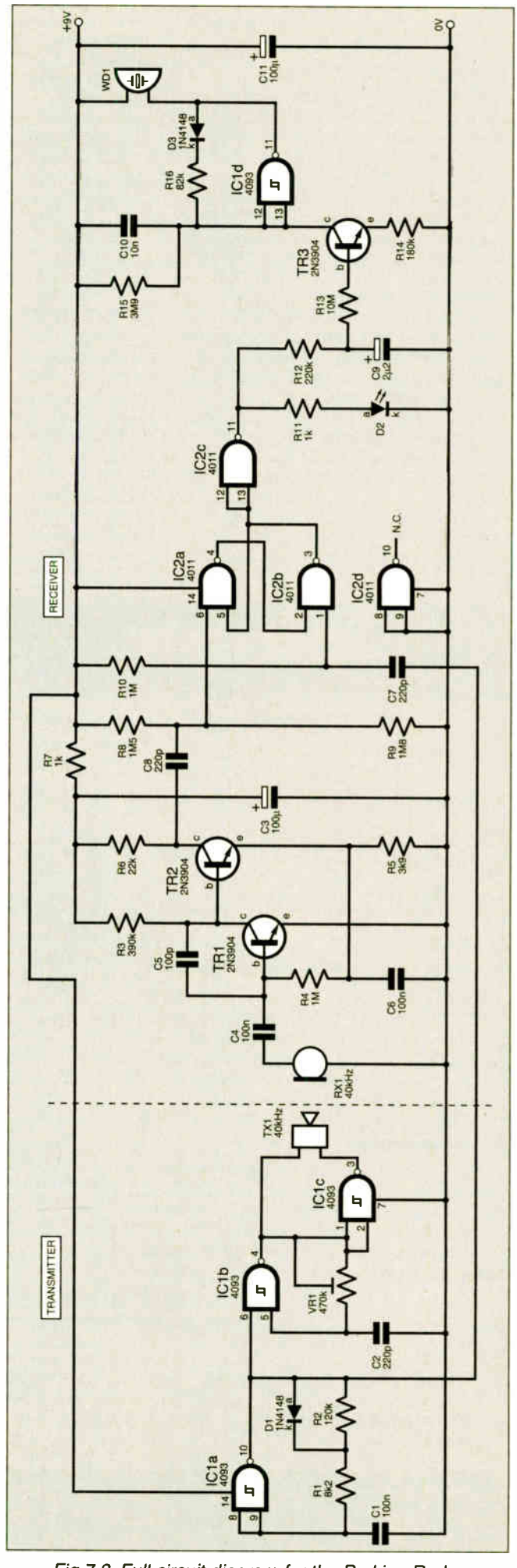


Fig.7.3. Full circuit diagram for the Parking Radar

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R15 is included to suppress oscillation due to leakage when TR3 is off.

Construction

Printed circuit board component and track layout details are shown in Fig.7.4. This board is available from the *EPE PCB Service*, code 533.

The board should be assembled in order of ascending component size. Normal precautions should be observed regarding component orientation for diodes, transistors etc. and when handling the CMOS i.c.s. Use sockets for i.c.s, but do not insert the i.c.s. until the board has been fully checked.

Pads for the battery connector are provided although some form of d.c. plug and socket may be more appropriate in this application. Care should be taken to ensure the correct polarity of the supply.

Transducers TX1 and RX1 are not interchangeable in this application. Their function should be marked on their case. The pin connected to the case is the 0V terminal. The transducers should be mounted on the p.c.b. pads provided, not on extension leads. Although the prototype used ordinary transducers, waterproof ones are preferable.

The only setting up required is the adjustment of VR1 to obtain a 40kHz signal across TX1. This is best done using an oscilloscope but in the absence of one, the voltage across RX1 or at TR2 collector (c) can be monitored and VR1 adjusted for maximum echo signal strength.

The circuit is fairly uncritical in component values but the values of R8 or R9 may need to be altered to ensure that the quiescent voltage (when no signal is present) at their junction is above the logic high threshold of IC2a. Typically, this means greater than about 5V with a 9V supply.

Enclosures

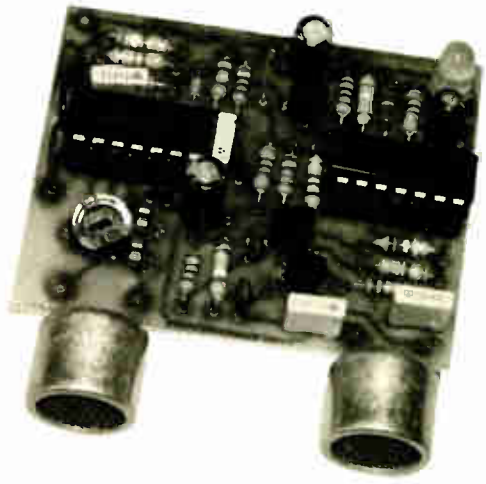
The p.c.b. should be housed in a suitable enclosure mounted somewhere on the back of the car. The type will depend on individual circumstances. It needs to protect the components from moisture and dampness. Added protection can be given by coating the p.c.b. with a "conformal" spray.

The l.e.d. and buzzer are mounted in a separate case connected back to the p.c.b. If preferred, the buzzer may be connected to the 0V line rather than to +9V, which will enable a 3-core cable to be used for the overall assembly interconnections.

Since the unit has a minimum range indication of about 5cms, note that the warning tone will not increase in frequency once this distance is reached. The circuit therefore does not give an indication of distance down to zero as this will normally be indicated by a crunching sound!

The maximum range is around one metre (depending on the target). This unit is not suited to modifying for greater distance detection.

The circuit should be powered by a 9V battery, although operation at 12V is also possible. The total current drawn at 9V is around 1.5mA, rising to some 10mA when sounding, so that an on/off switch is recommended. This can be a panel mounted type which can be switched on manually or by a relay activated by the reversing light when the reverse gear is selected if automatic switching is preferred. For the other applications mentioned, different arrangements for this will no doubt need to be devised.



COMPONENTS

PARKING RADAR

Resistors

R1	8k2k	R8	1M5
R2	120k	R9	1M8
R3	390k	R12	220k
R4,R10	1M (2 off)	R13	10M
R5	3k9	R14	180k
R6	22k	R15	3M9
R7,R11	1k (2 off)	R16	82k

All 0·25W 5% carbon film

See SHOP TALK page

Potentiometer

VR1	470k skeleton preset

Capacitors

C1,C4,C6	100n polyester or ceramic (3 off)
C2,C7,C8	220p disc ceramic (3 off)
C3,C11	100μ radial elect. 16V (2 off)
C5	100p disc ceramic
C9	2μ2 radial elect. 16V
C10	10n polyester or ceramic

Semiconductors

D1,D3	1N4148 signal diode (2 off)
D2	5mm red l.e.d.
TR1 to TR3	2N3904 *npn* transistor
IC1	4093 quad Schmitt NAND gate
IC2	4011 quad NAND gate

Miscellaneous

TX1	40kHz ultrasonic transmitter (see text)
RX1	40kHz ultrasonic receiver (see text)
WD1	piezo sounder

Printed circuit board, available from the *EPE PCB Service, code 533*; 14-pin d.i.l. socket (2 off); cases to suit; 9V battery and clip (see text); connecting wire; solder etc.

Approx. Cost Guidance Only **£15** ***excl case and batts***

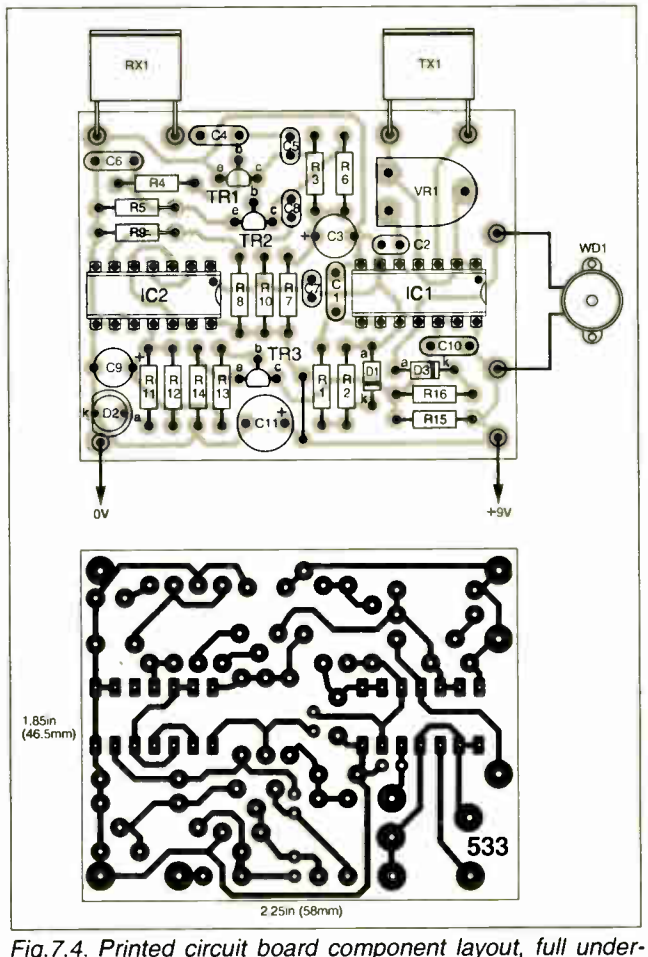


Fig.7.4. Printed circuit board component layout, full underside copper foil master and off-board wiring for the Parking Radar module

World Radio History

Telephone Switch

THIS simple Telephone Switch will enable you to remotely switch an appliance on or off simply by phoning home a specific number of times free of charge from anywhere in the world. Now how's that for remote control?

Basic Operation

The block diagram of Fig.7.5 shows that the basic operation is based on a counter and a timing unit built around a monostable which together control a bistable. The telephone rings are detected by an input circuit which provides an output pulse, the duration of which is determined by the length of the ringing signal.

A single pulse is generated each time, no matter how long the phone rings. The first ring resets the counter and also sets the monostable which has an adjustable period of between about 90 and 180 seconds.

The number of calls which occur before the monostable times out are counted and if this coincides with a preset number chosen, a bistable is either set or cleared. The bistable controls a transistor which drives a relay enabling any appliance from a lamp to a heating system to be switched on or off as required. The number of calls to switch the output on and off has been chosen to be five and three respectively, although this can be changed if required.

The circuit obviously cannot discriminate between a routine call to your number or your own call, but since it is most unlikely that anyone will call your number three times in the space of one and a half minutes, the system has a high immunity to false switching. Anyone trying to contact you would no doubt hang on for some time to allow the phone to be answered. They would thus be unable to make the required number of calls before the monostable timed out, even if they tried again a short time later.

Ringing-In

A problem could arise, however, if someone just happens to ring while you were in the middle of making your sequence of calls, in which case the appliance could end up being switched on when you wanted it switched off. This is not very likely as the caller would have to make his/her call immediately after your last one but before the monostable had timed out. In order to ensure that even this cannot happen, the difference in the number of calls required to switch the output on or off is made equal to two.

In this scenario, an engaged tone will probably be heard which should alert you to the possibility that the system may have gone wrong. Since this simple circuit cannot indicate the state of its output to you, it would be quite easy to lose track of whether the output was on or off. A Set/Reset bistable has therefore been used in preference to a toggle type so that a different number of calls is required to switch the relay on from that required to switch it off.

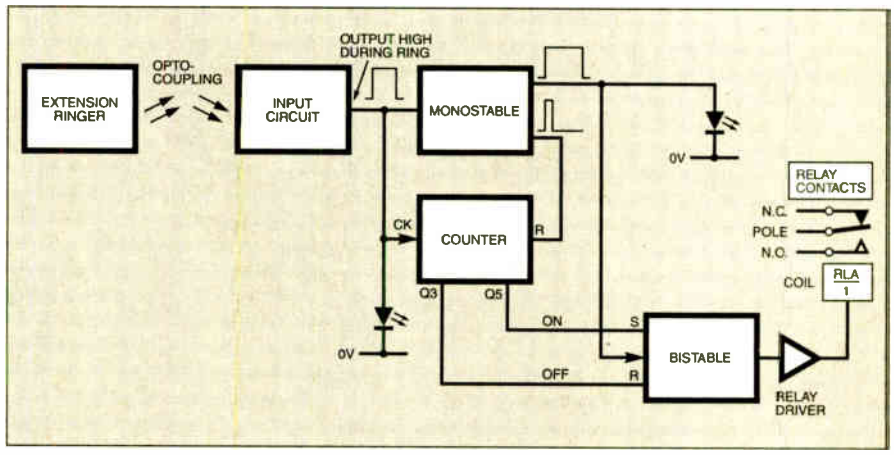


Fig.7.5. Block diagram for the Telephone Switch

It is therefore an easy matter to repeat the required sequence some time later if you are not sure that the unit responded correctly to the earlier sequence, in the full knowledge that you will not inadvertently switch the unit on when you wanted it off, or vice-versa.

Note that the circuit does not count the individual rings themselves, which normally (in the UK) occur as pairs with an equal period of silence between them. This pattern is generated by the local exchange and may be different to the pattern which the caller hears in his phone.

This means that the home number must be re-dialled the number of times required to switch the unit on or off. The phone should be allowed to ring at least three times before hanging up to ensure that the signal has got through. More rings can be allowed if required but as the monostable starts timing from the beginning of the first ring, time must be allowed to make the required number of calls.

COMPONENTS

TELEPHONE SWITCH

Resistors

R1	680k	See SHOP TALK
R2, R5, R6	1k (3 off)	
R3	10k	
R4	470k	
R7	1M5 (see text)	
R8	100k (see text)	

All 0.25W 5% carbon film

Potentiometer

VR1	1M skeleton preset

Capacitors

C1	10μ radial elect. 16V
C2	10n disc ceramic
C3, C4	100μ radial elect. 16V (2 off)

Semiconductors

D1	5mm red l.e.d.
D2	5mm green l.e.d.
D3	1N4148 signal diode
TR1	BP103 phototransistor or 2N3904 *npn* transistor (see text)
TR2	2N3904 *npn* transistor
TR3	2N3904 *npn* transistor (see text)
IC1	4093 quad Schmitt NAND gate
IC2	4017 decade counter
IC3	4011 quad NAND gate

Miscellaneous

MIC1	3V-30V piezo sounder (see text)
RLA	relay (see text)

Printed circuit board, available from the *EPE PCB Service*, code 534; 14-pin d.i.l. socket (2 off); 16-pin d.i.l. socket; case to suit; 9V mains adaptor (see text); connecting wire; solder etc.

Approx. Cost Guidance Only **£15**

excl case and power supply

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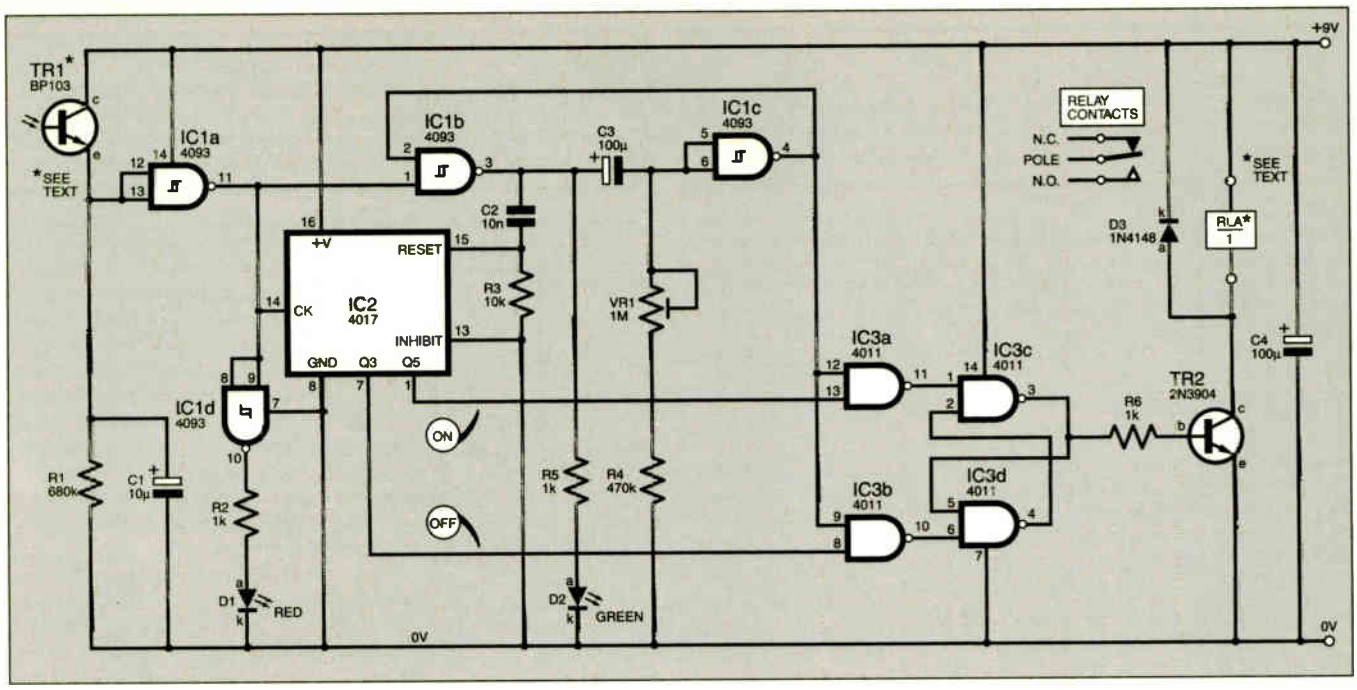


Fig.7.6. Complete circuit diagram for the Telephone Switch. No direct connection to the phone line is required. Two options of phone interfacing can be made, one optical, the other audio

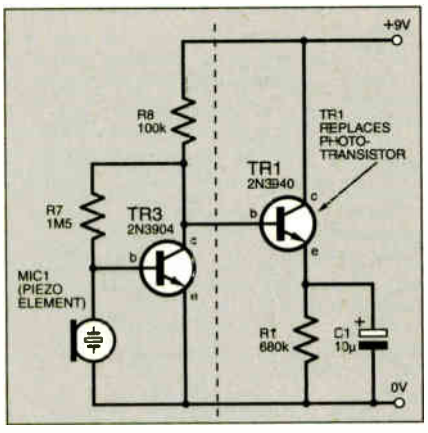
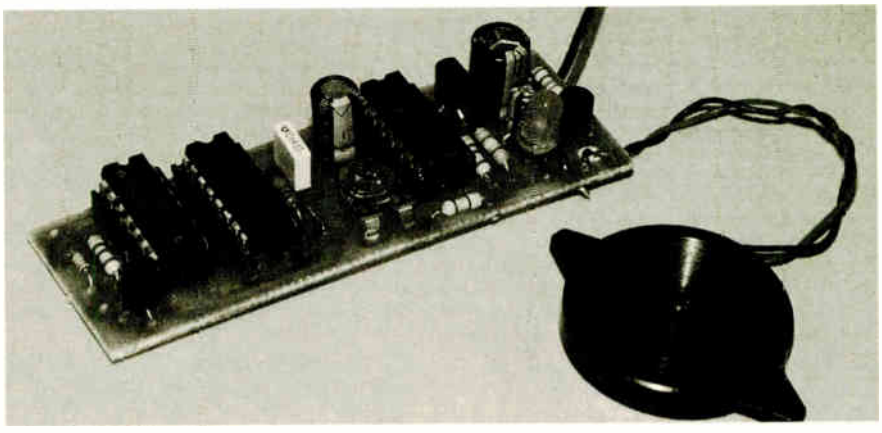


Fig.7.7. Alternative audio input circuit



Completed Telephone Switch incorporating the audio input circuit

Circuit Diagram

The complete circuit diagram for the Telephone Switch is shown in Fig.7.6. The circuit has been designed so that no direct connection to the phone line is required. Two choices of interface can be made, one optical, the other audio.

The optical interface can be via a commercial plug-in extension ringer unit. As well as an audio output, these normally have an l.e.d. which flashes in time with each ring. In Fig.7.5, a phototransistor, TR1, detects the flashing l.e.d. and its output is fed to the inputs of Schmitt NAND gate IC1a.

If an extension ringer is not available, the audio input circuit of Fig.7.7 may be used instead. The phone rings, detected by microphone MIC1, are amplified by transistor TR3 and fed to an *npn* transistor used as TR1 in place of the phototransistor.

Whichever method is used, when the telephone rings, TR1 will switch on causing capacitor C1 to charge and the inputs of IC1a to go high. This gate is connected as an inverter so that its output will go low, triggering the monostable built around IC1b and IC1c.

The values of resistor R1 and capacitor C1 are chosen so that the circuit will not respond to the ending of individual rings, and so the output of IC1a will therefore remain low throughout the overall time that the telephone rings.

The output from IC1a also feeds to IC1d, which drives l.e.d. D1 via buffer resistor R2. The l.e.d. indicates when the circuit responds to a call and it should remain on (and not flash) until the call is terminated.

When the monostable is triggered, the output of IC1b goes high (indicated by l.e.d. D2). This causes counter IC2 to be reset via C2, and the output of IC1c to go low, triggered via C3. With IC1c output low, gates IC3a and IC3b are disabled, preventing the output bistable formed by gates IC3c and IC3d, from changing state.

Time Out

Each time the call is terminated the output of IC1a will go high, switching off l.e.d. D1 and causing the counter to advance but not affect the monostable, which remains in its triggered state with l.e.d. D2 turned on.

Eventually, when the monostable times out after a period determined by the value of C3 and R4/VR1, the output of IC1c will go high, enabling gates IC3a and IC3b. If three or five calls have been received by this time, then counter outputs Q3 or Q5 will be high, causing the output of either gate IC3b or IC3a to go low.

If gate IC3a goes low, the bistable will be set with the output of IC3c going high. This switches on TR2 via R6 and turns on relay RLA, switching on the supply to the load to be controlled.

If IC3b's output goes low, however, the bistable will be cleared and the output of IC3c will go low, switching off TR2 and the relay. Diode D3 inhibits back-e.m.f. generation when the relay switches off.

If any other number of calls, except three or five, are received by the time that the monostable times out, counter outputs Q3 and Q5 will be low and the outputs of IC3b and IC3c will remain in their previous state, as will the relay. The circuit stays in this state until another call is received, which will again reset the counter and the operation will begin again. The output circuit will, however, only respond to three or five rings.

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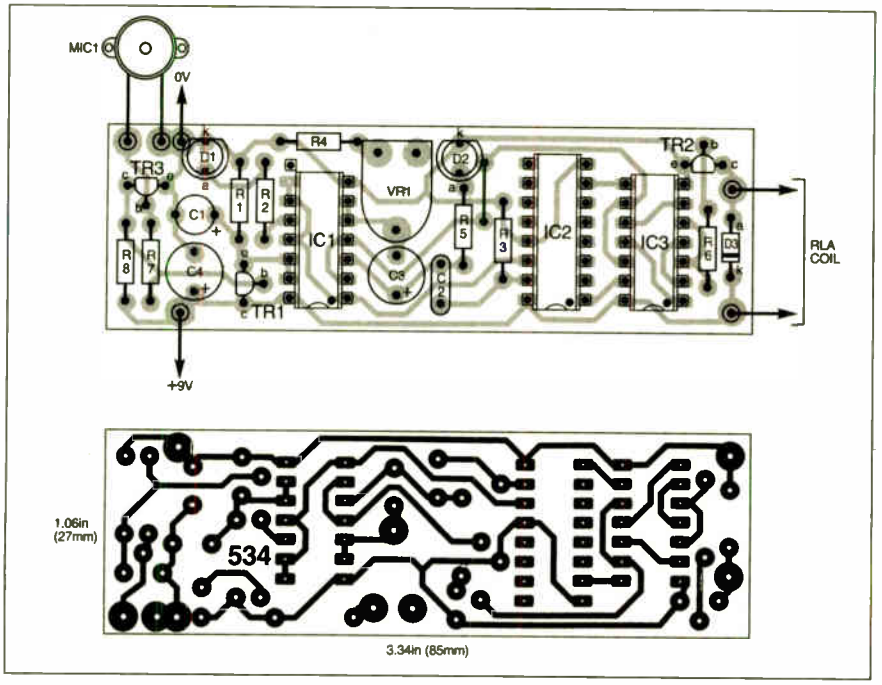

Fig.7.8. Printed circuit board component layout, full-size copper foil master and off-board wiring details for the "audio" version of the Telephone Switch

Power Supply

The unit can operate from a range of d.c. supply voltages, but 9V is suggested. It draws virtually no current (especially if the phototransistor input version is built) when no calls are being received. Current consumption will rise slightly when a call is received due mainly to the l.e.d.s, but will rise dramatically when the relay is energised.

A 9V battery supply can be used when testing the circuit, but for serious use a 9V d.c. mains adaptor is recommended, especially if the relay is to be left energised for long periods. A low voltage mains adapter of the type used for powering small appliances such as radios and calculators would be ideal. *Do not exceed a supply of 15V d.c.*

Construction

Printed circuit board component and track layout details are shown in Fig.7.8. This board is available from the *EPE PCB Service*, code 534 .

The p.c.b. will accommodate either version of the input circuit. If the phototransistor version is built, the microphone, TR3 and resistors R7 and R8 should be left out and the phototransistor fitted in place of TR1.

The phototransistor specified is housed in an l.e.d.-type package with only the collector and emitter terminals connected. There is no base lead and so the centre pad (b) on the p.c.b. for TR1 should be left unconnected. Note that the collector (c) terminal is adjacent to the flat area on the rim of the package so that this lead should go to the pad connected to the positive battery supply.

It will probably be necessary to mount the phototransistor on flying leads and these should be kept as short as possible. One possible method of coupling the phototransistor to the l.e.d. on the extension ringer is to use a clear epoxy resin to ensure a good light path between the two components. Once this has set, it should be painted black or covered with an opaque material to ensure that ambient light does not upset the operation of the circuit.

Flying Leads

The board should be assembled and checked as stated previously. Note that the relay and microphone (if used) should be connected to the allocated pads by means of flying leads. The microphone is a piezo type more often encountered in designs as a sounder (it can work in either mode). Although the type used in the prototype had red and black leads, it may be connected either way around.

If possible, these leads should not be extended as this could make the circuit sensitive to stray electrical fields. The microphone should be placed close to a telephone or glued to an extension ringer to ensure that the circuit responds. In noisy environments it is possible that the circuit could be triggered by other random sounds and care should be taken to ensure that this cannot happen by shielding the microphone. If these efforts prove unsuccessful, the phototransistor option should be used.

Relay

The relay should be chosen to suit the supply voltage, although in practice most relays will operate from a range of voltages. Most 12V relays for example will operate quite satisfactorily from a supply of 9V to 15V. A higher voltage rating is to be preferred as these will generally have a higher coil resistance and therefore draw a lower current when operating.

The relay contacts must be rated for the appliance to be switched. Do not connect the relay to an a.c. mains powered appliance unless you are suitably qualified or supervised.

Depending on the application, it may be desirable to mount the circuit in a box. The choice of case is yours. In may then be more convenient to mount the l.e.d.s on the panel, in which case the leads may simply be extended as required (although in use they are not really required as, hopefully, there will not be anyone at home to observe them!). Holes will also be required for the microphone or photo transistor as well as sockets for a d.c. supply.

Testing

The circuit may be tested and set up by connecting a 9V battery and a temporary l.e.d. (in series with a suitable ballast resistor of say 1k) across the relay coil terminals. When the microphone is tapped (or the phototransistor illuminated), both l.e.d.s D1 and D2 should light. D1 should switch off shortly afterwards while D2 should remain on.

The circuit should be activated a number of times by tapping the microphone or switching on the phototransistor, making sure each time that D1 switches off again. If five such "inputs" are made within the time D2 is on, the temporary l.e.d. should light (or the relay switch on) when D2 switches off. Repeating the procedure with only three "inputs" should cause the output to switch off, while any other number of "inputs" made within the time that D2 is on should be ignored by the circuit.

Once this has been done, it would be best to "phone a friend" or at least get him to phone you. When your phone rings, make sure that l.e.d. D1 only lights once and remains on for the duration of the ringing call. If it follows the individual rings by switching off each time, the value of R1 or C1 should be increased.

Do not make the values of R1 or C1 much larger than necessary to achieve this because the l.e.d. may then remain on for too long after the call has terminated and the circuit could fail to recognise the next call. The components specified should not need to be altered in the majority of cases.

It then only remains to set preset VR1 for a monostable time (D2 on) sufficiently long to enable five separate calls to be made to the number . This will obviously depend on how many digits must be dialled and if a re-dial facility is used, but the time should be made as short as possible to minimise the possibility of false switching.

Remember that extra digits such as area codes may need to be dialled, especially if the device is to be used from abroad. Of course, this unit has been designed to switch the output on after five calls and off after three but this could be easily changed by utilising the other outputs of the 4017 counter.

Next Month: Weather Vane Repeater and a Noughts & Crosses Emigma (see below).

World Radio History

Regular Clinic

Circuit Surgery

Ian Bell

Following on from last month, our "consultant surgeon" looks into some chopper op.amp i.c.s and offers some circuit advice on how to use them

LAST month, in response to one of the threads on the *EPE Chat Zone*, we looked at the theory of chopper stabilised amplifiers (also known as auto-zeroing amplifiers). These circuits have very low drift and are therefore suitable for use with very low frequency signals, where slow changes in the amplifier's offsets with time due to factors such as temperature and power supply fluctuations cannot be easily blocked or filtered out.

We discussed how these circuits achieved high precision by continuously nulling their own offsets. This month we will look at a couple of real chopper amplifier chips, with which you might like to experiment.

For the Chop

The TLC2654 is a high-precision chopper-stabilized operational amplifier from Texas Instruments. It has very good d.c. precision, featuring an extremely low change in offset voltage with temperature of around 0·003μV/°C, and a very low offset of around 1μV maximum.

These figures are much better than can be achieved with ordinary operational amplifiers. In addition, as we explained last month, low-frequency noise is significantly reduced compared with ordinary operational amplifiers by the chopper stabilization due to the reduction of $1/f$ noise.

The TLC2652, another chopper-amp from Texas Instruments, has even better noise performance than the TLC2654, but less precision. You have to choose the best chip for the job you want it to do. Of course other manufacturers make chopper stabilised amplifiers too, such as the National Semiconductor LMV2011, the Linear Technology LTC1050, the Analog Devices AD8551 and the Microchip TC7650. All have different combinations of capabilities and features. Both the TLC2652 and TLC2654 are available from Farnell in 8-pin d.i.l. packages for around £4. They also stock the LTC1050 and one or two other choppers.

The TLC2652 has a very high input impedance CMOS input stage and is particularly suitable for low-level signal processing applications such as strain gauges, thermocouples, and other transducer amplifiers. It has a default chopping frequency of 450Hz.

The higher chopping frequency of the TLC2654, compared with the TLC2652, accounts for the better noise performance and bandwidth, which covers a frequency spectrum from near d.c. to 10kHz, with best performance up to 5kHz. Like the TLC2652, it is suitable for wide-bandwidth low frequency and subsonic applications and is also appropriate for use with strain gauges and thermocouples.

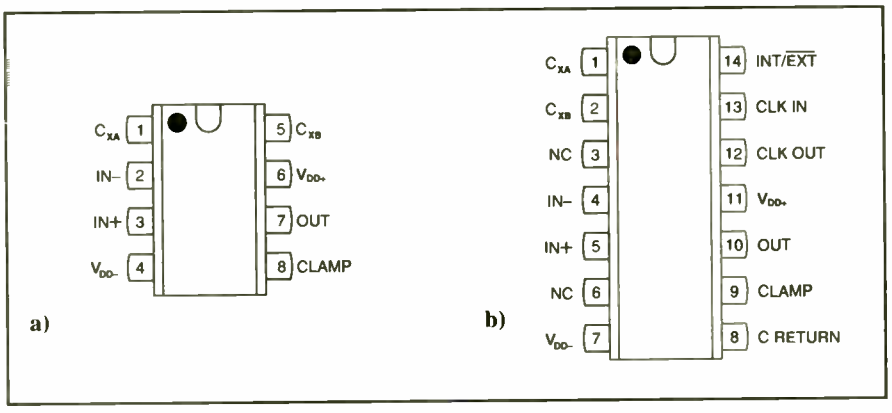

Fig.1. (a) Pinout connections for the TLC2652 and TLC 2654 8-pin version and (b) the pinout details for the 14-pin version

A Packaged Deal

Both the TLC2652 and TLC2654 are available in 8-pin and 14-pin d.i.l. versions and have the pinouts shown in Fig.1. On the 8-pin version you get the dual power supply (V_{DD+} and V_{DD-}), differential inputs (IN- and IN+), and output (OUT) that you would expect with any operational amplifier, plus three other less familiar pins: C_{XA}, C_{XB} and CLAMP.

These are for the nulling capacitors and clamping feature, which we will look at in more detail later. The 14-pin version includes provision for an external clock (INT/EXT, CLK IN, CLK OUT) and a special connection point for the nulling capacitors (C RETURN).

A number of other chopper stabilized op.amps have the same or similar pin connections, for example the TC7650. The LTC1050 is different: it does not need external capacitors so pin 1 and pin 8 are no-connections and has a clock input on pin 5.

The C_{XA} and C_{XB} pins are used to connect two capacitors which are required for operation of these amplifiers. The capacitors are used for holding the nulling trim voltage, as explained last month.

However, the user does not have to control the chopping process in any way and these devices can simply be used as operational amplifiers. The chopping frequency is fixed by the internal oscillator and is invisible to the user. The 14-pin versions do provide the user with more control – the chopping can be driven from an external clock.

The capacitors connected to C_{XA} and C_{XB} should be in the range of 0·1μF to 1μF and located as close as possible to the pins. On the 8-pin versions of the chips the other end of each capacitor is connected to either V_{DD-} or V_{DD+} (see Fig. 2). On the 14-pin version there is a special C RETURN pin to which the capacitors can be connected. In applications needing a fast response use high-quality film capacitors such as mylar, polystyrene, or polypropylene. In other applications, ceramic or other low-grade capacitor are satisfactory.

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In Response

One problem with chopper amplifiers that we did not discuss last month is their response to overload conditions, which occur when very large input signals push the output into saturation at one of the supply rails. Under these conditions the circuit is no longer a linear amplifier and is therefore unable to find the correct nulling voltage to compensate for offsets.

Thus, after an overload, a chopper amp may take some time to recover to full performance. The CLAMP pin provides a means by which the internal circuitry can detect overload conditions and hence prevent the amplifier from becoming heavily saturated. This in turn speeds up recovery once the overload condition is removed.

If clamping is required the CLAMP pin is connected to the inverting input IN- (in parallel with the closed-loop feedback resistor) (see Fig.3). If connected the clamp is automatically activated when the output is approximately 1V from either supply rail.

When activated the clamp reduces the gain of the amplifier and the output is prevented from going into saturation. Since the output must source or sink current through the clamp circuitry the maximum output voltage swing is slightly reduced when the clamp is used.

On Guard

In order to get the full benefit of high precision capabilities of chopper stabilised amplifiers, good circuit board layout is required. Problems are caused by leakage across the p.c.b. (printed circuit board), so thorough cleaning and drying after construction is important.

Also, a useful technique is to include an input guard in the p.c.b. layout. A guard is a p.c.b. copper track in a ring surrounding the input terminals, which absorbs leakage currents. The ring connects to a low impedance point ideally at the same common mode voltage as the inputs. The concept of the p.c.b. guard ring layout is shown in Fig.4; the actual layout for a given application will depend on the i.c. package used.

Chopper stabilised operational amplifiers can be used in the same circuit configurations as ordinary op. amps, including those for inverting and non-inverting amplifiers. These are shown in Fig.5. These schematics include the guard ring (the circles near the inputs). Two circles are drawn on the schematic as both inputs are guarded, but only one ring in created on the p.c.b., as shown in Fig. 4.

Of course, with the TLC2652 and TLC2654, and other choppers with external nulling capacitors, these are present whereas they may not be in a normal op. amp circuit. You may also use the clamp facility, but this is not included in Fig.5. If required, connect the clamp (pin 5) to the inverting input (pin 2) as shown in Fig.3.

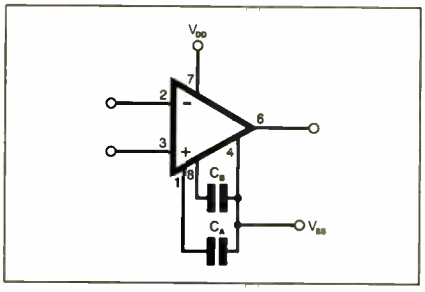

Fig.2. Connection details for the nulling capacitors

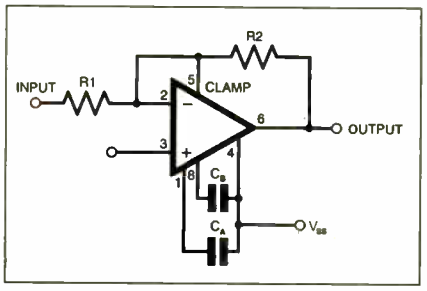

Fig.3. If clamping (overload protection) is required, the CLAMP pin is connected to the inverting input IN- pin

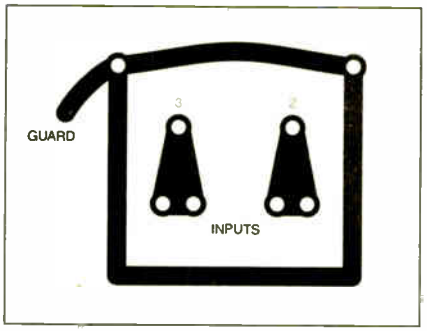

Fig.4. Input "guard ring" on a printed circuit board tracking

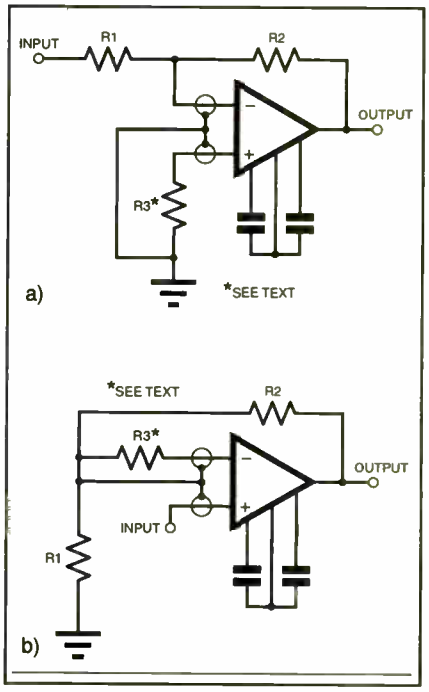

Fig.5. Circuit arrangement for (a) an inverting amplifier and (b) a non-inverting amplifier. Note the input guard ring connections and nulling capacitors

The gains of the circuits in Fig.5 are set by the values of resistors R1 and R2 in the usual way. The gain is R2/R1 for the inverting amplifier and 1+(R2/R1) for the non-inverting amplifier. Resistor R3 does not contribute to the gain setting, but is present to help minimise offsets. The value of R3 should be equal to the parallel combination of R1 and R2, that is (R1×R2)/(R1+R2). This value ensures that the impedance of the external circuit viewed from each input is equal, to minimise the difference in voltage drops due to input bias currents. □

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Cherry Nixon
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The book has been developed from Cherry's popular hands-on course "Buying and Selling on eBay for Technological Simpletons". In addition to fully explaning 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.

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World Radio History

Theory and Reference

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Clive (Max) Maxfield

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CD-ROM

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Ian Waugh

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ELECTRONIC MUSIC AND MIDI PROJECTS
R. A. Penfold

Whether you wish to save money, boldly go where no musician has gone before, rekindle the pioneering spirit, or simply have fun building some electronic music gadgets, the designs featured in this book should suit your needs. The projects are all easy to build, and some are so simple that even complete beginners at electronic project construction can tackle them with ease. Stripboard layouts are provided for every project, together with a wiring diagram. The mechanical side of construction has largely been left to individual constructors to sort out, simply because the vast majority of project builders prefer to do their own thing in this respect.

None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher. MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.

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THE INVENTOR OF STEREO – THE LIFE AND WORKS OF ALAN DOWER BLUMLEIN
Robert Charles Alexander

This book is the definitive study of the life and works of one of Britain's most important inventors who, due to a cruel set of circumstances, has all but been overlooked by history.

Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first electronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

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VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

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World Radio History

Circuits, Data and Design

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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.

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Richard Monk
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There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

250 pages (large format) **Temporarily out of print**

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".

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MICROCONTROLLER COOKBOOK
Mike James
The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

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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.

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FAULT-FINDING ELECTRONIC PROJECTS
R. A. Penfold
Starting with mechanical faults such as dry joints, short-circuits etc, coverage includes linear circuits, using a meter to make voltage checks, signal tracing techniques and fault finding on logic circuits. The final chapter covers ways of testing a wide range of electronic components, such as resistors, capacitors, operational amplifiers, diodes, transistors, SCRs and triacs, with the aid of only a limited amount of test equipment.

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

136 pages **Temporarily out of print**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

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W.D.Phillips
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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.

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.

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World Radio History

READOUT

Email: john.becker@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

WIN AN ATLAS LCR ANALYSER WORTH £69

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★ LETTER OF THE MONTH ★

Dalek Gigs!

I've recently been chatting with Mike Boyden, who has built several of my Cybervox *Dalek voice emulators (July '05) and which are being used by various Dalek "clubs". The concept of such "clubs" greatly amused my wife and I told Mike so. He replied:*

Tell your wife that Dalek stuff is far too serious a matter to be left in the hands of children! (I only found out about it when approached by a local guy who bought a Dalek from a (BBC licensed would you believe) workshop.

He earns a very tidy sum doing "gigs" with his Dalek which have included (and I am not making this up):

- Weddings
- A funeral (to press the button to move the casket into the next world – I kid you not)
- Shopping Mall promotions (he once stopped a running thief by shouting: "STOP OR I WILL EXTERMINATE YOU ..." at which point the thief stopped frozen to the spot, whereupon he was carted off by security people)
- Appearances at Strip Clubs (I didn't ask ...)
- POP Festivals

Oh yes, not to mention ... he has been set on fire, had water poured onto him (disabling the Dalek and all the electronics) and fallen off the stage and into a crowd of 50,000 drunken head bangers at some sort of rave event.

So tell her some Daleks have found a very eventful life on earth – he he he ...

Mike Boyden, via email

That's hilarious Mike, thanks for sharing it. And thanks too for your IU *offering in this issue – the Dalek lighting interface for* Cybervox. *I should've thought of doing that myself originally!*

Crossword Update

Dear EPE,

As a result of chatting with several readers I have made some updates to the *Crossword Solver* code (May '05). These changes address the following issues:

1. The l.c.d. access routines would not always start properly on power up.

2. Words greater than 16 characters in length had a character missing when displayed.

3. The unit did not reject a request for a word longer than its biggest entry, resulting in rubbish being displayed.

That was quite handy feedback from readers since I am using the 4-bit display method in my forthcoming *Camera Watch Mk2* project!

A quick question – do you have any PIC assembly code, or an algorithm, for taking a 16-bit unsigned binary number and displaying it in decimal ASCII? All the algorithms I have come across use the "divide by 10" technique which is quite "expensive", even on a PIC18F. I'll use them if necessary but I was wondering if there was a better algorithm?

Mike Hibbett, via email

Thanks for the updated code Mike, which is now on our Downloads site (via ***www.epemag.co.uk****).*

Regarding your query, I use Peter Hemsley's BIN2DEC (binary to decimal) routine, then OR (or ADD) 48 to all decimal digit values (each 0 to 9) so that an l.c.d. shows them as ASCII characters. You'll find many examples of my use of this in my published software. Peter's excellent 32-maths routines are on our Downloads site.

Rally Components

Dear EPE,

Your July '05 Letter of the Month cast doubts about buying cheap bargain components at rallies. I agree it is most frustrating to spend time and effort constructing a project, only to find it doesn't work because of cheap faulty components.

This is self-inflicted punishment. If one goes to the time and trouble to remove components from disregarded p.c.b.s and expect them to work – well, I wonder! My time is more valuable than this wasted exercise.

I consider it good practice to test all the components before I solder them into a project to verify they are within the correct tolerance. This saves time trying to trace a defective component after the circuit is built.

I buy my spares from a reputable small firm which attends all the major rallies, and is very reasonable pricewise.

Ken Barry, Blackpool, via email

Thanks for that Ken.

PIC Spanish Translator

Dear EPE,

After recently building your wonderful *TK3* PIC programmer, and going through the *PIC Tutorial*, I have been considering trying to develop a Spanish translator/study aid and was wondering whether you have anything similar planned for a future project?

Ideally I would like voice playback and recognition but maybe this would be stretching a PIC too far! Playback seems possible though by using a PWM output as the D to A converter but it would require an awfully large memory to store the samples.

Maybe something similar to the *Crossword Solver* (May '05) would suffice if it had the added feature of a couple of games, hangman etc, to help you learn new vocabulary. Again though I'm coming across problems in getting a dictionary file that I could use to base the design on and that comes in a compressed format so it will fit into a PIC's program memory along with the program code.

My final point is whether to code in assembly language, C or even BASIC? It seems that the device doesn't need to run extremely quickly so I'm thinking that C or BASIC may be the best way to go if I can get my hands on a freeware compiler.

I'd like to actually get this design off the ground one day and so I was hoping that you or one of your readers could possibly point me in the right direction or have any advice.

Thank you for listening and supplying such a thought provoking magazine. Hoping that now I have *TK3* up and running and with the help of your magazine I may at last be able to build my own PIC controlled device.

Lee Archer, via email

Thanks for the kind words Lee! A translator is not something that should be undertaken lightly by anyone. Whilst in principle the technique needed is simple, its implementation would be complex because of the vast vocab such a device would need, and that needs lots *of memory. And voice recognition is way beyond what hobbyists can realistically achieve.*

Also, there are commercial devices available, I have a German/English unit for instance – key in a word in either language and the equivalent in the other is shown on screen.

I'm not a great user of C and would suggest that the compactness of code written in PIC assembler might be better.

So best of luck if you attempt it, but it's not something I would feel comfortable trying, although I recognise the challenge!

World Radio History

As One Door Opens ...

Dear EPE,

I feel that the increased availability of the Internet and "black box" technology has been the final "nail in the coffin" for hobbies like amateur radio, weather satellite receiving and data communications by the airwaves. Increased competition in the consumer electronics manufacturing industry has also made the hobbyist construction of audio equipment largely unfeasible. But I'm pleased that *EPE* continues to contain many inventive designs.

We must, however, remember that current projects using the PIC processors may seem impressive today but years ago a designer would only have had a limited armoury of components including passive devices, semiconductors and a range of discrete analogue and digital i.c.s. Here the hardware design would have to be finalised and could not be "tweaked" later in the software.

What of the future for amateur electronics? The promised invasion of surface mounted devices failed to lead to the demise of dual-in-line integrated circuits, as the EU safety and EMC directive failed to stem the interest in amateur electronics and I don't suppose the introduction of lead-free solder in the future will do so either.

As long as there are people willing to design and publish high quality electronic projects and manufacturers produce suitable devices there seems no need to worry about the popularity of the hobby.

Chris Lewis, via email

To take your first point first, Chris, I think many will disagree with you about the demise of amateur radio. There is considerable evidence of thriving HAM activity, even though it may no longer be publicised so heavily as it used to be.

Furthermore, despite the availability of low cost (and not so low cost) audio equipment, there is still an interest in building one's own amplifier, and indeed there is considerable satisfaction to be gained by doing so. Reader response to Raymond Haigh's articles in this area prove the point.

But you are right about PICs in a sense – technology does move on, and techniques change because of that. Sooner or later something more advanced than a microcontroller may indeed come along and ultimately replace it.

But it's a case of "as one door opens another one shuts – partly". The microcontroller is not going to disappear until something better appears, even then it is likely to continue to exist alongside the new technology. Look at how valves were once dominant, but when transistors came along, valves were not totally ousted, and continue to be used even now in several forms. Nor have i.c.s replaced transistors. There is a role for both.

And as long as technology exists, there will always be those who wish to explore it in a variety of ways, including the construction of designs based upon it, and so will magazines like EPE *cater for such interests, in both practical and tutorial roles.*

Pain Monitor

Dear EPE,

I read with interest your article on how to build a pain monitor (Aug '05). We have developed a number of advanced units similar to yours (8051 based) over the last six years and have presented many studies, using the devices, to consultant anaesthetists at national meetings. Our professor is head of the pain management service at the University Hospitals of Leicester and director of UHL research and development, he specialises in pain management.

We have conducted considerable research in the area of portable pain measurement devices and have worked with large companies like GSK to evaluate our devices. We are looking into commercial opportunities, but unfortunately the market is very small and the free pain gauge that you show is widely used, even though it is not the correct format compared to paper VAS scores.

There was a commercial unit sold called the Clinitrac, this is no longer available due to poor sales and the advent of PDA questionnaire systems with VAS. PDA systems have been validated and are widely used by drug companies and researchers of chronic and acute pain, although we feel that they are not entirely suitable.

I think that your unit would be useful for a doctor/patient that wishes to gain a rough estimate of pain scores but would not be suitable for controlled research data.

Of course, if we could really measure pain electronically, instead of the subjective measures currently used, the unit would be on every doctors wish list. The problem is as elusive as measurement of depth of anaesthesia, although some progress has been made in this area.

I like your wildlife monitor idea, given folks increased interest in the environment, this has great potential and would provide very useful data for researchers in this area.

Ed Pallett,
University Division of Anaesthesia,
Leicester Royal Infirmary,
via email

Thanks for your interesting letter Ed, which I sent on to Mark Piper, the anaesthetist who inspired my design. One of the first questions I asked him was about electrically monitoring pain, and he confirmed it's not possible, although I had expected that there might be brain waves which could be monitored in this respect.

Laser ranges with PICs

Dear EPE,

Reading the August '05 *Readout*, I thought you might like to ponder the way radio altimetry worked. The frequency of transmission is linearly swept so that the return is at a slightly different frequency to the transmission, and the difference gives the range. If the difference frequency is small enough it could be handled by a PIC? But I don't know if the frequency of a laser can be swept.

John Waller, Plainfield, USA,
via email

That's intriguing John! I'll think on it, thank you.

GPS Validity

Dear EPE,

I refer to my letter about GPS validity in Aug '05 (thanks for printing it by the way).

It seems to me the Standard is not so standard after all! Perhaps I should explain a bit more. The values I refer to come directly from the NMEA GGA Standard and the validity flag can actually have any value from 0 to 8 (although many values are not used). This standard is used by all professional GPS equipment, Trimble Navigation is probably the industry standard.

The following was copied from **www.gpsinformation.org/dale/nmea.htm**

GGA – essential fix data which provide 3D location and accuracy data, e.g.:

$GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47

GGA	Global Positioning System Fix Data
123519	Fix taken at 12:35:19 UTC
4807.038,N	Latitude 48 deg 07.038' N
01131.000,E	Longitude 11 deg 31.000' E
1 Fix quality:	0 = invalid 1 = GPS fix (SPS) 2 = DGPS fix 3 = PPS fix 4 = Real Time Kinematic 5 = Float RTK 6 = estimated (dead reckoning) (2.3 feature) 7 = Manual input mode 8 = Simulation mode
08	Number of satellites being tracked
0.9	Horizontal dilution of position
545.4,M	Altitude, Meters, above mean sea level
46.9,M	Height of geoid (mean sea level) above WGS84 ellipsoid
(empty field)	Time in seconds since last DGPS update
(empty field)	DGPS station ID number
*47	the checksum data, always begins with *

Colin Gill, via email

Now the fog clears – thanks for the info Colin! So I'll keep my decoding as is for GPRMC (I don't use GGA).

FR4 Laminate

Dear EPE,

I have been buying your mag for years now and this is the first time I have needed to ask a question.

I need to get hold of some unclad, i.e. plain with no copper, FR4 laminate, or equivalent, to make a circuit board that I will put turret tags or equivalent onto.

Can you point me in a direction where I can get some?

Paul, via email

Sorry Paul, I regret that I don't know of any supplier – ask readers directly through our Chat Zone (via ***www.epemag.co.uk****). By quoting you now in* Readout, *let's see if this also gets you any reader response via the editorial office.*

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Printed circuit boards for most recent *EPE* constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for *airmail* outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872; Fax 01202 874562; Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag.wimborne.co.uk/shopdoor.htm.** Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

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

Please check price and availability in the latest issue.

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Receiver		446	£4.75
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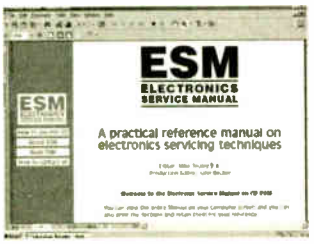

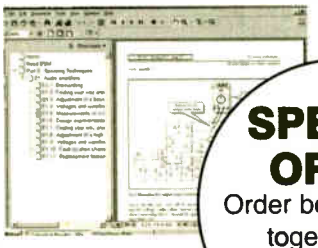

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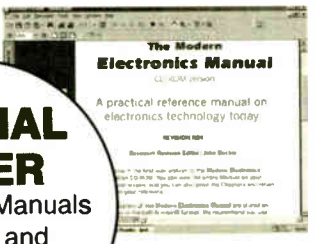

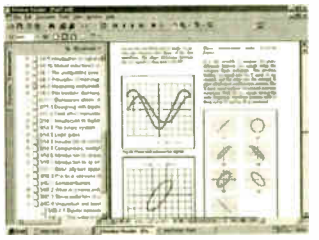

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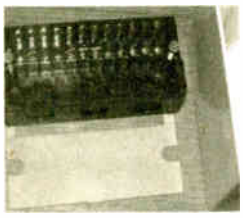

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SP12	30 x 1N4002 diodes	SP151	4 x 8mm Red LEDs
SP18	20 x BC182 transistors	SP152	4 x 8mm Green LEDs
SP20	20 x BC184 transistors	SP153	4 x 8mm Yellow LEDs
SP23	20 x BC549 transistors	SP154	15 x BC548 transistors
SP24	4 x CMOS 4001	SP156	3 x Stripboard, 14 strips x 27 holes
SP25	4 x 555 timers	SP160	10 x 2N3904 transistors
SP26	4 x 741 Op.Amps	SP161	10 x 2N3906 transistors
SP28	4 x CMOS 4011	SP164	2 x C106D thyristors
SP29	3 x CMOS 4013	SP165	2 x LF351 Op.Amps
SP33	4 x CMOS 4081	SP166	20 x 1N4003 diodes
SP34	20 x 1N914 diodes	SP167	5 x BC107 transistors
SP36	25 x 10/25V radial elect. caps.	SP168	5 x BC108 transistors
SP37	12 x 100/35V radial elect. caps.	SP171	8 Metres 18SWG solder
SP38	15 x 47/25V radial elect caps	SP172	4 x Standard slide switches
SP39	10 x 470/16V radial elect. caps.	SP173	10 x 220/25V radial elect. caps
SP40	15 x BC237 transistors	SP174	20 x 22/25V radial elect. caps
SP41	20 x Mixed transistors	SP175	20 x 1/63V radial elect. caps.
SP42	200 x Mixed 0·25W C.F. resistors	SP177	10 x 1A 20mm quick blow fuses
SP47	5 x Min. PB switches	SP178	10 x 2A 20mm quick blow fuses
SP49	4 x 5 metres stranded core wire	SP181	5 x Phono plugs – asstd colours
SP101	8 Metres 22SWG solder	SP182	20 x 4·7/63V radial elect. caps.
SP102	20 x 8-pin DIL sockets	SP183	20 x BC547 transistors
SP103	15 x 14-pin DIL sockets	SP187	15 x BC239 transistors
SP104	15 x 16-pin DIL sockets	SP189	4 x 5 metres solid core wire
SP105	4 x 74LS00	SP192	3 x CMOS 4066
SP109	15 x BC557 transistors	SP195	3 x 10mm Yellow LEDs
SP112	4 x CMOS 4093	SP197	6 x 20 pin DIL sockets
SP115	3 x 10mm Red LEDs	SP198	5 x 24 pin DIL sockets
SP116	3 x 10mm Green LEDs	SP199	5 x 2·5mm mono jack plugs
SP118	2 x CMOS 4047	SP200	5 x 2·5mm mono jack sockets
SP124	20 x Assorted ceramic disc caps		
SP126	6 x Battery clips – 3 ea. PP3 + PP9		
SP130	100 x Mixed 0·5W C.F. resistors		
SP131	2 x TL071 Op.Amps		
SP133	20 x 1N4004 diodes		
SP134	15 x 1N4007 diodes		

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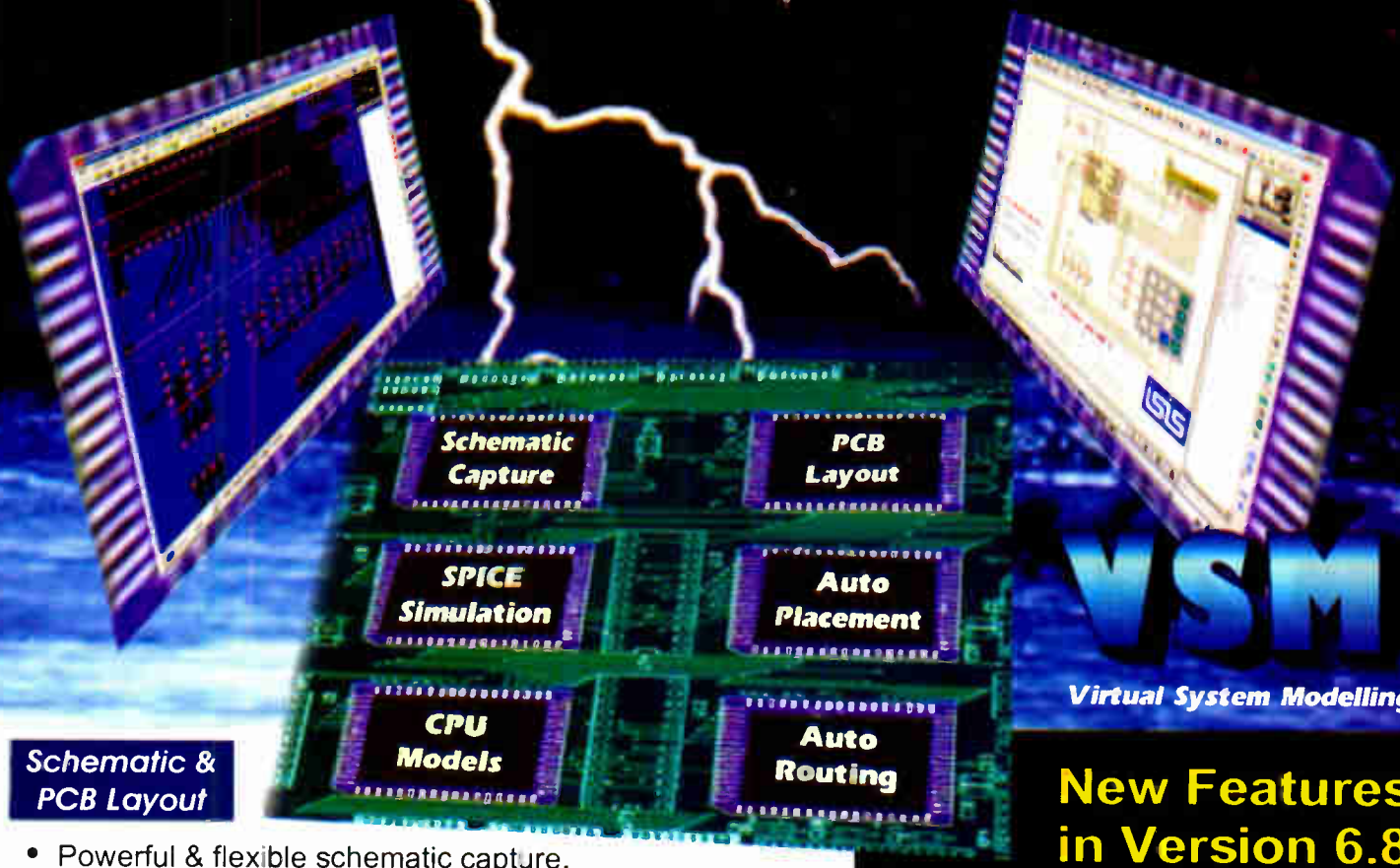

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Yes that's right, down town, down under in Sydney Australia. We are a bunch of electronics enthusiasts who sell a great range of goodies through our FREE 400 page catalogue! (see below) Don't be frightened! You can purchase on the Net from us 24/7/365 through our secure encrypted system. Post and packing charges are modest and you can have any of 8000 + unique products delivered to your door within 7 - 10 days of your order. Some specific products are shown below.

Theremin Synthesiser Kit

KC-5295 £17.50 + post & packing

The Theremin is a weird musical instrument that was invented early last century but is still used today. The Beach Boys' classic hit "Good Vibrations" featured a Theremin. By moving your hand between the antenna and metal plate, you create weird sound effects like in those scary movies! Kit includes a machined, silk-screened, and pre drilled case, circuit board, all electronic components, and clear English instructions.

4+ hours DETAILED

9VDC power supply required (Maplin #GG74R £9.99).

50MHz Frequency Meter Kit with LCD Display

KC-5369 £20.30 + post & packing

2 hours DETAILED

If you want a great value frequency meter, then this project is for you. It features autoranging operation for ease of use, switching between its three ranges. High resolution of 0.1Hz up to 150Hz, 1Hz between 150Hz and 16MHz, and 10Hz above 16MHz. It can be powered by a 9V battery or wall adaptor (not included) and the case measures just 5 1/8" x 2 5/8" x 1". Kit includes laser cut & silk screened case, circuit board, electronic components, & clear English instructions.

Lead Acid Battery Zapper Kit

KC-5414 £11.75 + post and packing

This simple circuit is designed to produce bursts of high-energy pulses to help reverse the effects of sulfation in "wet" lead acid batteries. This is particularly useful when the battery has been sitting for a period of time without use. Kit includes circuit board, case, leads, electronic components, and clear English instructions.

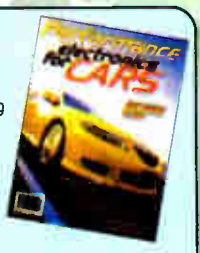
90 minutes DETAILED NEW KIT

Caution! Battery should be disconnected from the vehicle when using this project

3 minutes DETAILED

Performance Electronics for Cars Book

BS-5080 £6.35 + post & packing



Australia's leading electronics magazine, Silicon Chip, has developed a range of projects for performance cars. There are 16 projects in total, ranging from devices for remapping fuel curves, to nitrous controllers, and more! The book includes all instructions, components lists, colour pictures, and circuit layouts. There are also chapters on engine management, advanced systems, DIY modifications, and more. Over 150 pages! All of the projects described are available in kit form, exclusively from Jaycar. Check out our website for all the details.

Here are just two...

Universal Voltage Switch Kit

KC-5377 £8.70 + post and packing

This is a universal module which can be adapted to suit a range of different applications. It will trip a relay when a preset voltage is reached. It can be configured to trip with a rising or falling voltage, so it is suitable for a wide variety of voltage outputting devices eg., throttle position sensor, air flow sensor, EGO sensor. It also features adjustable hysteresis (the difference between trigger on/off voltage), making it extremely versatile. You could use it to trigger an extra fuel pump under high boost, anti-lag wastegate shutoff, and much more. Kit supplied with PCB, and all electronic components.

90 minutes DETAILED

Recommended box UB2 £0.97 each

Smart Fuel Mixture Display

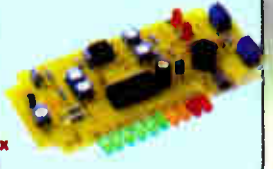
KC-5374 £8.15 + post & packing

This new 'smart' version has a few additional touches such as, auto dimming for night driving, emergency lean-out alarm, and better circuit protection. Another great feature, is the 'dancing' display which operates when the ECU is operating in closed loop. Closed loop means that the air/fuel ratio is optimum for fuel economy and emission performance. Kit supplied with PCB and all electronic components.

* Car must be fitted with air flow and EGO sensors (standard on all EFI systems) for full functionality.

90 minutes DETAILED

Recommended box UB3 £0.97 each



Digital Fuel Mixture Display

KC-5300 £18.30 + post and packaging

Monitor your car's air fuel ratio in real time on a three-digit display as well as on the programmable 10-LED bargraph. The kit will indicate ratios between 11.8 & 20.6 for petrol and 12.7 & 21.5 for propane/LPG. Features include: lean and rich indication, fast 220ms update time for bargraph, 440ms update time for 3-digit display, 0-1V display for setting up adjustments, dot or bar option for bargraph and automatic display dimming for night driving. All this in a case measuring just 3.25 x 2.12 x 1.22 in. Kit includes case with silk-screened panel, PCBs, pre-programmed PIC micro, 7-segment displays, red acrylic, hook-up wire and all electronic components.

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