THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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OCTOBER 2003

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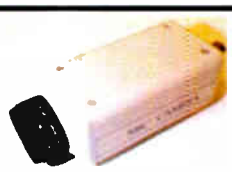

Colour CCTV camera, 8mm lens, 12V d.c. 200mA 582x628 Resolution 380 lines Automatic aperture lens Mirror function PAL Back Light Compensation MLR, 100x40x40mm. Ref EE2 £69

Built-in Audio .15lux CCD camera 12V d.c. 200mA 480 lines s/n ratio >48db 1V P-P output 110mm x 60mm x 50mm. Ref EE1 £99

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 – 100 x 70 x 170mm and 2 – 100 x 70 x 280mm. Ref EE6 £22 EE7 £26 multi-position brackets. Ref EE8 £8

Excellent quality multi-purposeTV/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 49·7MHz-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, 12V d.c. or mains. Accessories supplied Power supply. Remote control, Cigar lead power supply. Headphone Stand/bracket. 5" model £139 Ref EE9, 6" model £149. Ref EE10

Self-cocking pistol plcr002 crossbow with metal body. Self-cocking 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 drawweight 150ft sec velocity Break action 17" string 30m range £21.65 Ref PLCR002

Fully cased IR light source suitable for CCTV applications. The unit measures 10 x 10 x 150mm. 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 infra-red lamp is suitable for indoor or exterior use, typical useage would be to provide additional IR illumination for CCTV cameras. £49. Ref EE11

Mains operated and designed to be used with any CCTV camera causing it to scan. The clips can be moved to adjust the span angle, the motor reversing when it detects a clip. With the clips removed the scanner will rotate constantly at approx 2-3rpm. 75 x 75 x 80mm £23. Ref EE12

Colour CCTV Camera measures 60x45mm and has a built-in light level detector and 12 IR LEDs 0.2 lux 12 IR LEDs 12V d.c. Bracket Easy connect leads £69. Ref EE15

A high quality external colour CCTV camera with built-in infra-red LEDs measuring 60 x 60 x 60mm Easy connect leads colour Waterproof PAL 1/4in. CCD 542 x 588 pixels 420 lines 0·05 lux 3·6mm F2 78 deg lens 12V d.c. 400mA Built-in light level sensor. £99. Ref EE13

Colour pinhole CCTV camera module with audio. Compact, just 20x20x20mm, built-in audio and easy connect leads PAL CMOS sensor 6-9V d.c. Effective Pixels 628x582 Illumination 2 lux Definition >240 Signal/noise ratio >40db Power consumption 200mW £35. Ref EE21

A small colour CCTV camera measuring just 35 x 28 x 30mm. Supplied complete with bracket, microphone and easy connect leads. Built-in audio. Colour 380 line resolution PAL 0·2 lux +18db sensitivity. Effective pixels 628 x 582 Power source 6-12V d.c. Power consumption 200mW £36. Ref EE16

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 3 lux 6-12V d.c. manual tuning Available in two versions, pinhole and standard. £79 (pinhole) Ref EE17, £79 (standard). Ref EE18

Small transmitter designed to transmit audio and video signals on 2·4GHz. Unit measures 45 x 35 x 10mm. Ideal for assembly into covert CCTV systems Easy connect leads Audio and video input 12V d.c. Complete with aerial Selectable channel switch £30. Ref EE19

2·4GHz wireless receiver Fully cased audio and video 2.4GHz wireless receiver 190x140x30mm, metal case, 4 channel, 12V d.c. Adjustable time delay, 4s, 8s, 12s, 16s. £45. Ref EE20

The smallest PMR446 radios currently available (54x87x37mm).These tiny handheld PMR radios not only look great, but they are 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, 2 x Belt Clips & 2 x Carry Strap £59.95 Ref ALAN1 Or supplied with 2 sets of rechargeable batteries and two mains chargers £84.99. Ref Alan2

Beltronics BEL550 Euro radar and GATSO detector Claimed Detection Range: GATSO up to 400m. Radar & Laser guns up to 3 miles. Detects GATSO speed cameras at least 200 metres away, plenty of time to adjust your speed £319. Ref BEL550

TheTENS 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. £19.95 Ref TEN327 Spare pack of electrodes £5.99. 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 l.e.d. built in. £9.95. 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 infra-red output only using standard light bulbs Easily cut to shape. 6" square £15. Ref IRF2 or a 12" sq for £29 IRF2A

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LINEAR ACTUATORS 12-36V D C. BUILT-IN ADJUSTABLE LIMIT SWITCHES. POWER COATED 18in THROW UP TO 1,000lb. 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, 12in. and 18in throw. £29.95. REF ACT12, £34 95 REF ACT18.

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NIGHT VISION SYSTEM Superb hunting rifle sight to fit most rifles, grooved for a telescopic sight. Complete with infra-red illuminator. Magnification 2·7x. Complete with rubber eye shield and case. Opens up a whole new world! Russian made Can be usec as a hand held or mounted on a rifle. £99 REF PN1

These Samarium magnets measure 57mm x 20mm and have a threaded hole (5/16th UNF) in the centre and 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 170lb. (77kg) in weight before being pulled off. With keeper. £19.95. REF MAG77.

Peltier Effect heat pump. Sem conductor thermo-electric device which works on the Peltier effect. When supplied with a suitable electric current, can either cool or heat. Also when subject to an externally applied temperature gradient can produce an electric current. Ideal for cooling or controlling the temperature of sub assemblies. 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 40 x 40mm Imax, 5·5A Vmax, 16·7 Tmax (c-dry N2), 72. £29.95 (inc. manual. REF PELT1. Just manual £4 REF PELT2.

New transmitter, receiver and camera kit. £69. Kit contains four channel switchable camera with built-in audio, six IR l.e.d.s and transmitter, four channel switchable receiver, 2 power supplies, cables, connectors and mounting bracket. £69. Wireless Transmitter. Black and white camera (75 x 50 x 55mm). Built-in 4 channel transmitter (switchable). Audio built-in 6 IR l.e.d.s. Bracket/stand. Power supply 30m range Wireless Receiver 4 channel (switchable) Audio/video leads and scart adapter. Power supply and manual. £69. REF COP24

This miniature Stirling Cycle Engine measures 7in. x 4¼in. and comes complete with built-in alcohol burner Red flywheels and chassis mounted on a green base, these all-metal beauties silently running at speeds in excess of 1,000 r.p.m attract attention and create awe wherever displayed. This model comes completely assembled and ready to run. £97. REF SOL1

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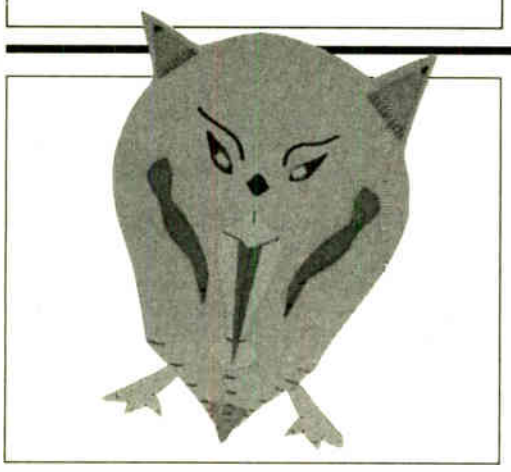

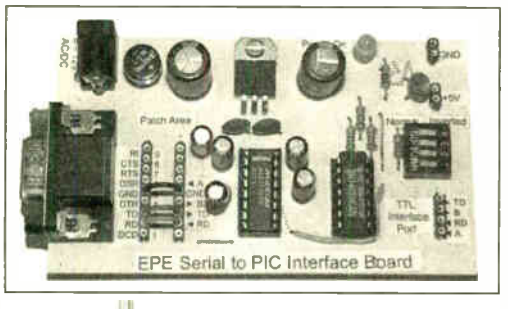

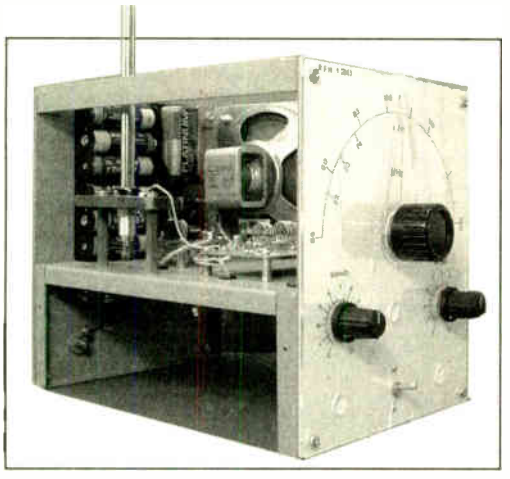

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NEW **State of the art PAL (UK spec) UHF TV tuner module** with **composite** 1V pp video & **NICAM** hi fi stereo sound outputs. **Micro electronics all** on one small PCB only 73 x 160 x 52 mm enable full tuning control via a **simple 3 wire link** to an IBM pc type computer. Supplied complete with **simple working program** and documentation. Requires +12V & + 5V DC to operate.
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A 10 mm fixed focus wide angle lens gives **excellent focus and resolution** from close up to long range. The **composite video** output will connect to any composite monitor or TV (via SCART socket) and most video recorders. Unit **runs from 12V DC** so ideal for security & **portable applications** where mains power not available. Overal dimensions 66 mm wide x 117 deep x 43 high. Supplied BRAND NEW & fully guaranteed with user data, 100's of applications including Security, Home Video, Web TV, Web Cams etc, etc.

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INFODEC 1U, 24 port, RJ45 network patchpanels. #TH93 **£49**
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Marconi 6310 Programmable 2 to 22 GHz sweep generator **£4500**
Marconi 2022C 10KHz-1GHz RF signal generator **£1550**
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HP3781A Pattern generator & **HP3782A** Error Detector **£POA**
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NEW SERIES TEACH-IN 2004

"How to apply electronics meaningfully" could be the sub-title given to our new 10-part educational series Teach-In 2004. *Many of you already know what electronic components do in the general sense – it's what you then do with that knowledge is where the puzzlement can come.*

This series aims to correct this situation – it explains in practical detail how the main categories of component actually function in electronic systems, giving life to circuit diagram concepts you may have studied in fascination but not fully understood.

The series is written by Max Horsey, Head of Electronics at Radley College, Oxford, who has great experience at inspiring his students in the art of practical electronics, enabling them to achieve success in national competitions, and in their subsequent careers.

In Part 1 next month, Max recaps on the nature of the main component families and illustrates experimentally some of their attributes. In the following parts he examines specific topics such as transistors, operational amplifiers and logic gates, and demonstrates how you can achieve some useful fully-functioning electronic designs.

PIC RANDOM L.E.D. FLASHER

We present this design in plenty of time for Christmas when it can be put to good use as a party dress enhancement or Christmas tree decoration etc. Employing just a handful of components plus the l.e.d.s, this project is inexpensive and easy to build. In addition to random flashing, various flashing sequences are included in the software, which, as usual, will be available free from our website.

CARDBOARD CLOCK

The Cardboard Clock uses a simple battery-powered circuit to control a pendulum and thus turn three gear wheels to show the time. There are just five moving parts, including the gear wheels, and you can watch them at work. The clock is unusual, inexpensive and will keep time to within 15 seconds per day. It is easy and fascinating to build using only normal home tools.

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USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied complete with 40-pin wide-slot ZIF socket, box and Windows Software.
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Will program virtually ALL 8 to 40 pin PICs plus certain ATMEL AVR, SCENIX SX and EEPROM 24C devices. Also supports In System Programming (ISP) for PIC and ATMEL AVRs. Free software. Blank chip auto detect for super fast bulk programming. Requires a 40-pin wide ZIF socket (not included)
Kit Order Code: 3144KT - **£54.95**
Assembled Order Code: AS3144 - **£59.95**

ATMEL 89xxxx Programmer

Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16VDC.
Kit Order Code: 3123KT - **£29.95**
Assembled Order Code: AS3123 - **£34.95**

NEW! USB & Serial Port PIC Programmer

USB/Serial connection. Ideal for field use. Header cable for ICSP. Free Windows software. Call or see website for PICs supported. ZIF socket not incl. 18VDC.
Kit Order Code: 3149KT - **£29.95**
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Introduction to PIC Programming

Go from a complete PIC beginner to burning your first PIC and writing your own code in no time! Includes a 49 page step-by-step Tutorial Manual, Programming Hardware (with LED bench testing section), Win 3.11—XP Programming Software (will Program, Read, Verify & Erase), and a rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). Connects to PC parallel port.
Kit Order Code: 3081KT - **£14.95**
Assembled Order Code: AS3081 - **£24.95**

ABC Mini Microcontroller Board

ABC Mini Starter Pack

Currently learning about microcontrollers? Need to do more than flash a LED or sound a buzzer? The ABC Mini Starter Kit is based on ATMELs AVR 8535 RISC technology and will interest both the beginner and expert alike. Beginners will find that they can write and test a simple program, using the BASIC programming language, within an hour or two of connecting it up. Experts will like the power and flexibility of the ATMEL microcontroller, as well as the ease with which the board can be "designed-in" to a project. The ABC Mini STARTER PACK includes everything you need to get up and experimenting right away. On the hardware side, there's a pre-assembled ABC Mini Board with parallel and serial cables for connection to your PC. Windows software included on CD-ROM features an Assembler, BASIC compiler and in-system programmer.
Order Code ABCMINISP - **£54.95**
The ABC Mini boards only can also be purchased separately at £34.95 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 PSU203 £9.95

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12VDC/6mA (standby). *Two & Ten Channel versions also available.*
Kit Order Code: 3180KT - **£41.95**
Assembled Order Code: AS3180 - **£49.95**

Computer Temperature Data Logger

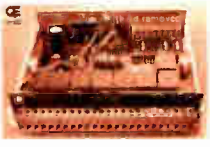
Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 38x38mm. Powered by PC. Includes one DS1820 sensor and four header cables.
Kit Order Code: 3145KT - **£22.95**
Assembled Order Code: AS3145 - **£29.95**
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

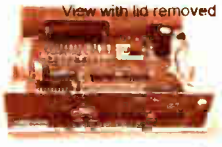


Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Once programmed, unit can operate without PC. Includes plastic case 130x100x30mm. Power: 12VDC/500mA.
Kit Order Code: 3108KT - **£54.95**
Assembled Order Code: AS3108 - £64.95

Infrared RC 12–Channel Relay Board

Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12VDC/0.5A
Kit Order Code: 3142KT - **£41.95**
Assembled Order Code: AS3142 - **£59.95**

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 appropriate 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 (140x110x35mm) 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 - **£69.95**
Assembled Order Code: AS3093 - **£99.95**

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

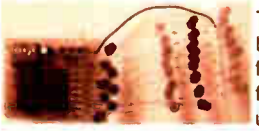
- Units of display: metres per second, feet per second, kilometres per hour and miles per hour
- Resolution: Nearest tenth of a metre
- Range: Zero to 50mph approx.

Based on the project published in Everyday Practical Electronics, Jan 2003. We have made a few minor design changes (see website for full details). Power: 9VDC (PP3 battery or Order Code PSU203). Main PCB: 50x83mm.
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 an 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 PSU203). Main PCB: 55x95mm.
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 super bright 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: 9-12VDC. LED supply: 9-45VDC (depending on number of LED used). PCB: 43x54mm.
Kit Order Code: 3169KT - **£10.95**

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 25x15mm. 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 supplied). 70x15mm.
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. 20x45mm.
Kit Order Code: 3016KT - **£7.95**
Assembled Order Code: AS3016 - **£13.95**

4 Watt FM Transmitter

Small, powerful FM transmitter. Audio preamp stage and three RF stages deliver 4 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. 45x145mm.
Kit Order Code: 1028KT - **£22.95**
Assembled Order Code: AS1028 - **£34.95**

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. 70x220mm.
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30, 130 - 200 and 300-in-1 project labs also available - see website for details.

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3082KT—2-Ch UHF Relay £26.95
3126KT—Sound Activated Relay £7.95
3063KT—One Chip AM Radio £10.95
3102KT—4-Ch Servo Motor Driver £15.95
3160KT—PIC16F62x Experimenter £8.95
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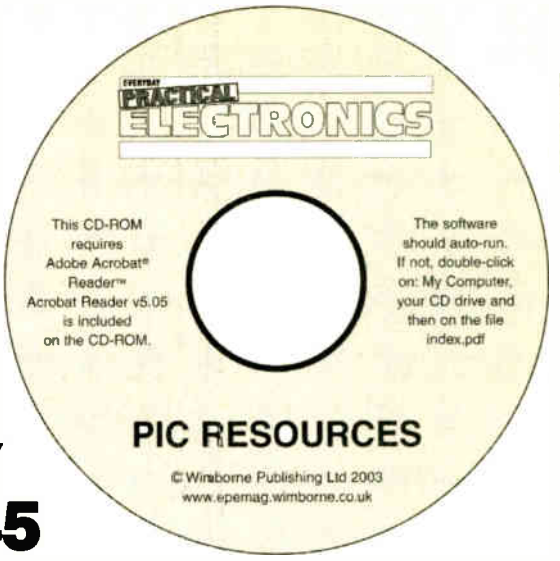

A companion to the EPE PIC Tutorial V2 series of Supplements (EPE April, May, June 2003)

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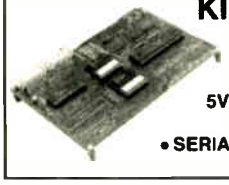

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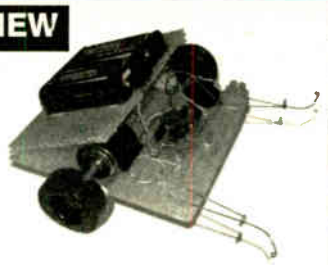
MAGENTA BRAINIBOT I & II

NEW

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



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PIC 16F84 MAINS POWER 4-CHANNEL CONTROLLER & LIGHT CHASER

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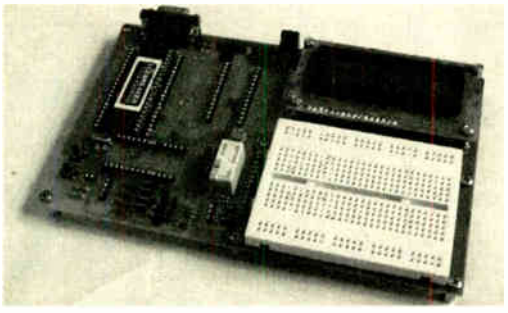

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- Links to Standard PC **Serial** Port (lead supplied)
- Windows™ (95+) Software included
- Works with MPASM and MPLAB Microchip software
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20 Way Plug	£0.66
26 Way Plug	£0.70
34 Way Plug	£0.80
40 Way Plug	£0.92
50 Way Plug	£1.12

PCB Box Headers

10 Way Straight	£0.22
14 Way Straight	£0.33
16 Way Straight	£0.32
20 Way Straight	£0.41
26 Way Straight	£0.52
34 Way Straight	£0.68
40 Way Straight	£0.68
50 Way Straight	£1.03
10 Way 90°	£0.32
14 Way 90	£0.39
16 Way 90	£0.42
20 Way 90	£0.63
26 Way 90°	£0.68
34 Way 90	£0.81
40 Way 90	£1.17
50 Way 90°	£1.14

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20 Way Straight	£0.55
26 Way Straight	£0.73
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40 Way Straight	£0.92
50 Way Straight	£1.27
10 Way 90°	£0.46
14 Way 90	£0.48
16 Way 90°	£0.54
20 Way 90°	£0.59
26 Way 90°	£0.81
34 Way 90°	£1.03
40 Way 90	£1.23
50 Way 90°	£1.41

DIL Headers

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16 Way DIL	£0.53
24 Way DIL	£0.90
40 Way DIL	£1.37

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14 Way Transistion	£0.42
16 Way Transistion	£0.48
20 Way Transistion	£0.48
26 Way Transistion	£0.52
34 Way Transistion	£0.56
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50 Way Transistion	£0.84

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9 Way Female Socket	£0.20
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15 Way Female Socket	£0.29
15 Way H.D. Plug	£0.42
15 Way H.D. Socket	£0.45
23 Way Male Plug	£0.60
23 Way Female Socket	£0.66
25 Way Male Plug	£0.30
25 Way Female Skt	£0.35

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15 Way Male Plug	£1.30
15 Way Female Socket	£1.32
25 Way Male Plug	£1.10
25 Way Female Socket	£1.13
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9 Way Female Socket	£0.33
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15 Way Female Socket	£0.32
15 Way H.D. Socket	£0.58
25 Way Male Plug	£0.43
25 Way Female Socket	£0.50

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9 Way Cover - Block	£0.30
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23 Way Cover - Grey	£0.40
23 Way Cover - Black	£0.38
25 Way Cover - Grey	£0.34
25 Way Cover - Black	£0.37
9 to 9 Cover / Case	£0.80
25 to 25 Cover / Case	£0.84
9 to 25 Cover / Case	£0.80

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3.5mm Mono Line Skt	£0.24
3.5mm Mono Chassis	£0.14
3.5mm Sterec Plug	£0.35
3.5mm Sterea Line Skt	£0.36
3.5mm Sterea Chassis	£0.22
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¼" Mono Line Socket	£0.36
¼" Mono Chassis Skt	£0.46
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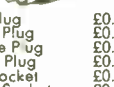
¼" Stereo Line Socket	£0.32
¼" Stereo Chassis Skt	£0.38
NEUTRIK Speakon Plug	£2.83

Phono Series



Red Line Plug	£0.20
Block Line Plug	£0.20
Yellow Line Plug	£0.20
White Line Plug	£0.20
Red Line Socket	£0.20
Block Line Socket	£0.20
Yellow Line Socket	£0.20
White Line Socket	£0.20
Red Chassis Socket	£0.20
Block Chassis Socket	£0.20
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Gold Plated Plug Block	£0.68

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3 Pin Line Socket	£0.96
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3 Pin Chassis Socket	£1.22
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Neutrik Line Socket	£2.10
Neutrik Chassis Plug	£2.24
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BNC Plug 75Ω Crimp	£0.69
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TNC Plug 50Ω Crimp	£1.04
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UHF Chassis Skt- Rnd	£0.75

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4mm Plugs - Screw	£0.38
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3 Pin IEC Line Socket	£1.08
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8 Way Bulgin

8 Pin Line Plug P551	£3.58
8 Pin Chassis Skt P552	£1.27

Toggle Switches

Sub-Miniature

3A 125V 1A 250V

5mm Ø Mounting Hole	
SPST 5 x 10mm	£0.47
SPDT 5 x 10mm	£0.53
SPDT C/Off 5 x 10mm	£1.01
DPDT 9.2 x 10mm	£0.63

Miniature

6A 125V 3A 250V

6.2mm Ø Mounting Hole	
SPST 8 x 13mm	£0.58
SPDT 8 x 13mm	£0.55
SPDT c/off 8 x 13mm	£0.65
SPDT c/o Biased 2 way	£0.84
SPDT c/o Biased 1 way	£1.15
DPDT 12 x 13mm	£0.65
DPDT c/off 12 x 13mm	£0.88
DPDT c/o Biased 2W	£1.20
DPDT c/o Biased 1W	£1.28

Standard

10A 250V Push on terminols

12mm Ø Mounting Hole	
SPST 18 x 30mm	£1.05
SPDT 18 x 30mm	£1.18
SPDT c/off 18 x 30mm	£1.18
DPDT 21 x 30mm	£1.78
DPDT c/off 21 x 30mm	£1.78

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Miniature

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7 x 15mm Mounting Hole	
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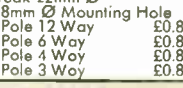
Standard

1A 125V

5.5 x 12mm Mounting Hole	
DPDT 12 x 35mm	£0.27
DPDT c/o 12 x 35mm	£0.25

Rotary Switches



150mA 250V Make before Break 22mm Ø

9.8mm Ø Mounting Hole	
1 Pole 12 Way	£0.84
2 Pole 6 Way	£0.84
3 Pole 4 Way	£0.84
4 Pole 3 Way	£0.84

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250mA 125V 28 x 10mm

7mm Ø Mounting Hole	
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12mm Ø Mounting Hole	
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DPST 4A Red Neon	£1.10
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DPST 3A Green Neon	£1.32

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SPST 15A Red Neon	£0.90
SPDT 16A 250V	£0.75
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5A 240V DPDT 12V	£1.50
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10A 240V SPDT 12V	£1.44
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9F- 6 Mini Din Female	£2.23
5M Din - 6F Mini Din	£1.73
5F Din - 6M Mini Din	£1.73

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13A Surge Protector	£10.00
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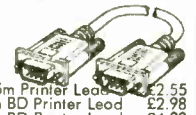

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5m BD Printer Lead	£4.98
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34 Way Grey Ribbon	£0.38
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50 Way Grey Ribbon	£0.52
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24 SWG Enamelled	£1.18
26 SWG Enamelled	£1.20
28 SWG Enamelled	£1.29
30 SWG Enamelled	£1.31
32 SWG Enamelled	£1.33
34 SWG Enamelled	£1.35
36 SWG Enamelled	£1.37
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5mm Green Led	£0.08
5mm Yelow Led	£0.08
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FERNDOWN, DORSET BH22 9ND
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TEACH-IN 2004

The *EPE Teach-In* series have established a world-wide reputation for excellence over the years. Every two years we publish a new series, each with a different slant. The last one – *Teach-In 2002* published in the November 2001 to August 2002 issues – was subtitled *Making Sense Of The Real World* and concentrated on sensors, explaining their operation and helping with the design of associated circuitry. The new series – *Teach-In 2004* – starts next month and goes back to basics for those with little knowledge of electronics, or for those with some experience who want to brush up on their background knowledge.

The series is being written by Max Horsey, who is Head of Electronics at Radley College, Oxford. Many readers will know Max from his previously published projects and from his students' regular appearances in the prizewinners list for the annual YEDA (Young Electronic Designer Awards) competition.

EXPERIMENTALLY

The new series is designed to show, experimentally, how components function as part of circuits and systems. It will cover a wide range of basic electronics, both analogue and digital and will be enhanced with relevant projects to build, each demonstrating the application of the theory being covered. The aim is not to get bogged down in detailed theory, but to provide a good basic understanding of how things work, for instance we will not be going into the internal atomic level theory of semiconductor operation but readers will get a good basic understanding of how a transistor or diode functions in a circuit.

In this way Max can cover a large range of subjects and impart a sound basic understanding of circuit operation. Enough to lead readers on to designing their own projects and fault-finding them.

No doubt this will be another popular series – don't miss Part 1 next month.

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World Radio History

Constructional Project

RC CAR WARS

JOHN LANIGAN

It's a bit like Robot Wars without the expense or final destruction!

UNLESS you are a dedicated radio control enthusiast the fun soon goes out of driving a radio controlled (RC) model car around the patio. The circuit described here will put back some of the fun into what is otherwise a solitary amusement and turn it into a battle for life or death.

At least two RC cars are required operating on different frequencies. The object of the "new" game is to avoid being hit yourself whilst scoring three hits on your opponent's car. This is a little like the popular TV game of *Robot Wars*.

Unlike *Robot Wars*, simply pressing a reset button returns you to the next game with another three lives – no extensive repair work necessary. Warning! You may find yourself spending too much time playing and being unable to do the dishes, wash the car, mow the lawn, clean the windows . . . etc.

UNDER THE BONNET

The simplest way to disable Radio Control model cars is to turn off the power to the Receiver Board. Interrupting the supply to the motor itself is complicated a little by the model's need for the motor to be reversible. This can, of course, be done but is not necessary for this project.

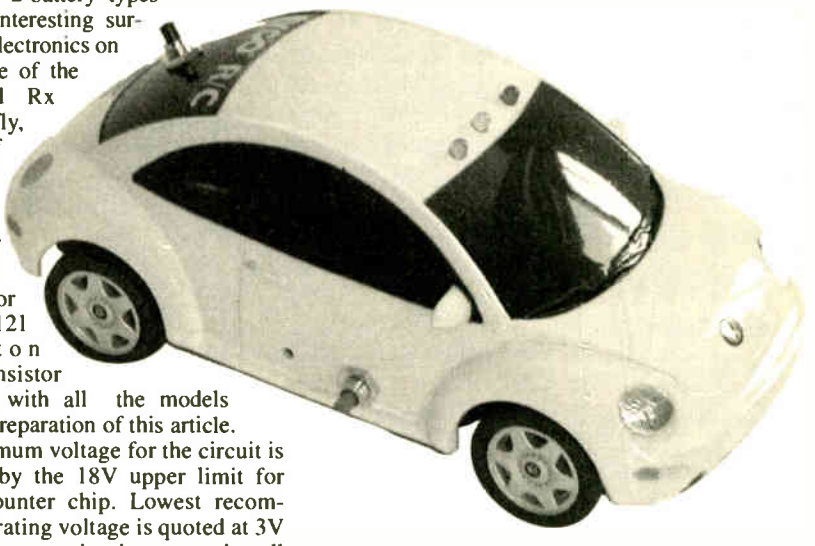
At the *budget* end of the range (you can do this with the really super and expensive models but the author has found that Dads want to kill you if you do), a single board handles all of the signal processing, motor control and steering functions. Interrupting the negative connection from this board to the battery box means a simple transistor switch can be used.

A digital counter i.c. will make sure a fixed number of "hits" produces the disable signal. Hit signals can be generated using cheap and simple push-to-make, non-latching switches and some de-bouncing circuitry. Mount the switches so their "collision buttons" are in exposed areas on the outside of the model car, and fit the disable circuit into the receiver (Rx) board's negative supply line and we have a means to inflict "virtual" damage – and have a bit more fun.

CAR POWER

Radio Controlled cars from High Street stores come with 2, 4 or 6 size AA battery compartments. This gives 3V or 6V operation and the 6-cell versions use two of the cells to run the electronics exclusively.

The circuit to be described here will work with either of the 4 or 6 battery models. The 3V, 2-battery types have some interesting surface mount electronics on the underside of the double-sided Rx board. Briefly, this part of the board boosts the speed performance of the motor. The author used a TIP121 Darlington power transistor successfully with all the models used in the preparation of this article.



The maximum voltage for the circuit is determined by the 18V upper limit for the 4017 counter chip. Lowest recommended operating voltage is quoted at 3V but the prototype circuit operated well below this, leaving plenty of room for battery run down.

HOW IT WORKS

This is the section read by die-hard enthusiasts or when things go wrong – the author always reads this section.

The full circuit diagram for the RC Car Wars is shown in Fig.1. This is, of course, for a single car and is repeated for each "contestant's" car. It breaks down into three sections: a switch and de-bounce circuit (IC1a to IC1c), followed by an i.c. counter (IC2) with optional l.e.d. state indicators, and a power "switch" (TR1).

The "hit" switches, S1 and S2, are connected in parallel and so a hit on either switch counts. Three NAND gates of IC1 are arranged as a flip-flop with capacitor C1 and resistor R1 providing a 100μs delay to mask contact bounce in the switches. Hit counting is performed by IC2, a 4017 CMOS decade counter, sometimes called a Johnson Counter. Transistor TR1 handles the power switching. Base current into TR1 is limited by resistor R5.

Light-emitting diodes, D1 to D3, are optional and indicate the current "life" state of the Robo-car. They make use of the first three outputs (Q0, Q1. Q2) on pins 3, 2 and 4 of IC2 as it counts up.

When three counts have been reached, IC2 pin 7 (Q3) goes high. This is inverted by IC1d so turning off Darlington transistor TR1. As the transistor no longer conducts it effectively disconnects the ground (or negative supply) lead from the Rx board that we have re-routed to the transistor's collector (c).

When the Reset pushbutton S3 is operated it momentarily pulls the reset pin (15) of IC2 high, which is the condition required to reset the counter to zero. Dead simple!

OUT FOR THE COUNT

On each clock input at pin 14 of IC2, it puts a "high" on one of its output pins. Any existing count output is turned-off. So the "active" output ripples up from 1 to 10. It is convenient that each output remains high only for one clock cycle.

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Only one load is driven by the outputs at any time thus reducing the battery drain – very important for RC models. A lot of batteries were recharged playing with the prototypes!

In this circuit we only need a count to 3 but, as stated earlier, the Johnson Counter will count to 10, therefore, counting must be stopped at three as a fourth hit would re-enable the car. Fortunately, a clock inhibit pin is provided, at IC2 pin 13, and any of the outputs can be connected to it. So connecting IC2 pin 7 (the count 3 output) to pin 13 (the clock inhibit input) effectively latches pin 7 high, stopping the count at 3 as required.

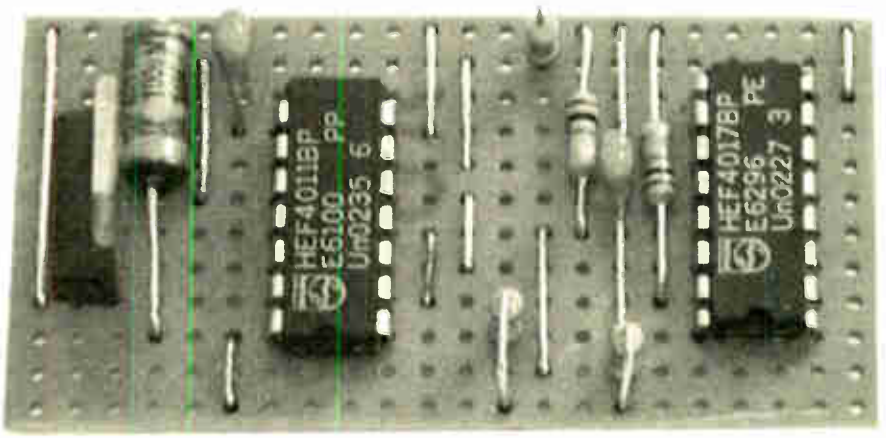
As IC2 pin 7 is also connected to both input pins of IC1d, this makes IC1d gate act as an inverter, therefore, its output will be "low" when the count reaches three. The output of IC1d (pin 11) is taken to the base of transistor TR1 so a "low" will turn-off the transistor. The counter electronics are independently connected to the battery supply so operating the Reset pushbutton S3 restores power to the model's receiver (Rx) board.

wiring one of the trial circuits did generate enough heat to make the transistor uncomfortable to hold. But it survived!

CONSTRUCTION

The RC Car Wars "hit counter" circuit is built on a small piece of stripboard just 12 strips by 22 holes. You will probably need to cut a piece from a larger board. The topside component layout, interwiring and details of breaks required in the copper tracks are shown in Fig.2.

Commence construction by first making the breaks (26) in the copper tracks. You can use a 5mm dia. drill, or a special hand-held tool which is available for this. Next,



Partially completed prototype "hit/counter" board showing most of the link wires in position.

COMPONENTS

PER CAR

See SHOP TALK page

Resistors

R1 to R3	10k (3 off)
R4	630Ω
R5	1k

All 0·25W 5% carbon film

Capacitors

C1	100n plate ceramic
C2	100n polyester
C3	100μ axial elect. 35V

Semiconductors

D1	3mm l.e.d., green
D2	3mm l.e.d., yellow
D3	3mm l.e.d., red
TR1	TIP121 *npn* Darlington transistor
IC1	4011 CMOS quad 2-input NAND gate
IC2	4017 CMOS decade counter/divider

Miscellaneous

S1, S2	sub-min. pushswitch, push-to-make (red – 2 off)
S3	sub-min. pushswitch, push-to-make (black)

Stripboard, size 12 strips x 22 holes; model RC car; 14-pin low-profile d.i.l. socket; 16-pin low-profile d.i.l. socket; multistrand connecting wire; piece of double-sided adhesive tape or pad; solder etc.

Approx. Cost Guidance Only **£6** per car excl RC car & batts

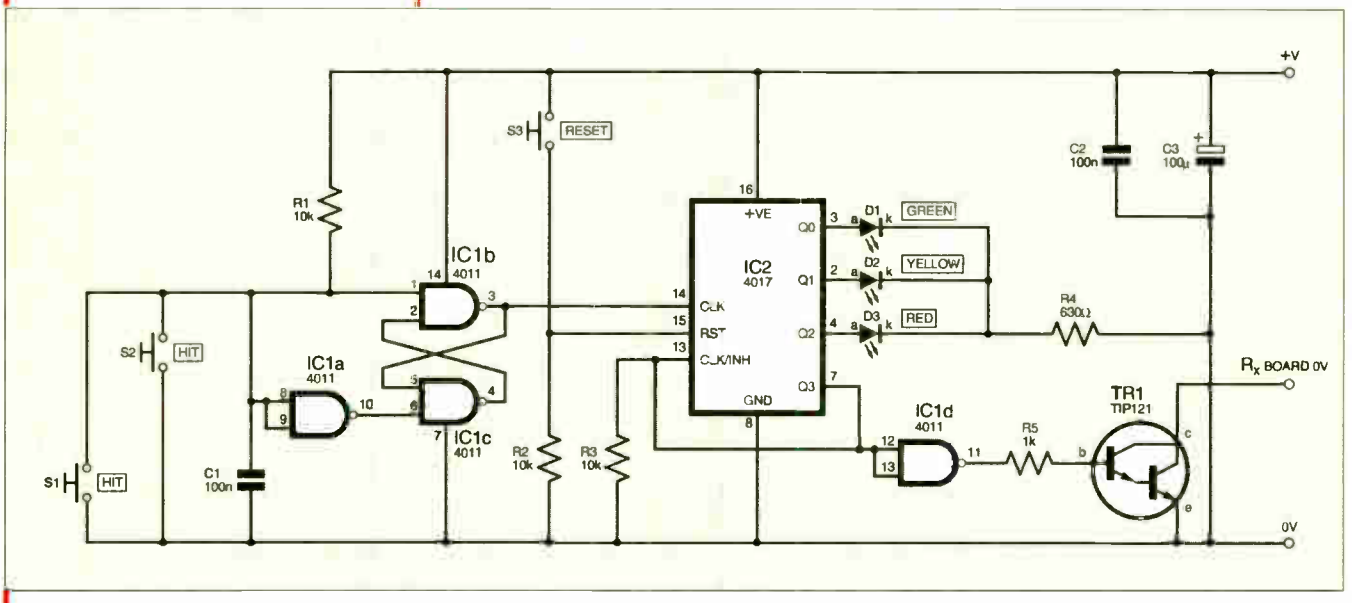
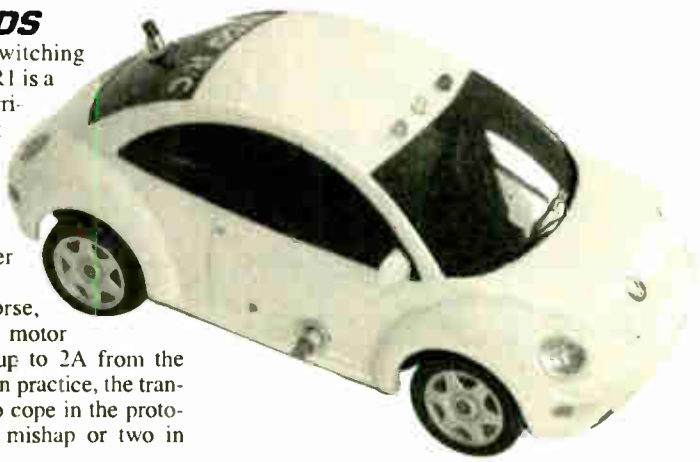


Fig.1. Complete circuit diagram for the RC Car Wars.

POWER NEEDS

The power switching Darlington transistor TR1 is a fairly heavy current carrier as transistors go. It needs to be because it will be passing the full load current of the motor plus a little overhead for the Receiver board.

Starting and worse, rapidly switching the motor into reverse, can pull up to 2A from the batteries momentarily. In practice, the transistor was easily able to cope in the prototype although a slight mishap or two in



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the inter-track links should be carefully inserted and soldered in position. Note the two diagonal dashed links can be inserted below the low-profile i.c. sockets or soldered on the copper track side when inserting the sockets.

Having double-checked the link wires, the rest of the components can be mounted on the board. Start with the i.c. sockets then the resistors, some of which are mounted upright (vertically).

The power transistor is mounted at one end of the board, with the metal tab towards the centre, see Fig.2. A small crocodile clip attached to each pin as it is inserted will act as a good heatsink while soldering the lead in position. Make sure the transistor pins are inserted correctly before soldering. The i.c.s should not be plugged into their sockets until all wiring has been completed and double-checked.

Board lead-off wires to the switches and l.e.d.s should be made long enough to allow comfortable assembly and disassembly of the model. Depending upon available space within the model car, it may be necessary to sleeve the legs of the l.e.d.s. The board interwiring is also included in Fig.2

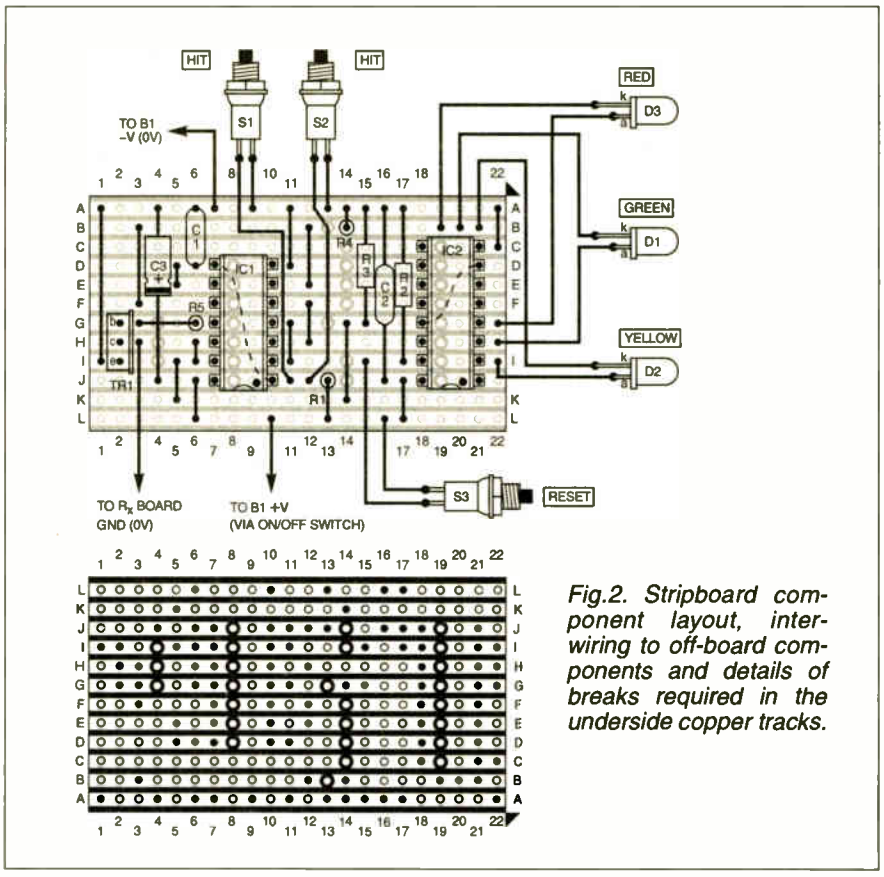


Fig.2. Stripboard component layout, interwiring to off-board components and details of breaks required in the underside copper tracks.

TEST RUN

To test the completed circuit board a load must be connected with its negative lead going to the collector of transistor TR1. A small motor or 6V lamp is suitable but if a motor is used make sure it has a ceramic "suppression" capacitor and diode (cathode on positive side) across the input terminals.

All of the RC model motors have this suppression capacitor and as well as reducing radio interference it absorbs some of the spikes generated by the motor commutation. That is it will offer a little protection to the power transistor during testing.

All of the prototypes performed perfectly well with their original, unmodified motors. The receiver (Rx) board will have been designed to cope with a dirty – digitally speaking, electro-mechanical component like the motor.

INSTALLATION

It helps to think of the new board as simply a switch operating in the negative battery lead of the Rx board, see Fig.3. The final interwiring between the receiver (Rx) board, on/off switch, the battery box and new "collision" board is shown in Fig.4.

The battery box is usually accessed from underneath the model car by a cover. The batteries should be removed before any disassembly work is undertaken. Several screws will hold the body moulding to the model base and the aerial wire will be fixed to the Rx board with a screw that also secures the Rx board.

The aerial wire passes through the body moulding of some models and will/should have a plastic bobble on the end or more likely be tightly wound into a coil. ***This is a safety feature and should not be removed.*** Without such protection the sharp end of the wire could very easily cause injury – particularly to the eyes.

It is not necessary to completely remove the aerial as unscrewing it from the Rx board will allow removal of both the body moulding and the aerial together. Cheaper and new

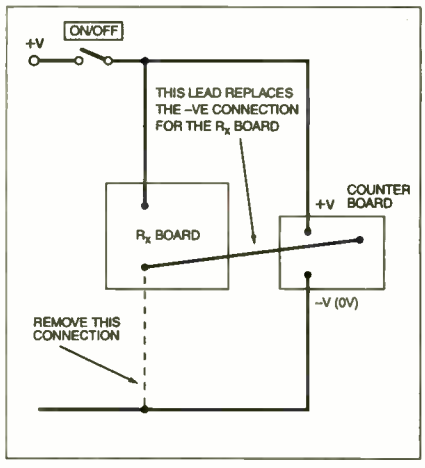
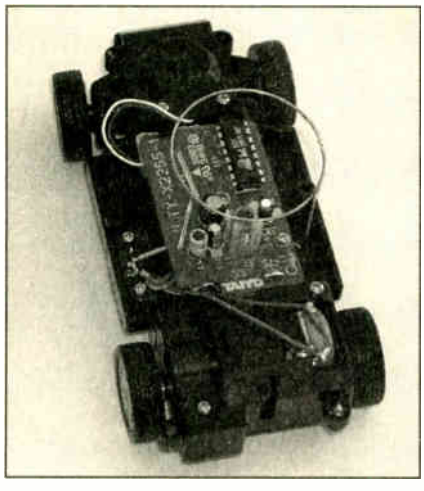
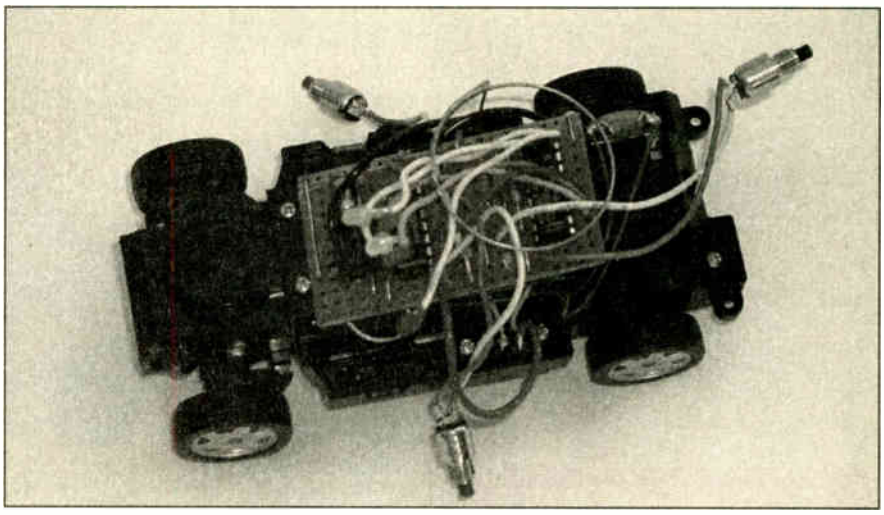


Fig.3. Re-routing the receiver (Rx) negative supply lead to the hit/counter board.



One of the prototype cars with its body-shell removed to reveal the receiver board and aerial.



The "collision/counter" board fixed above the receiver board using double-sided tape. The board should just squeeze below the aerial "loop".

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models have an aerial that is enclosed within the body moulding. These may present a challenge when fitting the new board.

Tracing the leads from the board to the battery connections should be straightforward. Release the wires from the nooks and crannies the manufacturer tucks them into so that you can turn the receiver board over. De-solder the negative lead from the board end and re-solder it to the counter board – see Fig.3.

The positive lead from the counter or "hit" board should now be connected to the switched contact of the model's on/off switch. That is the one already connected to the Rx board, (see Fig. 4).

Solder the remaining lead from the counter board into the Rx board in the same position from which the original negative lead came – you made a note of it when you took it out didn't you? Many of these mass produced boards are generic to a range of models and may have a number of unused component positions making it easy to forget which one you need to use.

PARKING SPACE

With the body mouldings separated you will be able to see how much space you have in which to fit the new parts. If you are using the l.e.d.s then somewhere on the roof or bonnet of the car is suitable. A spot of glue or l.e.d. clips will hold them in place, but a 3mm hole was found to give a reasonably snug fit – the prototypes did not need glue.

The Hit switches should be mounted on the side panels between the front and rear wheels – so that they are exposed enough to be "hit". The Reset switch can be mounted anywhere convenient. For the original prototypes the switch solder tags had to be bent at right angles as there was too little space behind the body moulding. The models used for this article were a little more accommodating.

THROTTLE TIME

Fixing the Hit counter board is best done with a strip of double-sided foam tape or self-adhesive pads on the copper side. This gives a good fix and insulates the board connections.

Test that everything works before re-assembly and then go and have some fun! □

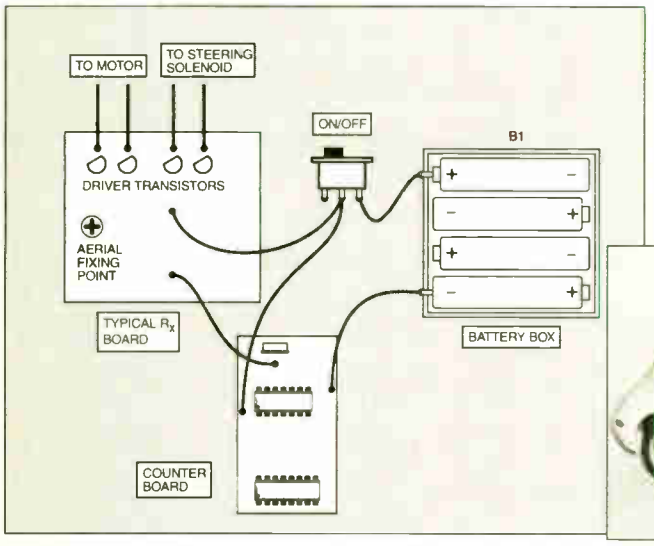

Fig.4 (left) Final interwiring between the counter board, receiver (Rx) board, battery box and receiver's on/off switch.

World Radio History

TECHNO-TALK ANDY EMMERSON

It's New . . . Or is It?

How new is new? Some of the latest ideas in electronics are positively old hat, as Andy Emmerson reveals.

In the mobile phone arena there's a battle royal going on currently. Front-runner in the third generation stakes, 3, has discovered the best way of winning new recruits to its network is by dropping prices. The tactic is certainly proving successful, with most new customers motivated more by attractive tariff options than the system's live video transmission capabilities and other multimedia gizmos.

Across the Atlantic another new-breed operator has a different USP or unique sales proposition. The winning feature of its cellphones is an additional "walkie-talkie" mode that allows users to talk directly to another user on the network, just like using a walkie-talkie or business radio handset.

PUSH TO TALK

It's called PTT mode (push-to-talk) and these phone-to-phone calls are included in the cost of users' monthly calling plan. Users love it and consider it a total novelty, even though from a boring technology viewpoint it's nothing more than a kind of abbreviated code dialling, in which the network memorises the person(s) to whom you want an instant hotline facility. Nevertheless, to users it seems like magic.

Each Nextel phone is assigned a unique 5-digit number which identifies it on the direct connect network. The phones are easily programmed with "talk groups" which are assigned groups of numbers – for example, within a single company or shared between a company and its primary suppliers, etc. – and you just select a name from the phone's display and press the push-to-talk button to connect.

If the other phone is turned on and within the coverage area, it issues a loud beep and one can immediately talk ("Hey, George, swing by the plant and pick up some items before you go to the customer's site."). If the target Nextel is not available, you can press an "alert" button and when the target phone is back on the network, it will immediately be alerted with a loud tone and display text that your phone is trying to reach it.

Of course, the Nextel also works as a typical digital cellphone and as an alphanumeric pager. It can be enabled for Internet email and the Web for an additional monthly fee.

SYSTEM ADVANTAGES

One of the advantages of the direct connect system is that you know it's an internal call coming in and the subscriber placing the call does not have to wait for dial switching and for the usual cellular delay as the cell system tries to determine if the called party is within range of a cell site. But, if the called party is not, the direct connect caller is not shunted into voicemail. Instead, the caller just leaves an alert that is sent when the called party is reachable once more. This beats leaving unnecessary voicemails that need attention when the called party is back in range.

If you're worried this will mean we shall all be saying "Over" and "Roger" like CB users, have no fear. It doesn't work like that... The Nextel bleeps to let you know when it's ready for you to talk and makes an unhappy-sounding note when you step on the other party's transmission. So you know instantly when not to talk.

OVER AND OUT

It's a clever novelty and certainly has its applications, even though in many situations a conventional full-duplex call (one in which you can both talk at the same time without waiting for "Over") is superior, both in quality and in ease. Direct-connect is a very poor system for conducting a normal conversation. It is a good system for quickly exchanging brief factual information and its format discourages the time-consuming social overhead of "small talk" and traditional telephone courtesies.

Adding this facility to an existing cellular network is not easy. In Britain, Orange demonstrated it to the press a while back but then dropped the idea, mainly because it required special handsets with an extra push-to-talk button. There were pricing problems too; if cut-price hotline calls became too popular, this would not be good for call revenue overall.

There is a network called Dolphin, which combines the benefits of cellular technology with instant press-to-talk connections that Dolphin calls Express Connect. Dolphin is targeted at business users, however, with tariffs that would not attract casual users.

ORIGINS IN CB

None of this hotline radio stuff is new. In fact the same technique, right down to 5-digit numbers, talk groups and instant connections, was on offer in the late 1980s, when the late lamented UHF personal radio service provide the self-same facility.

PRS, if you recall, was an ingenious cross between citizens' band and cellular radio, providing private communication between two radio users using automatic selective calling. It didn't use an exchange or anything like that and you could link up only with people within normal radio range, but conversations cost nothing once you had the equipment – and a £10 CB licence.

Operation was extremely simple. All you did was key in the five-digit call number of the person you want and then press the PTT switch briefly.

If the rig belonging to the person you want was switched on and was on stand-by, the set responded automatically and a spare channel found without any further action on your part. Your set then bleeped and you could speak. If you wanted to make an "All Stations" or CQ call you punched in five zeros and anyone in radio range tuned to the calling channel would hear you.

Dead clever, highly effective and extremely popular – in Japan, where the system originated. In Switzerland it appealed to business and private users alike and was also launched briefly in Holland.

However, it attracted only a handful of users on the 934MHz band in Britain (which was later withdrawn) and although the concept was re-launched twice, once as short range radio (SRR) using analogue technology and then with the title private advanced radio system (PARS) using the same digital technology as GSM cellular radio.

Nothing serious came of either scheme, however. Sometimes a good idea fails simply because it's ahead of its time.

AND EARLIER STILL!

Speaking of which, take a look at this quotation and have a guess when it was written...

Maybe it will sound a far-fetched idea today, but the time is surely approaching when everyone will be able to carry about with him a small radio telephone. Wartime development of apparatus to work on very short wavelengths has opened up many entrancing possibilities.

Hundred of thousands of "radio-telephone channels" can be used over short distances without interference; and the installation of a network of automatic telephone exchanges might well be utilized for handling the calls from a multitude of pedestrian or automobile telephone subscribers, to sort them out and pass them by line or by radio link to main exchanges. Certainly it is but a matter of time before the railway traveller is able to pick up the phone and dial his office or his home.

It comes from a British book of 1946, *The Miracle of Wireless* by Miles Henslow. Cellular radio was introduced here in 1985 by the way.

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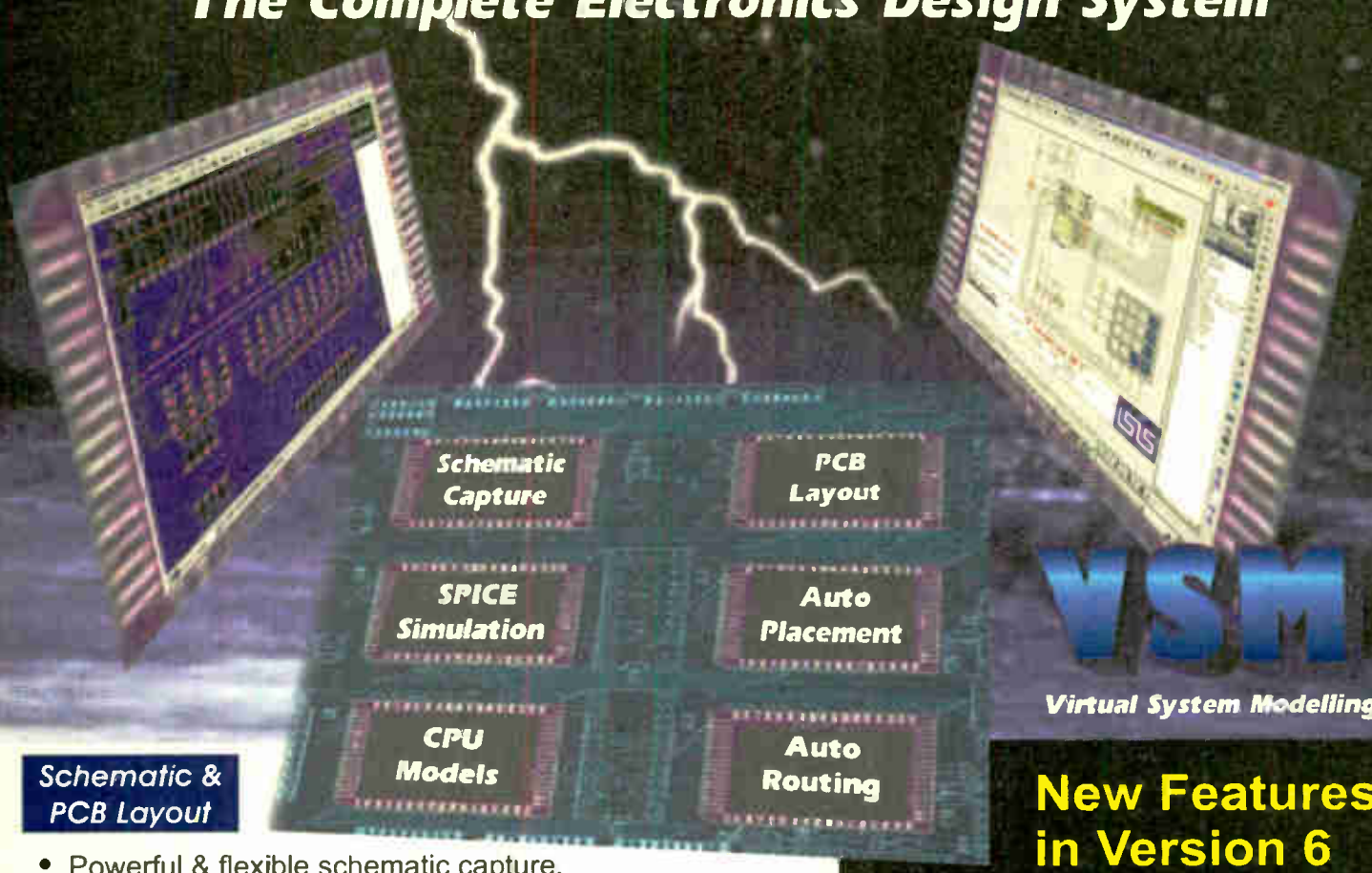

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New Technology Update

A new approach to an old technology promises improved current monitoring facilities, reports Ian Poole.

MEASUREMENT of current can present problems under a number of circumstances. The traditional method to make a measurement is to place a meter in series with the circuit in which the current needs to be measured.

This is usually possible for many small current applications such as those found in electronics circuit design. However, it may not be feasible where the service cannot be interrupted or where it may not be feasible to break into the circuit.

In many cases these problems occur in instances where high currents are involved, possibly on power lines or other similar applications. Here it is not possible to break the circuit, yet it is still necessary to be able to measure the current flow.

To overcome this problem there are a number of solutions that can be adopted. One is to use a Hall effect device that measures the magnetic effect around the conductor and in this way the current can be determined. A variety of forms of coil may be used, although a less well known approach is to use a coil known as a Rogowski coil.

Rogowski Coil

Rogowski coils are air-cored coils that have been used since 1912 as current sensors. The very early applications were limited because the output from the coils was very low.

Also, the measuring instruments of the day were not very sensitive and this meant that any measurements that were taken tended to be inaccurate. However, in more recent years, with the improvements in electronics technology, the low output has not been a problem and this has enabled their use to grow.

Many current sensors require that either an electric or magnetic circuit is made around the wire carrying the current to be measured. This introduces a number of mechanical and electrical problems as the circuits need to be made very efficiently. Also it introduces a number of mechanical problems and these can considerably increase the complexity and cost of any sensor.

The Rogowski coil, it is claimed, overcomes these problems. It consists of a coil as shown in Fig.1. Here it can be seen that there is a break in the circle, and this enables it to be placed over or around the conductor in which the current is to be measured. Whilst care has to be taken to ensure that there is sufficient compensation for the interruption in turns at the end of the coil, this can be achieved relatively easily. In operation the coil acts basically as a current transformer.

In construction the coils are wound evenly spaced in a toroidal shape and the output is largely independent of the distortions in the shape of the toroid. This means that the coil can be made flexible so that it can quickly wrap around the conductor to be measured. A further advantage is that being air-spaced the coils do not suffer from the saturation effects experienced by coils with cores.

The coils are produced by a number of manufacturers and for a number of different applications. Current measuring capabilities range from full-scale ranges extending from around 30A up to 100kA.

The frequency range is also important. Being an inductive component this is naturally limited, but this is not of great importance to many users as the coils are generally used for power applications that are normally limited to around 50Hz or 60Hz. Nevertheless, bandwidths range between 1kHz right up to 1·5MHz.

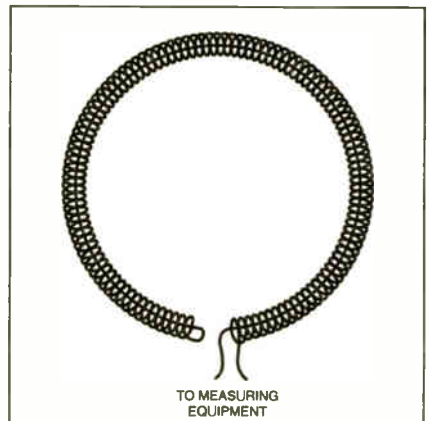

Fig.1. Traditional Rogowski coil.

One of the major problems with the Rogowski coil is its sensitivity. However, with the capabilities of modern electronics this can be overcome to a large degree. The coil itself can be designed to maximise the output by increasing the number of turns to increase the level of flux linkage. In some cases two or more layers of windings can be used.

New Development

In a new development, a Swiss sensor maker named LEM has developed a novel coil design. One of the problems with the Rogowski coils is that they are susceptible to interference caused by external fields.

To overcome this problem, LEM have introduced a second slightly larger coil around the sensing coil. By careful design of the geometry it can be wound such that the two-coil arrangement will be virtually immune to external fields whilst still remaining able to accurately measure the current in the conductor under test.

A further development simplifies the construction. Wound components of any sort are notoriously expensive to manufacture because they are time consuming and often require techniques that do not lend themselves to modern day automatic manufacturing techniques.

A Discrete Fix

As a result of this, LEM have used a series of discrete fixed coils on printed circuit boards. The arrangement is to have a main circular circuit board with a large slot cut in one side to accommodate the conductor under test. Then small boards with two coils side by side are mounted perpendicular to the main board. In this way the turns are effectively distributed in lumped elements around the circle.

The printed circuit boards for the small coils have eight layers and these are soldered to the main board making construction particularly easy. In addition to this the use of printed circuits makes the design far more repeatable as it is not dependent upon the tolerances of coil winding.

As a result, the new sensor is able to offer tolerances of better than 8%. This is a great improvement over coils made using traditional wound techniques. The bandwidth has also been tailored to suit the main requirements for these coils and extends from 10Hz to 1kHz and it can operate within the temperature range –20°C to +60°C.

The new sensors include a family of 12 devices covering the 10A to 400A range. They incorporate their own conversion electronics circuitry providing a 0V to 5V or 0V to 10V output and they require an external 24V power source

Summary

This new development provides a very useful and fascinating insight into the possibilities of a technology that has been around for many years. Despite its age there are many applications, particularly in the area of high power current measurement.

Further information about radio and electronics technology can be found at **www.radio-electronics.com.**

World Radio History

News . . .

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

DETER THE ARTFUL DODGER!

The world of fine arts should act to prevent high tech piracy that is crippling the music and movie industries. Barry Fox reports.

NEW schemes unveiled recently by the National Gallery in London may earn extra revenue, but risk making life easier for art pirates who sell unauthorised copies of famous paintings.

The National Gallery, and project partner Hewlett Packard, said that they want to model the future of fine arts on the music industry. This comes as the music industry warns that poor security in the CD system means that one in three music CDs is now a pirate copy.

The National Gallery has been working with HP for eight years on a scheme to digitise all its 2300 paintings. The images have been captured with a digital camera that steps backwards and forwards over the painting to achieve a resolution of 100 megapixels, twenty times that of the best consumer camera. Each image, of around 0·5 gigabytes, is stored on the Gallery's main computer. A six-colour printer in the Gallery's shop prints out very high quality copies on demand from the public, in just five minutes.

Says Huw Robson, Manager of HP's Digital Media Systems Lab: "Quality is unsurpassed. Automatic calibration of the colour means that the difference between the print and the original is imperceptible. We plan to have accredited print shops in other cities and other countries".

Says Vyomesh Joshi, Executive VP HP Imaging and Printing Group, said: "The music industry has gone digital, end-to-end. Distribution can be on the Internet. We want to see the same process in the world of Fine Arts. This is the first baby step to becoming just like the music industry. A whole new revolution has happened".

Reassures Clare Gough of the National Gallery: "We own the paintings and the copyright in the digital scans."

Superior Scans Help Forgers

The quality of home PC scanners, colour copiers and printers is now so good that the US and UK governments are changing the design of bank notes and identity cards to try and make them harder to copy. So is the National Gallery worried about people buying and scanning one of the Gallery's high quality prints, for posting on the Internet or selling prints in street markets and picture frame shops?

Says Gallery spokeswoman Jennifer Lea: "There is nothing we can do about it."

The video industry is already using watermarks to identify pirate copies. Huw Robson confirms that the National Gallery system uses no watermark in the prints, either visible or invisible.

The International Federation of the Phonographic Industry, world trade body for the record companies, recently warned that lack of effective music copy control and the proliferation of PC burners lets music pirates sell a billion discs a year, worth $4·6bn.

Said Jay Berman, Chairman and CEO of the IFPI: "If we had ever envisaged CD-R we would have pressed for greater protection in the CD system. We tried to talk to the computer industry about copy control. No way, they said. Nothing. We were desperate but there was no level of co-operation".

Think Tactically

After the National Gallery launch Berman added: "The music industry was the first to learn just what a huge threat internet piracy poses, and just how critical it is to protect your product in digital format. The film industry is now learning the same thing, and it would not surprise me if this will eventually be a big issue for the fine art world too".

Michael Kuhn helped Polygram and Philips launch CD twenty years ago, and then went on to run the highly successful Polygram Filmed Entertainment company which made *Four Weddings and a Funeral*. "Looking back," he says. "top management at record companies should have spent 9am to noon every day thinking about piracy and the Internet and nothing else. Film studio brass should be doing that now. So too the Fine Art bosses."

KEMPTON SHOW

THE autumn *2003 Kempton Radio and Electronics Show* will be held at Kempton Park Racecourse on 26 October. The organisers tell us that they are aiming to have a large number of young people at the rally so, as usual, they will be issuing *free* tickets to anyone under 16. They are also offering free entry to anyone who takes the Morse proficiency certificate.

The site offers easy access and free parking and "there will be great catering, live music, lots of marketing and big crowds".

Browse **www.kemptonrally.co.uk** for more information.

THUMP AND SNAP!

Barry Fox

CARCAMS are coming. Digital cameras and Webcams are now so cheap that cars will soon come with half a dozen factory-mounted to tell the owner who bumped and scratched the car while it was in the street or car park. Philips has filed a patent on the plan to catch culprits red-handed (WO 03/012746).

Pressure sensors are buried in the front and rear bumper fenders, and decorative trim down the sides. The sensors respond to any jolts by triggering one of four wide angle cameras hidden in the front windscreen, rear and side windows. The camera snaps a quick series of shots which are stored in memory as evidence. The cameras can use the new cellphone picture system to send an alarm call and image to the driver's mobile, for double quick return to the scene of the crime.

Luxury Lighting

VOS PAD has been launched as a "blueprint for future living" and is the world's first apartment to be lit solely by l.e.d.s. It is the brainchild of Marcel Jean Vos and is the first in a series of interior environments that integrate the latest technologies.

The apartment is completely lit by RGB colour-changing l.e.d.s., supplied by British company ACDC Lighting, all of which are fully dimmable with complete chromatic control. The ambience is controlled by a Lutron custom-built computerised system that operates the lighting and other features. The level and colour of the l.e.d.s in different areas can be changed instantly. Vos Pad is also the first property in the world to feature a new high-end range of "screw-free" sockets and switches from leading UK manufacturer MK Electric.

To quote the information on the Vos Pad website, **www.thevospad.com**, "colours and moods may be changed by using intelligent lighting systems and design features, rather than by repainting or papering walls . . . working in this way saves resources, energy and money".

Vos Pad has many more novel technological features apart from l.e.d. lighting. For more information browse the above URL and **www.vossolutions.com**.

World Radio History

HULL STUDENTS' COMPETITION SUCCESS

Hull's Team Random: Phil Price, Andrew Sterland, David Waby and Will Johnson.

THE first-ever Microsoft Imagine Cup was held at *Microsoft TechEd 2003 Europe* in Barcelona, Spain, with the awards being made on 1 July. This year's theme was: "Imagine a world where technology connects people, information, systems, and devices." Teams selected from universities around the globe demonstrated their entries to a panel of judges from academia and the technology industry in this prestigious showcase event.

Of particular interest to *EPE* is that a team of four first year students from the Department of Computer Science, University of Hull, came joint-third out of fifteen teams in a competition that had over 20.000 entries from around the world. The teams' overseeing lecturer in this department is Rob Miles, who regular readers will recall was a co-author of our *Teach-In 2002* series.

The team, who call themselves Team Random, consists of Andrew Sterland, Will Johnson, Phil Price and David Waby. Having taught themselves to program in .NET, they initially won an internal competition within the Computer Science Department at Hull. They then took their project to Microsoft in Reading and came away as winners of the UK heat. Their prize included an all expenses paid trip to Barcelona and a chance to pitch for the worldwide prize.

Rob Miles says "It is a wonderful experience for such a young team. They built their product from scratch in less than three months and then presented it in a thoroughly professional way." The judges were impressed with the flair of the presentation and the way that the students had thought through all the aspects of their product.

Their product is Mercury – The Traveller's Assistant, which is designed to make travel as convenient as possible. Mercury provides capabilities such as currency and language conversion, restaurant recommendations and directions, news and reviews, and tailored partnering opportunities for third parties. It won the team a cheque for $10,000 dollars.

First place in the competition went to a one-man team, Tu Nguyen, from Nebraska. He wowed the judges with a virtual presentation of his Point of Delivery System (iPODS), a multi-language wireless application that allows a waiter using a PDA to take orders in one language and transmit them immediately to a server for translation into the chef's native language.

Second place went to Team India. Bombay University students Tejas Shah, Abhijit Akhawe and Yash Doshi designed Sanjeevani to unleash the true potential of computers in the medical field. The solution integrates different mobile devices and helps to increase collaboration between health organizations, thereby empowering these organizations to provide mission-critical care and treatment.

Team Singapore tied with Hull's Team Random for third place. Kapil Vaidyanathan, Anumeha Bisaria, Harishankar Vijayarajan, and Kunal Talwar competed with Smart Cart, the world's first .NET-savvy shopping cart. Smart Cart allows shoppers to navigate through aisles to find a particular product, provides access to a customer's virtual shopping list, and displays product information and promotions.

You can find out more about the competition itself from **www.imaginecup.com/default.htm**, and take a peek at the Hull contender at **www.mercury-mobile.co.uk**.

Our congratulations to all this year's Imagine Cup winners!

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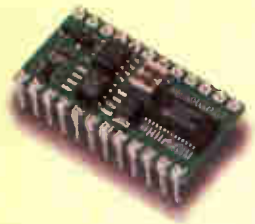


BS2-IC

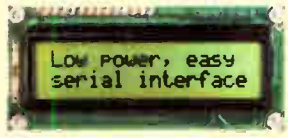
BS2-SX

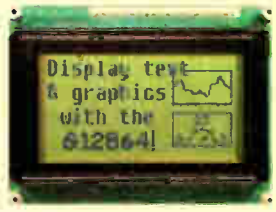
BS2E-IC

BS2P/24

BS2P/40

Parallax BASIC Stamps - still the easy way to get your project up and running!





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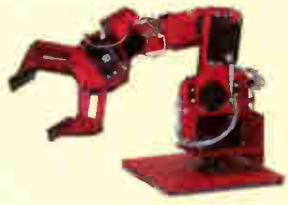

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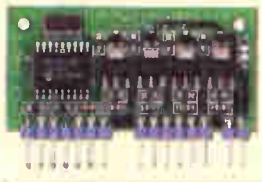

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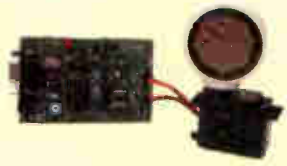

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Constructional Project

SERIAL INTERFACE FOR PICS AND VB6

JOE FARR

Serial hardware plus stand-alone licence-free OCX software for VB6 on Windows 95, 98, ME, NT4, 2000 and XP.

MANY PIC project developers would like to be able to interface their designs with a PC's serial port, but encounter several difficulties.

The principal one for those readers using Visual Basic on their PC is that not all versions of VB allow access to the MSCOMM Active-X serial communications control function. Whilst there are "work-arounds" to this problem, they have varying degrees of success.

The other problem is that serial port voltages can vary considerably from PC to PC, and these voltages need to be converted to standard TTL voltage levels to enable connection to a PIC.

The project described here provides a two-fold solution to this problem.

Firstly, a small circuit board is described that allows safe interfacing between a PC and a PIC, or other digital design.

Secondly, and importantly, a freeware Active-X (OCX control) software component suitable for use with all versions of Visual Basic 6 is provided and its use described. This software allows the developer complete access to the serial port and its pins and is compatible with all current versions of Microsoft Windows, namely 95, 98, ME, NT4, 2000 and XP. It can be used with other designs without the interface board described here.

HOW SERIAL COMMS WORK

For those readers who require detailed information on how serial communications work, there are many excellent books and texts available, and an Internet search turns up literally hundreds of pages of information. However, it is worth covering some of the basics here just to get you started.

Serial ports commonly come in two flavours, using 9-pin and 25-pin D-type connectors. Most PCs now ship with at least one 9-pin connector. Fig.1 and Tables 1 and 2 show the pin arrangement and functions. Note that the RI signal is not always available on all PCs, so using this signal should be avoided if possible.

To help make serial communications as reliable as possible, serial data is transmitted as a series of negative and positive voltages representing binary ones and zeros respectively. Using a *positive* voltage to represent logic 0 and a *negative* voltage to represent logic 1 (the opposite to what one might expect) instead of just +V and 0V helps remove the possibility of decoding errors introduced by resistance and pickup noise in long cable runs.

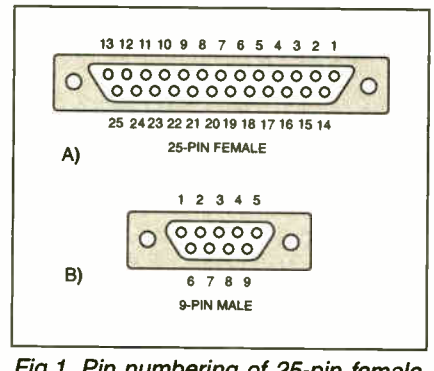

Fig.1. Pin numbering of 25-pin female and 9-pin male connectors.

The signal voltages on a serial port vary from manufacturer to manufacturer, but voltages from –2·5V to +12V or higher could be present. These negative/positive voltages need to be translated into TTL voltage levels (0V to +5V) that are suitable for use by a PIC and in this interface it is done with the aid of a MAX232 serial interface i.c.

From a single 5V supply, the MAX232 is capable of converting incoming signals to TTL voltage levels and outgoing TTL signals to serial line voltages.

When used with PCs and PICs, RS232 communication is asynchronous. That means that an external clock signal is not provided or required. Instead, the devices at each end of the cable are responsible for generating their own internal clock signals to control timing. Each frame transmitted is synchronised using a start bit, see Fig.2.

When there is no activity, the line is in the Mark state (logic 1). The start of a transmission is indicated by a Start bit being sent (logic 0). Each bit of the frame is then sent down the line sequentially, starting with the LSB (least significant bit) of the data word and then being followed by one or two Stop bits.

The waveform in Fig.2 shows that instead of the line returning to logic 1 after the Stop bit has been sent, it remains at logic 0. This indicates that another frame of data is

Table 1. Pin usage for a 9-pin male connector on a PC

Pin	Use	Direction	Description
1	DCD	IN	Data Carrier Detect (also called CD – Carrier Detect)
2	RX	IN	Receive data
3	TX	OUT	Transmit data
4	DTR	OUT	Data Terminal Ready
5	GND		Ground connection
6	DSR	IN	Data Set Ready
7	RTS	OUT	Request To Send
8	CTS	IN	Clear To Send
9	RI	IN	Ring Indicator

Table 2. Pin usage for a 25-pin male connector on a PC (only common pins)

Pin	Use	Direction	Description
1	PGND		Protective signal ground
2	TX	OUT	Transmit data
3	RX	IN	Receive data
4	RTS	OUT	Ready To Send
5	CTS	IN	Clear To Send
6	DSR	IN	Data Set Ready
7	SG		Ground connection
8	DCD	IN	Data Carrier Detect (also called CD – Carrier Detect)
20	DTR	OUT	Data Terminal Ready
22	RI	IN	Ring Indicator

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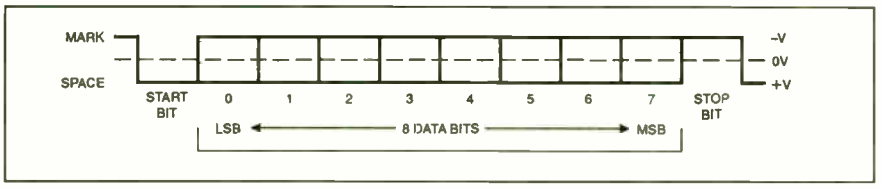

Fig.2. Expected waveform for an 8N1 frame of data (8 data bits, No parity, 1 stop bit).

expected and this is the next frame's Start bit. If the line status returns to logic 1 after a frame has been sent, this indicates that no more data is expected.

It is important that both ends operate at the same data rate, word length parity and use the same number of stop bits, otherwise data errors will arise.

SERIAL MONITORING

Because serial data is transmitted as a series of positive and negative pulses instead of the positive and 0V (ground) pulses that are more common in digital electronic circuits, there is a simple way of monitoring activity on a serial port.

By connecting a bicolour l.e.d. (actually two separate l.e.d.s wired in parallel but one being the opposite polarity to the other) and a suitable current limiting resistor, say 470Ω, between a serial port pin and the GND pin, it is possible to see the current logic state of the pin being monitored.

This technique often forms the basis of an "RS232 Break-out box". This device is extremely useful when attempting to connect different serial devices together and the exact serial connection pin assignment is unknown, or there is a need to monitor the signal levels on each pin – useful when debugging software that uses the serial port for example. (*Such a box is planned for a future issue. Ed.*)

This type of unit is classed as unpowered, which means that the current required to light the bicolour l.e.d.s is actually taken from the serial port being monitored and not supplied from an external source, such as a battery.

Because of this, the unit may actually interfere with the serial ports being monitored in some cases, especially with lap-top type PCs that do not have large amounts of voltage or current available on their serial ports. When using any type of serial monitor, cable lengths should be kept as short as possible

SERIAL INTERFACE CIRCUIT

The complete circuit diagram for the Serial Interface is shown in Fig.3.

When power is supplied to the board, it first passes through bridge rectifier REC1. If the input is a.c., the rectifier converts it to d.c. If the input is already d.c. the rectifier ensures that the polarity is correct for regulator IC1, which regulates the voltage down to +5V. A power-on indication is provided by l.e.d. D1, buffered by resistor R1. Capacitors C1 to C6 provide smoothing.

The RS232 to TTL level conversion is performed by IC2, a MAX232 device, whose functional drawing is shown in Fig.4. Capacitors C7 to C10 are used by IC2's internal circuitry to raise the supplied voltage from 5V to the required ±10V needed for serial data transmission.

Note that on the p.c.b., capacitor C5 is positioned as close as possible to the MAX232 to provide additional smoothing to it during peak power demands, in accordance with the manufacturer's (Maxim) datasheet.

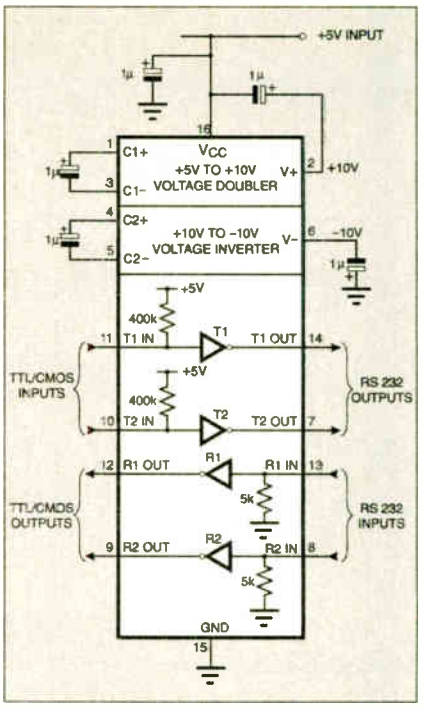

Fig.4. Functional diagram for the MAX232 device.

The TTL logic level signals to and from the MAX232 are fed via four quad 2-input XOR gates, IC3a to IC3d, that allow each of the four signals to be inverted by setting the appropriate setting of the quad dual-in-line (d.i.l.) switch S1. This feature will be of use with PICs which do not have serial interface support built in (e.g. PIC16F84).

Connector TB4 provides for input/output connections to be made to the gates, forming the "TTL Interface Port".

Connection to the PC is via a 9-pin female D-type connector, SK1.

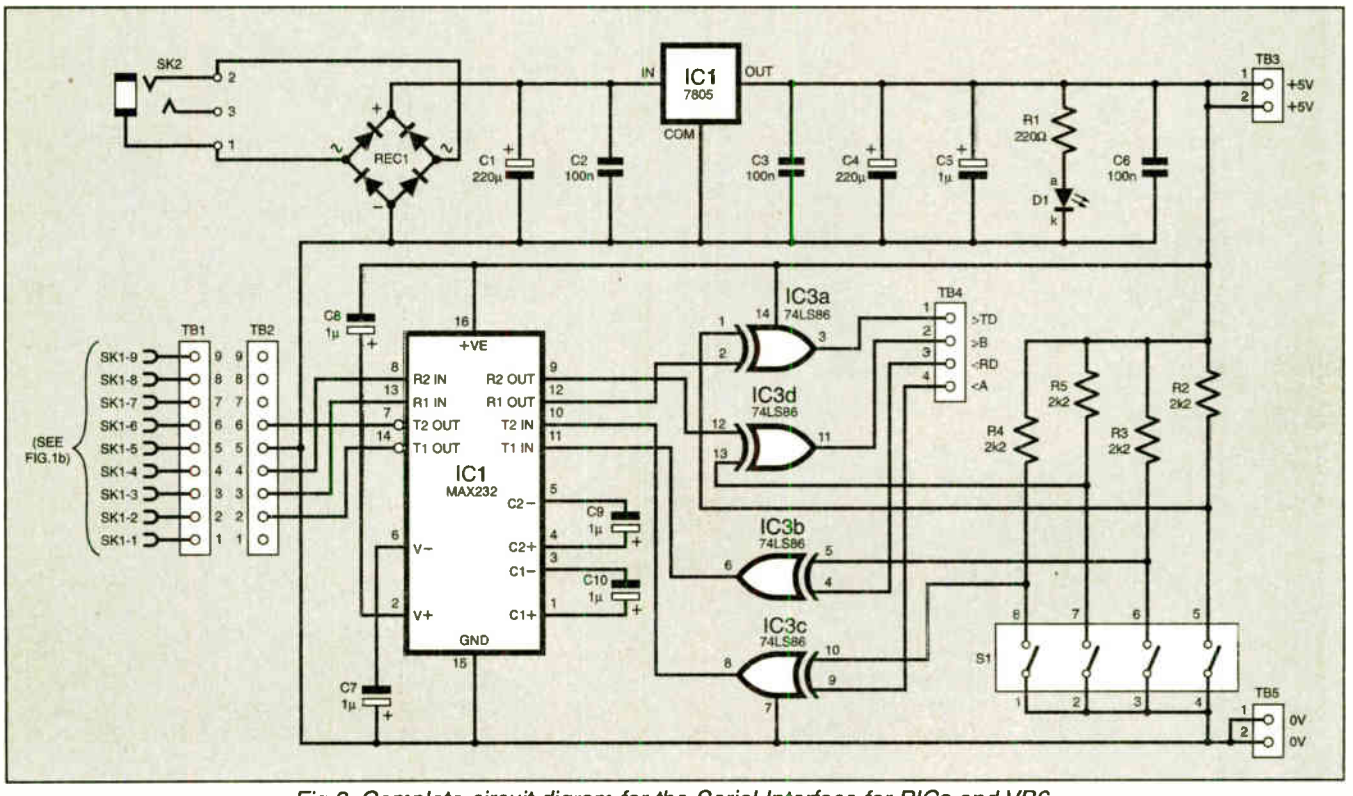

Fig.3. Complete circuit digram for the Serial Interface for PICs and VB6.

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COMPONENTS

Resistors

R1	220Ω
R2 to R5	2k2 (4 off)

See SHOP TALK page

Capacitors

C1, C4	220μ radial elect. 25V (2 off)
C2, C3, C6, C5, C7 to, C10	100n ceramic disc (3 off)
	1μ radial elect. 63V (5 off)

Semiconductors

D1	green l.e.d., 5mm
REC1	W01 50V 1A bridge rectifier
IC1	7805 +5V 1A voltage regulator
IC2	MAX232 RS232 interface
IC3	74LS86 quad XOR gate

Miscellaneous

S1	4-way DIP switch
SK1	9-pin female right-angled Cannon D-type connector, p.c.b. mounting
SK2	2·5mm d.c. power socket, p.c.b. mounting

Printed circuit board, available from the *EPE PCB Service*, code 416; heatsink, TO220 drilled (see text); turned-pin sockets as required; connecting wire; solder, etc.

Approx. Cost Guidance Only **£17**

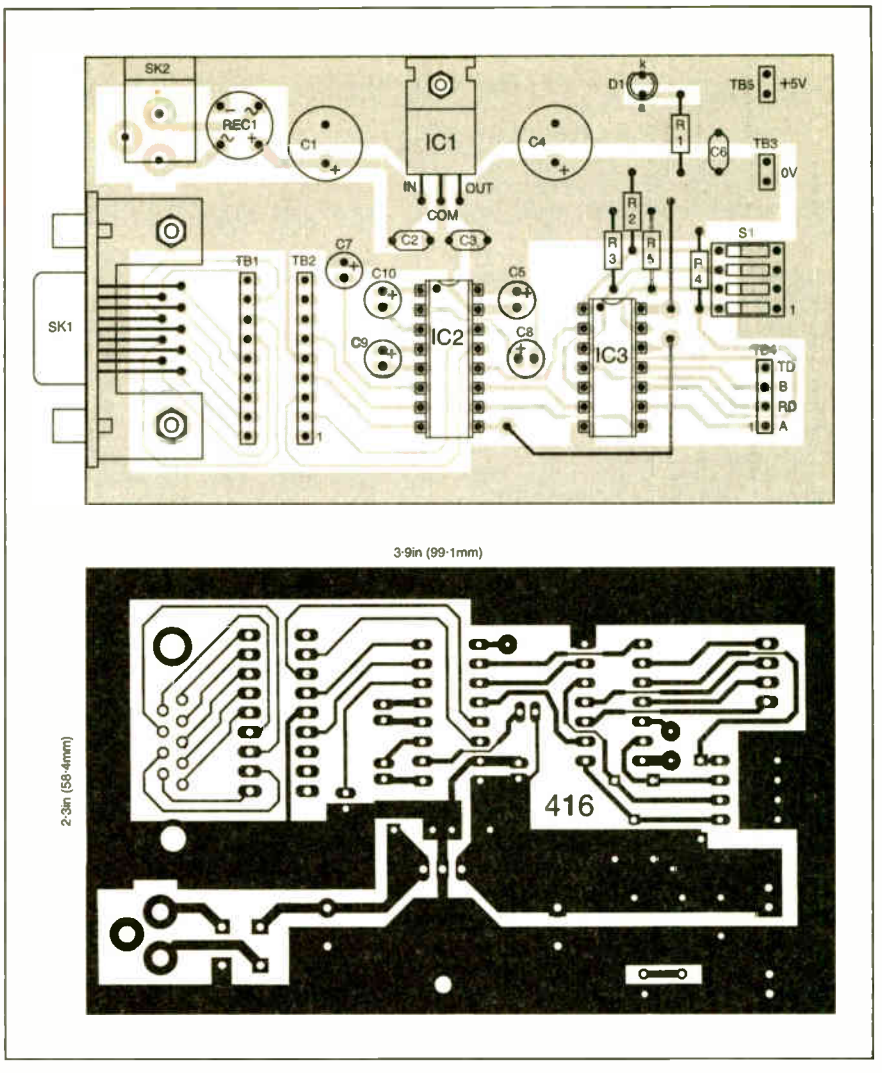
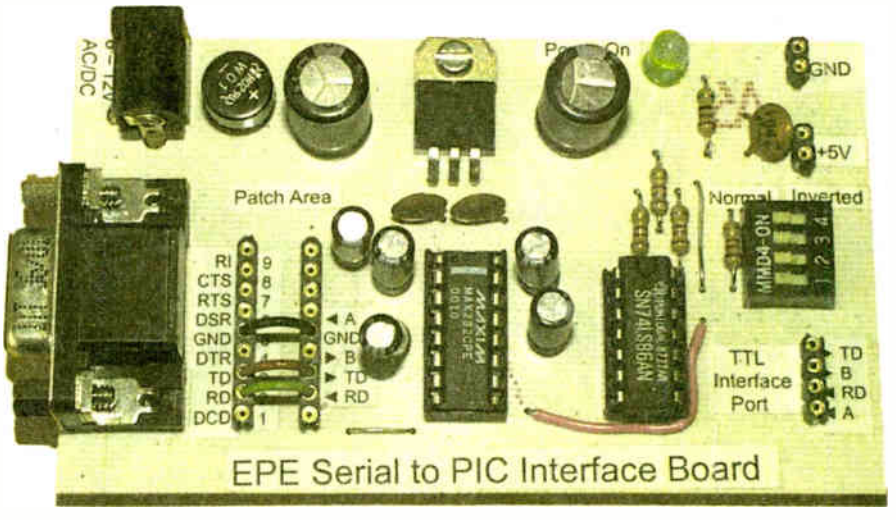


Fig.5. Component positioning and full size copper foil master track pattern for the Serial Interface for PICs and VB6.



POWER SUPPLY

It is expected that when in service, the interface will be powered from a sealed plug-in mains power supply unit. Either an a.c. or d.c. supply can be used and the connections to the p.c.b. are not polarity sensitive. A unit capable of supplying at least 50mA at between 7V to 12V should be ideal.

The prototype draws approximately 40mA when in use, but the exact current drawn will depend on whether the regulated 5V supply is used to drive external circuitry. In the later case, or if the input voltage exceeds 12V, then it will be necessary to fit a TO220 heatsink to regulator IC1.

CONSTRUCTION

The Interface is constructed on a single-sided p.c.b. whose component positioning and track layout details are shown in Fig.5. This board is available from the *EPE PCB Service*, code 416.

Assemble the board in order of ascending component size, and being careful to observe the correct polarity of the semiconductors and electrolytic capacitors. It is recommended that good quality d.i.l. sockets are used for IC2 and IC3, but do not fit IC2 or IC3 until the correct operation of the power supply has been verified.

The "patch connections" area on the board, notated TB1 and TB2, should be assembled using two strips of turned-pin sockets to allow single core wire or resistors to be used as jumpers (more on this later). The p.c.b. layout will accommodate a standard 18 pin d.i.l. turned-pin socket that can perform the same job if required. Turned-pin sockets should also be used for the external connection points marked TB3 to TB5.

Rigidity can be provided for regulator IC1 by bolting it to the p.c.b. The D-type connector should also be bolted to the board.

FIRST TESTS

Once construction is completed, recheck that all components have been oriented correctly and look for any solder splashes or bridges that might have occurred during assembly. Using a multimeter set to ohms, check the resistance across capacitor C4 to ensure that there is no short circuit. A brief reading may be obtained whilst C1 to C5 charge.

If all is OK continue, otherwise do not attempt to apply power until the short has

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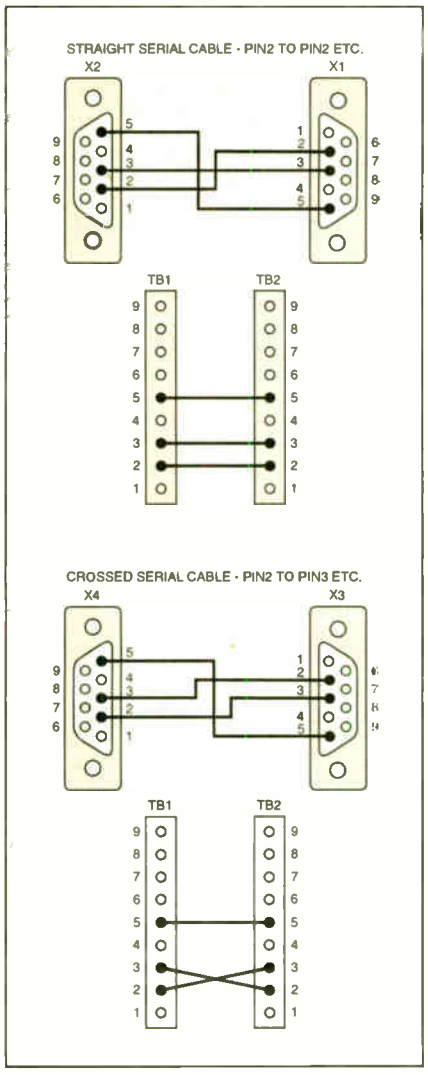

Fig.6. 9-pin serial cables and associated interface board patch area settings.

been removed as IC1, the bridge rectifier or the power supply unit may be damaged.

Making sure that the board is not resting on anything conductive, connect a suitable power supply unit. Switch on the power and l.e.d. D1 should illuminate. Switching the multimeter to d.c. volts, measure the voltage on pins 14 (+VE) and 7 (GND) of the socket for IC3. A reading of approximately 5V, within a few percent, should be present.

Switch off the power supply unit and disconnect it from the mains supply. If the 5V rail is not present or l.e.d. D1 did not illuminate, carefully check around IC1 for short circuits or dry joints and the polarity of the l.e.d.

Once everything seems to be in order, insert IC2 and IC3, ensuring their correct orientation and that none of their pins bend under the body whilst being inserted.

Next, jumper links must be inserted into the "Patch" area next to the serial port connector (TB1 and TB2). The links required depend on the type of cable being used to connect the board to your PC (see Fig.6). If you are plugging the board directly into the PC or using a straight through cable (pin 1 to pin 1, pin 2 to pin 2 etc.) then Patch pins 2, 3 and 5 should be linked ("patched") to their respective counterparts. If using a crossed serial cable, then pin 2 should be patched to pin 3, pin 3 to pin 2 and pin 5 to pin 5.

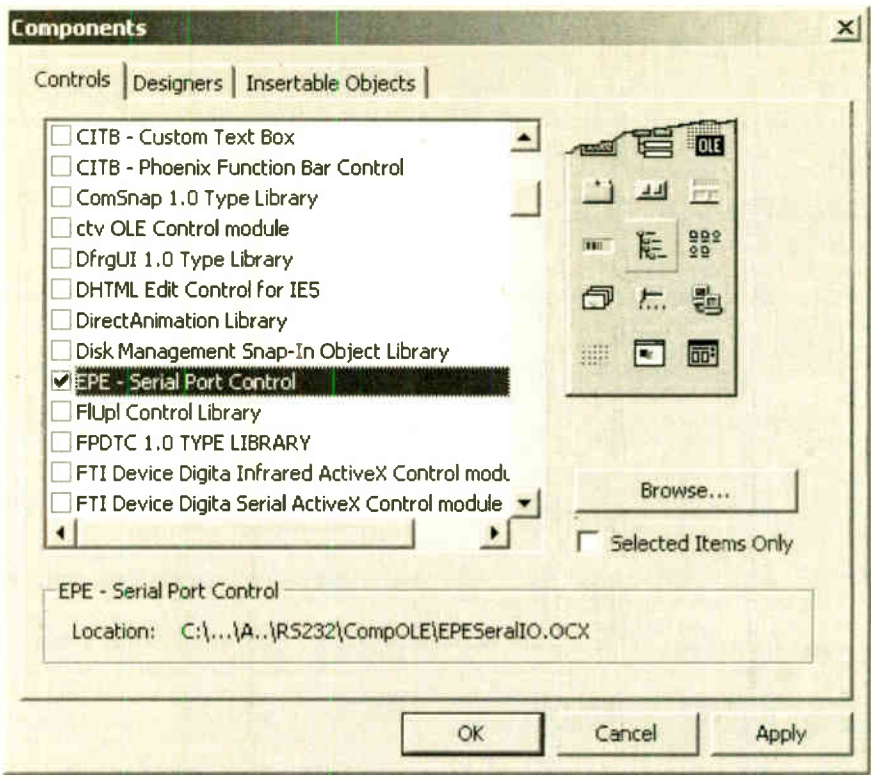

Fig.7. Visual Basic 6 Components window showing the EPE Serial Control selected.

SWITCH SETTINGS

The four slide switches that form S1 allow for the signals presented at the "TTL Interface Port" pins (via TB4) to be logically inverted. This feature will be of use to those developers who use PICs that do not support serial communications natively, or for use in none-PIC applications.

The MAX232 contains four buffers, two transmit and two receive. One pair is accessed by the TD (transmit) and RD (receive) connections at TB4, the other pair is accessed via TB4's A and B connections. For most applications it is expected that the TD and RD signals will nearly always be used, leaving one transmit (A) and one receive buffer (B) available for use as required.

So, if for example you also required use of the DTR signal from the PC, and since this is an output signal from the PC, it could be patched to "B". Likewise, if it is required to send an additional signal to the PC from the PIC, "A" could be patched to DSR or any other input pin on the serial port.

You should never connect any PIC/TTL, etc., circuits to any of the pins in the Patch area (TB1 and TB2) or directly to a serial port unless you are sure your circuit can handle the +VE/–VE voltages that might be present. For normal operation, only connect to the TB4 pins.

PATCH JUMPERS

As already explained, the TB1/TB2 Patch area allows control signals to be routed to and from the four buffers contained in the MAX232 chip. Under normal conditions, the MAX232 is a very hardy chip and should be able to cope with short circuits and incorrectly wired cables etc.

With the board in service, however, it was noted that with the PSU disconnected from it, l.e.d. D1 sometimes remained lit. This was traced to an incorrect cable being used that was feeding TX power form the PC, to the TX pin on the board and thus to an output on the MAX232.

Whilst the MAX232 seemed more than able to cope with this error, it might be advisable to replace the Patch jumpers with 47Ω resistors, for example, to provide some additional protection when using unproven cables and configurations. The GND jumper should *always* be used and *not* replaced by a resistor.

SOFTWARE INSTALLATION

Software for this project is available for free download from the *EPE* ftp site, accessible via the home page **www.epemag.wimborne.co.uk**, in folder **Serial OCX**. It is also available on CD ROM from the Editorial office, for which a nominal handling charge applies. See the *EPE PCB Service* page for details.

The PC software has been written in Visual Basic 6 (VB6) and should run on any Microsoft 32-bit operating system including Windows 95, 98, ME, NT4, 2000 and XP, providing it has VB6 installed.

The installation set consists of three files, **Setup.exe** which is the installation program, **Setup.lst** which provides setup control parameters to **Setup.exe**, and the **EPESerialIO.cab** which contains the **EPE Serial Active-X** control, VB6 runtime files and a Help file.

Also, a folder containing Sample applications is supplied. All the sample programs were written for VB6 and Microchip's MPASM PIC assembler.

Unzip the downloaded or CD ROM file into a hard-drive directory called, for example, **C:\EPESerial**, and then run the **Setup.exe** either by entering **C:\EPESerial\Setup.exe** in the Windows Run dialogue window or by double clicking the **Setup.exe** in the file explorer.

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Once the setup has begun, most users should be able to accept the default settings. During the installation process, you may be asked to restart your computer if you have not previously installed the VB6 runtime components or they are out of date. Reboot the computer and restart the setup process as required.

CREATING A TEST PROGRAM

Whilst a VB tutorial is beyond the scope of this article, it is possible to create a very simple test program to prove correct operation of the hardware and software.

First start a new Standard EXE project in VB6.

Select **Project** and **Components** from the VB main menu and scroll down the list until **EPE Serial Port Control** is found. See Fig.7. Select it by placing a tick in the box on the left, then click OK. This adds the **EPE – Serial Port Control** to the standard VB toolbox window.

Place the control icon (EPE symbol) on a form and add a **Command** button and a **List Box**, see Fig.8.

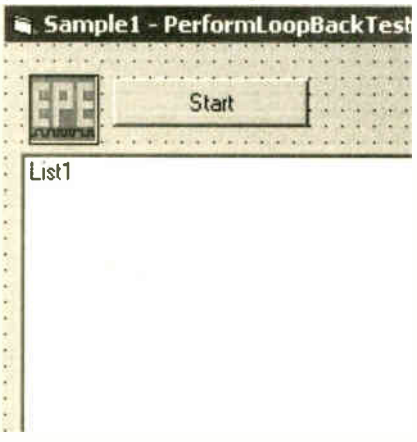

Fig.8. Section of VB Form showing the EPE Serial Control icon in the top left corner, plus a command button and a list box control.

Next, add the code in Listing 1 (be sure to include the decimal point that precedes the commands between **With EPESerial1** and **End With**. (The VB and PIC source codes for these demos are located within the Samples directories to save you typing it in.)

The comments in Listing 1 should make the code self-explanatory, however, a brief explanation of the **PerformLoopBackTest** function is in order:

This function sends a predefined sequence of characters out of the serial port selected on the TD pin, and checks that the same sequence is received back on the RD pin. This can be useful for checking cables and the interface board.

TESTING THE INTERFACE

To test the Interface, first make sure that the four slide switches of S1 are in the ON position (non-inverting).

Next, connect the Interface board to your PC using a suitable cable. Set the jumper links in the TB1/TB2 Patch area according to the cable being used (see Fig.6). On the "TTL Interface Port" pins section (TB4), place a jumper wire between RD and TD. Connect a suitable power supply unit to the board and switch on.

Run the program in Listing 1 and the screen shown in Fig.9 should be seen.

You will see that half way through the test, at line 7, it started to fail. This was because the jumper wire that had been placed between the RD and TD pins in the TTL Interface Port had been removed to prove that the signals were in fact travelling from the PC's serial port, through the cable and into the Interface, then through the jumper wire and back along the same path.

LISTING 1 – program Sample1

```
Private Sub Command1_Click()
List1.Clear
With EPESerial1
   .ComPort = 1                    ' Change this to your required COM port number (1 or 2)
   .Speed = sio19200               ' Sets speed to 19200 baud
   .WordLength = sio8Bits          ' 8 bits per word
   .StopBits = sio1Bit             ' 1 stop bit
   .Parity = sioNoParity           ' No Parity
   .PortStatus = sioPortopen       ' open the serial port
   .PerformLoopBackTest 10         ' perform loopback test 10 times
   .PortStatus = sioPortClosed     ' Close the serial port when done
End With

End Sub
```

```
Private Sub EPESerial1_LoopBack(TestNumber As Integer, TestPass As Boolean,
BufferContents As String)

   ' This event fires each time a loop-back test has been performed. '
   ' TestNumber counts from 1 to n
   ' TestPass indicates if the loop-back test completed correctly
   ' BufferContents contains any characters that were received from the serial port

List1.AddItem Format$(TestNumber) & ", " & Format$(TestPass, "Yes/No") & ", " &
BufferContents

End Sub
```

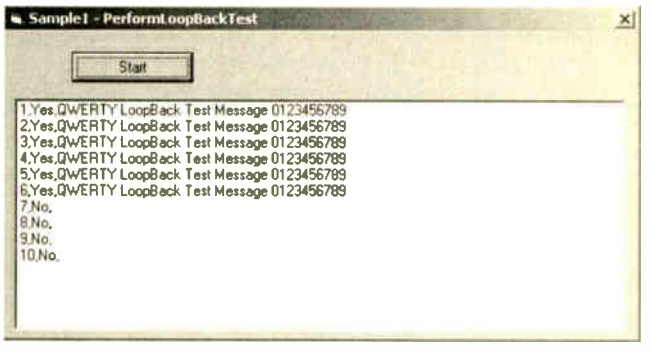

Fig.9. Test results from Loopback test program.

EXAMPLE CIRCUIT

The schematic diagram in Fig.10 shows a test circuit using a PIC16F877-20 and its connections to the Interface board. The *Toolkit TK3* p.c.b. (Oct '01) makes an ideal host for this simple circuit, and its software (Nov '01) can be used to program the PIC.

The **Sample2** directory contains the necessary VB source code and PIC Source Code/Assembled code for a PIC16F877-20. (*Note that TK3 software since V1.5 now includes a Baud rate calculation facility to simplify setting PICs for serial communications in respect of different oscillator rates. Ed.*)

With *TK3* connected to the Interface board and the PIC programmed with its **Sample2** code, run the VB **Sample2** application. Click the Start button and type some text into the TextBox (see Fig.11).

The upper window shows the EPESerial control's built-in data monitor. It will show exactly what data was sent to and from the PC's serial port. The red line at the top shows characters sent by the serial port. The three digits underneath are the decimal value of the ASCII character sent. The green line shows characters received and below that the decimal value of each character received.

The Control frame shows the status of the serial port's control signals. As can be seen, for each character entered the PIC responded with the binary representation of each character it received, followed by OK. The black vertical bars are characters that the VB ListBox cannot display. In this case, looking at the data-monitor window tells us that these characters are CR (Carriage Return – ASCII 13) and LF (Line Feed – ASCII 10) characters.

Note that some PCs, and the author's Sony lap-top included, send odd character sequences when the serial port is first opened. This can be seen in the first response sent from the PIC. Notice it has four black bar characters at the start of the line instead of two. This has been checked on various PCs and has occurred on several of them.

For this reason, it is best to get the PIC to send a message, "Ready" followed by CR+LF when it first starts up and then get the Visual Basic program to wait for this message – ignoring all leading characters that are not recognised.

DOCUMENTATION

The documentation for the **EPESerial** control is too large to reproduce here, so

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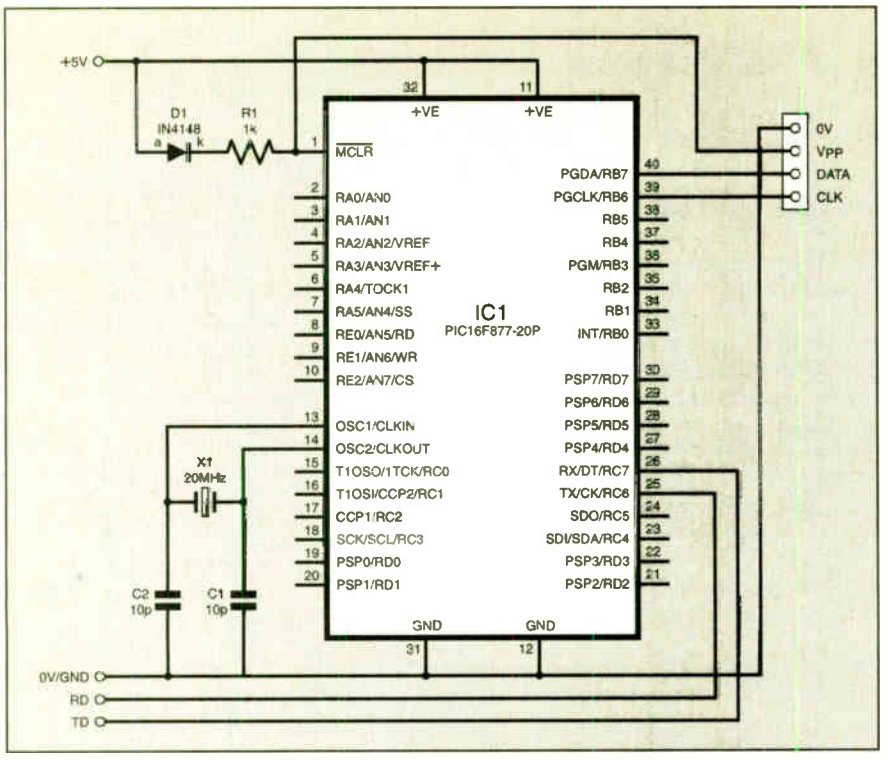

Fig.10. Example PIC16F877-20P test circuit.

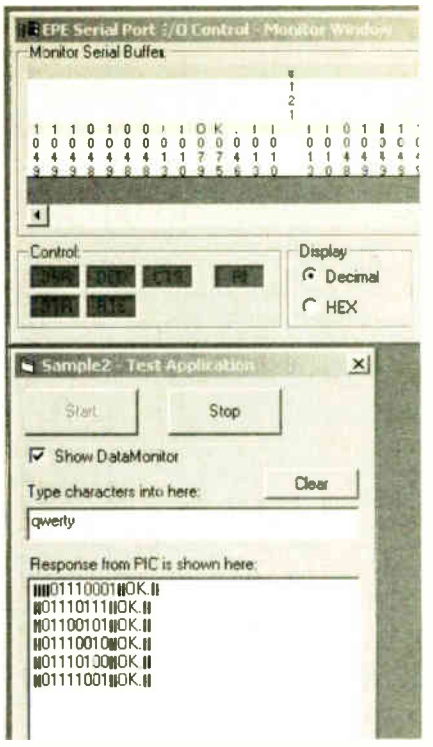

Fig.12. Section of the serial control data monitor window and the main form from the Sample 2 program.

it has been provided in a compiled HTML Help file (**EPESerialIO.chm**) which can be found in the installation folder and contains a wealth of information.

The Samples folder referred to earlier includes other small VB/PIC programs to demonstrate some of the features of the software.

CONCLUSION

Serial port programming under Visual Basic can be a little tricky, however, with some care, the *EPESerial* control and the sample programs to get you going, there is light at the end of the tunnel.

Happy interfacing.

EDITORIAL NOTE

Joe's **EPESerial** control was used in the VB source code for the *EPE Earth Resistivity Logger* (Apr/May '03) and *EPE PIC Met Office* (Aug/Sept '03). Readers who wish to modify the VB source code for these designs can now do so once they have installed Joe's facility. There are other VB projects in the pipeline that also use Joe's highly-useful OCX.

USEFUL WEB SITES

Maxim's web site is available at **www.maxim-ic.com** for information on the MAX232 i.c.

Two good resource sites for RS232 information are: **www.lammertbies.nl/comm/info/RS-232.html**, and **www.beyondlogic.org/serial/serial.htm#2**

Datasheets and related software downloads for PICs can be found at **www.microchip.com**. □

SHOP TALK with David Barrington

RC Car Wars

The circuit for the *RC Car Wars* project is aimed at the cheap "high street" stores type radio control cars and is not geared for the more sophisticated models.

All of the semiconductor devices, including the TIP121 power Darlington, should be readily available from most of our components advertisers. They should also stock low-profile i.c. sockets. You can, if you wish, like the author, solder the i.c.s directly on the circuit board and solder the diagonal link wires to their relevant pins on the board trackside.

With the space inside the car at a premium, the "collision" push-switches must be the sub-miniature, push-to-make, release-to-break, type. We see that **Rapid Electronics** (☎ ***01206 851166*** or ***www.rapidelectronics.co.uk***) list a micro-miniature pushswitch which they claim is just 12mm long, 7mm diameter (but only a red actuator), code 78-0090.

Practical Radio Circuits–5

All the coils and r.f. choke called for in the *Super-Regenerative Receiver*, this month's main project in the *Practical Radio Circuits* series, are hand-wound. As previously, the enamelled copper wire came from **JAB Electronic Components** (☎ ***0121 682 7045*** or ***www.jabdog.com***). They only supply by *mail order*.

The author claims almost any polyvaricon (polythene dielectric) variable capacitor designed for a.m./f.m. portable radios will work in these circuits. They consist of an antenna and oscillator section, plus trimmers. They are currently stocked by **ESR Components** (☎ ***0191 251 4363*** or ***www.esr.co.uk***), code 896-110 and **Sherwood Electronics** (see page 728), code CT9. The a.m./f.m. varicon capacitor used in the prototype models was obtained from **Maplin** (☎ ***0870 264 6000*** or ***www.maplin.co.uk***), code AB11M. Only one f.m. gang (5pF to 25pF) is used here.

All the printed circuit boards are available from the *EPE PCB Service*: code 419 (Super-Regen.); 406 (T/Cap – optional); 420 (Buffer Amp.) and 415 (Crystal). Ample alternative transistors are given in the article, so no sourcing problems should arise but check pinouts before inserting on the p.c.b.

Serial Interface for PICs and VB6

The only component that could possibly give local sourcing problems for the *Serial Interface for PICs and VB6* project is the Maxim MAX232 RS232 interface driver chip. The one in the model came from **RS Components**, code 655-290. You can order direct (*credit card only*) from **RS** on ☎ ***01536 444079*** or ***rswww.com***. A handling charge will be made.

Software for this project is available for *free* download from the *EPE* ftp site, easily accessed via the click-link on the home page when you enter the main web site at **www.epemag.wimborne.co.uk**, in folder **Serial OCX**. It is also available on a CD-Rom from the Editorial Office, for which a nominal admin. charge is made, see *EPE PCB Service*, page 723.

The Serial Interface printed circuit board can be obtained from the *EPE PCB Service*, code 416 (see page 723).

Spooky Bug (Top Tenner)

Only the Siemens SFH2030 photodiode used in *Spooky Bug*, this month's *Top Tenner* project, could prove troublesome to find. The one in the prototype "bug" was purchased from **Maplin** (☎ ***0870 264 6000*** or ***www.maplin.co.uk***), code CY90X.

If you encounter any difficulties in obtaining the BUZ71 *n*-channel power MOSFET, try **Cricklewood Electronics** (☎ ***020 8452 0161***). Rectangular l.e.d.s (for his/her eyes) do appear to be widely stocked.

The printed circuit board is available from the *EPE PCB Service*, code 409 (see page 723).

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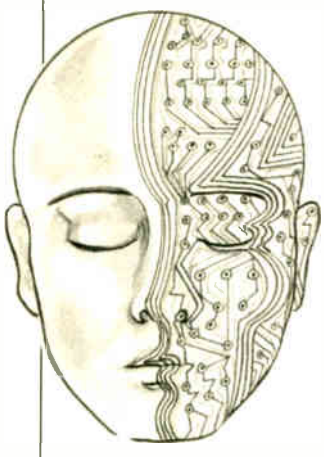

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ROBO-VOICE – EXTERMINATE!

One of the easiest sound effects to implement electronically is the "robotic voice", which chops up the voice to create the "robotic" effect, similar to the Dalek voice.

The circuit of Fig.1 possibly represents the simplest possible implementation of this, using a standard transmission gate oscillator to do so, employing any CMOS 4016 i.c. This particular i.c. is very sensitive to static, and requires antistatic precautions (discharge your body to earth before handling).

The timing components of the oscillator are preset VR1, resistor R2, and capacitor C1. The oscillator works by continually reversing the polarity across C1 through bilateral switches IC1b and IC1c. Note, therefore, that C1 must be a non-polarised type. As the polarity reverses, so bilateral switches IC1b and IC1c alternately open and close, thus sustaining the oscillation. The charge on C1 is further used to switch IC1a at control pin 13, which modulates the voice presented at input pin 1.

The frequency of the oscillator may be roughly calculated as follows:

$$f = 1 / (2{\cdot}2 \times (VR1 + R2) \times C1)$$

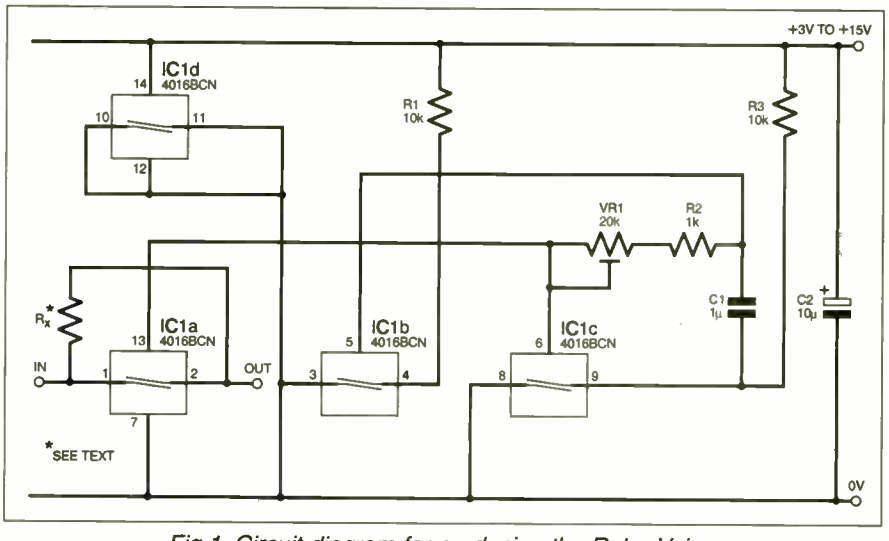

Fig.1. Circuit diagram for producing the Robo-Voice.

Preset VR1 serves to change the frequency of the "chopping", and its mid-position should be about ideal. A particular advantage of the circuit of Fig.1 is that it will admit almost any input, from a few millivolts up to the full supply line voltage, provided the output current does not exceed 25mA.

Since the "robotic" effect might be too exaggerated, resistor Rx (between about 220Ω and 5kΩ) may be inserted across IC1 pins 1 and 2 to reduce the effect. Strangely, the circuit has a more marked effect on the female voice.

Thomas Scarborough, South Africa

STEREO IMAGE ENHANCER – WIDER SPLITS

THE circuit diagram shown in Fig.2 improves the separation of an audio signal by enhancing the "leftness" or "rightness" of the stereo image.

If the signal is of the same amplitude in both channels, i.e. it is mono, the signal voltage across potentiometer VR1 is zero, so the signal remains unchanged. If, however, the signal is stronger in one channel than the other, there will be a signal voltage developed across VR1. This produces a current through VR1, which also flows through op.amp feedback resistors R1 and R2.

This current is produced by both op.amps, IC1a and IC1b, and their output voltage therefore changes in order to compensate for the voltages developed across the feedback resistors. These output voltage changes result in the "loud" channel getting louder, and the "quiet" channel getting quieter.

The amount of increase in separation produced by the circuit is a function of the ratio R1/VR1, although this can be taken too far. If this happens, an antiphase signal is generated in the "quiet" channel and the "over-separated" image sounds louder than it should.

In order to reduce the risk of this happening, a resistor of equal value to R1 is placed in series with VR1. A value for VR1 of 10 × R1 seems about right, because with VR1 at maximum there is virtually no increase in stereo separation.

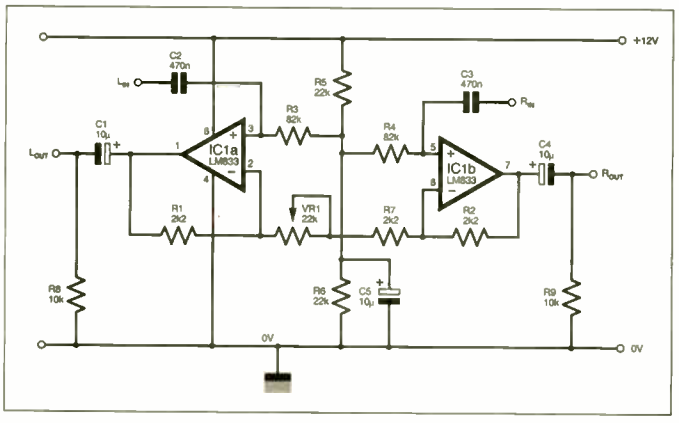

Fig.2. Circuit diagram for a Stereo Images Enhancer.

The overall circuit has a voltage gain of one. It can be fed directly from a CD player, the output feeding the CD input of a stereo amplifier. An LM833 dual op.amp was used in the prototype, though any dual op.amp should do.

P.A. Tomlinson, Hull

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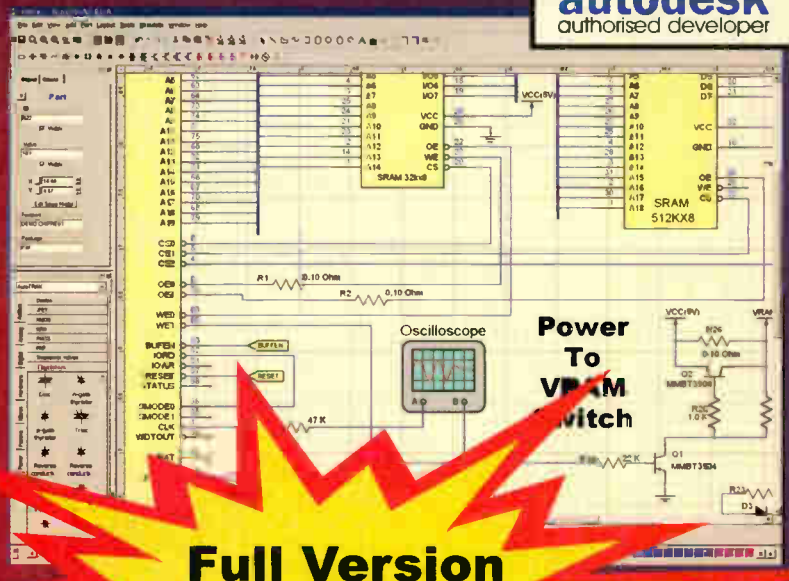

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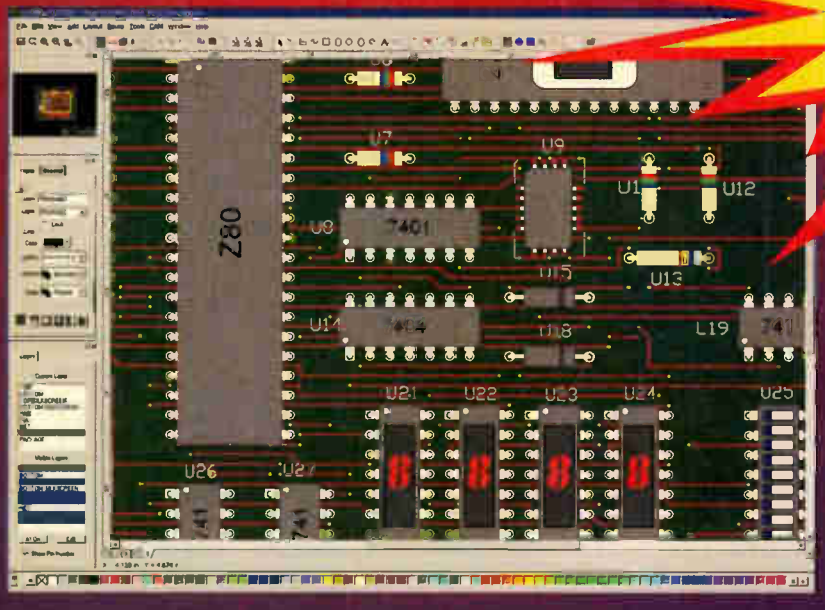

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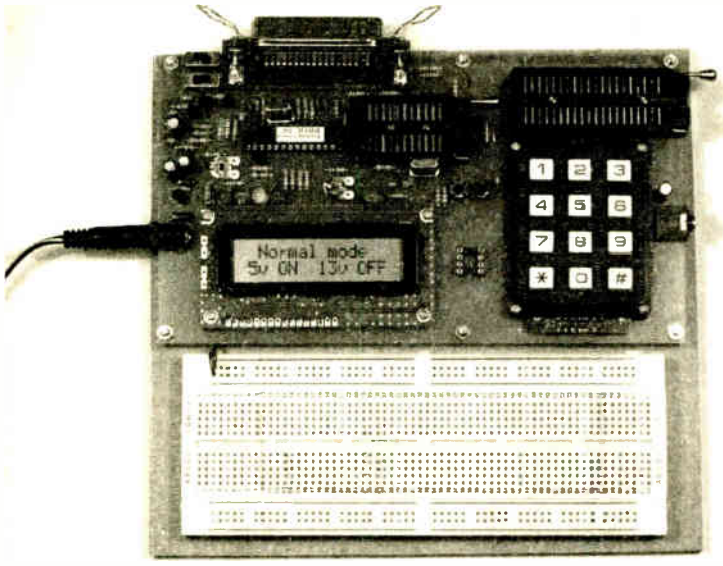

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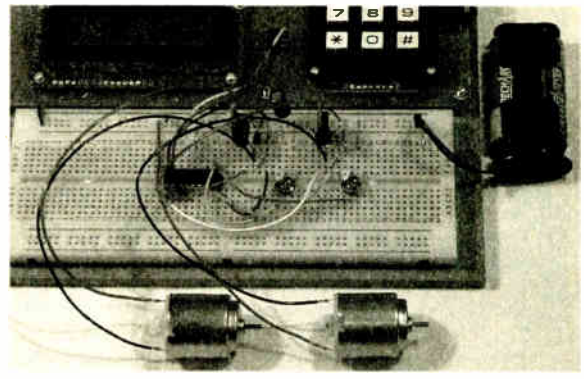

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The second PIC book starts with the simplest of experiments to give us a basic understanding of the PIC16F877 family. Then we look at the 16 bit timer, efficient storage and display of text messages, simple frequency counter, use a keypad for numbers,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

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READOUT

Email: john.becker@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

WIN AN ATLAS LCR ANALYSER WORTH £79

An Atlas LCR Passive Component Analyser, kindly donated by Peak Electronic Design Ltd., will be awarded to the author of the *Letter Of The Month* each month.

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★ LETTER OF THE MONTH ★

PCB TRACK COPYING

Dear EPE,

I've been playing with my p.c.b. etching kit and I think I've come up with a near-foolproof method for transferring a p.c.b. master from an issue of *EPE* onto a copper-plated p.c.b. blank using Press-n-Peel (PnP), though the method could probably be adapted for other "toner transfer" p.c.b. etching systems.

First of all, scan the p.c.b. image into IrfanView (from **www.irfanview.com**), making sure it's as straight as possible. Scan it in "256 Greyscales" mode at either 300dpi or 600dpi. When IrfanView has finished loading the scanned image, zoom out until all of the p.c.b. pattern is visible. Open the Image menu, then select Enhance Colours. Move the Contrast slider all the way to the right and click OK.

This should have left you with a near-flawless black and white image. Save it to disk and edit it in Paintshop Pro, Paint or whatever graphics editing program you usually use. The objective in this case is to get a p.c.b. image in black and white with no filled in pads or short-circuited tracks. Save the image and load it into IrfanView again.

Next, select Print from the File menu. Select your printer and set its resolution to match the resolution of the scanned image (300 or 600 dpi). Click OK. In the next window, select "Original size (from image DPI)". Make sure your printer is loaded with blank paper, then click the Print button. When the image has printed, cut a piece of PnP toner-transfer material to match the image, but oversize it by half an inch (13mm) on each side.

Remove a label from a sheet of laser printer labels (or tear a bit off). Use the label to stick down the PnP. Make sure the label is affixed to the leading edge – the side the printer starts loading from. Reload the paper. If your printer uses an oiled cleaning pad or roller to keep the fuser pads clean, remove it temporarily. Print the image again using the same settings as before.

When the transfer has printed, cut it off of the paper sheet with a sharp pair of scissors (or a craft knife). Cut a piece of p.c.b. laminate to size, leaving a 5mm or so border. Set a normal clothes iron to "No steam", "Cotton/Linen". Put on a pair of rubber gloves and clean the p.c.b. with a green scouring pad and some washing-up liquid. When properly cleaned, the board will be a bright copper colour with no signs of dirt or grime on it. Water should form a solid "sheet" on the board instead of beading up.

Make sure the surface of the PnP is clean (no dust) and place it on the p.c.b. blank. Heat one corner of the PnP for around five seconds to melt the toner and stick the PnP down. Place a sheet of paper on top of the PnP and start ironing down the transfer. This should take around 30 seconds – make sure you don't stay in one place for too long and don't apply too much pressure. Ideally the weight of the iron should be doing most of the work.

After the 30 seconds are up, remove the iron and the sheet of paper and put the board and PnP under cold running water for a few seconds to "set" the toner. Dry the board and use a craft knife to lift the corner of the PnP sheet. Keep pulling the PnP back carefully. If some of the PnP hasn't fused to the board, put the sheet of paper back on top and iron that area for an additional 30 seconds.

Cool the board and remove the PnP again. Generally, if the PnP didn't fuse the second time, either the iron isn't hot enough or there's some dirt on the PnP or the board. Touch up with a sharp tool (such as a craft knife) and an etch-resist pen.

Etch the board as normal (around 20 minutes in ferric chloride at around 25°C), then clean off the PnP and toner with a scouring pad and washing up liquid. If you want, you can use acetone (it's a bit quicker) but that's up to you.

Philip Pemberton, via email

Thank you Philip, that sounds extremely useful. I'll put your advice into our PIC Tricks *folder on our ftp site (even though it's not strictly speaking "PICing"!).*

*Doing a Google search showed about 1200 entries for PnP, of which the first two are: **www.techniks.com** and **www.cibs.co.uk**.*

BIOPIC UPGRADE

Dear EPE,

I'd like to suggest three possible enhancement ideas for your *Biopic Heartbeat Monitor* of Jun '02: a plug-in memory card (usual photo memory card), so as to be able to capture the heart activity on the move and to analyse it on a PC later; an l.c.d. display (with good resolution) for two pulses maximum; an ST deviation measurement/calculation with displayed result.

Cristian, via email

*Thanks for the suggestions Cristian. The first two I could probably implement should I ever do another Biopic, but I don't know what ST stands for, and **http://labs1.google.com/glossary** doesn't either in this context – enlighten me!*

RESOURCEFUL

Dear EPE,

I would like to express appreciation for your *PIC Tutorial V2*, *TK3* software and *PIC Resources* CD-ROM. They form, without doubt, the finest combination of articles and software I have seen on this topic for those starting out on PIC programming. I would also commend Magenta Electronics for the excellent quality and value for money of their version of the *TK3* board.

I hope other readers thinking of starting PIC programming will be encouraged to have a go through this route. All we need now is a cheap source of ZIF sockets!

Brian George, Orpington, via email

Thanks for your kind comments Brian! Yes, ZIFs do seem wickedly priced.

SERIAL L.C.D. CONTROL

Dear EPE,

Since starting to program PICs back in 1998, I've developed a habit of writing my code in reusable modules, the first of which is for a standard alphanumeric (HD44780) l.c.d. display controller module. It currently supports 4-bit mode and 2-wire serial mode.

Serial mode involves connecting a 74LS164 or 74HC164 parallel output shift register, a 1N4148 diode and a 10k resistor. It uses two I/O lines (shift reg data, shift reg clock and l.c.d. E-line). Basically, a data nibble is loaded into the shift register (bits 5 to 2), bit 6 is the RS bit and bit 7 is used to gate the l.c.d.'s E-line (enable/clock). After a data byte has been loaded (with reg pin 13 high), the diode and resistor act like an AND gate.

If reg pin 13 is low, l.c.d. pin E is pulled low through the diode. If reg pins 1, 2 and 13 are high, E is high and the l.c.d. clocks in the data nibble.

The connections required are:

-	74xx164	L.C.D.
PIC RB7	1 and 2	E, via 10k resistor
PIC RB6	8	-
-	5	D4
-	6	D5
-	10	D6
-	11	D7
-	12	RS
-	13	E, via 1N4148 diode *
Vcc	9 and 14	Vcc
Vss	7	Vss

*Connect the 1N4148's cathode to 74xx164 pin 13, and its anode to l.c.d. pin E (which also has the 10k resistor connected to it).

I could have used a CMOS or TTL AND gate, but that would have unnecessarily increased the chip count and a diode/resistor AND gate works just as well.

Run MPASM to compile one of the test files, program into a PIC16F874 (or PIC16F877), connect up an l.c.d. and power up. I've tested the code on a PIC16F84 and a PIC16F628 as well. But the standard disclaimer applies – it works for me, your mileage may vary.

I have to say that a 16 × 1 l.c.d. connected over a two-wire interface is one of the most useful PIC code debugging tools I've got.

Philip Pemberton, via email

That seems nice and simple Philip, and very useful, thank you. The test files you refer to have been put into the PIC Tricks *folder on our ftp site.*

SPURIOUS PIC RESETS

Dear EPE,

Your *PIC Met Office* project was worth waiting for. My own weather station, PIC16F877 based, runs from a mains PSU 24/7, but it's always suffered from the occasional spurious reset due to mains borne noise, usually when nearby equipment, often my PC printer, is switched on or off.

I've tried loads of capacitance and ferrites on the power rails near the PIC, but they never completely cured the problem. I mostly fixed it in software by writing startup code to detect these

World Radio History

spurious resets – they fortunately usually leave the PIC's data and EEPROM memory (where the accumulated weather data are stored) intact, so if consistency checks on this memory are OK at startup I ignore the reset.

Recently, however, browsing the Microchip disk in the knowledge base, I found an FAQ that seemed to apply to my case. This was: "My program works fine, but sometimes resets mysteriously. How can I prevent this?" The reply says:

"In the current architecture, a master clear reset is completely asynchronous (sic) and has very little pulse width requirement. It is usually a good idea to put a capacitor on this pin to decouple this noise away. A 0·01μF capacitor may be enough, but if there is noise of a high frequency nature, like RFI or ESD, it may be necessary to add a 0·001μF capacitor as well."

I put a 100nF polyester directly between MCLR and 0V, and since doing this several weeks ago I've had no further instances of the spurious reset. It's a negative test, of course, but I'm getting cautiously optimistic that it might have fixed the problem completely. It has certainly substantially reduced the incidence. So if anyone else suffers mysterious resets, particularly in mains powered PIC projects, they might care to see if this simple fix works for them too.

Malcolm Wiles, via email

Glad you like my Met, Malc. Writing the software for it was a marathon, but I enjoyed doing it and am pleased with the results.

Regarding spurious resets, I've never knowingly suffered from them, but your comments could prove useful to other PIC addicts, thank you.

PICtutor V1 PSF FILES

***Reader Ashley Preston-Rowen** emailed us to ask* "Please could you send me the user documentation for the *PICtutor* Version 1 by John Becker because we are having problems downloading the Virtual PIC programmer to the PIC on the project board. How do we convert a PSF file to an ASM?"

The PSF files Ashley refers to were only used with the original PICtutor *V1. They are* not *used by the current version, now called* Assembly for PICmicro V2, *which* only *uses ASM files in the MPASM format. With* PICtutor *V1, there was no facility provided for translating PSF to ASM.*

However, when I wrote the software for Toolkit TK3 *(Oct/Nov '01) I also wrote a facility that would do this translation. I told Ashley about it and that the* TK3 *software can be downloaded free from our ftp site (accessible via our home page at* ***www.epemag.wimborne.co.uk****). He replied later:*

Thank you very much John for letting me know about your *TK3*. It was very useful and saved a lot of work. I would like to thank you on behalf of the whole two years of ND students who would not have passed without it. The problem was that the only lecturer who knew what to do was taken ill and I was the only other person (and I'm only an ND1 student!) who knew how to use *PICtutor* and the assembler, but I couldn't convert to an ASM file. With your facility I was able to download everyone's program to the PIC from *PICtutor* so that their work could be marked. So thank you very much again,

Ashley Preston-Rowen, via email

That's great to know, Ashley, well done. It's a facility that I felt would be useful for TK3, *but you are the only person who has told me they've actually used it.*

MORE ON PICS AND XP

Dear EPE,

A few years ago I purchased a cheap programming unit for use on a PC parallel port, consisting of a circuit board with a 40-pin ZIF socket, some buffers/transistors and l.e.d.s capable of programming many of the PIC family. It came with a Visual Basic software routine which worked well with Windows 98. However, upgrading to a laptop supporting Windows XP, the programmer would not work.

I eventually stumbled across **http:/www.ic-prog.com/** which is a gem of a site for this very problem. If one can trace out the inner workings and PC interface signals of their programming unit, as I did, this site provides a free downloadable software package with sufficient details to configure the software to run many types of programmer.

This appears to include serial interfaced units, and details of several programmer types which are directly supported and are given in the form of schematics and links to appropriate sites. It is not too difficult to compare these with the programmer you own, and get a matching order of signals for PC interfacing. At worst one could electrically re-jig a programmer to appear like one of the examples.

One particularly nice feature of this software is a Hardware Check which allows the individual signals sent to the programmer to be exercised in real-time. This enables DVM measurement of the various signals arriving at the programmer to check that they are in the correct order and state of inversion. What is more, there is XP support, so save yourself a few quid and check it out.

If any readers want basic help with this, I am willing to reply to emails, provided they are discernable from spam.

Paul Bryce, via email, paul@brycep.freeserve.co.uk

Thanks Paul, that could prove useful to readers who are upgrading. As far as TK3 *is concerned, of course, we seem to have got a really simple solution through reader Ian Stedman's discovery of the new "universal" version of* ***Inpout32.dll****, which is in the* TK3 *and* Interface *folders on our ftp site and just replaces the previous version.*

Robert Penfold is covering it in his Interface *this month, and in a future issue.*

AVR PROGRAMMING

Dear EPE,

I read the letter from Davis (aka Techy Fellow) in the August '03 *Readout*, and I agree!

Us Intel MCS-51 fellows are left in the dark when it comes to microcontrollers. As one of the oldest microcontrollers around, it is a shame what little support there is for developers and hobbyists alike, apart from expensive development tools available from third party vendors. I also wish that we could have similar support for these versatile workhorses (I only use the MCS-51 code for programming, particularly the Atmel 89Cx range of microcontrollers).

Development tools like the ones available for PICs (*TK3*, etc.) would certainly come in handy. I have drooled over the prospect of being able to use graphics l.c.d.s on the 8051 controllers, with very little information available on the Net. The same goes for the AVR range. I was shocked at how few people actually know how to write programs for these. I've recently had to change the software code for one project and battled to find someone who could assist me, to no avail! So please *EPE*, **help us**!

I sometimes have to convert some of the interesting projects for PICs into code for the Atmel 89C2051 controller, like the *Virus Zapper* in the March '02 issue. I went a little further and added an l.c.d. display to the project to indicate the treatment periods and count down the 20 minute intervals.

Herman Beukes, South Africa, via email

Well Herman, that's two of you with an interest in AVRs! Sadly, though, commercial interests require that far more than two readers will be interested in something before we can commit time and space to it. Let's see if a lot more readers feel as you do.

WELL RECEIVED!

Dear EPE,

I was really pleased to see the *Regenerative Radio* article in the August '03 issue. I well remember building a circuit exactly like the one shown in Fig.3.1 from an article in *Practical Wireless* (circa 1968). If I remember correctly the author was F. G. Rayer. All the hardware was bought from Home Radio, sadly no longer in business.

At the end of the 60s – having just graduated and being short of money – I was teaching myself to build circuits so that I could make my own hifi amplifier (I did – several times!). My ambition was to have something comparable to the Quad 33/303 system which was way beyond my pocket. *Practical Electronics* in the early 70s actually produced a design which, while not being an exact copy, drew heavily on the Quad system's design even down to having triple Darlington output stages. Why I never built this one I do not know.

I also purchased other (cheaper) kits but was never fully satisfied each time. Do today's constructors know the exquisite agony of switching on an amplifier for the first time and seeing (and hearing!) the output transistors fry? (Yes I did – my first effort is best forgotten!). Another time I inadvertently put 45V across a BC169: there was a sharp crack and all that was left of the poor transistor were three wires standing proud of the p.c.b.

Another cause of an amplifier not working first time was not easy to find but I kicked myself when I did! I had wired the DIN plugs to pins 1, 2 and 3 and the sockets to pins 3, 4 and 5! Come on, own up, we've all done it or something similar.

I hadn't seen *EPE* for some time because not all branches of W H Smith's stock it, and those that do tend to put it in a different place every month so it is sometimes difficult to find. I have now treated myself to the back numbers with the radio circuits and the audio circuits from last year; it's nice to see some circuits that I can identify with.

I stopped making my own amplifiers many years ago when the price of off-the-shelf items became so low that it was hardly worth the bother making one. And when PIC circuits came on the scene I really could not understand them so my interest in building circuits waned. Now that you have rekindled my interest, perhaps I will reconsider my dream of making something like the Quad 33/303.

Thanks for an interesting read.

Alan Jones, London, via email

Glad you're pleased with our series Alan. Raymond's really good! So too was Rayer, a person whose designs I learned from in those far gone days. Best wishes for Quadding-up!

CLONING RAYMOND

Reader ***John North*** *recently posted a thread on our Chat Zone entitled "Is Raymond Haigh a synonym for Sony?", continuing within the text:*

I ask because I am astounded by the quality of construction manifest in photos of the gear he designs for *EPE*. I think it is the best I've ever seen in any electronics magazine in the thirty-odd years I've been reading them. Does he make it himself? If so *EPE* should despatch a staffer to interview him about his skills and facilities and ascertain whether his clones are available in pill form!

To which I replied that we are very proud that Raymond shares his excellent skills with us all. I don't know his origins but judging by the quality and style of the illustrations he sends us he's probably been trained as an engineer of "the old school".

If pills were available that would imbue us with his skills I for one would want them – on the NHS of course!

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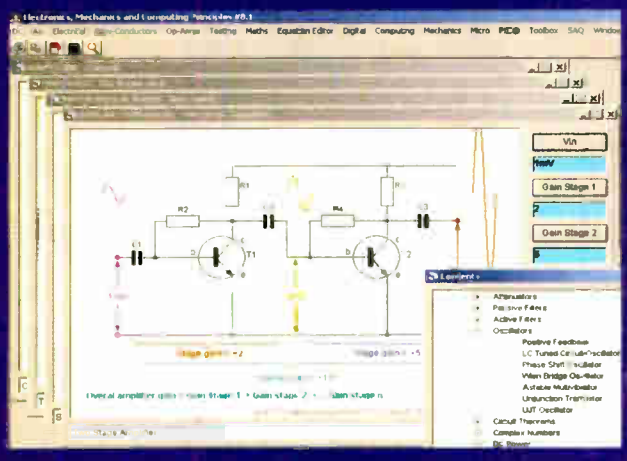

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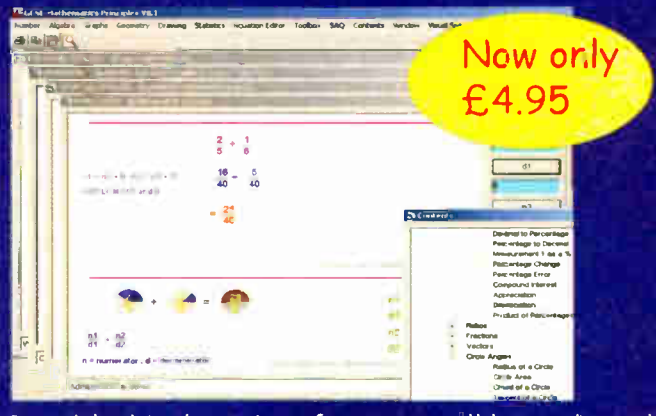

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SPOOKY BUG

OWEN BISHOP

This short collection of projects, some useful, some instructive and some amusing, can be made for around the ten pounds mark. The estimated cost does not include an enclosure.

Hocus-Pocus – Get your Hallowe'en party off to a shriek!

This is one of those novelty projects that leave the constructor with full scope to use their imagination and skill. The essential idea is that the circuit is made to look like a fearsome (or perhaps foolish) bug. In the light, the bug just stands there looking fearsome (or foolish). As soon as the light level falls below the preset level, the eyes of the bug start to glow and it emits a weird wailing sound. This continues until the light is switched on again.

This is only one of several possible applications for this circuit, some bug-related, some not.

HOW IT WORKS

Referring to the full circuit diagram for the Spooky Bug shown in Fig.1, light level is detected by the photodiode D1. This is reverse-biased so that a small leakage current flows through it and on through resistor R1. The current through R1 produces a positive voltage at the inverting input (–) of op.amp IC1. The voltage at the non-inverting input (+) is set by adjusting preset VR1.

In the light, leakage current through D1 is relatively large and so is the voltage across R1. The voltage at the inverting input is higher than that at the non-inverting input and the output of the op.amp (pin 6) swings low, turning off transistor TR1. In the dark, the voltage at the inverting input swings low, the output rises and TR1 is turned on.

When TR1 is on, it has a drain-source resistance of about 0·12Ω. Current immediately begins to flow through the remainder of the circuit. In other words, TR1 behaves as an on/off switch in the 0V line of that part of the circuit.

BUG-EYED

Light emitting diodes (l.e.d.s) D2 and D3 begin to glow. These are the eyes of the bug. If you prefer, you can use flashing l.e.d.s, in which case connect a wire link in place of resistor R2 (flashing l.e.d.s have their own built-in current limiter).

While TR1 is on, the astable circuit based on IC2 oscillates. Its frequency is determined by the capacitor C1 and the current flowing into it.

Each cycle takes about 1·7 seconds. Of this, the output of IC2 is high for about 0·2s and low for about 1·5s. Normally the high period of a 555 timer is longer than the low period, but diodes D4 and D5 in the timing chain cause the reverse effect.

The values of C2 and R6 are chosen so that, with the timing fixed by R3 and R4, a sawtooth waveform passes to IC3. It rises sharply, then falls slowly, reaching its minimum before rising sharply again.

SOUNDS SPOOKY

Device IC3 is connected as a voltage controlled oscillator

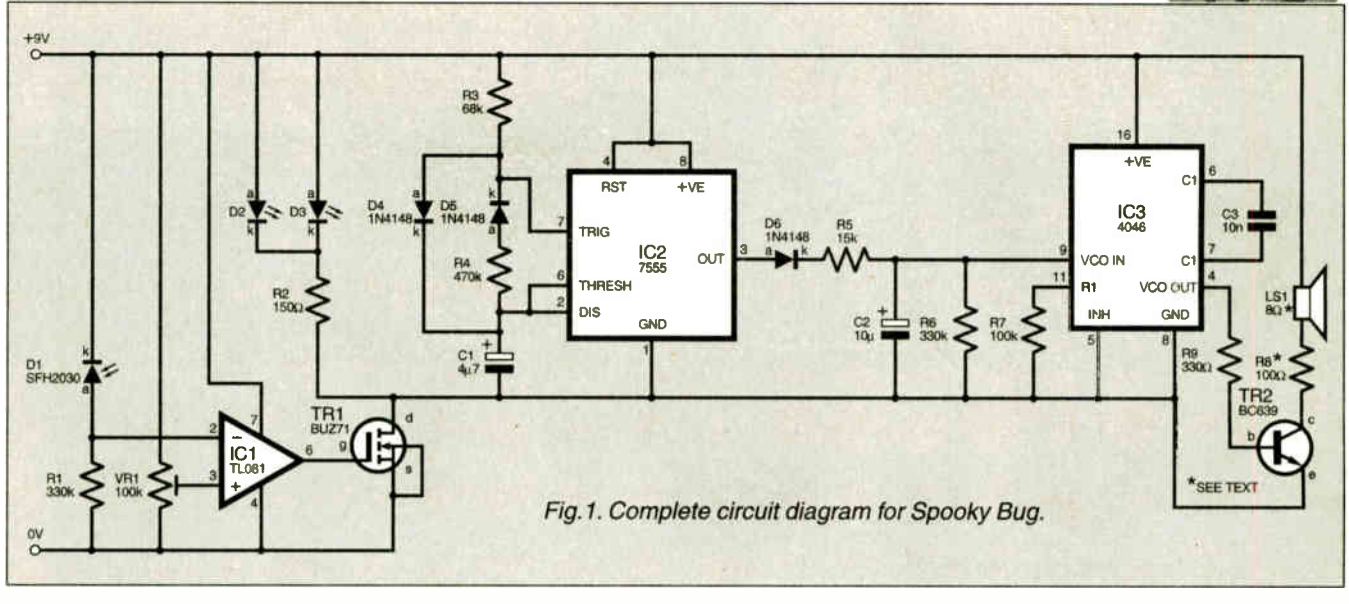

Fig.1. Complete circuit diagram for Spooky Bug.

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(v.c.o.). Its output at pin 4 drives TR2, which switches current through the loudspeaker LS1. The basic frequency of the sound is fixed by the values of R7 and C3.

As the input voltage at pin 9 varies with a sawtooth waveform, the pitch of the sound rises sharply and falls slowly, repeating every two seconds. The effect is a spooky, wailing sound.

This circuit can be tailored to produce a range of sounds. You can alter:

- The repetition rate (R3 and R4)
- The length of the high output pulse (R3)
- The length of the low output pulse (R4)
- The rate of rise of pitch (C2 and R5)
- The rate of fall of pitch (C2 and R6)
- The basic frequency of the sound (R7 and C3)

There is plenty of scope for the ambitious experimenter!

CONSTRUCTION

Apart from the battery, miniature loudspeaker and an on/off switch (not shown), all other Spooky Bug components are mounted on a printed circuit board (p.c.b.). This board is available from the *EPE PCB Service*, code 409.

The component layout, full-size copper foil master and four lead-off wires to off-board components are shown in Fig.2. The on/off switch goes in the battery positive lead. Rectangular l.e.d.s were used for the eyes in the prototype, slanting these slightly to give a demonical expression.

The circuit diagram shows an 8Ω speaker with a 100Ω resistor (R8) in series with it. You can try reducing the resistor value to obtain a louder sound, though this may cause feedback troubles and prevent the circuit from working properly.

In tests, it was found that the arrangement shown gave a sound that is plenty loud enough.

COMPONENTS

Approx. Cost Guidance Only **£10** excl. case, batt. & speaker

Resistors

R1, R6	330k (2 off)
R2	150Ω
R3	68k
R4	470k
R5	15k
R7	100k
R8	100Ω (see text)
R9	330Ω

All 0·25W, 5% carbon film or better.

Potentiometer

VR1	100k min. horiz. preset

Capacitors

C1	4μ7 tantalum bead or radial elect. 16V
C2	10μ tantalum bead or radial elect. 16V
C3	10n ceramic disc

Semiconductors

D1	SFH2030 photodiode, or similar
D2, D3	red l.e.d. rectangular (see text) (2 off)
D4, D5, D6	1N4148 signal diode (3 off)
IC1	TL081 f.e.t. op.amp, or similar
IC2	7555 CMOS low power timer
IC3	4046 phase-lock loop
TR1	BUZ71 *n*-channel power MOSFET, or similar
TR2	BC639 *npn* medium power transistor

Miscellaneous

LS1	min. loudspeaker (see text)

Printed circuit board, available from the *EPE PCB Service*, code 409; 1mm solder terminal pins (4 off); 8-pin d.i.l. socket (2 off); 16-pin d.i.l. socket; PP3 battery and clip; materials for making model (see text); connecting wire; solder etc.

See SHOP TALK page

If you have a spare 64Ω speaker, perhaps cannibalised from a defunct radio set, you could use this instead. A suitable value for R8 would be 33Ω.

The position of the battery and speaker depend on how you have constructed the model. Instead of mounting the battery in or on the model, use a small box to hold the battery and to act as a plinth on which to stand the model. To adjust VR1, place the bug in a moderately dark place and turn VR1 until the bug just becomes inactive.

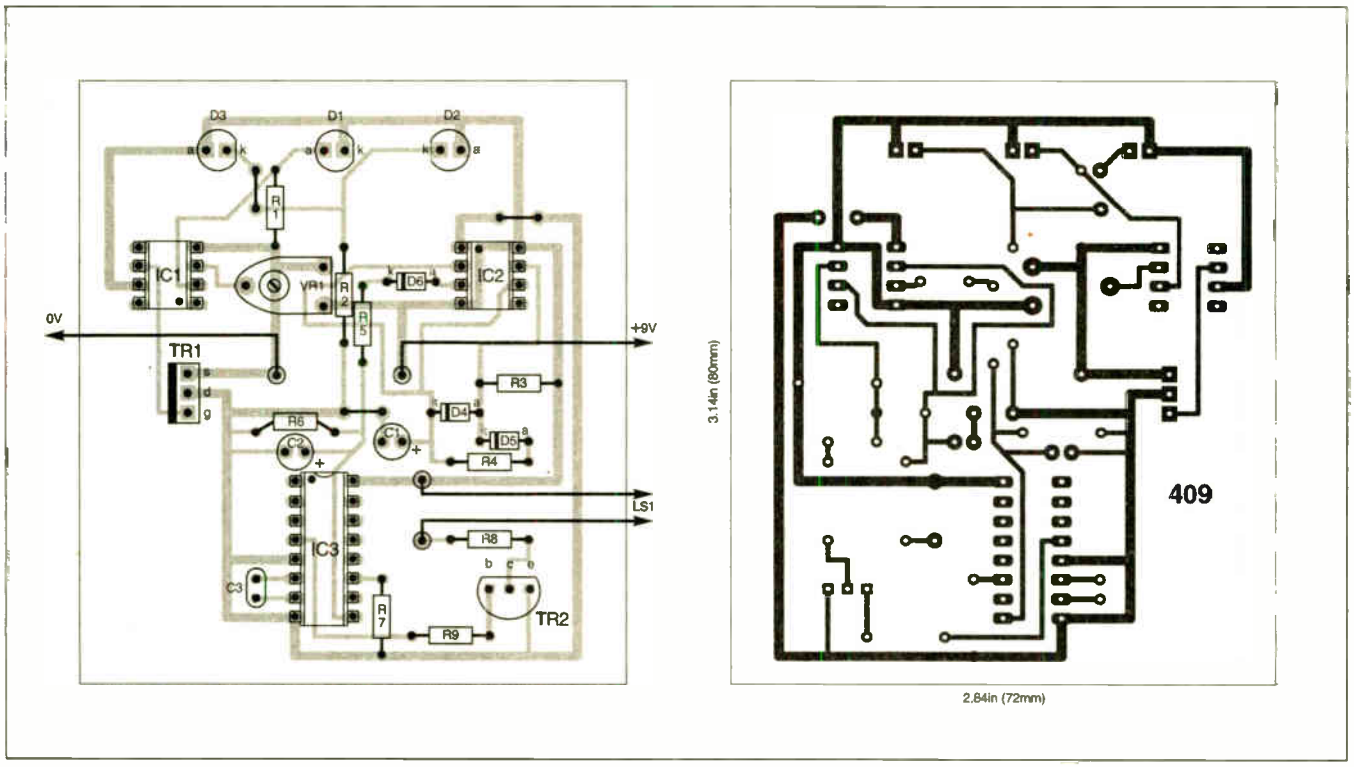

Fig.2. Spooky Bug printed circuit board component layout, wiring and full-size copper foil master. Note an on/off switch should be inserted in the battery positive lead.

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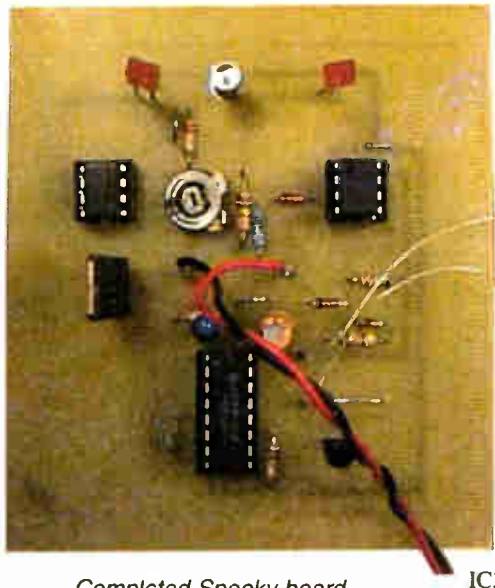

Completed Spooky board.

Any further decrease in light intensity turns it on.

TESTING

Following thorough checking, the completed circuit is easily tested in stages. Insert IC1 in its socket (right way round!) and apply power. The l.e.d.s should come on when light sensor D1 is shaded. The light level at which they switch on is adjustable by altering preset VR1. If this section of the circuit fails to work, check the polarity of diodes D1, D2 and D3, noting that D2 has its anode on the right.

Next insert IC2 (other way round to IC1) and apply power, then shade D1 to switch on TR1 and so apply power to IC2. Check the rise and fall of the output from IC2 pin 3. Finally, insert IC3. A wailing sound from the speaker should be heard when you shade D1.

The real fun begins when you dress up the circuit to look like a bug! □

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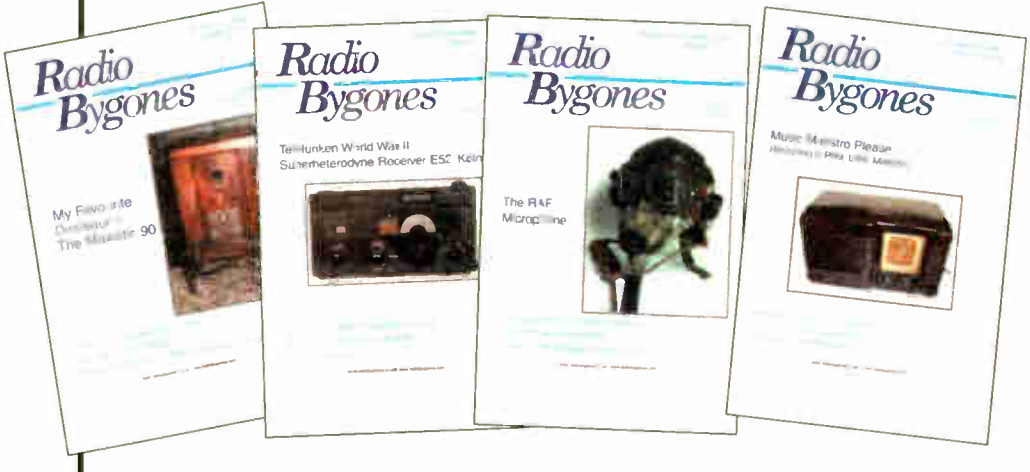

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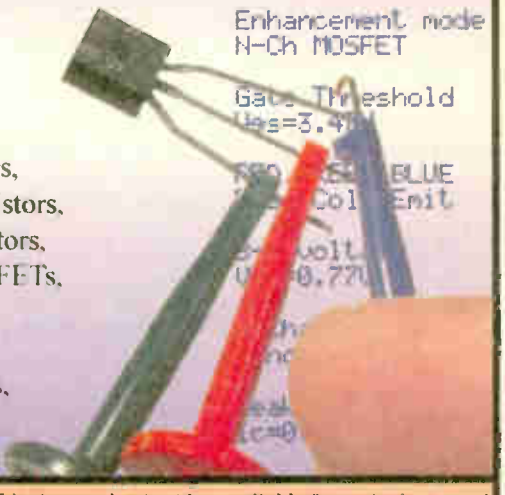

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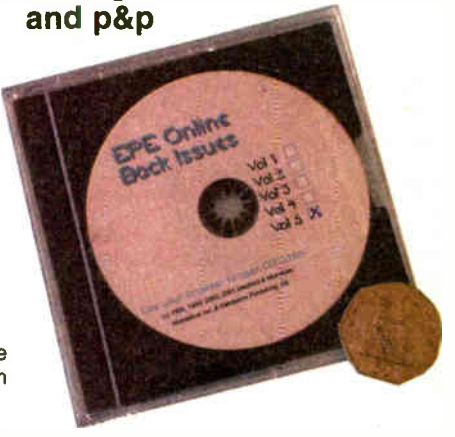

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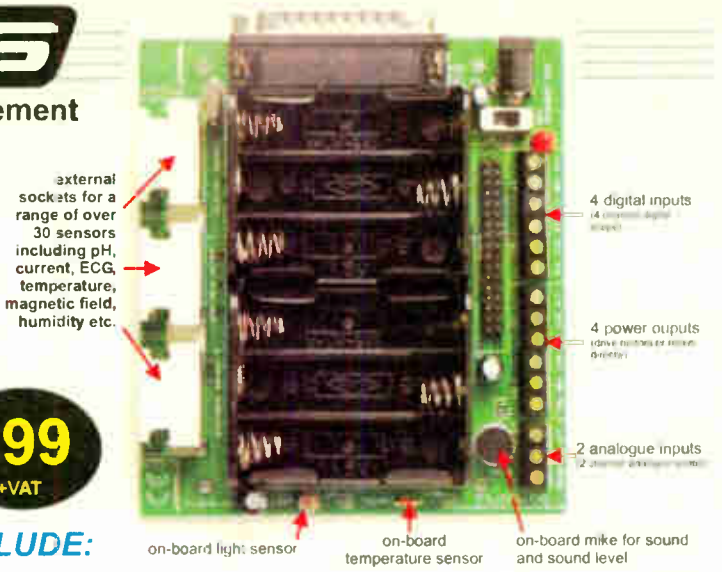

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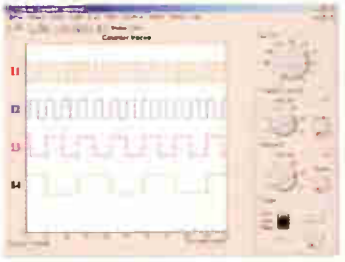

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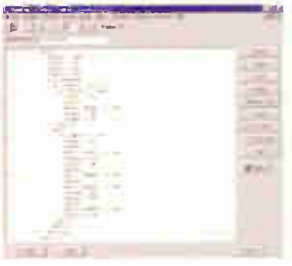

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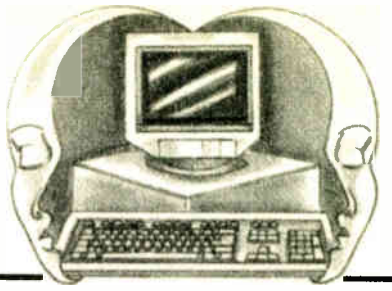
INTERFACE



Robert Penfold

INTERFACING VISUAL BASIC WITH THE NEW INPOUT32.DLL

INTERFACING via the PC parallel and serial ports port using **Inpout32.dll** has been covered in previous *Interface* articles, and in conjunction with Visual BASIC it represents what is probably the easiest means of using a PC with your own circuits. As regular readers will be aware, it does have a major flaw in that this add-on does not work with Windows NT4, 2000 or XP.

With Windows ME to be phased out in due course and many PC users having already changed to Windows XP, this is an increasing important failing. Fortunately, there is now an easy solution to the problem.

Chat Line

I am grateful to John Becker (*Tech. Ed*) for pointing out an item in the *EPE Chat Zone* that gives the source of a new version of **Inpout32.dll** that will work with any version of Windows from 95 through to XP. In the original item Ian Stedman explained that it could be used to make the *EPE PIC Toolkit TK3* run under Windows NT/2000/XP, but the new version seems to have the same effect with any program designed for use with the original **Inpout32.dll.**

This means that these earlier programs should now work with Windows NT/2000/XP provided the new version of **Inpout32.dll** is used. It also means that users of these operating systems can now directly access the serial and parallel ports under Visual BASIC with a minimum of fuss.

Recap

The original **Inpout32.dll** was written by Jan Axelson to accompany her books on interfacing PCs, but she kindly made it available as freeware. It works fine with Windows 95, 98, and ME, but not with Windows NT, etc., which do not permit programs to directly access ports. The new version is also freeware, and it is available from the Logix4U website: **http://www.logix4u.net/inpout32.htm**

This version accesses the ports via the operating system's approved channels, and it will therefore work with any 32-bit version of Windows. Although it operates in a rather different fashion, it is used in exactly the same way as the original.

The purpose of both versions is to add the Inp and Out commands to Visual BASIC. These commands are present in QBASIC and some other BASIC languages, but have never been a feature of Visual BASIC. They enable bytes of data to be written to or read from a specified port.

Using **Inpout32.dll** seems to have given some readers a few problems, so it is perhaps a good idea to go over the basics once again. It is very easy to use, but Visual BASIC does need a certain amount of help in order to find and utilise any **.dll** file.

It is simplicity itself to use if you are just running an *EPE* program that requires this file. Provided **Inpout32.dll** is in the same directory as the executable program file (the ***.exe** file), the program should work properly. The alternative is to place it in the **C:\windows\system** folder, where there will probably be a few thousand other **.dll** files.

The advantage of this method is that you can use the same copy of the file with several programs. Regardless of the location of the program, Windows will look in the system folder for **Inpout32.dll** and use the copy it finds in that location.

A Bit More To Do

There is a bit more to do if you wish to write your own programs that utilise **Inpout32.dll**. This file must be available to Visual BASIC, and the easiest way of achieving this is to place it in the **C:\windows\system** folder. Next you have to give Visual BASIC the information it needs in order to use the added commands provided by the **.dll** file. There is a file with a **.BAS** extension that is provided with both versions of **Inpout32.dll**, and this must be loaded into Visual BASIC.

Start Visual BASIC in the normal way and opt to produce a standard EXE program file. Once the program has loaded, choose Add File from the Project menu. This is correct for Visual BASIC 6, but the Add File command might be under a different menu with other versions.

The usual file browser will appear, and this is used to locate and load the BAS file, which will be called something like **INPOUT32.BAS** or **INPOUTV4.BAS**. The Inp and Out commands are then ready for use, and they operate in the same way as the QBASIC equivalents. Note that the BAS file must be loaded each time that you start work on a program that uses the Inp and Out instructions.

Proof of the Pudding

It is a good idea to try a simple test program to ensure that everything is working properly. For those new to **Inpout32.dll** a test program or two can also serve to demonstrate how the two new commands are used.

Enlarge the form slightly and equip it with a label, a timer, and a horizontal scrollbar. Select the timer component and using the Properties window set its interval at 50 milliseconds.

Next, select the scrollbar and use the Properties window to set its maximum value at 255. The minimum value must be 0, but it should have this setting by default. Make the label quite large and set a large font size (about 48 or 72 points).

The idea of the program is to output to a printer port the values produced via the scrollbar. In order to do this it is necessary to know the base address of the printer port.

These days most PCs only have one printer port, and it is usually at a base address of &H378. However, a few PCs use &H3BC as the base address. If there is a second printer port it is usually at &H238, but it will be at &H378 if the first port has &H3BC as its base address.

The certain way of determining the base address of a port is to go into the Windows Control Panel, double-click the System icon, and then launch Device Manager. Expand the Ports (COM and LPT) section, select the appropriate port, and then operate the Properties button. In Windows XP either double-click the entry for the appropriate port or select it and then choose Properties from the Action menu.

In the Properties window operate the Resources tab, and the address range of the port will then be shown in the main

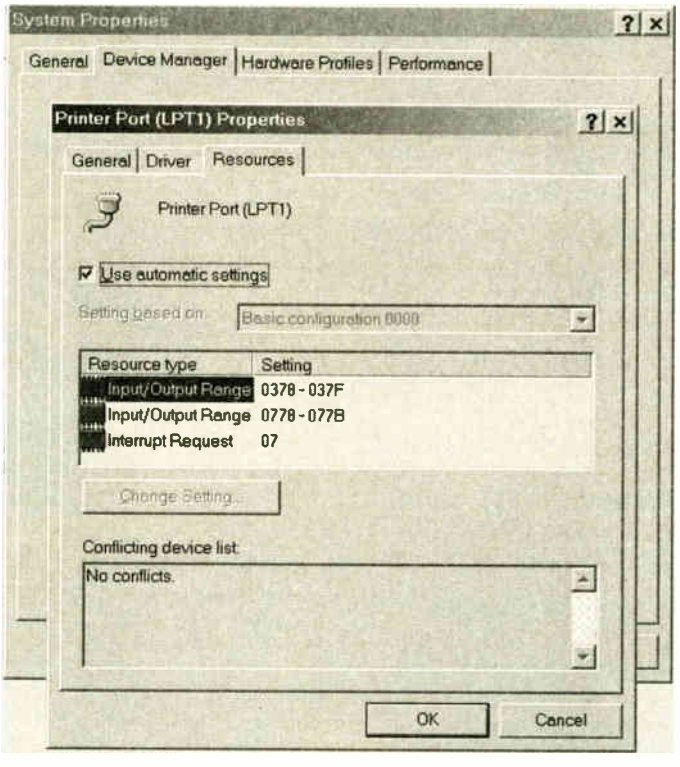


Fig. 1. Device Manager can be used to locate port addresses.

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panel of the window (see Fig.1). It is the first figure in the entry at the top that provides the base address, and note that the values are in hexadecimal.

It's a Scroll

In order to get the program to work it is merely necessary to double-click on the timer component to bring up the Code window, and then add these two lines of code into the timer's subroutine:

```
Out &H378, HScroll1.Value
Label1.Caption = HScroll1.Value
```

The first line outputs the current value of the scrollbar to the port at address &H378, which is the base address for printer port 1 on my PC. This address is used to write data to the port, so setting a value using the scrollbar should result in the corresponding bit pattern appearing on the data outputs. Of course, if the printer port has a different base address in your PC, this address must be used in the Out instruction.

The second line of code simply writes the scrollbar's value to the label. This enables the scrollbar to be adjusted to produce the required value. The program in operation is shown in Fig.2.

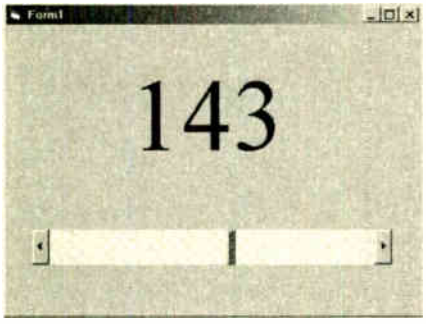

Fig.2. The output program in operation. It worked perfectly when tried with Windows XP.

When using the original version of **Inpout32.dll** it was not unusual for programs to give the outward appearance of normality. However, there could be error messages or other problems, but more usually the program ran and looked plausible, but did not actually read or write any data. Using the new **Inpout32.dll** the program ran properly under Windows XP with the correct bit patterns appearing on the printer port's eight data lines.

Inputting

Inputting data from a port is equally straightforward. The same basic setup can be used for a program to read a port, but the scrollbar is not required. Double-click on the form and add this line of code into its subroutine:

```
Out &H37A, 32
```

This will write a value of 32 to a control register of the printer port, which sets its data lines to operate as inputs. The input mode requires a bidirectional printer port, but any PC built within the last seven years or so should have a suitable port.

Return to the form and double-click on the timer component. It is assumed here that the printer port's base address is &H378. The control register is at &H27A if the base address is &H278, or at &H3BE if the base address is &H3BC.

Next add this line of code to the timer's subroutine:

```
Label1.Caption = Inp(&H378)
```

The Inp instruction reads the data lines and the returned value is used as the caption for the label. Like QBASIC, Visual BASIC does not require any string conversions in order to get the returned value to display properly. The returned value will be automatically converted to the corresponding character string and displayed properly on the label.

The port reading program in operation under Windows XP is shown in Fig.3. Floating data lines are normally taken high by internal pull-up resistors, so a value of 255 will probably be returned if no input signals are applied to the port. In Fig.3 the D4 data line has been connected to ground and the display is reading the correct value of 239.

Easy VB

The original **Inpout32.dll** was a really excellent add-on for PC interfacing, and with its Windows XP compatibility the new version is even better. There are numerous add-ons to permit Visual BASIC to communicate with the outside world, but most of them are difficult to use, or expensive, or unreliable, or all three! Using **Inpout.32.dll** with a project tends to bring in enquiries from readers having difficulties, but Visual BASIC add-ons do not come any simpler than this one.

Remember that any program requiring this file can only work if the file is available to the system. If you download an *EPE* program that uses **Inpout32.dll**, make sure that you also download this **.dll** file. Also make sure that it is available to the system.

Place it in the same folder as the program file or move it into the Windows System folder. If you wish to produce your own Visual BASIC programs using the Inp and Out commands, copy **Inpout32.dll** to the Windows System folder.

Do not forget to load the **Inpout32.BAS** file into Visual BASIC before you start using the Inp and Out commands. This seems to be a common error, but Visual BASIC will definitely not recognise the Inp and Out instructions until the file with the BAS extension has been loaded, even if **Inpout32.dll** is in the System folder.

The BAS file must be loaded each time a program that uses **Inpout32.dll** is started. There is no need to load it when you return to one of these programs, as it should be automatically loaded along with the rest of the project. Do not move or remove the BAS file, or Visual BASIC will not be able to find it and an error message will be produced. Remember to distribute **Inpout32.dll** with the programs that you produce. The programs will not function without it.

Fig.3. Operating under Windows XP, the port reading program also worked perfectly.

Using **Inpout32.dll** should be a doddle provided you stick to these simple guidelines. Although it has been used here to access a printer port, it can also be used for directly accessing the built-in serial ports. In fact any port can be accessed, but as few PCs have an ISA expansion port these days, the built-in serial and parallel ports are probably the only ones that can be usefully accessed.

Accessing the serial port using the new **Inpout32.dll** will be discussed in a future *Interface* article.

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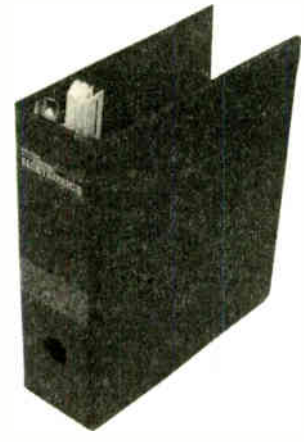

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Constructional Project

PRACTICAL RADIO CIRCUITS

RAYMOND HAIGH

Part 5: Super-regeneration: A highly sensitive receiving system

Circuits for the set builder and experimenter

THIS month we consider the technique known as super-regeneration. No other radio circuit, it is claimed, produces more gain from a single valve or transistor.

Readers who have access to a Frequency Counter may wish to use it as a digital readout dial for the Regenerative Receivers covered in Parts Three and Four, and the Direct Conversion receiver to be described later in the series. Details of a simple buffer amplifier for linking receiver to counter are given this month.

Before we tune-in to the subject of super-regeneration, readers may care to build the simple low-cost Crystal Marker calibration aid shown opposite. This is aimed particularly at last month's amateur bands receiver.

SUPER-REGENERATION

Regeneration, whereby positive feedback from an amplifier is used to cancel out losses in a tuned circuit and increase its *Q* factor, was covered at length in Part Three. For the greatest increase in sensitivity and selectivity, the feedback has to be sufficient to almost completely overcome the losses. A little more and the circuit oscillates and becomes unsuitable for processing signals (other than single-sideband transmissions).

In practice it is impossible to set and hold a Q-multiplier on the very threshold of oscillation when a signal is being received, and the ultimate sensitivity which regeneration can offer is never fully realised.

The super-regenerative receiver overcomes this by imposing an oscillating voltage on the Q-multiplier to repeatedly sweep it across the critical threshold. This "quench oscillation", as it is called, can be provided by a separate stage or the multiplier itself can be made to perform a dual function.

Quenching must be at a supersonic frequency or it will be heard as a tone in the headphones or loudspeaker. In practice, the signal frequency is usually more than 1000 times the quench frequency, and this confines the circuit to the radio spectrum above 20MHz.

SENSITIVITY

Oscillations in the super-regenerator build up from a signal voltage developed across the tuned circuit. In the absence of an external signal, the random movement of electrons, or "noise", triggers the action.

During the build-up, the amplitude of the oscillations can exceed that of the signal by as much as a million times. These phenomena give rise to the enormous sensitivity of the circuit and the loud hiss emitted by the speaker under no-signal conditions.

It is important that Q-multiplier oscillations die away during quench cycles or they will build up again from fading oscillations instead of the signal. Some means of controlling quench amplitude must, therefore, be provided.

QUENCHING

Signal frequency oscillations can be "quenched" before they reach their maximum amplitude. The peak amplitude of the oscillations is then proportional to signal voltage and the receiver is said to operate in the *linear* mode.

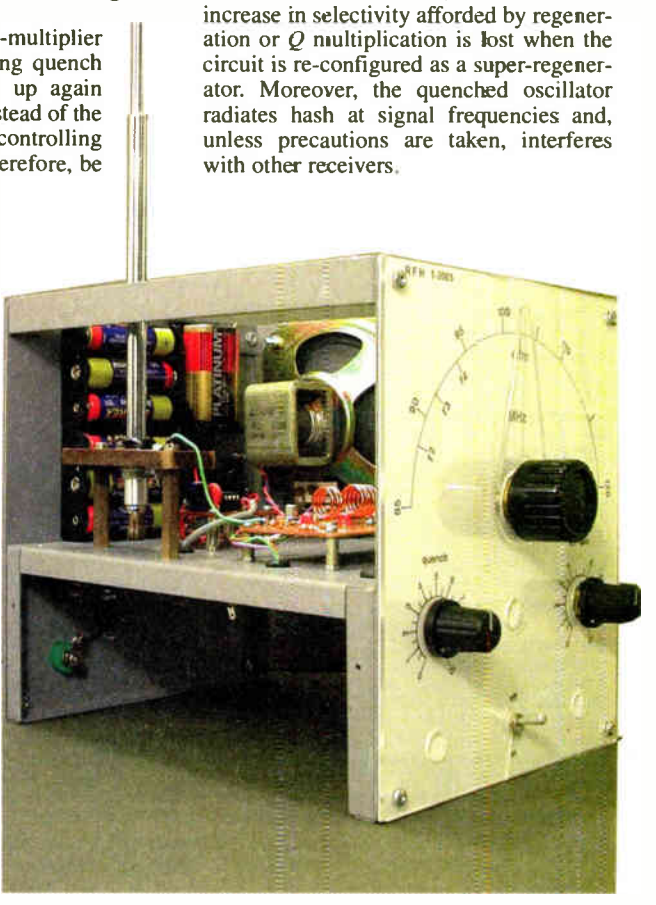
If the quenching action is such that the oscillations reach, or even momentarily rest at, their maximum value, the circuit is said to be in *logarithmic* mode. Signals across the tuned circuit then speed up the rate at which the oscillations rise to, and decay from, their maximum value.

Operation in logarithmic mode causes Q-multiplier current drain to follow the signal modulation. Because of this, the circuit combines detection with signal amplification, delivering an audio output that has a logarithmic relationship to the applied signal.

This condition introduces noticeable distortion on a.m. (amplitude modulation), but the drawback is not so pronounced with f.m. (frequency modulation). Logarithmic operation imposes a limiting action on noise spikes and strong signals, and the inherent a.g.c. (automatic gain control) is very apparent.

In the case of separately quenched receivers, they can be made to operate in either mode. Self-quenching receivers, which are, in effect, squegging oscillators, operate logarithmically.

Whatever the mode, the enormous increase in selectivity afforded by regeneration or *Q* multiplication is lost when the circuit is re-configured as a super-regenerator. Moreover, the quenched oscillator radiates hash at signal frequencies and, unless precautions are taken, interferes with other receivers.



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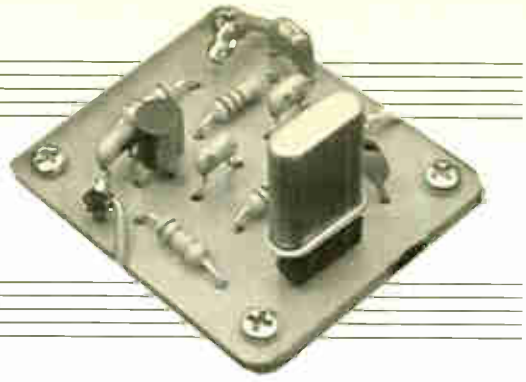
CRYSTAL MARKER



Calibration aid

The amateur bands receiver described last month presents particular calibration problems. Signals can be weak and difficult to resolve; sometimes the bands are dead.

Constructors who do not have access to a calibrated receiver with a b.f.o. need some means of locating them. This can take the form of a simple and inexpensive crystal marker and. as the bands have a harmonic relationship, one crystal will pinpoint them all.

A circuit diagram for a simple amateur bands Crystal Marker is given in Fig.5.1. where transistor TR1 and crystal X1 are configured in Clapp's version of a Colpitt's oscillator. The crystal acts as a tuned circuit with high inductance, very low capacitance, extremely high *Q*, and exceptional stability.

Feedback from TR1 emitter is applied to the capacitance tap provided by C2 and C3. Crystal loading capacitor C1 is usually a 5pF to 60pF variable used to set the crystal frequency to its stated value against a known standard. The simpler circuit given here is accurate enough for our purposes.

Base bias is fixed by resistors R1 and R2. and TR1 emitter bias is developed across R4. Collector load resistor R3 must not be greater than R4 or oscillation will be inhibited. The signal output is taken from TR1 collector, via capacitor C4. Capacitor C5 avoids the possibility of erratic operation with ageing batteries.

The marker crystal used in this circuit is a 3·579545MHz component used in the colour sub-carrier circuitry of American TV receivers. It is widely available at low cost. Its fundamental lies within the 80 metre band. the second harmonic within the 40 metre band (just outside the UK allocation), and the third harmonic within the 20 metre band.

IN USE

If the marker unit is placed very close to the receiver. the coil cores can be adjusted until the relevant harmonic beats with the oscillating *Q*-multiplier to produce an audible tone. Band allocations. marker frequencies and harmonic numbers were listed last month in Table 4.1.

This particular circuit will oscillate with 1MHz to 15MHz crystals, and units cut to convenient round-figure frequencies can be used to calibrate the general coverage receiver's shortwave ranges. A 1MHz crystal will inject signals at reasonably close intervals. It is easy to lose track of the higher harmonics. and an 8MHz or 10MHz crystal is needed to provide unambiguous markers at higher frequencies.

ASSEMBLY

The Crystal Marker unit is assembled on the printed circuit board illustrated in Fig.5.2, together with the p.c.b. foil master and wiring. This board is also available from the *EPE PCB Service*. code 415 (Marker). If it is to be used for general calibration purposes, a socket should be fitted so that the crystal can be changed easily.

The lead spacing on common HC-49/U and the lower profile U4 crystals is 4·88mm. This spans three pins on an i.c. holder, from which a socket can be cut.

COMPONENTS

CRYSTAL MARKER

Resistors

R1	100k
R2	120k
R3	680Ω
R4	1k2

All 0·25W 5% carbon film

See SHOP TALK page

Capacitors

C1	27p polystyrene or ceramic "low k"
C2, C3	220p polystyrene or ceramic "low k" (2 off)
C4	10p disc ceramic
C5	100n disc ceramic

Semiconductors

TR1	BC549C *npn* silicon transistor
X1	3·579545MHz crystal (American TV colour sub-carrier)

Miscellaneous

S1	s.p.s.t. toggle switch

Printed circuit board available from the *EPE PCB Service*, code 415 (Crystal); plastic case, size 111mm x 57mm x 22mm approx.; 4mm terminal/socket (2 off); 2-pin crystal holder, cut from i.c. socket (3-pins, see text); 9V battery and holder; connecting wire; solder pins; solder etc.

Approx. Cost Guidance Only **£9** ***excl. case & batt.***

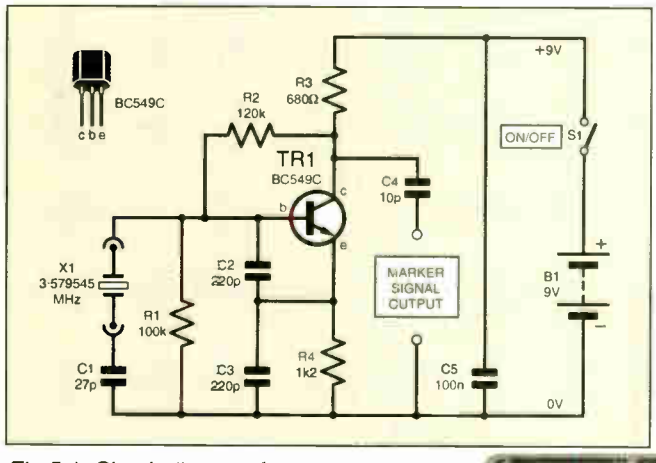


Fig.5.1. Circuit diagram for an amateur bands Crystal Marker.

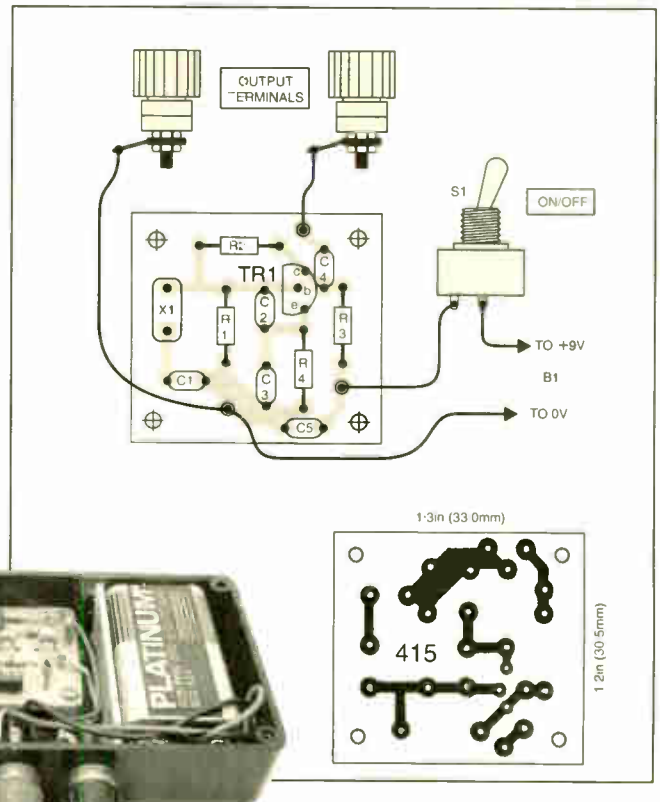


Fig.5.2 (right). Crystal Marker printed circuit board component layout, interwiring and full-size copper foil master. Also shown is the completed prototype; note the spare crystal compartment.

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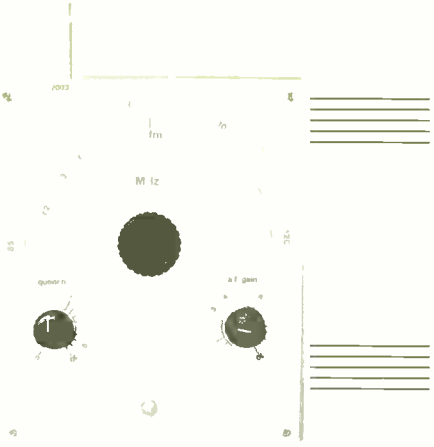
SUPER-REGENERATIVE RECEIVER



A low-cost super sensitive three-band (85MHz to 150MHz) regenerative receiver

PRACTICAL CIRCUIT

A practical, semiconductor interpretation of a Super-Regenerative V.H.F. Receiver is shown in the circuit diagram of Fig.5.3. Originality is not claimed: the design is typical of many produced during the late sixties and seventies.

Grounded base signal amplifier TR1 isolates the regenerative detector TR2 from the aerial circuit. The audio preamplifier stage TR3 boosts the demodulated signal so that a decent loudspeaker output can be delivered by the simple audio power amplifier described in Part Two.

Emitter resistor R1 and bias resistors R2 and R3 fix the operating conditions of transiistor TR1. Incoming signals from the aerial are applied to TR1 emitter via capacitor C1, and coupling coil L1 acts as the collector load. The stage is decoupled from the supply by R4 and C3, and C2 grounds TR1 base (b) at radio frequencies.

Input impedance is of the order of 50 ohms: a reasonable match to coaxial aerial cables. Quite short whip aerials are a quarter wavelength long at v.h.f., and they, too, can be adjusted to present a decent match.

The output from the r.f. stage is lightly coupled by L1 to the tuned circuit formed by coil L2 and tuning capacitor VC1. Increasing coupling to maximize signal transfer is likely to result in the erratic operation of the detector.

REGEN. OSCILLATOR

Super-regenerative detector, TR2, is configured as a Colpitts oscillator. Colpitt's capacitor tapping is a little obscure with this v.h.f. version of his circuit. The internal gate-source capacitance of TR2 forms one element and trimmer capacitor VC2 the other. The trimmer presets the feedback that makes the transistor oscillate at the signal frequency.

The source (s) of TR2 is held at r.f. potential by r.f. choke L3 and C5 is a d.c. blocking capacitor. Quenching action is adjusted by potentiometer VR1, the range of control being confined to the critical region by resistor R6. Supply line decoupling is provided by R5 and C4, and this capacitor also eliminates potentiometer noise.

The tuning capacitor VC1 is one of the 5pF to 25pF f.m. gangs of a polyvaricon. Stray capacitances with this simple receiver are comparatively low, and the swing is consequently too great for the required tuning range (88MHz to 108MHz). Moreover, if the tuning capacitance is too high, the super-regenerator will behave erratically or not function at all. Accordingly, fixed capacitor C6 reduces the maximum capacitance to suit the tuning range, and alternative values for different bands are given in Fig.5.5. Winding and construction details of the coils, including r.f. choke L3, are also depicted in Fig.5.5.

AUDIO OUTPUT

An audio signal is developed across TR2 source resistor R7; and C7, R8 and C10 remove residual radio and quench frequencies. The signal is then applied to the base (b) of audio preamplifier TR3 by d.c. blocking capacitor C9.

The preamplifier stage is biased by R9 and emitter resistor R12. Resistor R11 forms TR3's collector (c) load which is shunted by capacitor C8 in order to attenuate the higher audio frequencies. Decoupling is effected by R10 and C14. Blocking capacitor C15 couples the output to Volume control potentiometer VR2.

Audio and radio frequency bypass capacitors, C12 and C13, ensure the

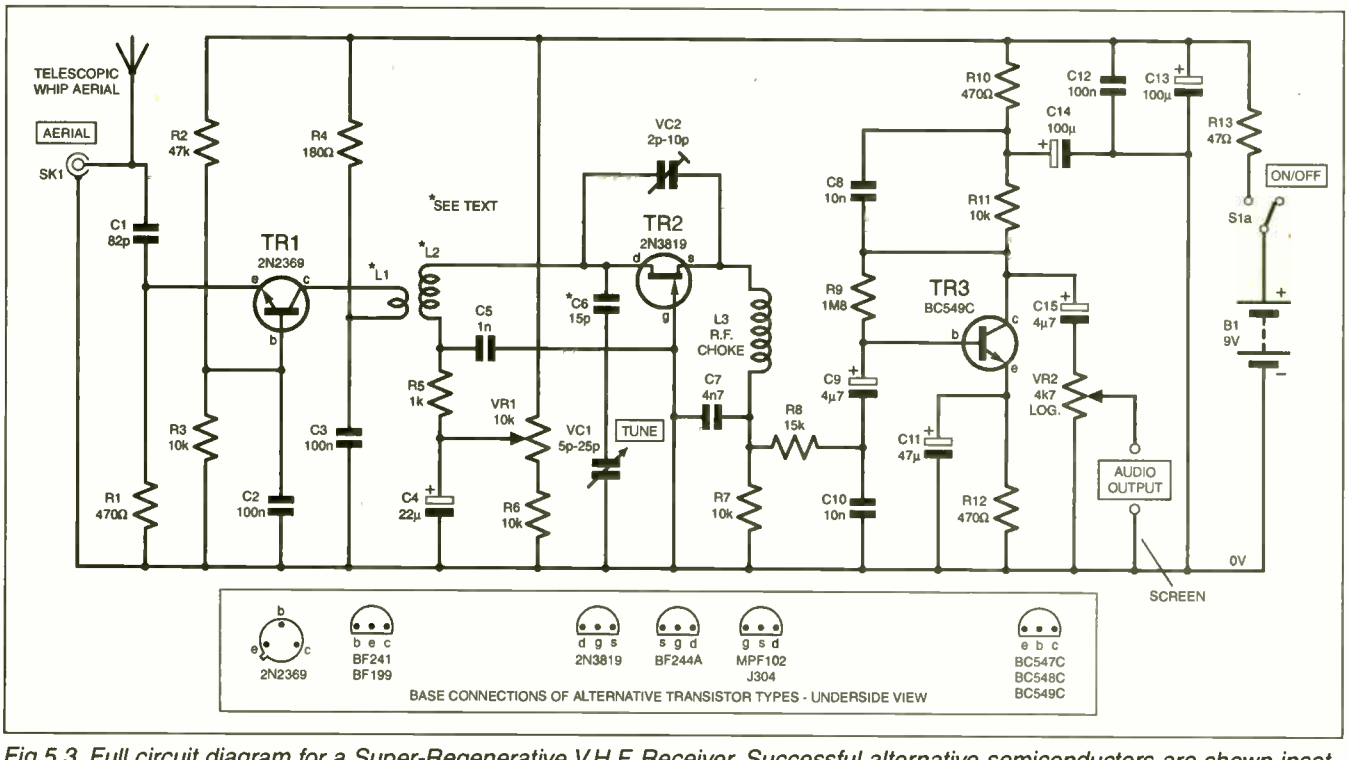


Fig.5.3. Full circuit diagram for a Super-Regenerative V.H.F. Receiver. Successful alternative semiconductors are shown inset. The other half of switch S1(b) controls the power supply to the simple Power Amp module from Part 2.

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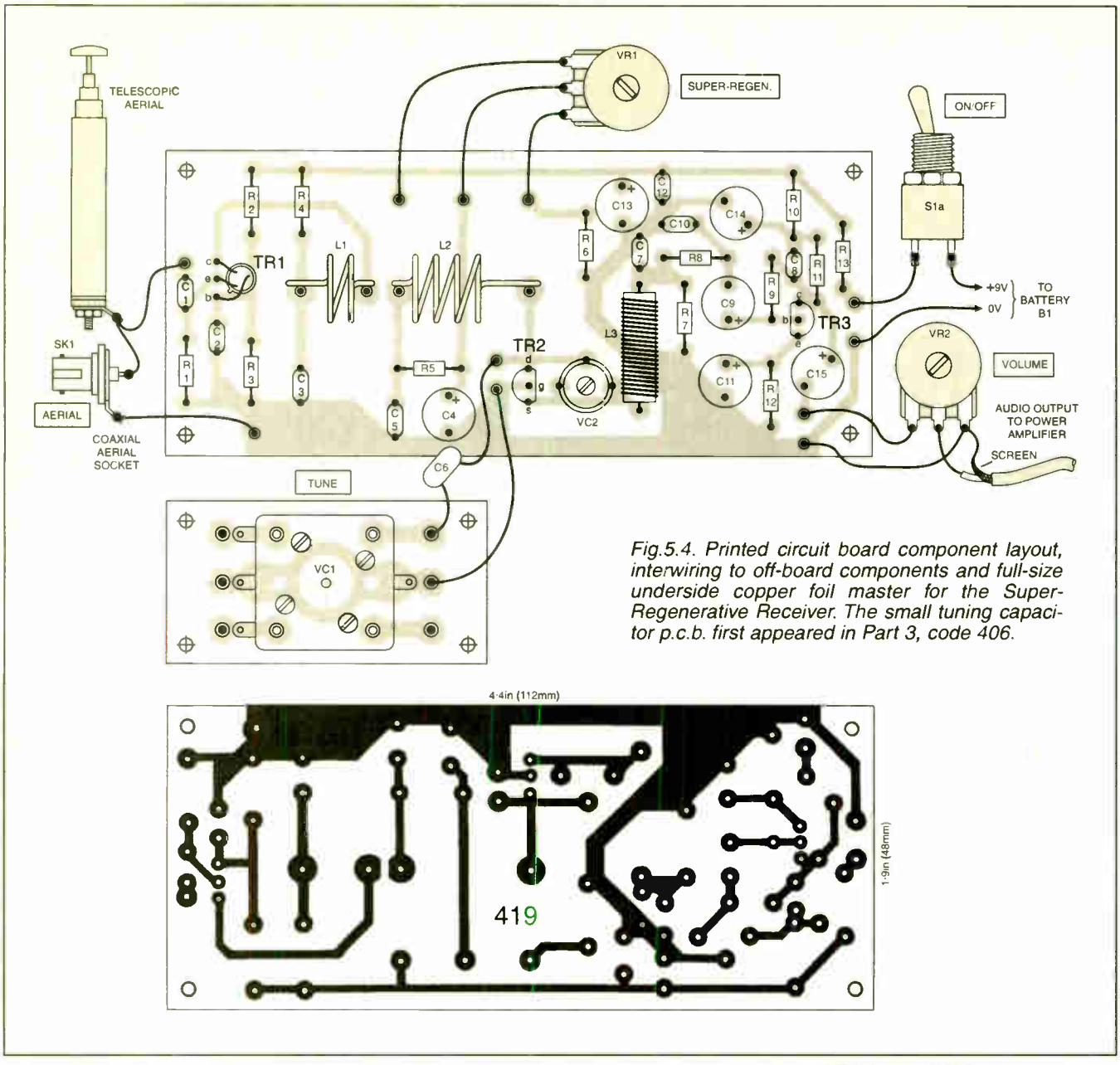


Fig.5.4. Printed circuit board component layout, interwiring to off-board components and full-size underside copper foil master for the Super-Regenerative Receiver. The small tuning capacitor p.c.b. first appeared in Part 3, code 406.

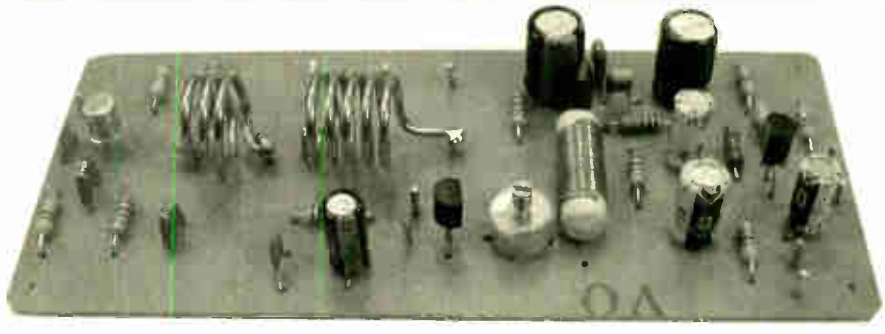
stability of the circuit, and resistor R13 isolates the battery and its supply leads at radio frequencies (signal pick-up by off-board wiring can make simple v.h.f. receivers behave erratically). The other half of the On/Off switch S1 (S1b) controls the supply to the audio power amplifier module, see Part Two.

As with the Regenerative Radio (Part 3), *separate* battery supplies for the receiver and audio power amplifier are strongly recommended. Even low power audio amplifiers can cause significant voltage swings on the supply rail and this will disturb the operation of receivers of this kind, even when decoupling is generous.

SEMICONDUCTORS

Transistor types are not critical, and base connections for a number of alternative devices are included in Fig.5.3. The r.f. stage transistor, TR1, should have a high f_T, preferably not less than 500MHz.

Of all the devices tested in the TR2 position, only the 2N3819 would oscillate up to 150MHz, and available samples of J310 did *not* work well in this circuit. The suggested alternative transistors will, however, function on the v.h.f. f.m. band. Any small-signal *npn* transistor should work in the TR3 position, but a low-noise device with an h_{fe} of 500 or more is to be preferred.



Completed Super-Regen. circuit board.

CONSTRUCTION

All of the components, with the exception of tuning capacitor VC1, swing limiting capacitor C6 and potentiometers VR1 and VR2, are mounted on a single-sided printed circuit board. The topside component layout, full-size copper foil master and the off-board wiring details are illustrated in Fig.5.4. This board is available from the *EPE PCB Service*, code 419, together with the small variable tuning capacitor p.c.b., code 406.

Begin construction by inserting solder pins at the lead-out and coil mounting points, then solder the resistors and capacitors in position. Mount the semiconductors last. The leads of TR1 and TR2 should be kept quite short: just leave sufficient to attach a miniature crocodile clip to act as a heat shunt during soldering.

World Radio History

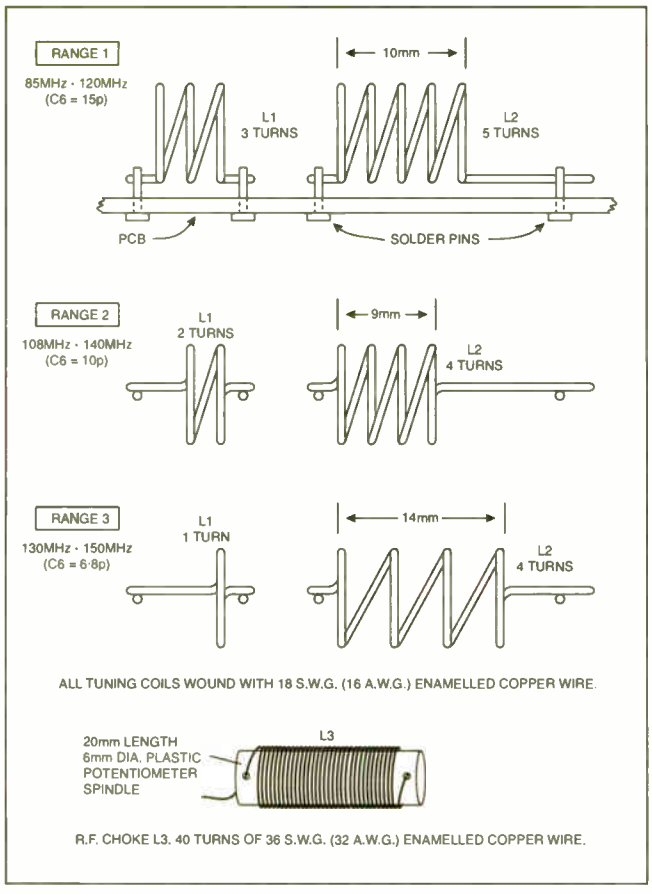
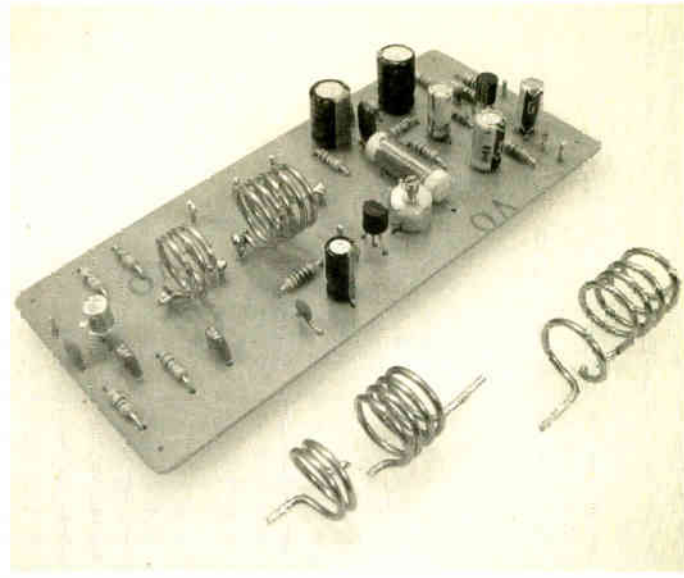


Fig.5.5. Individual coils and r.f. choke details for the three tuning ranges. Tuning coils L1 and L2 both have a 10mm internal diameter. Wind around the shank of a 10mm drill



Completed receiver board with alternative bands coils.

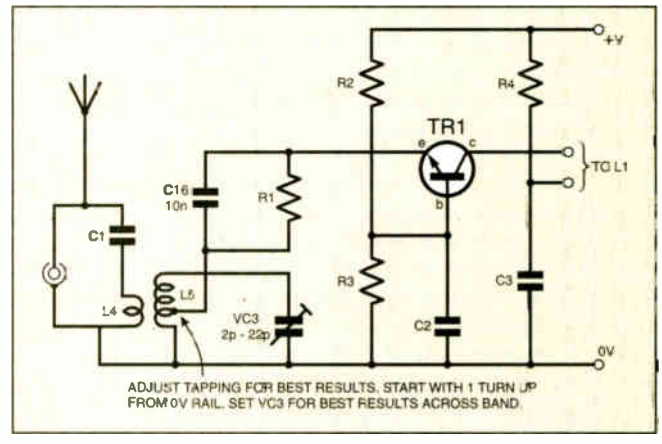


Fig.5.6. Circuit diagram for a simple front-end modification for tuning the input to the receiver. Note that L4 and L5 are identical to L1 and L2.

COILS

The simple coils are hand-wound and full details are given in Fig.5.5. Coupling and tuning coils, L1 and L2, are formed by winding them around the shank of a 10mm drill bit. Wind the turns on tightly, and bend the ends as shown in the diagram, before withdrawing the drill from the coil.

Radio frequency choke L3 is wound on a short length of 6mm diameter plastic potentiometer spindle (you could use a piece of wood dowelling). Holes, drilled close to the ends, secure the turns of wire.

Scrape the enamel from the wire until bright metal is exposed, then thoroughly "solder tin" the ends of the windings. Failure to make a perfect connection will prevent the receiver functioning at these frequencies.

Coupling and tuning coils are mounted on solder pins. The short, horizontal extension to the tuned winding permits the coil to be squeezed or extended to adjust its inductance and frequency coverage.

Quite small changes in coil dimensions, wiring and components have a significant effect on coverage at these frequencies. If, however, the receiver is constructed as described, the coils depicted in Fig.5.5. should be within gentle "squeezing and pulling" range of the specified bands.

The Range 1 coils, which span the v.h.f. f.m. band, should be soldered in place first. Broadcast signals on these frequencies are strong and reliable, and this is of great assistance during the setting-up process. The Range 2 coils cover the v.h.f. Aircraft Band, and Range 3 the Two Metre Amateur band.

TESTING

Check the printed circuit board for poor soldered joints and bridged tracks. Check the semiconductors and electrolytic capacitors are correctly orientated. If all is in order, the board can be tested on the workbench before being mounted on a chassis or in an enclosure.

Connect variable capacitor VC1 to the receiver p.c.b. using the leads of capacitor C6 as the "hot" connection, and wire up controls VR1 and VR2, see Fig.5.4. Use screened audio/coaxial leads to connect the receiver to the audio power amplifier described in Part Two. Set the vanes of trimmer capacitor VC2 to quarter-mesh and connect the batteries, via S1. Current consumption should be in the region of 3mA.

Advance Quench control VR1 until a loud hiss is heard in the speaker, indicating that TR2 is oscillating and quenching or squegging. If the set seems dead, or if the hiss dies away at the maximum or minimum setting of the tuning capacitor, adjust trimmer VC2. The setting of VC2 is fairly critical and varies from transistor to transistor. It should, however, lie between 10 percent and 50 percent of full mesh.

Now connect a short length of flex (about 600mm or 24in.) to act as an aerial, and rotate tuning capacitor VC1 very slowly. Broadcast transmissions should be heard. When they have been identified, coil L2 can be compressed or expanded until the entire band is covered.

Despite the fairly broad selectivity of the super-regenerative detector, tuning at these frequencies is quite critical. Demodulation of the f.m. signal is achieved by tuning the receiver onto the carrier's side skirts. There are thus two, closely spaced, points on the dial where each station can be heard comparatively free from distortion.

After tuning the receiver, refine the adjustment of Quench control VR1: best results will usually be obtained with it set as low as possible.

ASSEMBLY

The printed circuit board and tuning capacitor must be rigidly mounted and located so that the wiring between the two is as short as possible. Indeed, the back of the capacitor should almost touch the receiver p.c.b. Tuning will be considerably eased if tuning capacitor VC1 is fitted with some form of slow-motion drive.

The accompanying photographs show the board and VC1 mounted on the metal chassis and front panel used to evaluate other receivers in the series. The arrangement works well and the printed circuit board is reasonably accessible for coil changing.

If an aluminium box is used as an enclosure, make sure it is big enough for the coupling and tuning coils to be spaced at least 25mm (1in.) from its metal sides.

World Radio History

COMPONENTS

Approx. Cost Guidance Only excl. case, batt, wire, slow-motion drive & whip aerial **£14**

SUPER-REGEN. RECEIVER

Resistors

R1, R10, R12	470Ω (3 off)
R2	47k
R3, R6, R7, R11	10k (4 off)
R4	180Ω
R5	1k
R8	15k
R9	1M8
R13	47Ω

All 0·25W 5% carbon film

See SHOP TALK page

Potentiometers

VR1	10k rotary carbon, lin.
VR2	4k7 rotary carbon, log.

Capacitors

C1	82p disc ceramic
C2, C3, C12	100n disc ceramic (3 off)
C4	22μ radial elect. 16V
C5	1n disc ceramic
C6 (Range 1)	15p ceramic "low k"
(Range 2)	10p ceramic "low k"
(Range 3)	6p8 ceramic "low k"
C7	4n7 polyester
C8, C10	10n disc ceramic (2 off)
C9, C15	4μ7 radial elect. 16V (2 off)
C11	47μ radial elect. 16V
C13, C14	100μ radial elect. 16V (2 off)
C16	10n disc ceramic (optional – see text)
VC1	5p to 25p polythene dielectric variable capacitor (see text)
VC2	2p to 10p min. film dielectric trimmer capacitor
VC3	2p to 25p min. film dielectric trimmer (optional – see text)

Semiconductors

TR1	2N2369 *npn* small signal, high frequency transistor
TR2	2N3819 *n*-channel field effect transistor
TR3	BC549C *npn* low power general purpose transistor

Miscellaneous

L1, L2, (L4, L5)	hand-wound with 18s.w.g. (16a.w.g.) enamelled copper wire – see text and Fig.5.5)
L3	r.f. choke, hand-wound with 36s.w.g. (32a.w.g.) – see Fig.5.5
S1	d.p.s.t. toggle switch
SK1	coaxial aerial socket

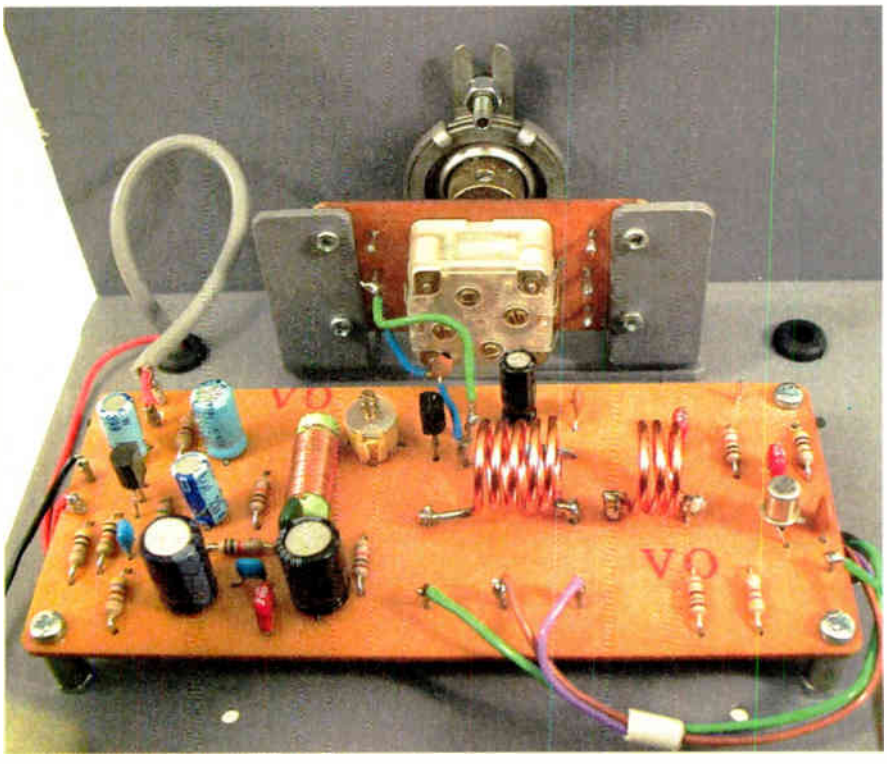
Printed circuit board available from the *EPE PCB Service*, code 419 (Super-Regen.) and optional 406 (T/Cap); 50g (2oz) reel 18s.w.g. (16a.w.g.) enamelled copper wire for coils; 50g (2oz) 36s.w.g. (32a.w.g.) enamelled copper wire for r.f. choke; 20mm approx. length, 6mm dia., plastic rod for r.f. choke former; one large and two small control knobs; telescopic whip aerial (optional); tagstrip (see text); batteryholder, with clips; slow-motion drive, spindle extender and/or coupler (optional – see text); multistrand connecting wire; solder pins; solder etc.

ALTERNATIVE TUNING

The electronic tuning (Varicap Tuner) system, described last month, can be used with this receiver; at least on the v.h.f. f.m. band. The fine-tuning version, incorporating a BB105 varicap diode, should be built, and the connections between the boards must be as short as possible.

The varicap diode bias supply can be taken from the battery used to power the receiver. When this arrangement is adopted, it is *imperative* that the audio power amplifier be connected to a separate battery.

Readers who wish to carry out serious experiments with super-regenerative receivers should fit an air-spaced variable capacitor with ceramic insulation. A Jackson C804 with a 3pF to 10pF swing would be suitable, and series capacitor C6 would only be required on Range 3. The slightly higher *Q* of the air-spaced component should help to maximize the operating frequency of the circuit.



Super-Regen. Receiver board mounted on the metal chassis, via stand-off pillars, and wired to the tuning capacitor.

R.F. STAGE TUNING

The grounded-base r.f. stage (TR1) isolates the super-regenerative detector from the aerial, helps to reduce the radiation of oscillator "hash", and makes the performance of the receiver more predictable. However, the simple arrangement adopted here provides little or no signal gain, and readers may wish to try an additional tuned circuit at the input in an attempt to improve performance.

The circuit diagram for a simple front-end modification is given in Fig.5.6. Aerial coupling coil L4 and the additional tuned winding L5 are duplicates of L1 and L2. A 2pF to 22pF trimmer capacitor, VC3, tunes L5 to the centre of the band.

Emitter resistor R1 is connected to the 0V rail via a tapping on L5. One turn above the 0V rail is a good starting point, but the position which gives the best signal-to-noise ratio should be found by trial and error. The emitter resistor R1 must be bypassed by additional capacitor C16.

Increasing TR1's collector current may improve performance. To do this, connect resistors ranging in value from 100 kilohms to 22 kilohms in parallel with R2 (the lower the value the greater the current).

The additional coils and trimmer capacitor can be mounted on a short solder tagstrip, and L4 and L5 must be orientated at right angles to L1 and L2. If the

World Radio History

HISTORY

The discovery of super-regeneration is attributed to that great American radio pioneer, Howard H. Armstrong. In presenting his paper on the technique to the American Institute of Radio Engineers in 1922, he paid tribute to the earlier work of Turner and Bolitho. L. B. Turner had used critical biasing to hold a valve on the threshold of oscillation and make a signal-activated relay more sensitive. Bolitho patented a refinement of Turner's design in which the mechanical relay was replaced by a valve.

RCA purchased Armstrong's patents and various experimenters made attempts to apply the technique to medium wave reception which, by that time, had growing commercial importance in the USA. Designs usually incorporated a small frame aerial to overcome shortcomings in selectivity, and crude audio filtering to reduce the whistle from quenching oscillations.

For reasons already outlined in the main text, the circuit is unsuited to amplitude modulated broadcast reception, particularly on medium waves. Not surprisingly, therefore, the concept was not taken up by domestic receiver manufacturers, and ownership of the patent rights failed to produce much income for RCA (Radio Corporation of America).

During the twenties and thirties the circuit was used extensively by the police and emergency services. The Second World War saw the technique adopted for I.F.F (identification-friend-or-foe) responders. These devices received a radar pulse and responded, with a minimum of delay, by transmitting an identifying signal.

German air interception radar systems also relied upon the circuit. Perhaps the best known of these war-time applications was the American "walky-talky", in which the super-regenerative detector doubled as the transmitter valve.

The post-war years saw the establishment of high-quality frequency modulation broadcasting systems in Europe and America. In 1947, B. D. Loughlin developed a design for a double-triode (12AT7) super-regenerative f.m. tuner, one valve being used as a frequency changer, the other as the detector. Known as the "Fremodyne", the circuit was licensed by the American Hezeltine Electronics Corporation. Whilst the Fremodyne suffered all of the defects super-regenerators are prone to, it did have the advantages of simplicity and low cost.

At the present time, super-regeneration is still used for simple toy and model control receivers, car central locking and garage door opening systems.

modification causes instability, fix a metal screen between the tagstrip and the printed circuit board.

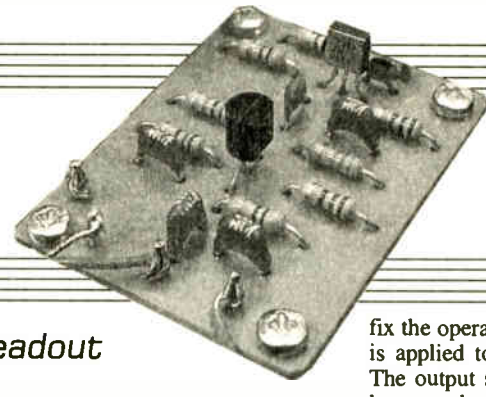
PERFORMANCE

This simple Super Regen. circuit effectively demonstrates the extremely high sensitivity of Armstrong's super-regenerative system. Frequency stability is remarkably good, hand-capacitance effects are not too pronounced and the super-regeneration control is smooth and effective. Automatic gain control action (a.g.c.) is very evident, and the loud hissing which characterizes circuits of this kind is completely suppressed by a strong signal.

On the v.h.f. f.m. band, careful adjustment of the tuning and super-regeneration controls enables an acceptable compromise to be struck between audio output and distortion. However, as constructors of the Hazeltine Fremodyne (including the author) found, performance falls short of a conventional superheterodyne receiver with a ratio detector or Foster-Seeley discriminator as the signal demodulator.

Domestic f.m. superhets have seven or more tuned circuits and perhaps five transistors amplifying at radio frequencies. A basic super-regenerator has only one tuned circuit and one valve or transistor providing gain at radio frequencies. Armstrong's genius continues to inspire.

BUFFER AMPLIFIER



Adding tuned frequency digital readout

Some readers who have built one of the versions of the regenerative radios described in Parts Three and Four will have access to a Digital Frequency Counter, and they may wish to use it to give a digital readout of receiver tuning.

Damping of the receiver's tuned circuit must be kept to an absolute minimum, and the signal levels across it are usually too low to reliably trigger most frequency counters. Direct connection is, therefore, out of the question, and a buffer amplifier must be placed between the two units.

BUFFER CIRCUIT

The circuit diagram for a suitable Buffer Amplifier is given in Fig.5.7.

Field-effect transistor TR1 is arranged as a common drain or source follower stage. Its high input impedance, together with the low value of coupling capacitor C1 minimises disturbance and damping to the receiver's tuned circuit. The d.c. potential on TR1 gate is held at 0V by resistor R1 and TR1's output is developed across source load resistor R3. Supply rail decoupling is provided by R2 and C2.

The circuit output stage consists of an r.f. transistor, TR2, configured as a common-emitter amplifier. Bias resistors R4 and R5 fix the operating conditions, and the signal is applied to TR2 base via capacitor C3. The output signal is taken from TR2 collector to the Frequency Counter, via capacitor C6. The collector load resistor is R7, and R6 and C5 decouple the output stage.

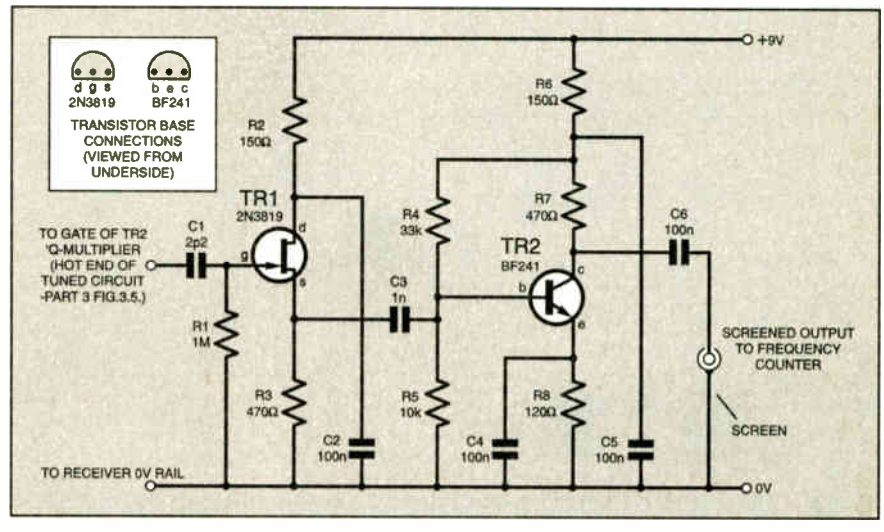


Fig.5.7. Circuit diagram for a Buffer Amplifier for a Digital Frequency Counter. A frequency counter, connected to the tuned circuit via this buffer, will give a digital display of the receiver tuning. This arrangement is NOT suitable for the Super-Regen. Receiver – see text.

World Radio History

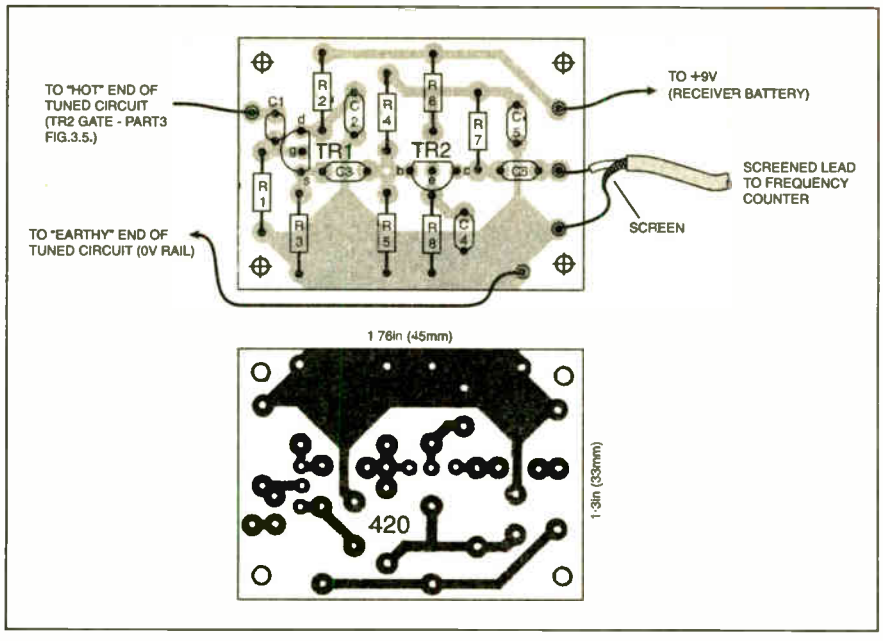


Fig.5.8. Buffer Amplifier printed circuit board component layout, wiring details and full-size copper foil master.

Most *n*-channel field-effect transistors will prove suitable for TR1. The BF199, BF494 and 2N222A were in-circuit tested in the TR2 position and they all worked well. Base connections vary and should be checked.

CONSTRUCTION

All of the Buffer Amp. components are mounted on a small printed circuit board and the component layout, copper foil master and wiring detils are shown in Fig.5.8. This board is available from the *EPE PCB Service*, code 420.

Solder pins at the lead-out points simplify the off-board wiring, and they should be inserted into the p.c.b. first. Follow these with the resistors, then the capacitors and, finally, the transistors. As before, keep the transistor leads just long enough to permit the use of a miniature crocodile clip as a heat shunt during soldering.

TESTING

Check the printed circuit board for poor soldered joints and bridged tracks, and check the positioning of the transistors. Connect the unit to a 9V supply. Current consumption should be in the region of 7mA.

Make a very short connection, certainly no more than 75mm (3in.), between the buffer amplifier's input and the "hot" end of the receiver's tuned circuit. Connect the amplifier's 0V rail to the ground or 0V tag on the tuning capacitor. Power for the amplifier can be taken from the receiver battery.

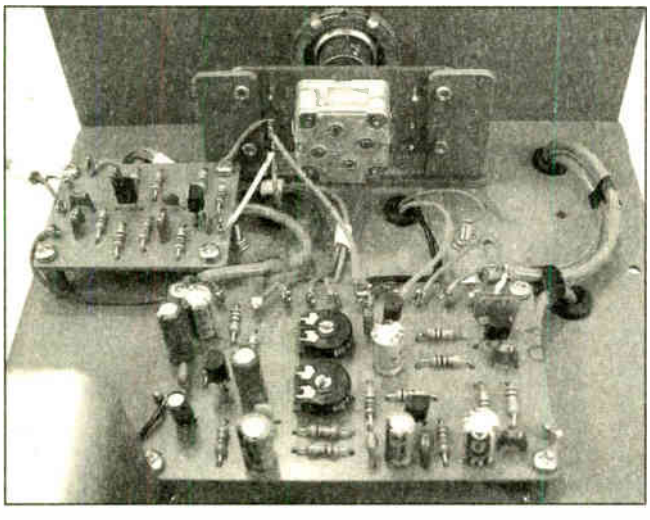
Connect the output from the buffer amplifier to the Frequency Counter via a short (no more than 600mm or 24in.) length of screened cable.

OPERATION

Set the counter's input controls, tune in a station and advance the regeneration control, turning down the receiver's input attenuator, as necessary. When tuning is correct and the regeneration setting has been optimized, the counter should display the "tuned" frequency.

The counter will normally only give a frequency reading when a station is tuned in. To check tuning on a quiet part of the dial, advance the regeneration control until the Q-multiplier is oscillating. The counter will then display the operating frequency.

When receiving single-sideband signals the regeneration control has to be advanced until the Q-multiplier is oscillating in order to replace the carrier suppressed at the transmitter. The counter will, therefore, give a continuous frequency readout as the receiver is tuned across the amateur bands.



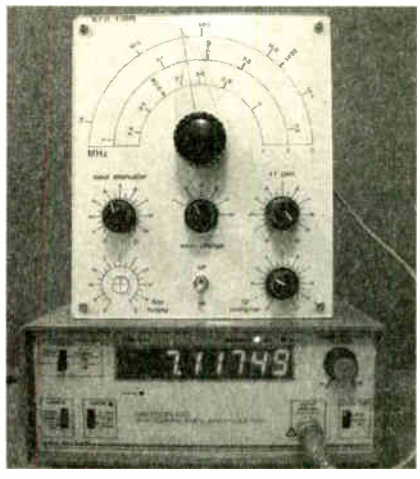
The Buffer Amplifier wired to the Regenerative Radio (Part 3) and the tuning capacitor p.c.b.s.

OTHER RECEIVERS

The Buffer Amplifier and Frequency Counter combination cannot be used with the Super-Regen. Receiver. Here the oscillating stage is "squegging" and the counter cannot distinguish between signal and quenching frequencies. Moreover, buffer amplifier loading, although extremely light, makes detector operation erratic.

The arrangement is also unsuitable for superhet receivers (*to be offered in a later issue*) in which the oscillator runs at a higher frequency than the reception frequency. Additional circuitry is required to accommodate the difference.

Direct conversion receivers incorporate an oscillator that operates at signal frequency. The Buffer Amplifier and counter set-up will, therefore, form an accurate digital tuning display. Widely used by amateur radio enthusiasts for the reception of single-sideband transmissions, this receiving system will be covered next month.



A frequency counter wired, via the Buffer Amplifier, to the Regenerative Radio and showing an amateur band frequency readout.

COMPONENTS

BUFFER AMP.

Resistors

R1	1M	
R2, R6	150Ω (2 off)	
R3, R7	470Ω (2 off)	
R4	33k	
R5	10k	
R8	120Ω	

All 0·25W 5% carbon film

See SHOP TALK page

Capacitors

C1	2p2 disc ceramic
C2, C4 to C6	100n disc ceramic (4 off)
C3	1n disc ceramic

Semiconductors

TR1	2N3819 *n*-channel field effect transistor
TR2	BF241 *npn* small signal, high frequency transistor

Miscellaneous

Printed circuit board available from the *EPE PCB Service*, code 420; input connector, to suit frequency counter; single-core screened audio cable; multistrand connecting wire; solder pins; solder etc.

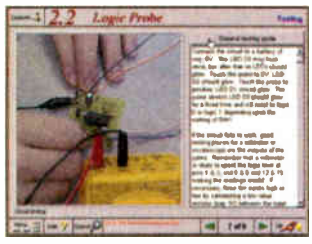
Approx. Cost Guidance Only **£8**

World Radio History

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS



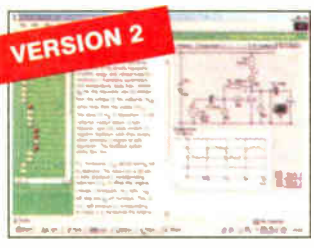
Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture**, **circuit simulation** and **p.c.b. design** software is included.

The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

VERSION 2



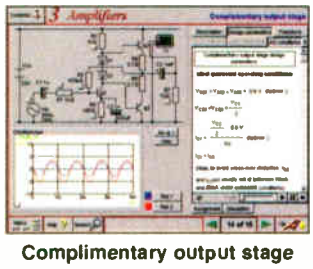
Circuit simulation screen

Provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols.

Sections include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits. Active Circuits.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.

Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS



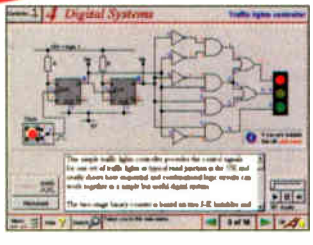
Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

VERSION 2

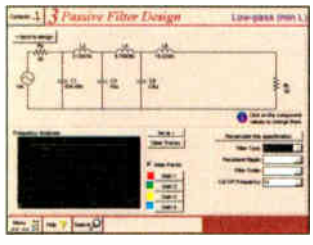


Virtual laboratory – Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.

Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

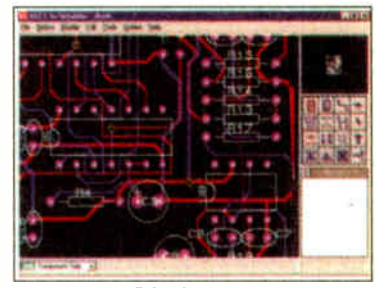
FILTERS



Filter synthesis

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

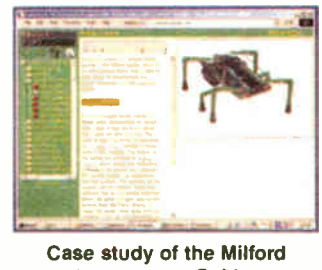
ELECTRONICS CAD PACK



PCB Layout

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

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

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

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

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

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

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

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PICmicro TUTORIALS AND PROGRAMMING

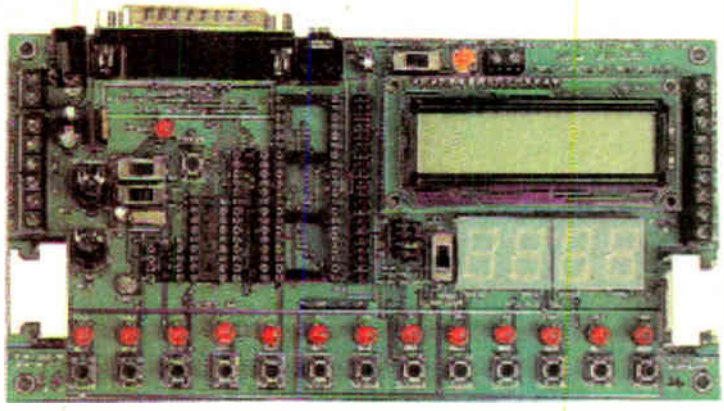
HARDWARE

VERSION 2 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

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

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



£145 including VAT and postage

12V 500mA plug-top PSU (UK plug) £7

25-way 'D' type connecting cable £5

SOFTWARE

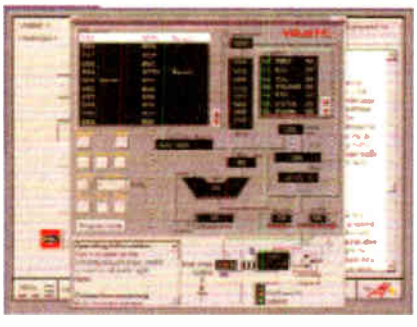
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V2

(Formerly PICtutor)

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

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



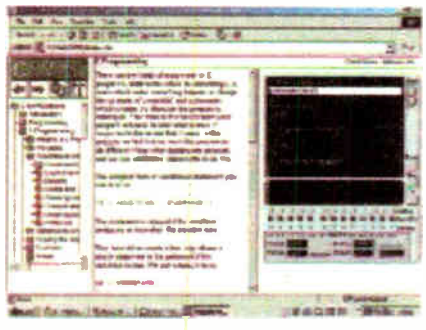
Virtual PICmicro

'C' FOR PICmicro VERSION 2

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

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

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



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

FLOWCODE FOR PICmicro

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

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

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

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

Burglar Alarm Simulation

PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

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

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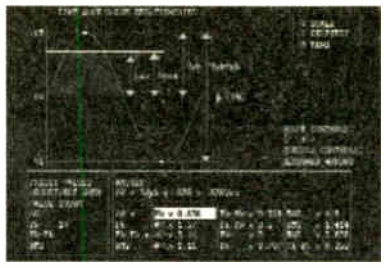
World Radio History

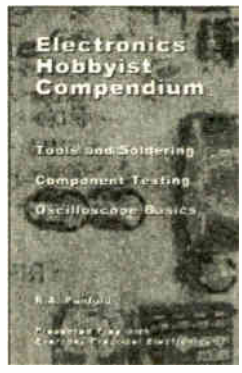
TEACH-IN 2000 – LEARN ELECTRONICS WITH EPE

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



Sine wave relationship values

FREE BOOK WITH TEACH-IN 2000 CD-ROM



Each part has an associated practical section and the series includes a simple PC interface so you can use your PC as a basic oscilloscope with the various circuits.

A hands-on approach to electronics with numerous breadboard circuits to try out.

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

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

ELECTRONICS IN CONTROL

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

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Student copies (available only with a multiple user copy) £6 plus VAT

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MODULAR CIRCUIT DESIGN

VERSION 3

Contains a range of tried and tested analogue and digital circuit modules, togetner with the knowledge to use and interface them. Thus allowing anyone with a basic understanding of circuit symbols to design and build their own projects. Version 3 includes data and circuit modules for a range of popular PICs; includes PICAXE circuits, the system which enables a PIC to be programmed without a programmer, and without removing it from the circuit. Shows where to obtain free software downloads to enable BASIC programming.

Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design. Over seventy different Input, Processor and Output modules are illustrated and fully described, together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc.

Single User £19.95 Inc. VAT. Multiple User £34 *plus* VAT

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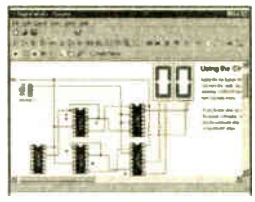
DIGITAL WORKS 3.0



Counter project

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

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ELECTRONIC COMPONENTS PHOTOS

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

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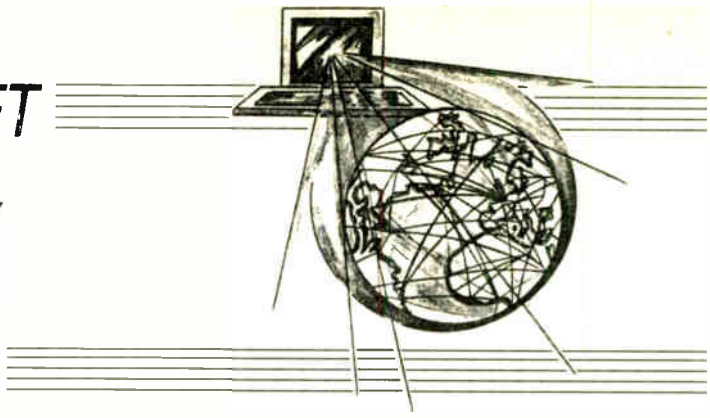
SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY



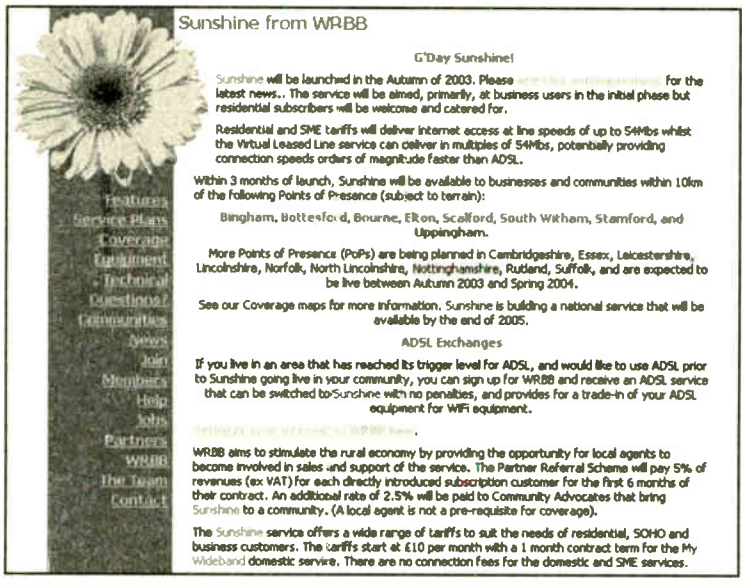
MANY urban regions now enjoy ADSL broadband through their phone lines, much to the chagrin of the rest of us in non-urban or rural areas – the ones who could probably benefit the most from having broadband Internet access. Some readers who emailed me are doubly frustrated, living in large "progressive" towns where broadband ADSL isn't available to them either.

British Telecom dangles a tantalising carrot in the form of "trigger levels" for each telephone exchange. A spokeswoman for BT Wholesale told me that the targets reflect the actual costs of upgrading an exchange, in the sense that they are set at 50% of the amount of customers they need to return the investment on that exchange within a reasonable time. They are not set as percentage of the amount of connections on that exchange.

If narrowband dial-up exasperates you and ADSL is never likely to arrive, then it's time to start thinking about other emerging technologies. As usual, I take a general-interest view without dwelling on systems that relate more to industrial or commercial applications.

Look, No Wires!

A number of wireless solutions are starting to roll out which on the surface appear to be just localised services. Invisible Net-works (**http://www.invisible.uk.net**) is one such supplier, but they have recently slashed the numbers on the workforce. Another company is WRBB (Wireless Rural Broadband) at **http://wrbb.net** – a small but dynamic Lincolnshire-based company that is planning some highly attractive services to rural users all around the country, deliberately avoiding urban or ADSL/cable enabled regions. WRBB promises to bring us "Sunshine" and is dedicated to providing rural users with broadband solutions using wireless technologies.



As always, the problem is that trying to nail down new technology is like trying to pour cement on shifting sands: many users will remember what dial-up was like, moving from 9·6kbps then 14·4, 28·8, 33·6 and finally V.92 56k. Then came serial, ISA, PCI and USB modems, not to mention US Robotics' own standard X2. Modems and racks were being thrown away almost annually.

Wireless technology is no different with a number of standards having evolved, with the attendant risk that they can be superseded almost overnight. There is the on-going problem of customers buying the wrong or obsolete equipment.

In considering the IEEE 802.11 standard, WRBB chose to delay and wait until the newest 802.11g standard was finally ratified in 2003. This operates on a rate of 54Mbps maximum, which is not the "surfing speed" as such: we're told to expect up to five or ten times faster broadband services than BT 512k ADSL. Just twice as fast (1Mbps) would be good . . .

Neighbourhood Watch

WRBB also highlights other benefits of working wirelessly – for example, a network could be provided locally so that you could play games or network with friends across the road, and this would be free. Only when users reach out onto the Internet would costs be incurred.

The proposed costings are extremely attractive and are built on a PAYG (pay-as-you-go) structure, so customers just buy a chunk of gigabytes of Internet traffic and do what they like with it. The cheapest service will be £10.00 per month, for 1Gb of traffic + 0·014 per extra MB. An attractive range of rates for home and business is quoted on their web site.

WRBB's CEO "TJ" or "Titch" is extremely enthusiastic and highly skilful, clearly appearing to have considered all the technical and commercial implications of building a wireless network from scratch. A live demonstration of IEEE 802.11g highlighted its remarkable transmission rate over a LAN – which anyone can actually demonstrate with suitable bits of 54Mbps wireless kit – but, of course, the actual rollout of this Internet service is still tantalisingly distant.

On Trial

Trials are under way in deliberately "difficult" places – and indeed the terrain is likely to be one of the biggest hurdles to overcome: 802.11g needs "line-of-sight" between aerials. Trees, hills or even ferrous strata in the earth may badly affect the service.

Computer simulations of the geography help to determine the best sites for aerials, and in some places you take on 802.11g "at your own risk" helped by online computer maps. Critically, the target range will be 10km line-of-sight of a point of presence, using a suitable antenna.

WRBB has started a registration process (which didn't cope with the initial volumes), gathering figures just as BT did, but 'TJ' is adamant that unlike BT broadband, meeting a trigger level is not a prerequisite before the service could be installed. Although they will target business users initially, residential clients will be catered for as well. Refreshingly, "TJ" accuses BT of adversely conditioning users' expectations into accepting "trigger levels" as the *de facto* criterion for activating a broadband service. Ultimately, WRBB will just build it anyway, and you can sign up if you want.

The "Sunshine" that WRBB promises to deliver has however suffered from a false dawn, because there aren't yet enough 802.11g certified broadband routers available to them for re-distribution. So the rollout date has already been postponed, the company being clearly very nervous about selling non-certified equipment.

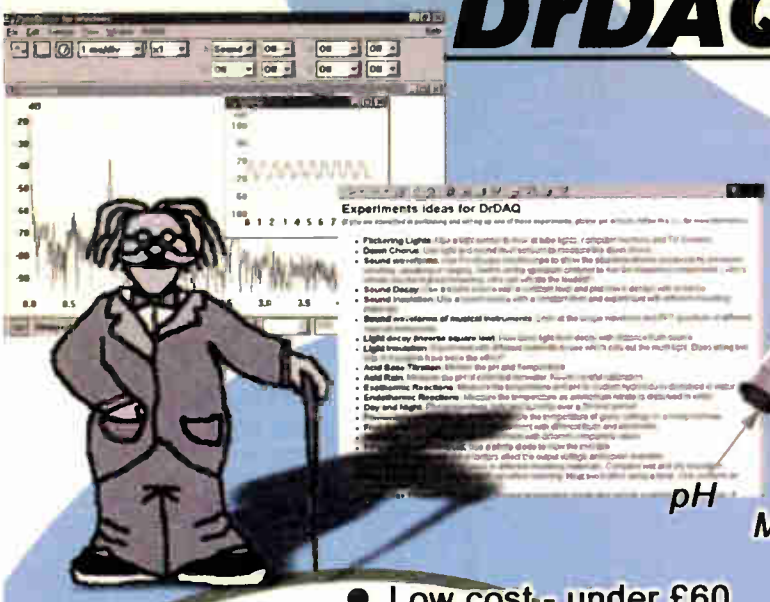
Keeping one's powder dry until a fully compatible wireless network is ready for launch is admirably brave. However, one risk is that further methods of deploying wireless networks will come along, leading to a myriad of confused customers with wrong or obsolete equipment.

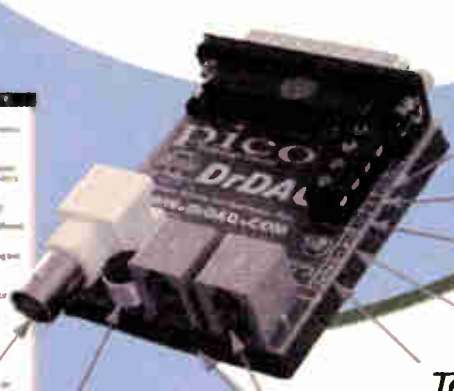
The older protocol 802.11b runs at 11Mbps maximum, although 802.11g is retro-compatible with it. More new wireless standards are in the pipeline that could overcome "line-of-sight" problems altogether, but that's some time ahead yet.

We need the likes of WRBB with its young and enthusiastic team, and its refreshingly customer-focused approach deserves to be highly successful. Fingers crossed . . . You can email comments to **alan@epemag.demon.co.uk**.

World Radio History

DrDAQ Data Logger





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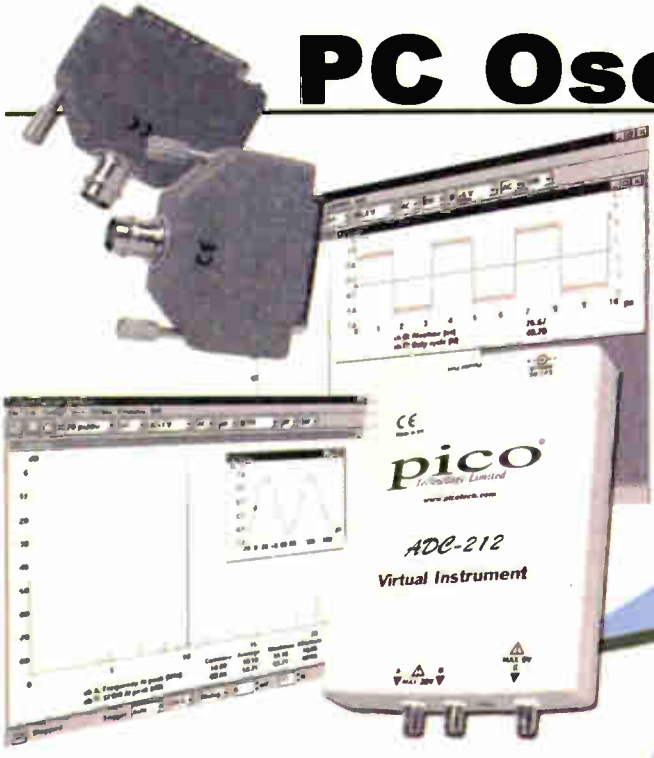
PC Oscilloscopes



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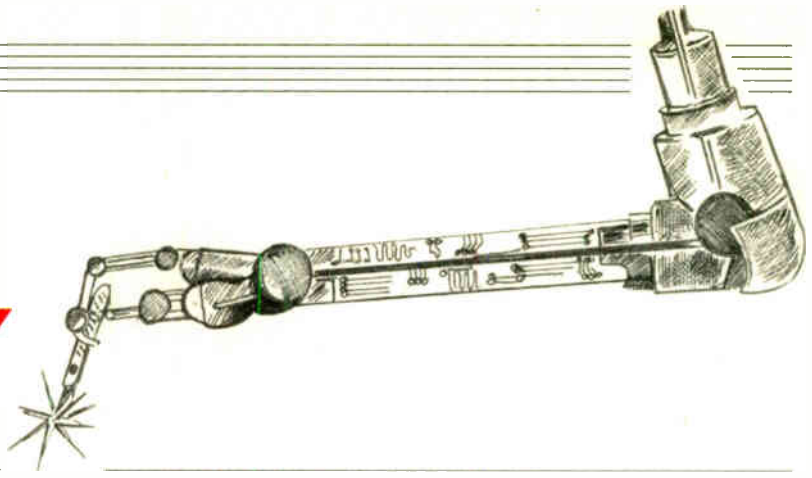
CIRCUIT SURGERY



ALAN WINSTANLEY and IAN BELL

Concluding our introduction to SPICE simulation software, creating a netlist and running the various simulator functions.

LAST month we highlighted the student version of PSpice circuit simulator software that is available as a free download from Cadence Design Systems Inc. (**www.cadencepcb.com/products/downloads/Pspicestudent**). The software weighs in at a mighty 28MB and the documentation adds a further 13MB, and a free utility such as Leechget (**www.leechget.de**) may help dialup users with this mammoth download.

This month we continue with instructions for running a PSpice Simulation using the Demo Version, to show some of the software's powerful simulation functions that are available.

Start the Capture Program

Run the Capture program (Start ->Programs->PSpice Student->Capture Student). When the program opens use the iconbar or select File->New->Project... from the menu. Type your project name into the Name box. Select 'Analog or Mixed A/D' from the list of project types.

Browse to create a target location to file the project: it is best to use a new directory. Then select 'Create a blank project' and click OK.

Expand the OrCAD window to full screen. You will see three sub-windows, resize them as desired, see Fig.1. As usual, when entering data into an application, you should save your work regularly (File ->Save or CTRL + S).

Example Circuit

The example circuit we are going to simulate is the one shown in Fig.1 last month (page 622), and also repeated here in Fig.6 with "voltage labels", which was captured from the PSpice schematic editor. The circuit is a single stage transistor amplifier with bias stabilisation feedback provided by resistor R4. This is bypassed at a.c. by capacitor C3 to give plenty of gain. The circuit is a well-known standard configuration. The 2N2222 is used simply because it is one of the transistor models available in the demo version.

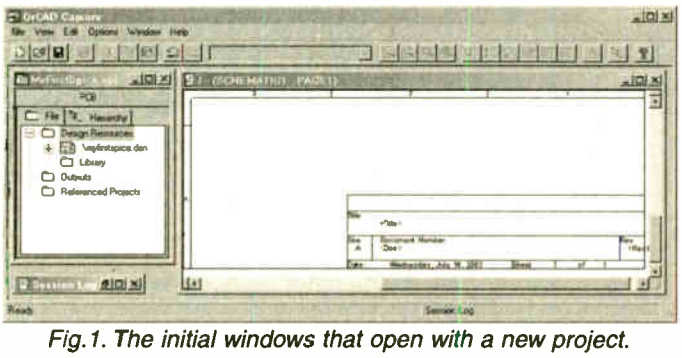


Fig.1. The initial windows that open with a new project.

Note that the schematic includes a voltage source to create the input signal, and a load resistor for the output. This is usual when simulating – you must include the input signals and load conditions in order to have a meaningful simulation, although these items would not normally be shown on a schematic used for construction purposes. During simulation work, be prepared to edit the schematic to change the input signals for different types of analysis.

Adding Components

Select Place->Part... from the menu then click the Add Library... button in the Place Part window which opens. Select analog.olb, eval.olb and source.olb (hold down the Ctrl key and click on them in turn). Then click on the OPEN button. The libraries will appear in the Libraries: list in the Place Part window.

Select Place ->Part... from the menu again. Click on EVAL in Libraries: list, then scroll down the Part List: and click on Q2N2222. Click OK and move the cursor over schematic window.

Click on the schematic to place the transistor symbol on the schematic and then hit the ESC key. If you click the schematic again before pressing ESC you will finish up with two or more transistors. To delete one, click on it near the centre to select it and hit the Delete key. You can also use the Edit ->Undo menu item to undo unwanted schematic drawing operations.

Now add the five resistors in a similar way. Place->Part... then click on ANALOG in library list, scroll down part and click on R (for resistor). Click OK and move cursor over the schematic window. Hit the R key to rotate the resistor to the required orientation. Click to place the four resistors symbols by clicking on the schematic and then hit the ESC key.

Try to place the resistors exactly where they should go to form a neat schematic, if you end up with one in the wrong place you can click on it and the drag it with the mouse to the desired location. Don't worry about what resistor values are shown at the moment, we will set these later. Leave space between the components for the wires we will be adding later.

Add the capacitors like the resistors (they are called C and are in the ANALOG library). Add input and output capacitors

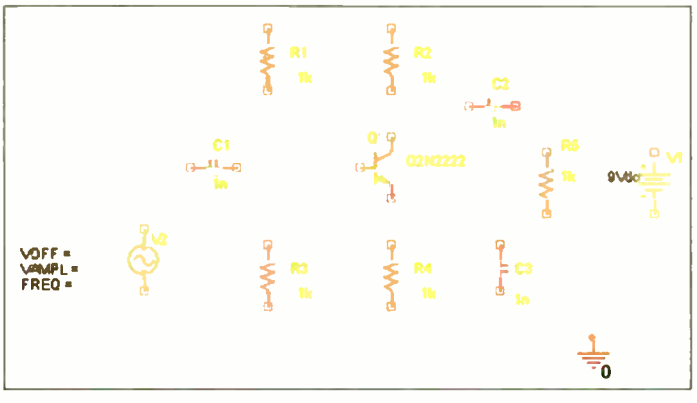


Fig.2. All components added and labelled. Note the Ground '0' element, bottom right.

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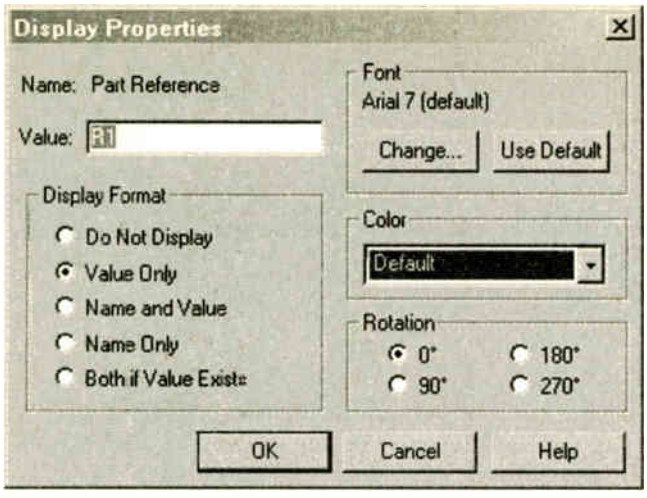

Fig.3. Naming a part by giving it a value.

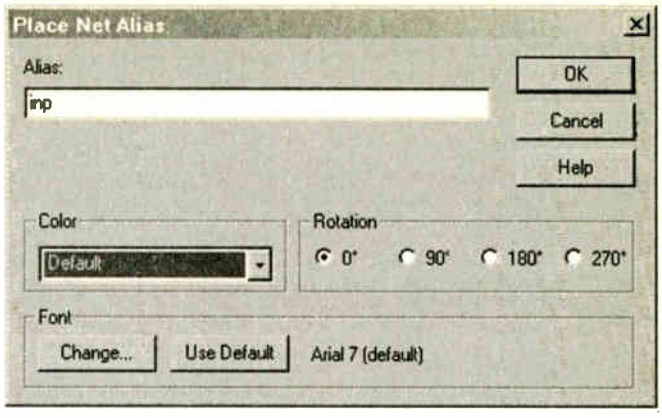

Fig.4. Naming a wire by giving it an Alias.

(C1 and C2), then hit the R key to rotate the symbol for adding the feedback bypass capacitor (C3). Also place the VDC element for supply voltage and the VSIN element for the input signal from the SOURCE library.

We also have to add the correct ground to get the "node zero" which must be present in all SPICE circuits. Not doing this is a common cause of mysterious problems for novice SPICE users!

To place the ground connections, first click on the Ground button in the tool palette on the right hand side of the main OrCAD Capture window (you can also use this tool palette for other actions such as placing components). It is marked with a Ground symbol and "GND". When clicked, a window will appear similar to the Place Part window. Click on Add Library... and add source.olb from the PSpice library as you did before. Select the source library and the 0 element from the Parts List. Place the ground symbol on the schematic. Make sure there is a Zero next to your ground symbol on the schematic, see Fig.2.

Add the wires

Having placed the parts and ground, you are now ready to add the wires to the schematic. Select Place->Wire from the menu. A crosshair cursor will appear over the schematic. Click on the start point of a wire – the ends of the wire stubs on the components, which will have little grey boxes around them.

If you move the cursor over a valid point for wiring to – another wire or component pin – then a red blob appears. Clicking at this point will make the connection. If you move the cursor to a point that would create an error if you put the wire there, then a warning symbol appears instead.

The wires automatically form one right-angle bend as you move the cursor around. If you need a more complicated wire path (i.e. one with more bends), simply click at the point where you need a corner. Each time you click you add a new segment to the wire. Hit the ESC key to stop drawing the wire. You can start and finish a wire in "mid-air " if you wish, this point will then get a little grey box indicating it is an open connection.

If you make mistakes with the wiring you can use Edit->Undo from the menu or click the undo button. You can also click on a wire segment to select it (it changes colour) and hit the Delete key to remove it. Make sure you hit ESC to edit wiring before doing some other operation.

All Change

To change the component names from the defaults created when you placed them double-click directly on the name (not on the component symbol). A window will open titled Display Properties in which you will see the text "Name: Part Reference". Change the text in the Value box to the name you require for your component, see Fig.3.

To change component values double-click directly on the value text (again not on the circuit symbol). This will also open a Display Properties window, this time with "Name: Value". Change the Value text to what you require.

Note the voltage source for the input signal has three values to set. Double click these in turn to set the three values, VOFF as 0, VAMPL as 10m, and FREQ as 1k. You can edit the document information at the bottom right hand corner of the schematic in a similar way to the component values.

Name the Wires

To label wires: Select Place->Net Alias... from the menu. This will open the Place Net Alias window. Type the wire name you want into the Alias: box and click on OK, see Fig.4.

A small box will move over the schematic with the cursor, place this right next to the wire you want to name. Hit ESC to cancel the command. Repeat for each wire name and save your schematic. Eventually your schematic should look like Fig.6, without voltage labels.

Netlisting

It is useful to netlist the schematic as this will tell you if there are any errors in the drawing. Select PSpice->Create Netlist. If there are errors a message dialogue will appear, if not nothing much will happen. To see the netlist go to the project hierarchy window, expand the outputs section if necessary (click on +) and then double click on the schematic1.net item. Our netlist is given below, yours may be a little different, but it should contain the same items.

```
* source          CIRCUIT1
R_R4              0 EMITTER 1k
Q_Q1              COLLECTOR BASE
                  EMITTER Q2N2222
R_R3              COLLECTOR VCC 4.7k
R_R2              0 BASE 10k
R_R1              BASE VCC 47k
C_C1              INP BASE 1u
C_C2              COLLECTOR OUTP 1u
```

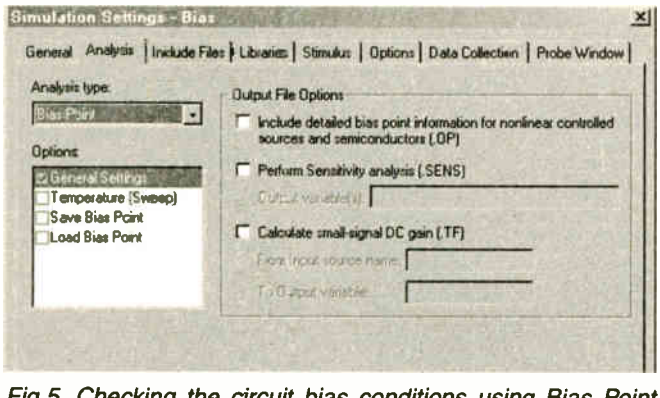

Fig.5. Checking the circuit bias conditions using Bias Point analysis type.

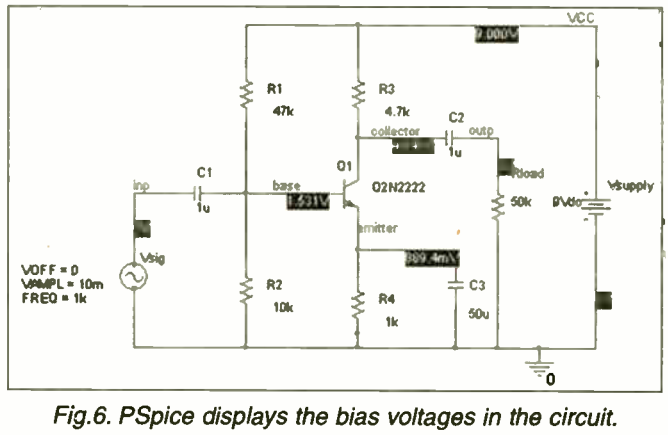

Fig.6. PSpice displays the bias voltages in the circuit.

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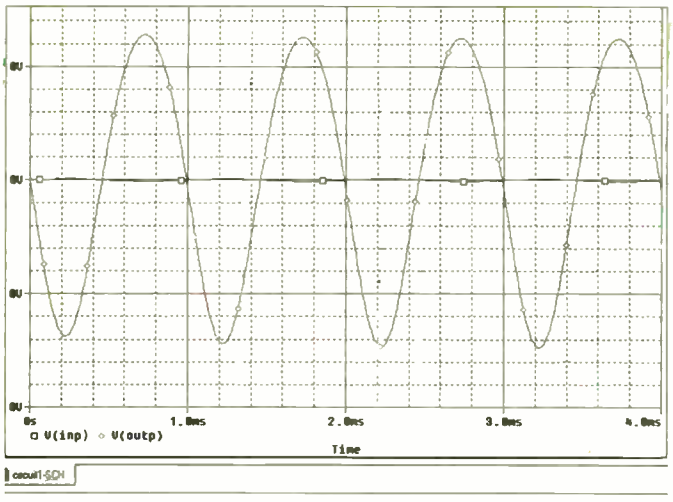

Fig.8. The simulated output sinewave, appprox. 1·3V peak

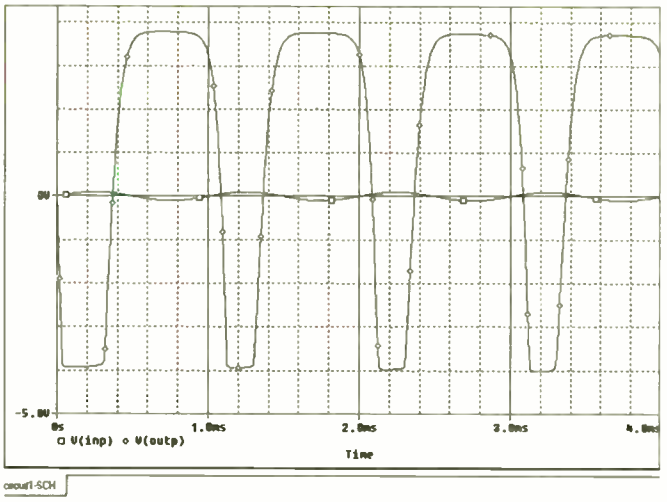

Fig.9. Simulating distortion of the sinewave, due to amplifier

```
C_C3          0 EMITTER  50u
R_Rload       0 OUTP  50k
V_Vsupply     VCC 0 9Vdc
V_Vsig        INP 0
+SIN 0 10m 1k 0 0 0
```

Simulation

We can run the simulator using the following method, starting by checking the circuit's bias conditions. Select PSpice->New Simulation Profile. Type Bias into the Name: box and leave Inherit From: as None. Click Create. A window titled Simulation Settings – Bias will open. Change Analysis Type: to Bias Point and click OK, see Fig.5.

Now select PSpice->Run to start the simulation. A simulation output window will appear and report progress of the simulation. If you get any error messages check that your schematic was drawn correctly and that it matches Fig.1 last month.

No waveforms will be displayed at this point as we are only looking at the bias conditions. The bias voltages will be displayed on the schematic, see Fig.6. If you built the circuit you should be able to measure d.c. voltages similar to this with zero input applied.

Now we can simulate the circuit to see how it responds to the 10mV input sine wave. Select PSpice->New Simulation Profile. Type Transient into the Name: box and leave Inherit From: as None. Click Create. In the Simulation Settings window set the following (see Fig.7).

Analysis Type: Time Domain (Transient)
Run to Time: 10ms
Maximum Step Size: 10us

Note that the maximum time step controls the time accuracy of the simulation. If this is too low the simulation will take too long, but if it is too high the results will not be accurate.

Select PSpice->Run to start the simulation. Again the output window will appear and after a while you will get a blank waveform display. Select Trace->Add Trace... In the Add Traces window scroll down the list of signals and click once on V(inp) and once on V(outp). These names will appear in the Trace Expression: box at the base of the window. Click on OK to display the waveform. You should see that the output is a clean sinewave of much larger amplitude than the input (around 1·3V peak), see Fig.8.

Close the simulation window and go to the schematic. Double click on the VAMPL text next to the Vsig input signal voltage source. This will open the Display Properties window. Change the Value to 100mV. We now have a 100mV input signal, rather than 10mV.

Run the simulation again and display the input and output waveform as before. You will now see that the output is distorted due to saturation of the amplifier, see Fig.9. Close the simulation window.

Now we can look at the frequency response. Go to the schematic, click on the Vsig source symbol and hit the Delete key to remove it. Add a VAC element from the SOURCE library in place of Vsig. This has two values to set, change ACMAG to 10mVac and leave DC as 0V d.c.

Select PSpice->New Simulation Profile. Type the label Frequency into the Name: box and leave Inherit From: as None. Click Create. In the Simulation Settings window set the following (see Fig.10).

Analysis Type: AC Sweep/Noise
Logarithmic
Decade
Start Frequency: 10
End Frequency: 100Meg
Points/Decade: 5

Leave the noise analysis enabled box unchecked. Click OK and select PSpice ->Run to start the simulation.

When the blank results display appears in the simulation window select Trace->Add Trace... as before. This time, however, do not click on any signals, simply type the following into the Trace Expression: box (make sure you get it exactly right)

DB(V(outp)/V(inp))

This calculates the gain V(outp)/V(inp) and converts it to decibel format. Click on OK to display the frequency response of the circuit. Note this result is fairly idealised. We have not included stray capacitances in the simulation, which would reduce the high frequency gain.

This concludes our simulation example which we hope is sufficient to give you the confidence to try creating your own projects in PSpice. For more examples, read Chapter 2 of the pspug.pdf file (user guide) supplied in documentation download.

Next month, we will answer a reader's query on op.amps, by simulating it in PSpice. *I.M.B.*

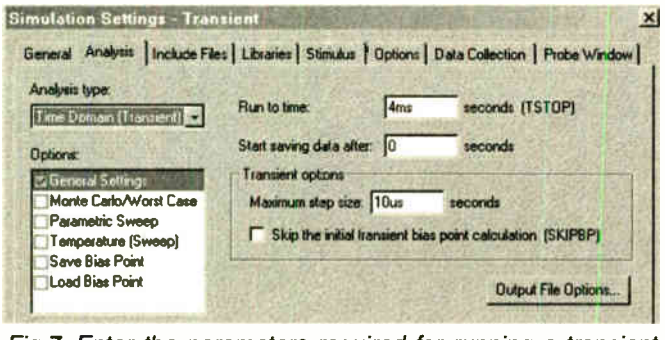

Fig.7. Enter the parameters required for running a transient analysis.

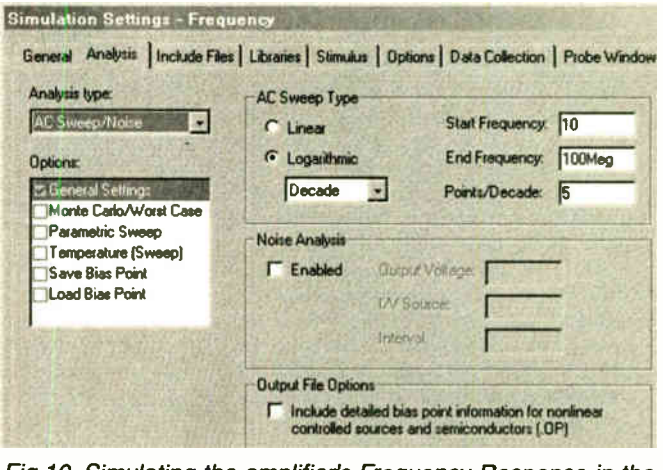

Fig.10. Simulating the amplifier's Frequency Response in the AC Sweep dialogue box.

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Special Feature

PIC BREAKPOINT

RICHARD HINCKLEY

A PIC debugging tool that allows your PC to display all register contents at selected stages of a program's operation.

AFTER a particularly frustrating afternoon trying to debug a PIC-controlled transmitter circuit, which had no l.c.d. or l.e.d.s attached to help, the author decided that a breakpoint debugging aid would be a useful addition to the *EPE Toolkit TK3* assembly and programming aid (Oct/Nov '01). So a Visual Basic program was written to upload the whole of the PIC data memory to a PC at various points in the program.

In summary, PIC Breakpoint (PB1) runs as part of *TK3* on any PC that will run *TK3* and has a bi-directional parallel port for verification. Either the *EPE* or the Magenta version of the *TK3* board may be used, but both require the addition of an extra link and a 10kΩ resistor, as described in a moment.

To use PB1 the program to be debugged is simply edited to include temporary breakpoint commands at positions of interest. When the program reaches a breakpoint the whole of the data memory, including the special registers, is uploaded to the PC for display and analysis. PB1 is written for 800 × 600 displays. It will work on larger ones and on 640 × 480 displays – in the latter case the screen layout is slightly different from that shown in the photos.

PREPARING TK3 P.C.B.

Two straightforward modifications are required to the *TK3* board. The layout of the *EPE* board together with the modifications is shown in Fig.1. The Magenta board is slightly different, but the equivalent needs should be obvious.

Modification 1. An insulated wire link is required between the RB6 external input/output terminal pin at the righthand side of the board (which derives from pin 5 of IC3, the 4053 i.c.) and pin 31 (INIT) of the Centronics connector. The link should be made on the underside of the board. (Note that the RB6 I/O pin is *not* the RB6 pin used for in-circuit programming.)

Modification 2. A 10kΩ resistor needs to be soldered on the component side of the board as shown. (Circuit-wise this resistor is connected between 0V and the RB7 pin used for in-circuit programming).

SOFTWARE

Install *TK3* V5.0 (or later). Version 5.0 was released onto the *EPE* ftp site (access via the *EPE* home page at **www.epemag.wimborne.co.uk**) in early August 2003 (via path **PUB/PICs/Toolkit3**). Ensure that verification is enabled.

If you are installing *TK3* for the first time you also need the published text. This is available as back issues from the Editorial Office, and on the *PIC Resources CD ROM*. See elsewhere in this issue for ordering details. The CD ROM also holds the software for *TK3*, but it as an earlier version than V5.0 and will not work with PIC Breakpoint.

You also need the suite of files for PIC Breakpoint. These are obtainable from the Editorial office on 3·5in disk, for which a nominal handling charge applies (see the *EPE PCB Service* page for ordering details). They are also available *free* from the *EPE* ftp site (via path **PUB/PICs/Breakpoint**).

Unzip the file **PB1.zip** into any folder of your choice. The files contained are:

README.TXT. This gives a brief summary of PB1, and may contain other information that was too late for the publication date of this article.

PBM.INC. This is an INCLUDE file which contains PIC PB1 code that will be inserted into the program to be debugged.

TUT26TEST.ASM. This is a version of the *PIC Tutorial V1* demo program TUT26.ASM modified to demonstrate the features of PB1.

Four **.HEX** starting with **PB_CAL_**, whose purpose is described next.

CALIBRATING PB1

A calibration program must be run to match the frequency of a PIC's oscillator to the speed of the PB1 program being run on the PC.

First insert any of the PIC devices that are supported by *TK3* into the appropriate socket on its board. Load *TK3*, select the

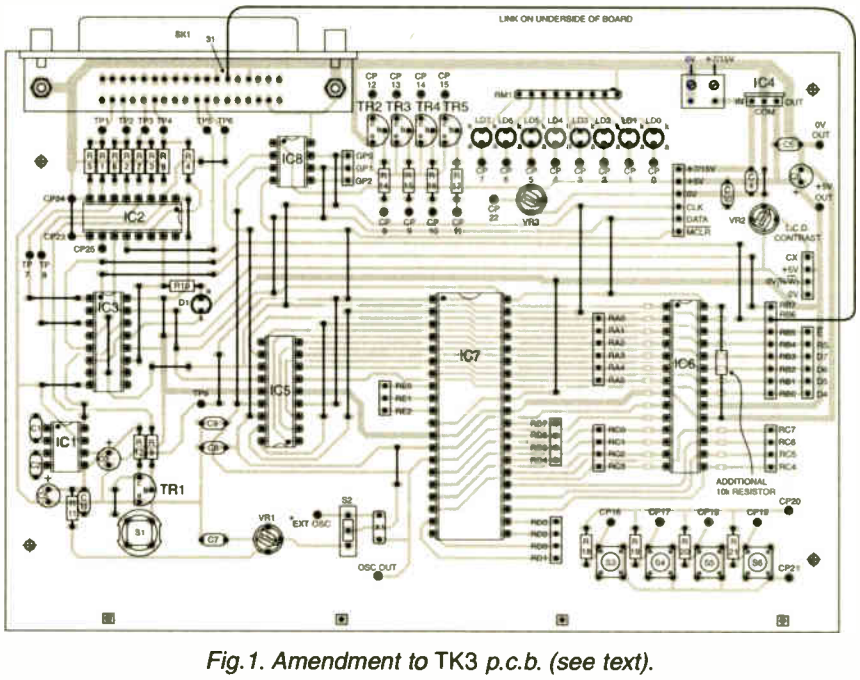

Fig.1. Amendment to TK3 p.c.b. (see text).

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PIC type and configure the PIC (POR on, WDT off, oscillator type as appropriate).

On the *TK3* screen use the DIR button in the Programming main screen area to select the folder containing PB1. Four .HEX files will be shown:

PB_CAL_16F62x.HEX
PB_CAL_16F83.HEX
PB_CAL_16F84x.HEX
PB_CAL_16F87x.HEX

Select the hex file applicable for the PIC type that is being used (e.g. **PB_CAL_16F84x.HEX** for a PIC16F84) and SEND it to the PIC. Assuming Verification is OK, the *TK3* Send Program Code to PIC screen will be seen to have an extra button on it, **TEST HEX** (see Fig.2). Click it.

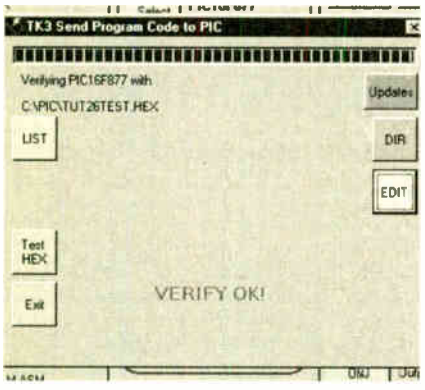

Fig.2. Programming sub-screen showing new TEXT HEX button.

The PB1 screen will appear (Fig.3) with a message explaining that calibration is to take place. If a mistake has been made and the wrong calibration program for the PIC device has been sent, an error message will be given. In this case click the **Return to TK3** button and send the right one.

Clicking OK to the message will cause calibration to start and a progress bar to appear. What happens next depends on the frequency of the PIC oscillator. At frequencies above about 1·5MHz only one iteration of the progress bar will be seen, very briefly, for less than a second (though the period may vary according to the speed of the PC), followed by a message advising that calibration is complete.

For frequencies between about 60kHz and 1·5MHz the progress bar will iterate, getting gradually slower, until PB1 decides that the calibration is satisfactory. Follow any messages output during the process. Note that PB1 will not work with PIC oscillator frequencies of 60kHz and below, and will give up quickly if tried.

The final message announces that calibration is complete, and also advises that PB1 should be re-calibrated if the PIC oscillator frequency is changed. This is important as otherwise incorrect results might be obtained. It is NOT necessary to recalibrate if the PIC is changed to a different type, but the frequency remains the same. If it is necessary to recalibrate, just click the SETUP button.

If the calibration process iterates to the point where it gives up using a PIC oscillator frequency that should be acceptable, then it is possible that the PIC has a byte of duff memory (dead register location). The author found one such PIC in his collection.

Ignore the other buttons visible on the screen, and the temptation to click one. Although no harm will occur, it is better to use the **TUT26TEST** program to understand what PB1 can do. Instead, click the OK message and then click the **Return to TK3 button**.

PIC BREAKPOINT DEMONSTRATION

The original **TUT26** program uses the TMR0 counter to measure one-second intervals, at which point a second count is incremented and output to an l.e.d. display via PORTB. **TUT26TEST** has been modified to show how PB1 is used.

Referring to the full **TUT26TEST.ASM** file listing supplied with the software, the extra PB1 lines used in the program are indicated by the comment **;**********PB1**. Ignore the statements within the "<>" chevron brackets for the moment.

For timing accuracy the PIC oscillator frequency should be 3·2768MHz, but if a different frequency is being used it does not matter for the purposes of this demonstration. The l.e.d. display is *not* required.

Returning to *TK3*'s main screen, from within the Assembly section use DIR to select **TUT26TEST.ASM** from whatever folder it was unzipped to, and then click the Edit ASM button to load it into the editor. It might be helpful to print off the file (and the assembly listing file later).

The first line following the introductory comments lines is an assembler directive:

LIST p = PIC16F877, r = dec

This tells the *TK3* assembler that the program is to be assembled for a PIC16F877, and that the radix to be used is decimal. (For a more detailed explanation of the radix directive see John Becker's *EPE PIC Tutorial V2* Part 3, June 2003).

This directive is essential for PB1 to work correctly. It must be edited to specify the appropriate PIC device if a PIC other than a PIC16F877 is being used. For instance if you are using a PIC16F84, the line should be edited to read:

LIST p = PIC16F84, r = dec

Having edited the line, resave the file. Note that this directive over-rides that previously specified via the Select PIC Type option.

The LIST directive is followed by:

INCLUDE PBM.INC

This causes the PB1 macro code to be loaded when the program is assembled.

Further down the listing the next additional PB1 lines are:

clrf PORTB
clrf TRISB
bsf TRISB,6
bsf TRISB,7

These instructions clear the pins used by PB1 (RB6 and RB7 of PORTB) to zero and set them to inputs (there are other ways to do this, but the **bsf** instructions have been shown for clarity). If might seem a little strange to set both pins to inputs. This is done to prevent premature triggering of the PC PB1 program by an error in the PIC program. The PB1 code will set RB7 to output before being used.

Following label OUTPUT, these extra lines appear:

setc
bkpt
clrc

The **setc** and **clrc** instructions have been inserted only to demonstrate one of PB1's features.

The **bkpt** instruction is a macro call, which will cause part of the PB1 code to be inserted into the program when assembled. (Macros were discussed in Malcolm Wiles' *PIC Macros and Computed GOTOs*, Jan '03). A further **bkpt** macro call has been made three instructions from the end of the program.

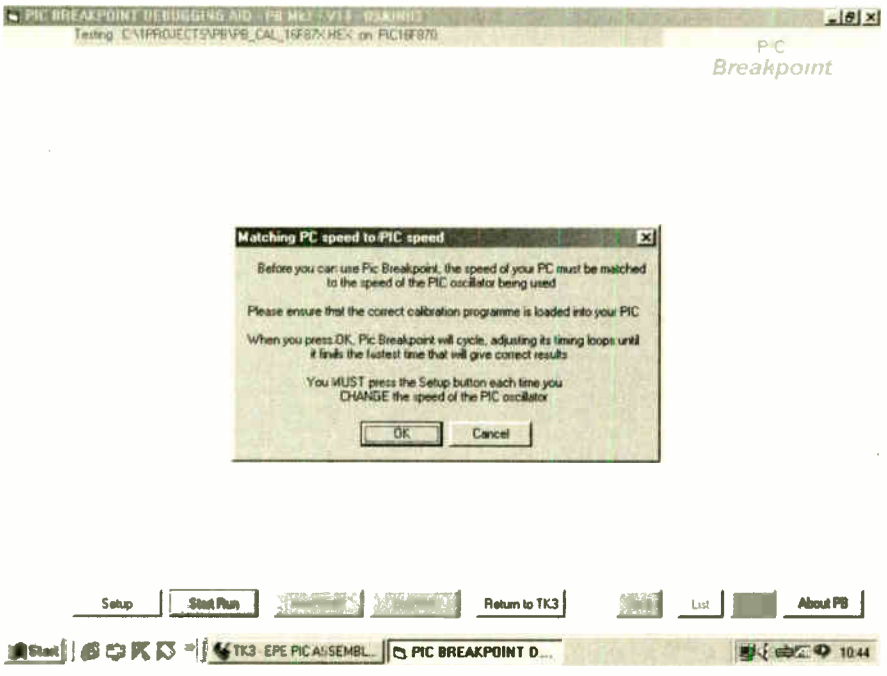

Fig.3. PIC Breakpoint's calibration sub-screen superimposed on its main screen.

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The final additional line is just:

pb

This is another macro call that causes the bulk of the PB1 code to be inserted into the program when it is assembled.

ASSEMBLING AND TESTING

Assemble the **TUT26TEST.ASM** program. If you examine the assembly listing via the LIST button you will see where the PB1 statements and instructions have been inserted during assembly, corresponding to where the text in "<>" chevron brackets occurs in the ASM file.

Now, finally, it is time to try out PB1. Click the new **TEST HEX** button on the Programming sub-screen, or in the Programming section on the main screen.

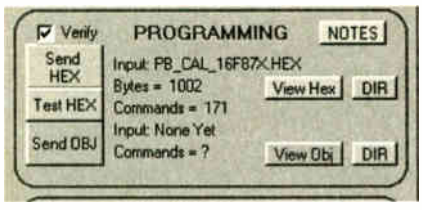

Fig.4. TK3's Programming zone on the main screen, showing new TEST HEX button

The PB1 screen will appear. Note that the top line of the screen shows the full path of the program being tested and the PIC type.

Now click **Start Run**. A message WAITING FOR PIC BREAKPOINT will appear briefly, followed by a progress bar. When this has finished (usually in less than one second) Bank 0 (128 bytes) of user memory data plus other information now appears on the screen (see Fig.5).

The top line of the screen is now replaced by an expansion of the STATUS byte. The next line shows the number of the breakpoint and the program address, in hex, at which it occurred. Reference to the listing will show that the address points to the first instance of the **bkpt** statement. As this was immediately preceded by a **setc** (Set Carry) instruction, the STATUS expansion shows C as 1.

On the left hand side of the screen the special registers relating to the particular PIC device being used are displayed, except for INDF. As this register always reads as whatever FSR is pointing at, it has been replaced in the display by the contents of the W register. Apart from RB6 and RB7 of PORTB, the contents of all the registers are shown as they were at the point of the **bkpt** statement.

Each line in the boxes (yellow on screen) shows the contents of a byte of data memory in the format:

Hex Address, Decimal Contents, Hex Contents, Binary Contents shown as two nibbles.

The contents of some lines may be shown blank – this is because this address is not available for this particular PIC type. Zero contents are shown in black, and non-zero contents are shown in red at this stage.

From the assembly listing (access via the LIST button) address 20h (hex) is known to hold CLKCNT, and shows the value of 25. This checks with the first few program instructions where CLKCNT is decremented according to the TOIF flag in INTCON, when it falls through the loop and is reset to 25.

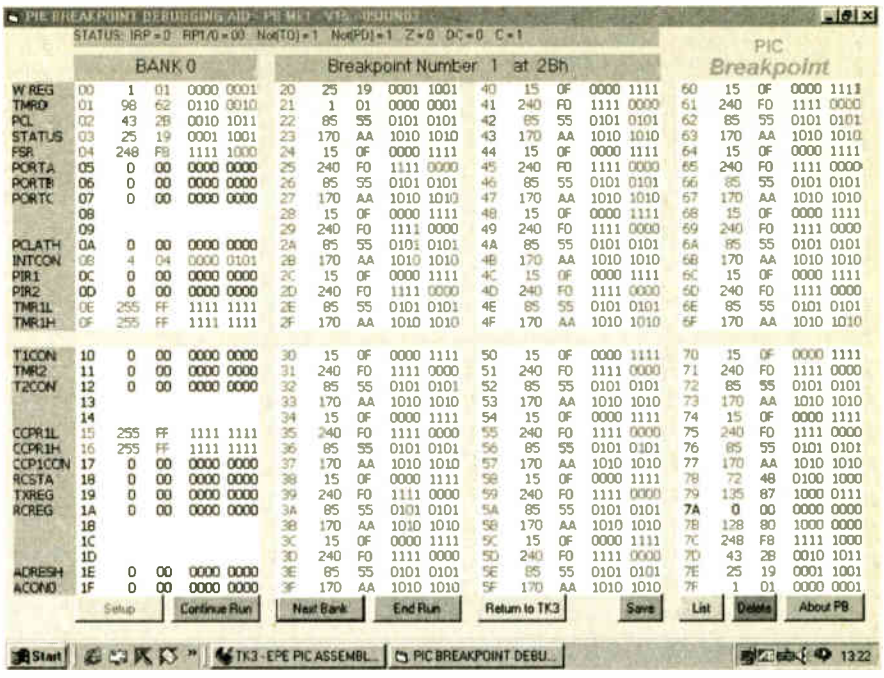

Fig.5. Example of PIC Breakpoint's display of Bank 0 registers as they occurred at one breakpoint interruption.

CLKSEC at address 21h has been incremented to 1, and just before the **bkpt** statement it is loaded into the W register. Most of the rest of the data memory addresses are binary patterns left over from the calibration process.

Clicking the **Next Bank** button will show Bank 1 of data memory. Depending on whether the PIC type has two or four banks, further clicks of the **Next Bank** button will display either Bank 0 again, or go on to show Banks 2 and 3.

The last eight or nine bytes of data memory are reserved for PB1 use, depending on whether the PIC has more than 2K words of program memory. For PIC16F62x and PIC16F87x devices the last 16 bytes of data memory are the same in all banks – see Table 1 for a summary of resources used by PB1.

The caption on **Start Run** button has now changed to **Continue Run**. If this is clicked the data memory as it stands at the second breakpoint is uploaded. The expanded STATUS line now shows C as 0, matching the **clrc** in the program.

The breakpoint address now reflects the second **bkpt** statement in the program. Most of the display has turned to blue numbers, which indicates that they have not changed since the previous breakpoint – this is to help show what is going on.

Examination of the assembly listing shows that a table call has been made to convert CLKSEC into an output for the l.e.d. display, which is returned in register W and output via PORTB. Examination of the PB1 display indeed shows that W contains the expected value. binary 11111001, but PORTB contains 00111001. This is because PB1 uses RB6 and RB7, and overwrites any data there.

Further clicking of the **Continue Run** allows **TUT26TEST** to cycle, and the increasing count in CLKSEC and the conversion in the W register can be viewed on the PC screen.

Finally, clicking the **Save** button will append the current screen of uploaded

Table 1. Resources used by PIC Breakpoint

Pic Type	*Program Memory*	*Data Memory*	*Instructions per bkpt*	*Instructions in pb*	*PB1 Reserved Addresses*
PIC16F627	1K	224	10	69	78 – 7F*
PIC16F628	2K	224	10	69	78 – 7F*
PIC16F83	512	36	10	69	28 – 2F
PIC16C84	1K	36	10	69	48 – 4F
PIC16F84	1K	68	10	69	48 – 4F
PIC16F84A	1K	68	10	69	48 – 4F
PIC16F870	2K	128	10	69	78 – 7F*
PIC16F871	2K	128	10	69	78 – 7F*
PIC16F872	2K	128	10	69	78 – 7F*
PIC16F873	4K	192	16	72	77 – 7F*
PIC16F874	4K	192	16	72	77 – 7F*
PIC16F876	8K	368	16	72	77 – 7F*
PIC16F877	8K	368	16	72	77 – 7F*

*On these PICs equivalent addresses in Banks 1, 2 and 3 are also reserved

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data to a file and clicking **List** will send the file to the editor specified in *TK3*, where it can be saved to a named file and/or printed off for later analysis. The editor should use a fixed font such as Courier New or FixedSys for correct spacing. Any number of screens can be saved. The **Delete** button deletes the file of saved screens.

If a re-run of the program is required, click **End Run** followed by **Start Run.** Otherwise click **Return to TK3**.

USING PIC BREAKPOINT

Using PIC Breakpoint with your own programs requires exactly the same technique as shown for **TUT26TEST** – you simple place the breakpoints at the places in your program where you wish to know the register details.

Note that the **PBM.INC** file *must* be copied into the folder that holds the .ASM source of the program you want to test.

Ensure that *TK3*'s verification is enabled. Run the calibration program if the PIC oscillator frequency has been changed. Insert the LIST and INCLUDE directives. Remember to specify the correct PIC type in the LIST directive.

Clear RB6 and RB7 of PORTB to zero and define them as inputs. Insert **bkpt** statements into the code at as many points as required (subject to program memory space). Insert the **pb** statement anywhere a subroutine can be inserted, but it is usually convenient to place it at the end of the program. Note that **pb** can be placed in any program memory segment.

There are a few other items to be taken into account:

- Pins RB6 and RB7 should not have circuitry attached to them
- The program should avoid writing to RB6 and RB7
- Do not let your program use the eight or nine bytes reserved for PB1 use
- PB1 disables all interrupts during its processing by clearing the GIE bit in INTCON. If GIE was set prior to the **bkpt** statement being encountered, it will be set again on return
- Although PB1 clears the RBIF flag in INTCON to prevent false interrupts arising from PB1 use, using the port change interrupt feature may prove difficult – the author has not tried it
- **bkpt** statements can be placed in interrupt routines. However, the relevant interrupt flag should be reset *after* the **bkpt** call rather than before it, otherwise the program under test may interrupt continuously
- Because PICs can respond to interrupts, PB1 does not actually halt the PIC program after it has uploaded data – instead the program is allowed to continue and can process interrupts in the usual way. The program will stop when the next breakpoint is reached, where it will wait until the **Continue Run** button is pressed
- PB1 will display a message if the **Start** or **Continue Run** button is clicked and no breakpoint is reached within five seconds. PB1 cannot determine whether the program is operating correctly and no breakpoint should have been reached yet, or has hung up because of a program bug. If you suspect the latter, insert a few more breakpoints earlier in the program to see what is going on.

Happy Debugging!

ACKNOWLEDGEMENTS

The author thanks some "guinea pigs" – John Becker, Andrew Jarvis, John Waller and Malcolm Wiles – for making many invaluable suggestions during "field testing" of PIC Breakpoint. Special thanks to John for implementing some elements of MPASM macros, and for enabling the integration of PIC Breakpoint into *TK3*. □

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By Clive (call me Max) Maxfield

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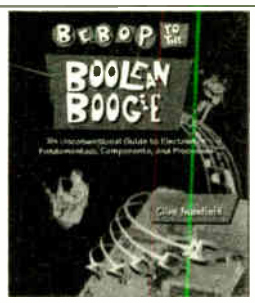
An Unconventional Guide to Electronics Fundamentals, Components and Processes



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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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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.

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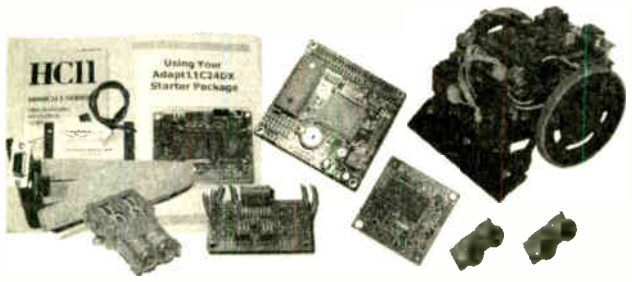

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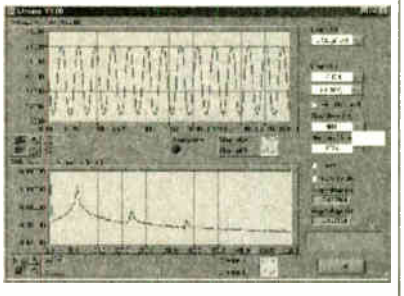

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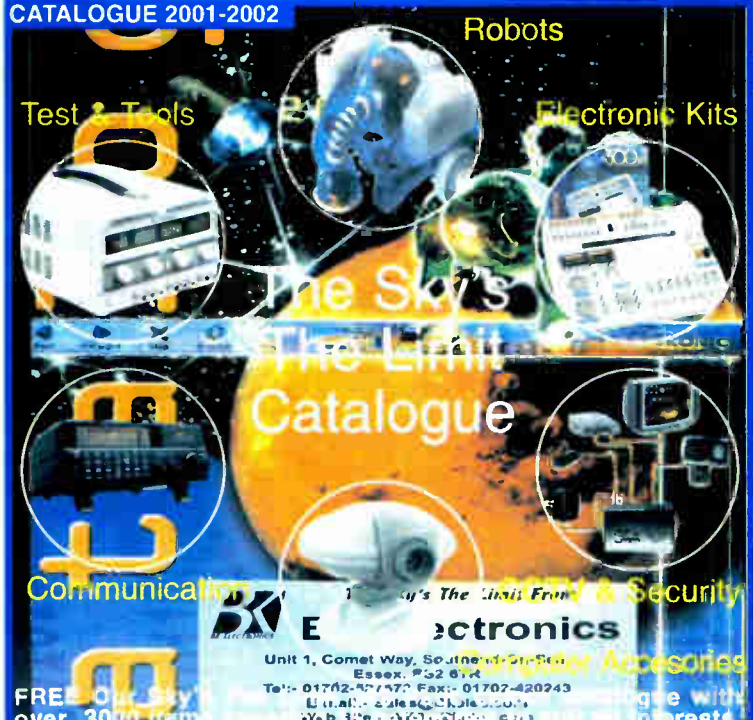

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DELIVERY CHARGES:- PLEASE INCLUDE AS ABOVE, TO A MAXIMUM AMOUNT £30.00. OFFICIAL ORDERS FROM SCHOOL, COLLEGES, GOVT., PLCs ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER. CREDIT CARD ORDERS ACCEPTED BY POST PHONE OR FAX.

OMP XO3-S STEREO 3 WAY ACTIVE CROSSOVER

SWITCHABLE 2-WAY

BASS MID TOP — CONFIGURED 3 WAY
BASS/MID TOP — 2 WAY BASS/MID COMBINED
BASS MID/TOP — 2 WAY MID/TOP COMBINED

FEATURES:-

Advanced 3-Way Stereo Active Cross-Over (Switchable two way), housed in a 19" x 1U case. Each channel has three level controls: Bass, Mid & Top. The removable front facia allows access to the programmable DIL switches to adjust the cross-over frequency: There are two versions available:- XO3-S Bass-Mid 125/250/500Hz, Mid-Top 1.8/3/5kHz, all at 24 dB per octave. XO3 Bass-Mid 250/500/1kHz, Mid-Top 1.8/3/5kHz, all at 24 dB per Octave. *Please make sure you ask for the correct model when ordering.* The 2/3 way selector switches are also accessed by removing the front facia. Each stereo channel can be configured separately. Bass Invert Switches are incorporated on each channel. Nominal 775mV Input/output. Fully compatible with the OMP Rack Amplifier and Modules.

BOTH MODELS PRICED AT :- £117.44 + £5.00 P&P

OMP MOS-FET POWER AMPLIFIER MODULES

SUPPLIED READY BUILT AND TESTED

These modules now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models are available to suit the needs of the professional and hobby market ie Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE that all models include toroidal power supply, integral heatsink, glass fibre P.C.B. and drive circuits to power a compatible Vu meter. All models are open and short circuit proof

THOUSANDS OF MODULES PURCHASED BY PROFESSIONAL USERS

OMP/MF 100 Mos-Fet Output Power 110 watts R.M.S into 4 ohms,frequency response 1Hz - 100kHz -3dB, Damping Factor >300, Slew Rate 45V/uS T.H.D. typical 0.002%, Input Sensitivity 500mV, S.N.R. 110dB. Size 300 x 123 x 60mm.
Price:- £42.85 + £4.00 P&P

OMP/MF 200 Mos-Fet Output Power 200 watts R.M.S. into 4 ohms,frequency response 1Hz - 100kHz -3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV. S.N.R. 110dB. Size 300 x 155 x 100mm.
Price:- £66.35 + £4.00 P&P

OMP/MF 300 Mos-Fet Output Power 300 watts R.M.S. into 4 ohms,frequency response 1Hz - 100kHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. 110dB. Size 330 x 175 x 100mm.
Price:- £83.75 + £5.00 P&P

OMP/MF 450 Mos-Fet Output Power 450 watts R.M.S. into 4 ohms,frequency response 1Hz - 100kHz -3dB, Damping Factor >300, Slew Rate 75V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. 110dB Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti Thump Delay. Size 385 x 210 x 105mm.
Price:- £135.85 + £6.00 P&P

OMP/MF 1000 Mos-Fet Output Power 1000 watts R.M.S. into 2 ohms, frequency response 1Hz - 100kHz -3dB, Damping Factor >300, Slew Rate 75V/uS. T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. 110dB. Fan Cooled, D.C. Loudspeaker Protection, 2 Second Anti Thump Delay Size 422 x 300 x 125mm.
Price:- £261.00 + £12.00 P&P

NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV,BANDWIDTH 100kHz OR PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV BANDWIDTH 50kHz **ORDER STANDARD OR PEC**

B.K. ELECTRONICS

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