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● PROJECTS ● THEORY ●
● NEWS ● COMMENT ●
● POPULAR FEATURES ●
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EPE EVERYDAY PRACTICAL ELECTRONICS

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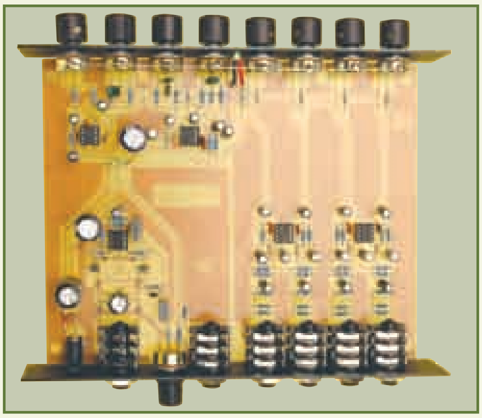

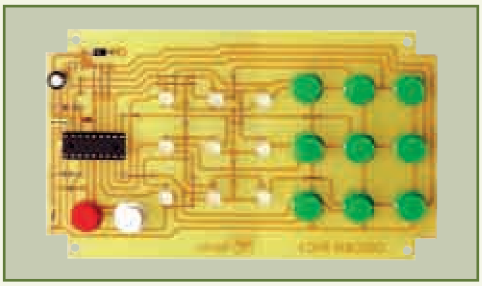

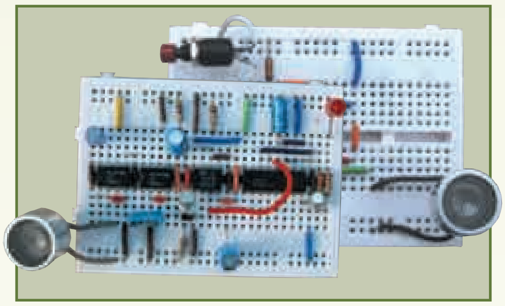

Projects and Circuits

Series and Features

Regulars and Services

Our May 2009 issue will be published on Thursday 9 April 2009, see page 72 for details.

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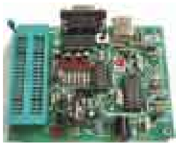
PIC & ATMEL Programmers

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

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

NEW! USB & Serial Port PIC Programmer



USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.
Kit Order Code: 3149KT - **£49.95**
Assembled Order Code: AS3149 - **£59.95**

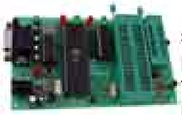
NEW! USB 'All-Flash' PIC Programmer

USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows XP Software. ZIF Socket and USB lead not incl.
Assembled Order Code: AS3128 - **£49.95**
Assembled with ZIF socket Order Code: AS3128ZIF - **£64.95**

'PICALL' ISP PIC Programmer

Will program virtually all 8 to 40 pin *serial-mode* AND *parallel-mode* (PIC15C family) PIC microcontrollers. Free Windows software. Blank chip auto detect for super fast bulk programming. Optional ZIF socket.
Assembled Order Code: AS3117 - **£29.95**
Assembled with ZIF socket Order Code: AS3117ZIF - **£44.95**

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 - **£27.95**
Assembled Order Code: AS3123 - **£37.95**

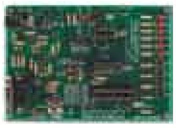
Introduction to PIC Programming

Go from complete beginner to burning a PIC and writing code in no time! Includes 49 page step-by-step PDF Tutorial Manual, Programming Hardware (with LED test section), Win 3.11—XP Programming Software (Program, Read, Verify & Erase), and 1rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). PC parallel port.
Kit Order Code: 3081KT - **£16.95**
Assembled Order Code: AS3081 - **£24.95**

PIC Programmer Board

Low cost PIC programmer board supporting a wide range of Microchip® PIC™ microcontrollers. Requires PC serial port. Windows interface supplied.
Kit Order Code: K8076KT - **£39.95**

PIC Programmer & Experimenter Board



The PIC Programmer & Experimenter Board with test buttons and LED indicators to carry out educational experiments, such as the supplied programming examples. Includes a 16F627 Flash Microcontroller that can be reprogrammed up to 1000 times for experimenting at will. Software to compile and program your source code is included.
Kit Order Code: K8048KT - **£39.95**
Assembled Order Code: VM111 - **£59.95**

Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. 12Vdc PSU for all units: Order Code PSU445 £7.95

USB Experiment Interface Board

5 digital input channels and 8 digital output channels plus two analogue inputs and two analogue outputs with 8 bit resolution.
Kit Order Code: K8055KT - **£38.95**
Assembled Order Code: VM110 - **£64.95**

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 - **£49.95**
Assembled Order Code: AS3180 - **£59.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 45x45mm. Powered by PC. Includes one DS1820 sensor.
Kit Order Code: 3145KT - **£19.95**
Assembled Order Code: AS3145 - **£26.95**
Additional DS1820 Sensors - **£3.95 each**

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

4-Ch DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.
Kit Order Code: 3140KT - **£74.95**
Assembled Order Code: AS3140 - **£89.95**

8-Ch Serial Port Isolated I/O Relay Module

Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA.
Kit Order Code: 3108KT - **£64.95**
Assembled Order Code: AS3108 - **£79.95**

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 - **£59.95**
Assembled Order Code: AS3142 - **£69.95**

Audio DTMF Decoder and Display

Detect DTMF tones from tape recorders, receivers, two-way radios, etc using the built-in mic *or* direct from the phone line. Characters are displayed on a 16 character display as they are received and up to 32 numbers can be displayed by scrolling the display. All data written to the LCD is also sent to a serial output for connection to a computer. Supply: 9-12V DC (Order Code PSU445). Main PCB: 55x95mm.
Kit Order Code: 3153KT - **£34.95**
Assembled Order Code: AS3153 - **£44.95**

Telephone Call Logger

Stores over 2,500 x 11 digit DTMF numbers with time and date. Records all buttons pressed during a call. No need for any connection to computer during operation but logged data can be downloaded into a PC via a serial port and saved to disk. Includes a plastic case 130x100x30mm. Supply: 9-12V DC (Order Code PSU445).
Kit Order Code: 3164KT - **£54.95**
Assembled Order Code: AS3164 - **£69.95**

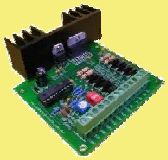
Hot New Products!

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

40 Second Message Recorder

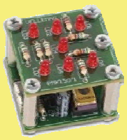
Feature packed non-volatile 40 second multi-message sound recorder module using a high quality Winbond sound recorder IC. Standalone operation using just six onboard buttons or use onboard SPI interface. Record using built-in microphone or external line in. 8-24 Vdc operation. Just change one resistor for different recording duration/sound quality. sampling frequency 4-12 kHz.
Kit Order Code: 3188KT - **£28.95**
Assembled Order Code: AS3188 - **£36.95**
120 second version also available

Bipolar Stepper Motor Chopper Driver



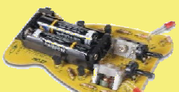
New bipolar chopper driver gives better performance from your stepper motors. It uses a dual full bridge motor driver based on SGS Thompson chips L297 & L298. Motor current for each phase is set using an on-board potentiometer. Can handle motor winding currents of up to 2 Amps per phase. Operates from a DC supply voltage of 9-36V. All basic motor controls provided including full or half stepping of bipolar steppers and direction control. Synchroniseable when using multiple drivers. Perfect for desktop CNC applications.
Kit Order Code: 3187KT - **£39.95**
Assembled Order Code: AS3187 - **£49.95**

Shaking Dice



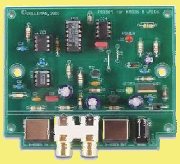
This electronic construction kit is great fun to build and play with. Simply shake and watch it slowly roll to stop on a random number. Great fun project.
Kit Order Code: MK150KT - **£12.95**

Running MicroBug



This electronic construction kit is an attractive bright coloured bug-shaped miniature robot.
The MicroBug is always hungry for light and travels toward it!. Great fun robot project.
Kit Order Code: MK127KT - **£12.95**

Video Signal Cleaner



Digitally cleans the video signal and removes unwanted distortion in video signal. In addition it stabilises picture quality and luminance fluctuations.
You will also benefit from improved picture quality on LCD monitors or projectors.
Kit Order Code: K8036KT - **£32.95**
Assembled Order Code: VM106 - **£49.95**

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

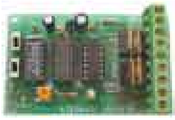
Motor Speed Controllers

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

DC Motor Speed Controller (100V/7.5A)

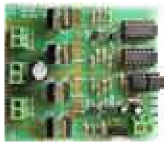
Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£17.95**
Assembled Order Code: AS3067 - **£24.95**

Computer Controlled / Standalone Unipolar Stepper Motor Driver



Drives any 5-35Vdc 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps. Provides speed and direction control. Operates in stand-alone or PC-controlled mode for CNC use. Connect up to six 3179 driver boards to a single parallel port. Board supply: 9Vdc. PCB: 80x50mm.
Kit Order Code: 3179KT - **£15.95**
Assembled Order Code: AS3179 - **£22.95**

Computer Controlled Bi-Polar Stepper Motor Driver



Drive any 5-50Vdc, 5 Amp bi-polar stepper motor using externally supplied 5V levels for STEP and DIRECTION control. Opto-isolated inputs make it ideal for CNC applications using a PC running suitable software. Board supply: 8-30Vdc. PCB: 75x85mm.
Kit Order Code: 3158KT - **£23.95**
Assembled Order Code: AS3158 - **£33.95**

Bidirectional DC Motor Speed Controller

Control the speed of most common DC motors (rated up to 32Vdc/10A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections.
Kit Order Code: 3166v2KT - **£22.95**
Assembled Order Code: AS3166v2 - **£32.95**

AC Motor Speed Controller (700W)

Reliable and simple to install project that allows you to adjust the speed of an electric drill or 230V AC single phase induction motor rated up to 700 Watts. Simply turn the potentiometer to adjust the motors RPM. PCB: 48x65mm. Not suitable for use with brushless AC motors.
Kit Order Code: 1074KT - **£14.95**
Assembled Order Code: AS1074—**£20.95**

See www.quasarelectronics.com for lots more motor controllers

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Order Code EPL500 - **£199.95**
Also available: 30-in-1 **£19.95**, 50-in-1 **£29.95**, 75-in-1 **£39.95** £130-in-1 **£49.95** & 300-in-1 **£84.95** (see website for details)

Tools & Test Equipment

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

Two-Channel USB Pc Oscilloscope

This digital storage oscilloscope uses the power of your PC to visualize electrical signals. Its high sensitive display resolution, down to 0.15mV, combined with a high bandwidth and a sampling frequency of up to 1GHz are giving this unit all the power you need.
Order Code: PCSU1000 - **£399.95**

Personal Scope 10MS/s

The Personal Scope is not a graphical multimeter but a complete portable oscilloscope at the size and the cost of a good multimeter. Its high sensitivity - down to 0.1mV/div - and extended scope functions make this unit ideal for hobby, service, automotive and development purposes. Because of its exceptional value for money, the Personal Scope is well suited for educational use.
Order Code: HPS10 - ~~£189.95~~ £169.95

See website for more super deals!

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EVERYDAY PRACTICAL ELECTRONICS
FEATURED KITS

April '09

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

Jaycar Electronics

LED WATER LEVEL INDICATOR MKII KIT

KC-5449 £10.25 plus postage & packing

This simple circuit illuminates a string of LEDs to quickly indicate the water level in a rainwater tank. The more LEDs that illuminate, the higher the water level is inside the tank. The input signal is provided by ten sensors located in the water tank and connected to the indicator unit via light duty figure-8 cable.

- Kit supplied with PCB with overlay, machined case with screenprinted lid and all electronic components.

* As published in EPE Magazine March 2009

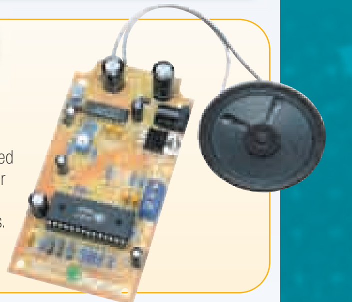
STARSHIP ENTERPRISE DOOR SOUND EMULATOR KIT

KC-5423 £11.75 plus postage & packing

This easy to build kit emulates the unique noise made when the cabin doors on the Starship Enterprise open & close. The 'shut' noise is also duplicated. The sound emulator can be triggered by switch contacts (normally open) which means you can use a reed magnet switch, IR beam or PIR detector to trigger the unit.

- Kit includes PCB with overlay, case & all electronic components with clear English instructions.
- Requires 9-12VDC power

* As published in EPE Magazine June 2008



MINI THEREMIN SYNTHESISER MKII KIT

KC-5426 £43.50 plus postage & packing

By moving your hand between the metal antennas, create unusual sound effects! The Theremin MkII improves on its predecessor by allowing adjustments to be made to the tonal quality and features better waveform. With a multitude of controls this instrument's musical potential is only limited by the skill of its player.

- Kit includes stand, PCB with overlay, machined case with silkscreen printed lid, loud speaker, pitch and volume antennas & all specified electronic components.

* As published in EPE Magazine May/June 2008

LUXEON STAR LED DRIVER KIT

KC-5389 £9.75 plus postage & packing

Luxeon high power LEDs are some of the brightest LEDs available in the world. They offer up to 120 lumens per unit, and will last up to 100,000 hours! This kit allows you to power the fantastic 1W, 3W, and 5W Luxeon Star LEDs from 12VDC. This means that you can take advantage of what these fantastic LEDs have to offer, and use them in your car, boat, or caravan.

- Kit supplied with PCB, and all electronic components.

* As published in EPE Magazine April 2007

VOLTAGE MONITOR KIT

KC-5424 £6.00 plus postage & packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features a 10 LED bar graph that lights the LEDS in response to the measured voltage, preset 9-16V, 0.-5V or 0-1V ranges complete with a fast response time, high input impedance & auto dimming for night time driving.

- Kit includes PCB with overlay, LED bar graph & all electronic components.
- Requires 12VDC power
- Recommended box: UB5 HB-6015

* As published in EPE Magazine June 2008

GALACTIC VOICE KIT

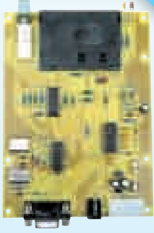
KC-5431 £13.25 plus postage & packing

Effect and depth controls allow you to vary the voice to simulate everything from C-3PO to the hysterical ranting of Daleks.

- Kit includes PCB with overlay, enclosure, speaker and all components.

* As published in EPE Magazine August 2008

SMART CARD READER PROGRAMMER KIT



KC-5361 £15.95 plus P&P

Program both the microcontroller and EEPROM in the popular gold, silver & emerald wafer cards. Card used needs to conform to ISO-7816 standards, which includes ones sold by Jaycar. Powered by 9-12 VDC wall adaptor or a 9V battery. Instructions outline software requirements that are freely available on the internet.

- Kit supplied with PCB, wafer card socket & all electronic components. PCB measures: 141 x 101mm

* As published in EPE Magazine May 2006

RADAR SPEED GUN MKII KIT

KC-5441 £29.00 plus postage & packing

If you're into any kind of racing like cars, bikes boats or even the horses, this kit is for you. The electronics are mounted in the supplied jiffy box and the radar gun assembly can be made simply with two coffee tins fitted end to end. The circuit needs 12VDC at only 130mA so you can use a small SLA or rechargeable battery pack.

- Kit includes PCB and all specified electronic components.

* As published in EPE Magazine December 2008

AC/DC CURRENT CLAMP METER KIT FOR DMM'S

KC-5368 £8.75 plus postage & packing

It uses a simple hall effect sensor & iron ring core set up, & connects to your digital multimeter. It will measure AC & DC current & has a calibration dial to allow for any magnetising of the core. Much cheaper than pre-built units.

- Kit supplied with PCB, clamp, case with silk screened front panel & all electronic components.

* As published in EPE Magazine June 2006

COURTESY INTERIOR LIGHT DELAY KIT

KC-5392 £5.95 plus postage & packing

Many modern cars feature a time delay on the interior light. It still allows you time to buckle up and get organised before the light dims and finally goes out. This kit provides that feature for cars which don't already provide it. It has a soft fade out after a set time has elapsed, and features much simpler universal wiring than previous models we have had.

- Kit supplied with PCB with overlay, and all electronic components.
- Suitable for circuits switching ground or +12V or 24VDC (car & truck with negative chassis.)

* As published in EPE Magazine February 2007

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CAR KITS FOR ELECTRONIC ENTHUSIASTS
HAND CONTROLLER KIT
KC-5386 £25.95 + post & packing
This LCD hand controller is required during the initial setting-up procedure. It plugs into the main unit and can be used while the engine is either running or stopped. Using this Hand Controller, you can set all the initial parameters and also program the ignition advance/retard curve.
• Kit supplied with silk screened and machined case, PCB, LCD, and all electronic components.
DIGITAL FUEL ADJUSTER KIT
KC-5385 £25.95 + post & packing
This unit gives you complete control of the air/fuel ratio at 128 points across the entire engine load range and provides incredible mapping resolution and brilliant drivability. It uses the Handheld Digital Controller - KC-5386 (available separately) so there is no need for a laptop. Supports both static and real-time mapping.
• Kit supplied with a quality solder masked PCB with overlay, machined case with processed panels, programmed micro and all electronic components.
ECONOMY ADJUSTABLE TEMPERATURE SWITCH KIT
KC-5381 £9.75 plus postage & packing
It has an adjustable switching temperature (up to 245°C) and can be configured to trigger on rising or falling temperature. Useful for running cooling fans or over-temp warning lights or alarms, etc.
• Kit supplied with PCB, NTC Thermistor, and all electronic components.
UNIVERSAL VOLTAGE SWITCH KIT
KC-5377 £9.95 plus postage & packing
This is a universal module which can be adapted to suit a range of different applications. It will trip a relay when a preset voltage is reached. It can be configured to trip with a rising or falling voltage, so it is suitable for a wide variety of voltage outputting devices eg., throttle position sensor, air flow sensor, EGO sensor. It also features adjustable hysteresis (the difference between trigger on/off voltage), making it extremely versatile. You could use it to trigger an extra fuel pump under high boost, anti-lag wastegate shutoff, and much more.
• Kit supplied with PCB, & all electronic components.
FREQUENCY SWITCH KIT
KC-5378 £11.75 plus postage & packing
This is a great module which can be adapted to suit a range of different applications. It uses a standard tacho, road speed, or many other pulse outputs to switch a relay. The switch frequency can be set to trip when it is rising or falling, and it features adjustable hysteresis (the difference between trigger on/off frequency). You could configure it to trigger water spray cooling on deceleration, shift light activation, adjustable aerodynamics based on speed, intake manifold switching and much more.
• Kit supplied with PCB, and all electronic components.
FUEL MIXTURE DISPLAY KIT FOR FUEL INJECTED CAR
KC-5374 £8.95 plus postage & packing
This kit features auto dimming for night driving, emergency lean-out alarm, and better circuit protection. Another great feature is the 'dancing' display, which operates when the ECU is operating in closed loop.
• Kit supplied with PCB and all electronic components.
• Car must be fitted with airflow and EGO sensors (standard on all EFI systems) for full functionality.
ELECTRONIC PROJECTS FOR CARS VOL. II
BS-5075 £4.75 plus postage & packing
This informative magazine contains a collection of 17 electronic projects for cars from Silicon Chip Magazines.
The interesting articles and projects include:
• Ignition projects
• PIC-based projects
• Alarms & Engine monitors
• Limiters and Immobilisers
• Miscellaneous projects.
• 128 pages.
CAR BATTERY MONITOR KIT
KA-1683 £5.50 plus postage & packing
Don't get caught with a flat battery! This simple electronic voltmeter lets you monitor the condition of your car's battery so you can act before getting stranded. 10 rectangular LEDs tell you your battery's condition.
• Kit includes PC board and all components.
IMPROVED TACHOMETER KIT FOR CARS
KC-5290 £19.95 plus postage & packing
Unlike its' bulky predecessor from August 1991, this PIC based tachometer is housed neatly in a small jiffy box (83 x 54 x 31mm), which mounts nicely on your dashboard. It's amazing features include 4-digit LED display showing up to 9,900rpm in 100rpm increments, 10 LED bargraph with optional dot or bar mode (showing 8-independent rpm thresholds), calibration options for 1- 12 cylinder 4-stroke or 1- 6 cylinder 2-stroke engines, anti-display flickering feature and automatic night-time display dimming, to perform engine limiting.
• Kit includes case with silk-screened panel, PCBs, pre-programmed PIC micro, 7-segment displays, red acrylic, hook-up wire and all electronic components.
FREE CATALOGUE
Checkout Jaycar's extensive range
We have kits & electronic projects for use in:
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Retro electronics

Reading Brian Healy's fascinating account of how he first developed his Oscar Noughts & Crosses game in the late 60s reminded me that few things date as quickly as old electronic equipment. Electronic engineers, from new-to-the-hobby amateurs to seasoned professionals are generally forward-looking people who relish the prospect of better, cheaper, neater solutions to problems, and that is of course a good thing. It's driven the digital revolution in just a few decades from mechanical relay decoders to astonishingly powerful super computers – and despite ongoing predictions of reaching 'physical limits' to development, physicists and engineers in R&D teams have been endlessly creative in squeezing more and more out of less and less semiconductor real estate.

Every now and again though, it's worth pausing and revisiting old technology to see if in the rush to discard it, a viable or just plain interesting solution has been overlooked. I was reminded of this twice in the last week. First, in my random wanderings in eBay I came across Nixie tubes for sale. Nixie tubes are those now obsolete display devices that were primarily used to indicate numbers – they look like vacuum tubes, give out a warm glow and are now used to make attractive retro electronic clocks. Is there anyone out there who would like to write a short piece for us on how to use these devices?

My other trip down electronic memory lane occurred when I met up with an old friend from Sussex University. He's a highly skilled technician with a particular interest in hifi. His latest project is a vacuum-tube-based DAC to play digital music – a wonderful combination of the oldest and newest technologies. He's no crank! At the university he specialises in developing low noise circuitry to accurately measure minute signals, so I'm sure the results will be well worth listening to – if not exactly iPod sized.

Matt

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NEWS

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

Broadband by satellite

The UK government wants everyone to have two-meg broadband by 2012. Barry Fox reports that a new two-way broadband-by-satellite service should help achieve this.

AT least 100,000 and probably up to 800,000 homes in the UK are in 1300 'notspots'. These are areas where there is no hope of getting broadband by DSL phone line or cable because homes are too far from a telephone exchange (5km or more) or are using old and poor quality phone lines.

"We are only selling to people who can only get dial-up" says Mike Locke of Eurosat. "We know where they are. There is no need to spend a lot of money on TV adverts. We can target the notspots".

The service – called Astra2Connect – comes from the 23.5 East slot vacated by Germany's Kopernikus satellite, using *Astra 1E* and *3A* craft. A2C is already used by around 50,000 homes in 11 European countries. Data packages range from 256kbps to 2Mbps, with monthly rental from £20 to £75 after purchase of the 79cm dish and receiver modem kit for £300. The dish has a dual feed, enabling it to get data from 23.5 East and receive conventional TV from 19.2 East (for mainland Europe) and 28.2 East (for the UK).

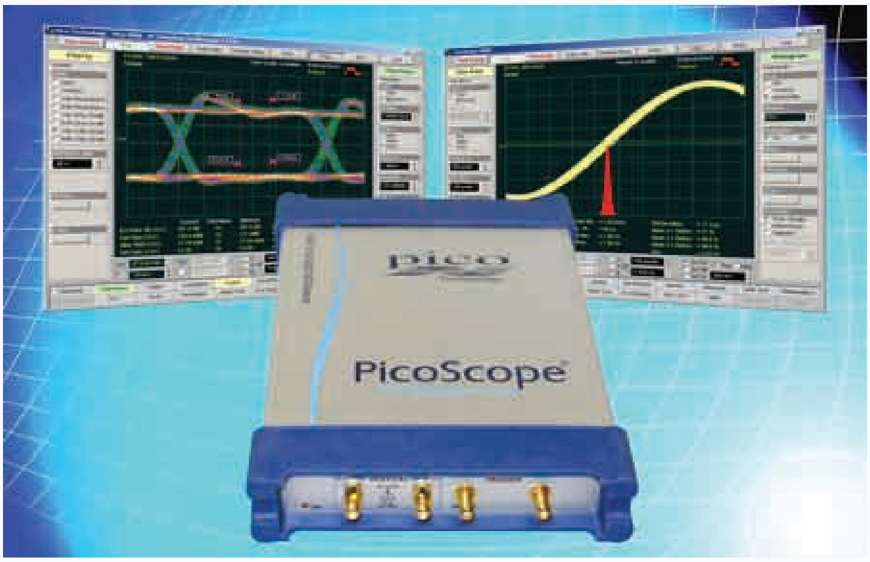
Eurosat charges around £100 for installation, but DIY fitting is possible thanks to a 'point and play' device that connects between the dish and receiver/modem and makes guide sounds in an earpiece as the correct satellite is found and accurately sighted. Uplink transmission power is 500mW, and Astra has negotiated a class licence, which means the user does not have to apply for official permission to transmit.

No software is installed on the PC. The receiver/modem connects to the PC by Ethernet cable and is accessed by a web browser in the same way as a DSL modem. This avoids the problems Astra encountered five years ago with a one-way service that used a dial-up phone line as the return link to control satellite downloading, and required complex control software on the PC.

A2C has no data caps, but fair use policies throttle the few users who are downloading large files such as movies at peak hours in the evenings or over weekends. Astra plans a Voice Over IP service 'later this year' to bring speech calls to parts of Europe which cannot get a phone line and where there is no cellphone service. Although the current service will support Skype, A2C VOIP will use a dedicated channel for speech.

Latency delays can never be less than 240ms, the round trip between ground and satellite, plus delays in the communications hubs, so the service is not recommended for online gaming, which needs a more rapid response.

PICO'S 12GHZ SAMPLING SCOPES



Pico Technology has unveiled the PicoScope 9000 Series dual-channel PC Sampling Oscilloscopes. With a bandwidth of 12GHz, they redefine the performance of sampling oscilloscopes at this price level.

The dual-channel PicoScope 9201 uses sequential equivalent-time sampling to achieve a sampling rate of 5TS/s. The wide bandwidth allows acquisition and measurement of fast signals with a transient response of 50ps or faster. Timebase stability, accuracy, and a sampling interval of 200fs allow timing characterization of jitter in the most demanding applications. The ability to trigger on high frequencies up to 10GHz allows measurements on microwave components with extremely fast data rates.

With excellent measurement repeatability, exceptional vertical resolution (16 bits) and fast display update rate, the PicoScope 9201 is a powerful measurement tool for semiconductor testing and high-speed digital data communications.

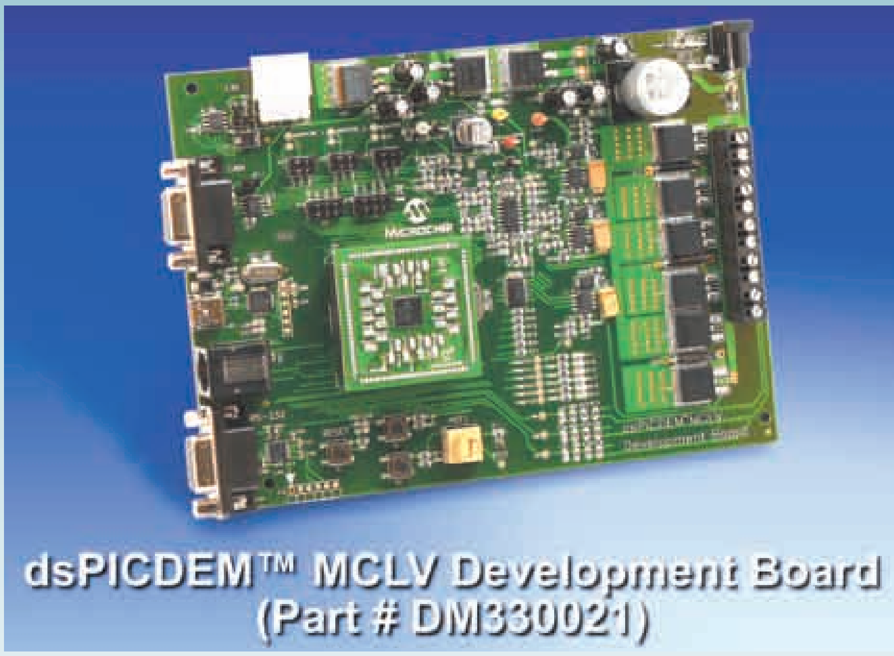
Data acquisition and measurement analysis are performed in parallel, enabling the instrument to achieve outstanding measurement throughput. The instruments provide fast acquisition speed up to 100kS/s and waveform performance analysis with automated direct or statistical measurements on both single-valued signals (sinewave, pulse, impulse) and multi-valued signals (NRZ, RZ). Markers and histograms, maths and FFT analysis, colour-graded display, parametric limit testing, eye diagrams and mask template testing can be used independently or in concert.

For more information, browse ***www.picotech.com****.*

Microchip Expands Support

Microchip has announced expanded support for Motor Control applications based on the dsPIC Digital Signal Controller (DSC). The dsPICDEM MCLV Development Board (part #DM330021) is a new low-voltage brushless DC (BLDC) motor-control development platform supporting the dsPIC33F family of motor control DSCs. It provides a cost-effective method for evaluating and developing sensored or sensorless BLDCs and permanent magnet synchronous Motor (PMSM) control applications.

The board contains a three-phase inverter bridge circuit, which can drive a BLDC or PMSM motor using different control techniques, without requiring any additional hardware. The dsPICDEM MCLV board is capable of controlling motors rated up to 48V and 15A, and supports multiple communication channels, such as USB, CAN, LIN and RS-232. It employs a processor-differentiated Plug-In Module (PIM) strategy to support a variety of dsPIC33F motor-control DSCs with different memory and pin configurations. The dsPICDEM MCLV Development Board also includes a dsPIC33FJ32MC204 PIM (32kB Flash 44 pins).



Additionally, Microchip has announced two new motor-control software solutions; one shows how power factor correction (PFC) algorithms can be combined with sensorless motor-control algorithms on a single chip. Application Note AN1208 describes the process. The second software solution demonstrates how to run an AC induction motor (ACIM) faster than its rated speed for a class of applications, to lower cost, save space or reduce weight. The strategy is described in Application Note AN1206. Both solutions are available today, free of charge, from **www.microchip.com/motor**.

The MPLAB IDE's graphical Data Monitor and Control Interface (DMCI) has been further enhanced, to include a real-time data monitor (RTDM) function. This provides a graphical method to input and adjust motor parameters in real time and see the effect immediately, without halting the application. The MPLAB IDE v8.15, including RTDM and DCMI can also be downloaded for free, from **www.microchip.com/mplab.**

The dsPICDEM MCLV Development Board (part #DM330021) is available now. Source code for the motor control libraries is also available now and can be downloaded free from **www.microchip.comfmotar**.

Research Will Create Robot Societies

The creation of a society of robots able to communicate with each other and perform both individual and group tasks is being carried out by researchers at the University of Wales, Newport. The aim of the research, being conducted by a team led by Dr Torbjorn Dahl, of the Robotic Intelligence Laboratory at Newport Business School, is to reproduce in robots the behaviour patterns of ants and people.

"We currently have eight e-puck, or mini-robots, and will soon have 25 or more, the biggest collection of mini-robots in the UK, which we will program to exist together as a self-regulating society," explained Dr Dahl.

"By studying ant and human societies, we hope to implement this behaviour into robots so that they become a self-organising community that functions without top-down control.

"Our aim is to create a mini-society of robots with built-in behavioural patterns that enable them to not only do tasks set them but also realise what else needs to be done, as worker ants do. The robots are equipped with spatial awareness and use this to communicate and tell each other about various tasks. Each robot learns how to work in a way that improves the group by filling the roles of others as well as the role they are assigned to do.

"The results of this research could impact upon the organisation of towns, villages and cities, as well as improving automation in factories so that there is minimal human input required."

For this collaborative research project, which is sponsored by the Engineering and Physical Sciences Research Council (EPSRC), Newport's University is working closely with the University of the West of England (UWE), University of Hull and Imperial College London.

WIDER TVs

Philips says that "cinema will come home" with "no more black bars" after the commercial launch of the world's first ultra-wide screen 21:9 TVs this Spring.

At a demonstration of preview sets in London, Philips showed widescreen cinema movie material on a 42-inch 16:9 LCD TV, and on a 56-inch Cinema 21:9 LCD set. The two sets had the same height screen and the 21:9 set clearly showed the advantage of completely filling the screen without black letterbox bars at the top and bottom.

Although Philips promises that conventional 16:9 broadcast programming, and even old 4:3 material, will look equally good thanks to intelligent auto-formatting, there was no demonstration of this crucial consideration. "This is a pre-production sample without the necessary picture processing circuitry" said Consumer Marketing Director, Paul Hobden.

When some 16:9 material was accidentally fed to the 21:9 set during the demonstration, it displayed the on-screen message 'video format not supported'. Hobden explained that in the final set 16:9 source material will be auto-expanded to fit the 21:9 screen by slightly stretching the outer edges, much as done when current 16:9 sets display 4:3 material. When 4:3 material is played through the new 21:9 sets, there will be some stretching, with black borders at the sides of the screen to complete the picture.

Some confusion arose during the London briefing over the slight mathematical difference between the exact cinema aspect ratio of 2.39:1 and the Cinema 21:9 name used by Philips. Philips confirms that technically the set is "absolutely aligned with the cinema format" and the numerical ratio has been rounded to 21:9 "for marketing reasons". So no formatting and auto-expansion of the picture will be needed if the set is fed with true cinema format material.

However, slight formatting and auto expansion may be needed with Blu-ray discs until the disc producers use the option in the BD standard to record true cinema format pictures.

Barry Fox

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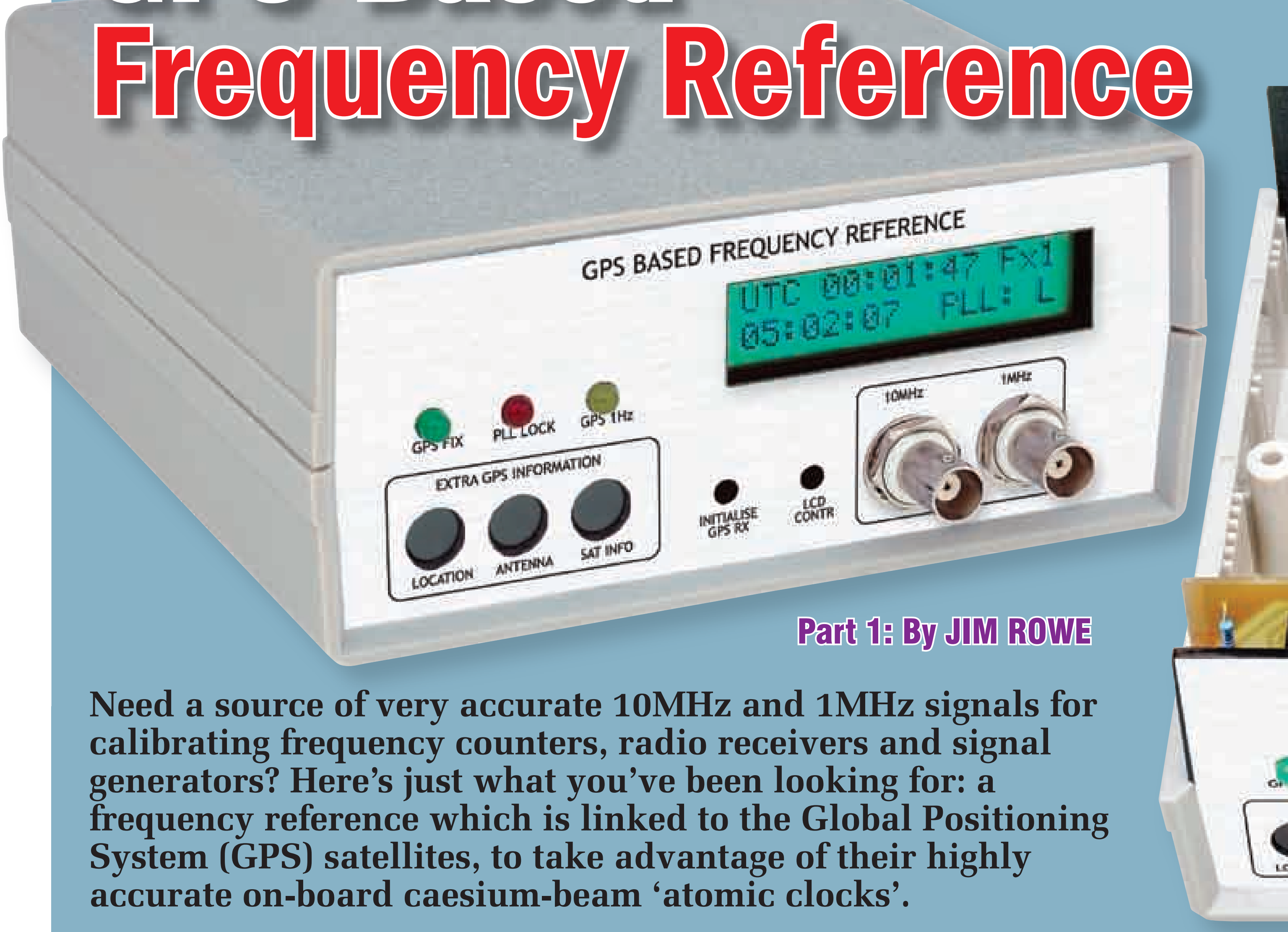
GPS-Based Frequency Reference



Part 1: By JIM ROWE

Need a source of very accurate 10MHz and 1MHz signals for calibrating frequency counters, radio receivers and signal generators? Here's just what you've been looking for: a frequency reference which is linked to the Global Positioning System (GPS) satellites, to take advantage of their highly accurate on-board caesium-beam 'atomic clocks'.

NOT TOO MANY decades ago, the only way most people could generate reasonably accurate frequency signals was by using a quartz crystal oscillator. Following this, it became possible to achieve slightly better accuracy by heterodyning a local quartz oscillator with an HF radio signal from one of the standard frequency and time stations, such as WWV in the USA or VNG in Australia.

By about 1980, even higher accuracy could be obtained by locking a local quartz crystal oscillator with the horizontal sync signals from one of the national TV networks. That's because the networks used a master timing clock that was locked to an 'atomic clock' based on either a caesium beam or rubidium vapour oscillator.

GPS system

The Global Positioning System (GPS) became operational around 1990 and is run by the US Department of Defense (US DOD). By using this system as a reference, it's possible to generate reference frequencies with extremely high accuracy – even better than using the previously listed methods.

That's because each of the 22-odd GPS satellites orbiting the Earth has two caesium beam atomic clocks on board. These are necessary to generate the very accurate frequency and time signals needed for accurate positioning. Since there are always at least four GPS satellites 'in view' at any time from any point on the Earth, this means that there's always access to an 'ensemble' of about eight caesium beam clocks to serve as a frequency reference – provided you have the right GPS receiving equipment, that is.

The only problem was that until recently, GPS receivers were quite expensive. However, costs have fallen quite dramatically since then – so much so, that handheld and mobile GPS navigators are now everyday consumer items. In fact, low-end navigators with colour LCD screens are now down to around £140. Small wonder they're becoming so popular!

The unit is housed in a plastic case and provides accurate 10MHz and 1MHz reference frequencies via front-panel BNC sockets. A range of data can also be displayed on the LCD, including UTC time and date and the receiving antenna's latitude, longitude and height above mean sea level (see panel).

As you might expect, inside each of these navigators is a complete GPS receiver module. However you don't have to buy a navigator to get the receiver module, because they are also available separately for use in other equipment. And that's just what we've done here – used one of these 'bare bones' receiver modules as the heart of this project.

Garmin GPS 15L

The GPS module we chose to use is a Garmin GPS 15L, which is available from local distributors for about £40. It's quite a small device, measuring just 46 × 36 × 8.5mm and weighing in at only 14g. But don't let the size fool you, because there's a lot packed into it.

Inside, there's a complete 12-channel GPS receiver, which can track and use up to 12 GPS satellites at once. And it can provide a swag of GPS-derived time, date, position and satellite status information in serial RS-232C text form – updated each second.

It also provides a one-pulse-per-second (1PPS) output, where the leading edges of the pulses are very accurately locked to the UTC-derived GPS timing system. It's these pulses that we mainly use in the reference to control the frequency of a local 10MHz crystal oscillator.

Antenna

For best performance, you do need to feed the Garmin GPS 15L receiver with good-quality signals. This means mounting a small active GPS antenna in a clear area outside; as high as possible, so that it can get an unobstructed 'view' of the sky in order to receive the satellite signals.

The antenna is connected to the antenna input of the receiver using a suitable length of good quality 50Ω coaxial cable. This delivers the amplified 1.575GHz GPS signals to the receiver and also feeds the active antenna with DC power (provided by the receiver).

In our case, we chose a Garmin GA 29 flush-mount active antenna, which costs about £40. This was mounted on a plastic junction box and fitted to the top of the author's TV antenna mast (see photo).

Taken together, the GPS receiver module and an active antenna will set you back about £80. The rest of the parts will probably be around the £60 mark, so you should be able to build the whole shebang for about £140. This is just a fraction of the price you'll pay for a commercially available GPS-based frequency reference.

How it works

To get some idea on how it all works, refer to the block diagram of Fig.1. Basically, the frequency of the 10MHz crystal oscillator (top, right of Fig.1) is controlled using a phase-locked loop (PLL). This PLL, in turn, uses the very accurate 1Hz pulses from the GPS receiver module as its reference. However, the PLL configuration is a bit more complicated than normal, so let's look at this in greater detail.

Basically, the reason for the added complexity is that it isn't easy to control a 10MHz crystal oscillator using a reference frequency as low as 1Hz – at least not using a standard PLL. That's because with a standard PLL configuration, the oscillator frequency must be divided by 10,000,000 (to get 1Hz), to be compared with the reference frequency in the phase comparator. However, such a high division factor involves a relatively long time delay and this adversely affects the error correction feedback, making it very difficult to stabilise the PLL.

A small active GPS antenna is necessary to receive the GPS signals. The author used a Garmin GA 29 antenna. This was mounted on a plastic junction box and fitted to the top of an existing TV antenna mast.

To get around this problem, we divide the 10MHz oscillator output by a much smaller factor – just 200. This is done in separate divide-by-10 and divide-by-20 stages using synchronous divider ICs, so that we end up with 50kHz pulses which have the timing of their leading edges (L-H transitions) very closely synchronised with the leading edges of every 200th pulse from the 10MHz oscillator.

This means we have effectively transferred the phase of the 10MHz oscillator signal (averaged over 20µs) to the 50kHz signal at the output of the divide-by-20 divider. And it's the phase of this signal which we feed into the second input of the phase comparator, where it's compared with the leading edges of the 1Hz pulses from the GPS receiver module.

Phase compactor

The phase comparator does exactly what its name implies – it compares the leading edge of each 1Hz GPS pulse with the 50kHz pulse nearest to it and generates a 'phase error' pulse, the width of which is directly equivalent to the timing difference. One of these phase error pulses is produced at the start of each 1Hz GPS pulse and they can vary in width from zero (when the two signals are exactly in step) up to a theoretical maximum of 20µs (when the two signals are one period of 50kHz out of step).

In practice, we use the PLL's feedback loop to maintain a fixed phase error of about 10µs (ie, halfway in the range). This gives the PLL the widest possible control range, to ensure reliable locking of the 10MHz crystal oscillator.

Deriving the feedback voltage

OK, so how do we use the varying phase error pulses from the comparator to produce an error correction feedback voltage for the 10MHz oscillator? Well, what we do is use the error pulses to control an AND gate, which then passes pulses from a second crystal oscillator (running at about 10MHz) to an 8-bit binary counter. So, as the error pulse width varies, it allows a varying number of these 'about-10MHz' pulses to reach the counter.

For example, if the phase error pulses are 8.0µs wide, 80 pulses will be gated through to the counter. And if the pulses are 11µs wide, 110 pulses will be fed through, and so on. So, at the start of each 1Hz GPS pulse, a burst of 'about-10MHz' pulses will be fed to the counter, the number of pulses in the burst being directly proportional to the phase error.

The counter is actually reset at the end of each 1Hz GPS pulse, so it counts up from zero each time. At the output of the counter we also have an 8-bit latch and a simple digital-to-analogue converter (DAC) using a resistor ladder network. After the end of each phase error pulse, the latest error-proportional pulse count is transferred into the latch, replacing the previous count.

As a result, the output of the DAC is a DC voltage which varies in level each second, according to the phase error. So, the phase error has been converted into a varying DC error voltage.

Get the idea? When there's a fixed phase error of say 10µs, the counter will have a count of 100 each time and the DAC will have an output voltage of almost exactly 1.953V.

This voltage will vary up or down, in steps of 19.53mV, as the phase error pulses vary in width and the number of 'about-10MHz' pulses fed to the counter varies up or down. Each of the 'about-10MHz' pulses fed to the counter corresponds to a phase error step of close to 100ns, so our phase error-to-DC error voltage conversion circuit has a conversion gain of 19.53mV/100ns or just under 2mV for every 10ns change in phase error.

Why two 10MHz oscillators?

By now, you are probably wondering why we go to the trouble of using a second 10MHz crystal oscillator to provide the 100ns pulses for the phase error counter. Why not just use the output of the main temperature-controlled 10MHz oscillator (shown upper right)?

We use a second 10MHz oscillator because this inevitably drifts in phase compared with the main oscillator and this introduces a small amount of 'dither' into the phase error counting operation. The random noise introduced into the DAC's output voltage as a result of this dither allows the PLL's error correction to have a significantly higher resolution than if we used pulses from the main 10MHz oscillator.

The reason for this is quite straightforward. If we had used the pulses from the main oscillator, the fact that they would be locked to the 50kHz pulses (and hence the phase error pulses as well) would mean that the DC error voltage could only ever change in 19.53mV increments. This corresponds to 100ns changes in phase error.

However, the dither introduced by using the second oscillator means that the average error voltage will change in somewhat smaller increments. And that means that we can maintain the main oscillator's phase locking to much closer than 100ns.

As shown in Fig.1, the DC phase error voltage from the DAC is fed through a buffer to a low-pass filter stage based on capacitor C1 and resistors R1 and R2. The filtered error correction voltage is then used to control the capacitance of a varicap diode (VC1), to fine-control the frequency and phase of the main 10MHz oscillator.

This unusual type of PLL system is very effective when it comes to phase-locking a 10MHz oscillator to

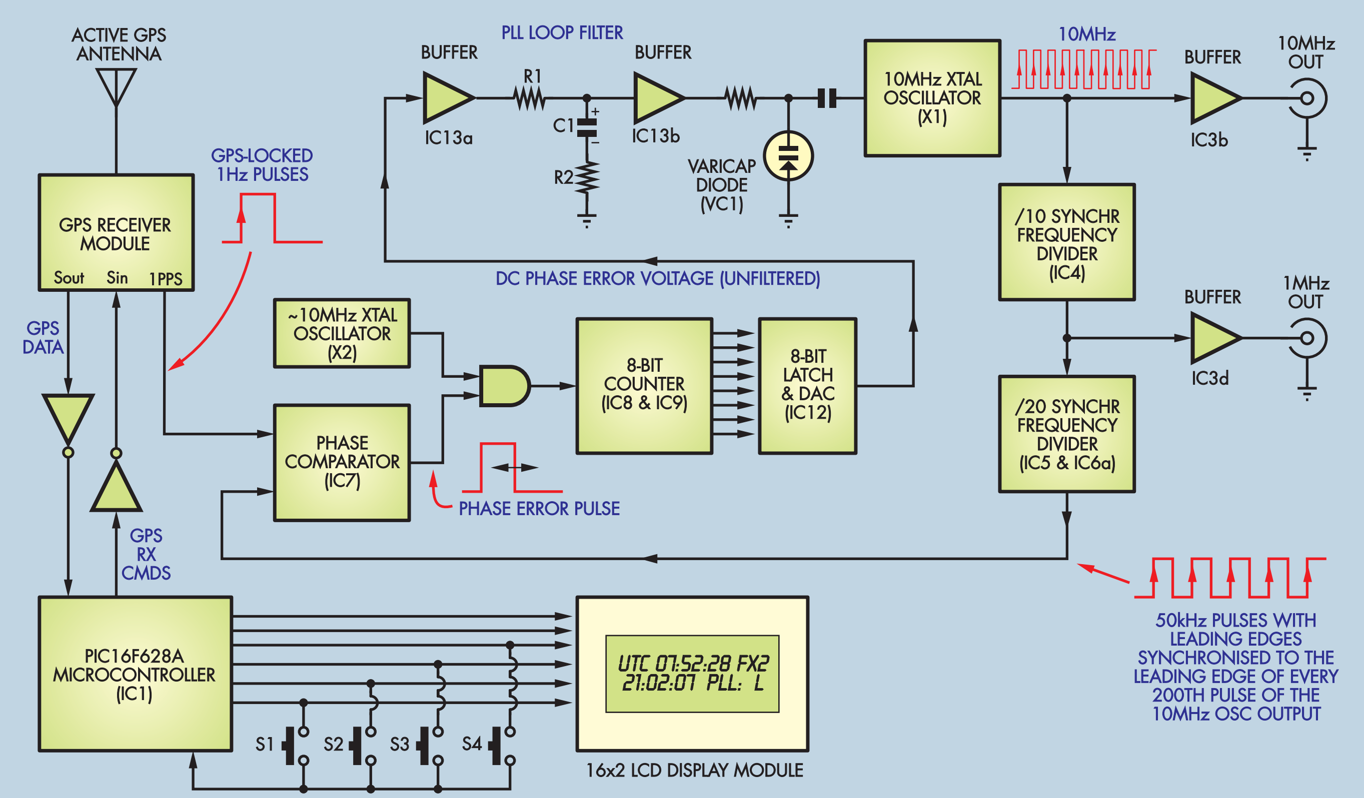


Fig.1: the GPS-Based Frequency Reference uses a phase-locked loop (PLL) to control the frequency of a 10MHz crystal oscillator (top right). This PLL in turn is referenced to the very accurate 1Hz pulses from the GPS receiver module. A PIC microcontroller decodes the GPS data, interprets the switches and drives the display module.

the GPS 1Hz pulses, but it does have a limitation. Because it divides down the oscillator frequency by only 200 times instead of 10,000,000, it's just as effective at phase-locking an oscillator at a frequency of 9.999800MHz or 9.999600MHz, or 10.000200MHz or 10.000400MHz.

In other words, it's capable at phase-locking at frequencies that are separated from 10.000000MHz by exactly 200Hz or multiples of that frequency difference. This means that when you are setting up the frequency reference, it's very important to adjust the free-running frequency of the main crystal oscillator to within 100Hz of 10.000000MHz. If you don't, the PLL may lock it to 9.999800MHz or 10.000200MHz instead of the correct frequency!

Making use of the data

OK, that's how the main part of the GPS Frequency Reference works. The only part we haven't discussed yet is the section down in the lower left of the block diagram. This section is functionally quite separate from the main section. Its purpose is to make use of the stream of useful data that emerges from the GPS receiver module each second, along with (but separate from) those accurate 1Hz pulses.

This data is delivered as ASCII text and appears at the module's RS-232C serial output port. It's in the form of coded data 'sentences', sent at a rate of 4800bps (bits per second) using a sentence format known as NMEA1083. This format was first standardised by the US National Marine Electronics Association (NMEA) for information exchange between marine navigation equipment.

As shown in Fig.1, we use a programmed PIC16F628A microcontroller to 'catch' and analyse this serial data. The decoded data is then fed to an LCD module. Pushbutton switches S1-S3 are included to allow you to display some of the more esoteric information for a short time, as required. Normally, the display simply shows the current UTC time and date (updated each second), plus the GPS fix and PLL locking status.

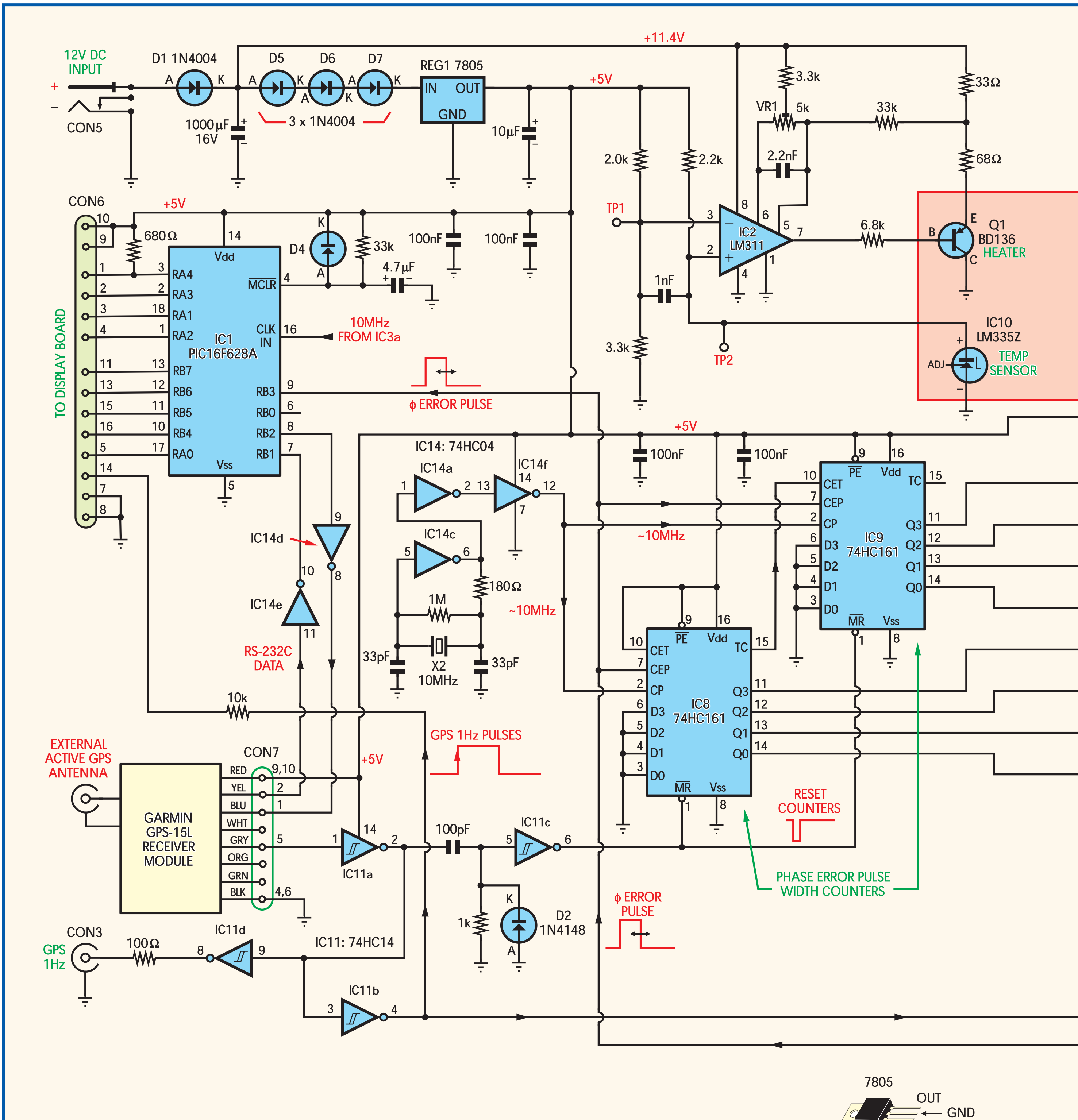
The fourth switch (S4) forces the PIC micro to send an initialisation code command to the GPS receiver module, to initialise it correctly if it ever becomes 'confused' (the GPS receiver also contains a microcontroller, of course). In fact, the receiver module has an RS-232C serial input as well as the output, provided for this very purpose.

However, because this initialisation is rarely required, S4 is not readily accessible like switches S1 to S3. Instead, it must be accessed through a small hole in the front panel of the project, using a small screwdriver or probe tip.

Circuit details

Now that you have a basic understanding of the way the GPS-Based Frequency Reference works, we should be able to work quickly through the main circuit, to clarify the fine details. Fig.2 shows the main circuit diagram, while Fig.3 shows the associated display circuit with its LCD module. The two connect via a 16-way header cable.

In operation, the Garmin GPS 15L receiver module (lower left of Fig.2) is fed via an external active antenna. The resulting GPS-locked 1Hz pulses are on the grey wire of its 8-way output cable and this goes to pin 5 of a 10-way IDC line socket that mates with CON7. The 1Hz pulses are then fed through Schmitt inverters IC11a and IC11b,



GPS-BASED FREQUENCY REFERENCE MAIN BOARD

which act as buffer stages. The resulting 5V peak-to-peak pulses from IC11b are then fed directly to pin 14 of IC7, which is the phase comparator.

The 10MHz crystal oscillator that's phase-locked to the GPS pulses is based on inverter IC3f and crystal X1, plus varicap diode VC1 and several low-value capacitors. Its 10MHz output is fed via inverting buffer stage IC3b to CON1 and also via IC3c to divider stage IC4. This stage divides the signal by 10 and provides two 1MHz outputs, at pins 12 and 15. Pin 12 output is then fed via inverter IC3d to CON2, to provide the 1MHz output signal at BNC connector CON2.

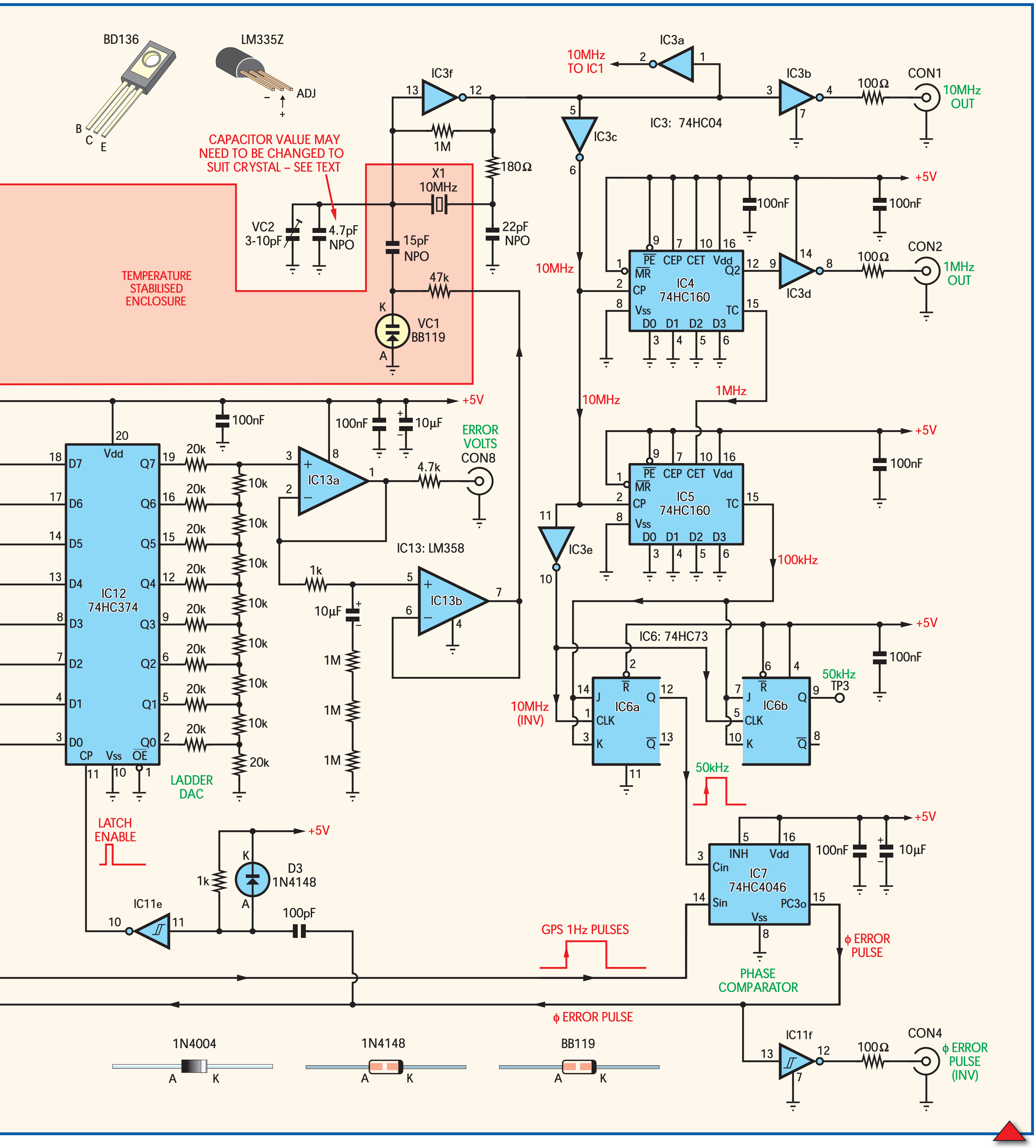


Fig.2 (above): the complete circuit for the GPS-Based Frequency Reference except the display circuitry (LCD and LED indicators). The PLL-controlled 10MHz oscillator is built into a small temperature-controlled oven to ensure stability, with power transistor Q1 acting as the oven heater.

By contrast, the 1MHz pulse output from pin 15 is fed to a second divide-by-10 stage based on IC5 (ie, to the CET input at pin 10). The resulting 100kHz pulse output from pin 15 of IC5 is then fed to the J and K inputs of flip-flops IC6a and IC6b. Note that the 10MHz output from IC3c is used to clock IC5, IC6a and IC6b, the latter two stages via inverter IC3e. This ensures that the counter and divider outputs are correctly synchronised.

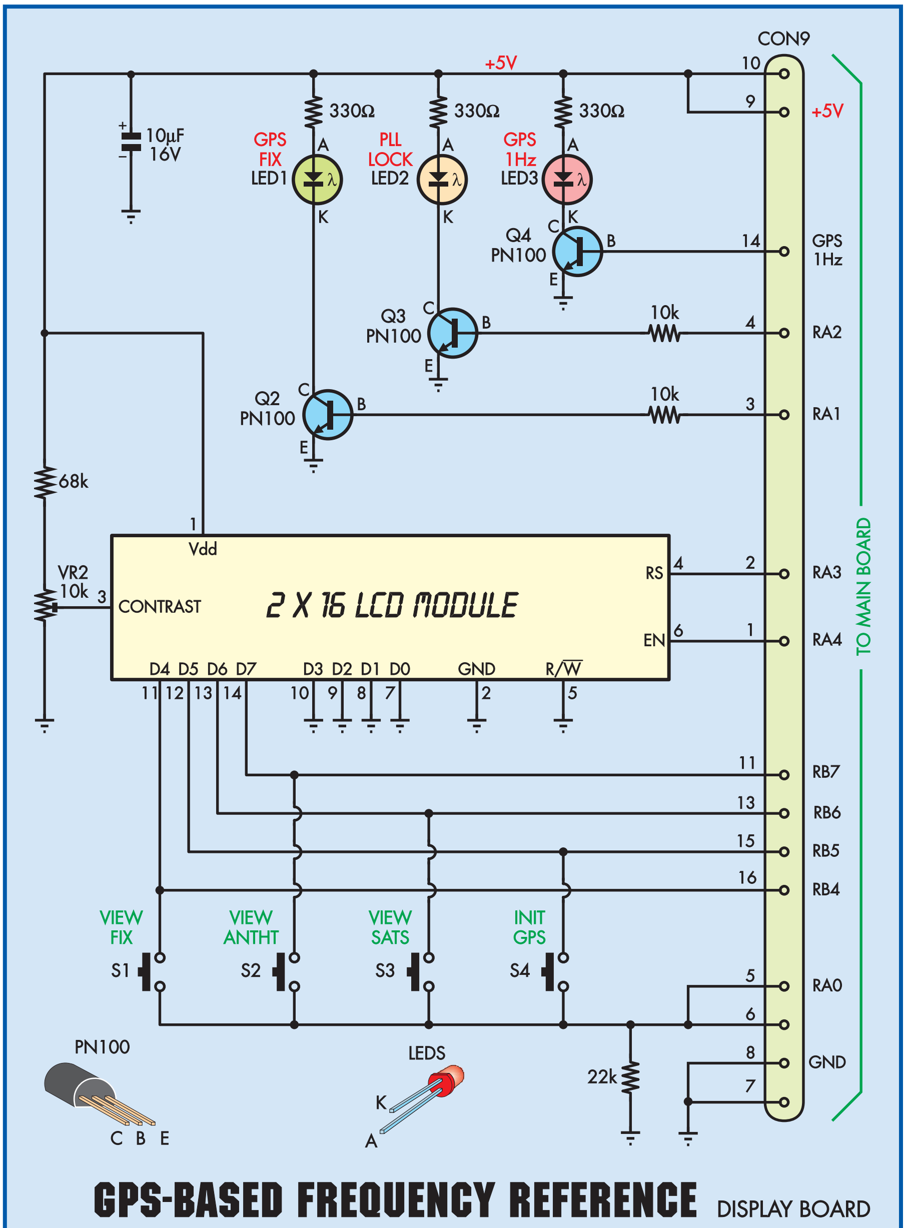


Fig.3: the display circuit interfaces to the PIC microcontroller (IC1) in the main circuit via IDC connector CON6. It includes the LCD module, three LED indicators (LED1-LED3), switching transistors Q2 to Q4 and four pushbutton switches (S1 to S4).

IC6a and IC6b are both wired for divide-by-2 operation. The 50kHz pulses from the Q output (pin 12) of IC6a are fed to the C_{in} input (pin 3) of phase comparator IC7, for comparison with the 1Hz GPS pulses on pin 14 (S_{in}). Note that these 50kHz pulses have their rising edges closely aligned with the rising edge of every 200th pulse from the 10MHz oscillator.

The phase error pulses emerge from pin 15 of IC7 and are fed directly to the clock gating inputs of 4-bit synchronous counters IC8 and IC9 (74HC161), which together form the 8-bit phase error pulse width counter. This is done because the AND gate shown in Fig.1 is actually inside the two counter chips, rather than being a separate device.

The 'about-10MHz' clock oscillator used by the error counter is based on crystal X2 and inverter stage IC14c. Its output is buffered by IC14a and IC14f and fed to the clock inputs (pin 2) of the two counters. The eight output bits from the two counters are then fed to the data inputs of IC12, the octal latch. Its outputs are used to drive the resistive-ladder DAC (digital-to-analogue converter).

In practice, this counter-latch-DAC sub-circuit is arranged so that it performs a new count of the phase error pulse width at the start of every 1Hz pulse from the GPS receiver module. The sequence is as follows: on the falling edge of each 1Hz pulse (100ms after the start), the counters (IC8/IC9) are reset by a very short pulse on their $\overline{MR}$ pins (pin 1). These short reset pulses are derived from the 1Hz pulses at the output of IC11a. The 1Hz pulses are differentiated using a 100pF capacitor and a 1kΩ resistor and fed to the $\overline{MR}$ pins of IC8 and IC9 via IC11c.

The two counters begin counting when the phase error pulse from IC7 arrives at their CEP pins (7). This allows them to count the 'about-10MHz' pulses, which are fed to their CP (pin 2) inputs via buffer stages IC14a and IC14f. Counting continues until the end of the phase error pulse and then stops. Another very short pulse, this time derived from the falling edge of the phase error pulse signal and applied via IC11e to pin 11 of IC12, then transfers the count into IC12's latches, replacing the previous count.

As a result, the DC output voltage from the DAC changes in response to the new count. The counters are then reset again at the end of the 1Hz GPS pulse, ready for the next sequence.

The varying DC error voltage from the DAC is fed first through buffer stage IC13a and then to a low-pass loop filter which is formed using a 1kΩ resistor (R1 in Fig.1), a 10µF capacitor (C1) and three 1MΩ resistors (R2). From there, the filtered error voltage is then fed through IC13b to become the automatic phase correction (APC) voltage. This APC voltage is applied to varicap diode VC1, which varies its capacitance accordingly.

As previously stated, VC1 forms part of the 10MHz crystal oscillator circuit and its capacitance variations bring the oscillator into phase lock. Trimmer capacitor VC2 and its parallel 4.7pF capacitor are used to initially adjust the oscillator so that its free-running frequency is within 100Hz of 10MHz – ensuring that the PLL locks correctly to this frequency.

Temperature stabilisation

OK, so that's the basic PLL section of the GPS-Based Frequency Reference

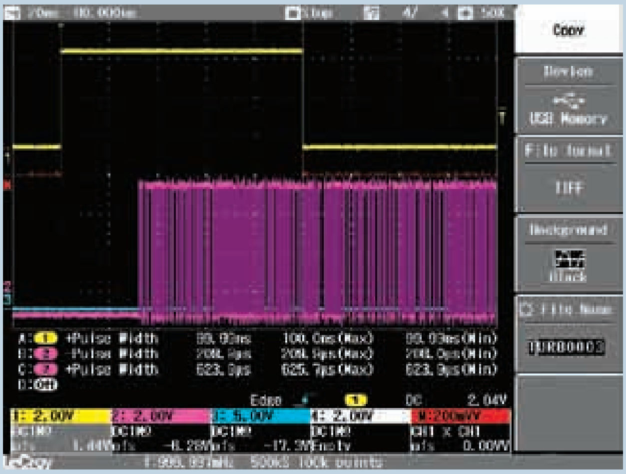


Fig.4: here are the two outputs provided by the Garmin GPS 15L receiver module. The upper trace (yellow) shows one of the extremely accurate 1Hz pulses, while the lower (purple) trace shows the start of the RS-232C data stream giving UTC time and date, latitude and longitude. Note that the frequency reading on the bottom line should read exactly 1.000000Hz; the actual reading shows the scope's measurement error.

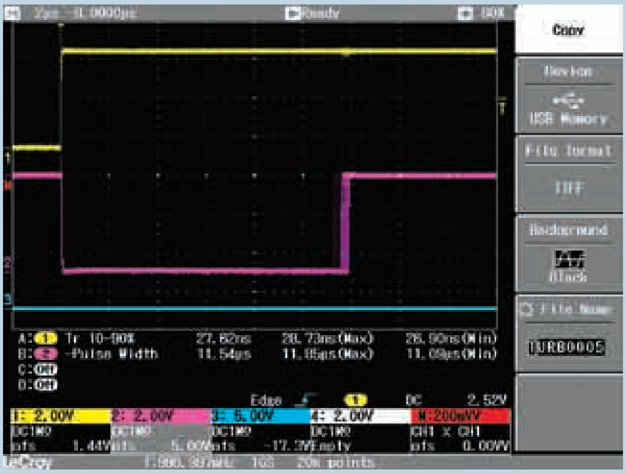


Fig.5: shown here are the leading edge of the GPS 1Hz pulses from the receiver module (upper yellow trace), and the inverted error pulse from the Frequency Reference's phase detector (lower purple trace), when the PLL is locked with a fixed phase error of 11.54µs. The jitter visible on the trailing edge of the error pulse is normal and is caused by noise, GPS propagation variations and so on (see text).

circuit. By now, though, you're probably wondering about the function of comparator IC2, transistor Q1 and the LM335Z temperature sensor (IC10). What are they for?

These parts are used to achieve temperature stabilisation of the main 10MHz oscillator crystal (X1), varicap diode VC1 and its series 15pF capacitor. In practice, these components are housed in a 'mini oven' to keep the temperature constant. This oven includes a small TO-220 heatsink to which is attached the crystal, the LM335Z temperature sensor and a power transistor (Q1). It's basically an insulated enclosure made from a cut-down 35mm film canister, which is lined inside using expanded polystyrene.

The construction of this mini oven will be described next month. All you need to know for now is that IC10 (LM-335Z) is mounted inside the enclosure to sense the internal temperature.

Basically, the voltage across IC10 is directly proportional to its temperature (in Kelvin) and this voltage is applied to the non-inverting input of comparator IC2. IC2's inverting input is fed with a reference voltage of close to 3.15V, derived from a voltage divider (2kΩ and 3.3kΩ) across the regulated 5V supply rail. As a result, IC2's pin 7 output switches high when the temperature sensor's voltage rises slightly above 3.15V and switches low when the sensor's voltage falls somewhat below this level (depending on the hysteresis applied to the comparator).

IC2 is used to control power transistor Q1, which is used here purely as a heater. This transistor is attached to the finned heatsink which forms the frame of the mini oven, so when it conducts it generates heat to increase the temperature. As a result of the feedback provided by IC10, the temperature inside the mini oven is maintained at very close to 42°C (315K) – within about ±1°C, in fact. The exact temperature can be adjusted over a small range using trimpot VR1.

Specification summary

(1) This unit is a low-cost frequency and time reference based on a Garmin GPS 15L receiver module. It is able to control the frequency of a local 10MHz crystal oscillator by reference to the very accurate 1pps (1Hz) pulses broadcast by GPS satellites (referenced back to UTC as maintained by the USNO). This allows the frequency of the local 10MHz oscillator to be controlled to within about 0.2Hz averaged over a 30 second period and even more tightly when averaged over a longer period such as 30 minutes.

(2) The built-in 10MHz reference crystal is housed in a small temperature-stabilised enclosure or 'mini oven'. Buffered 10MHz and 1MHz outputs are provided for external use. Buffered outputs are also provided for the 1Hz GPS pulses and the phase error signals from the internal phase-locked loop (PLL) used to control the 10MHz oscillator. The error signals allow the user to log instantaneous phase error in the PLL, if this is desired for traceability.

(3) The unit provides a continuously updated display on an LCD module, showing UTC time and date, GPS fix and PLL lock status information. It also allows optional short-term display of receiving antenna latitude, longitude and height above mean sea level, plus the number of satellites in current view and their reception quality.

(5) The complete reference operates from 12V DC, which can be supplied from a battery or a mains power supply. Average current drain is approximately 340mA, while peak current drain is about 420mA.

A few facts about GPS

The GPS satellite network is controlled and operated by the US Department of Defense (US DOD). Currently, there are between 22 and 24 GPS satellites orbiting the Earth at a height of 20,200km, in six fixed planes angled at 55° to the equator.

Each satellite orbits the Earth in 11 hours 58 minutes – ie, about twice each day. This means that at least four satellites are within 'view' of a given GPS receiver at almost any time, wherever it is located (providing it has a clear sky view).

The GPS satellites broadcast pseudo-random spread spectrum digital code signals on two UHF frequencies: 1575.42MHz (known as 'L1') and 1227.6MHz ('L2'). There are two different code signals broadcast: the 'coarse acquisition' or C/A code, broadcast on L1 only, and the 'precision' or P code broadcast on both L1 and L2. Most commercial GPS navigation receivers process only the L1 signal.

Each GPS satellite carries either caesium-beam or rubidium vapour 'atomic clock' oscillators, or a combination of both. These are 'steered' from US DOD ground stations and are referenced back to Coordinated Universal Time (UTC), as maintained by the US Naval Observatory (USNO) – itself kept within 100ns of UTC as maintained by the US NIST. This ensures they provide an accurate reference for both the carrier frequencies and the code signals from each satellite.

Although the GPS network was designed mainly for accurate terrestrial navigation, the high frequency and time accuracy of the signals from the satellites has made them very useful as a reference source for frequency and time calibration.

How accurate is it?

What kind of frequency accuracy can you get from this DIY GPS reference? Well, the 10MHz output is accurate to within 0.2Hz, averaged over a 30-second period. It's even more accurate when averaged over a longer period, such as 30 minutes or an hour.

The accuracy of the 1MHz output is the same in relative terms, since it's derived from the 10MHz output by frequency division. So it's quite reasonable to describe the nominal frequency accuracy as within two parts in 10^8 – considerably better than a free running crystal oscillator, and good enough for most frequency calibration purposes.

The rear panel carries BNC sockets for the antenna and for the GPS 1Hz and phase error pulse outputs, plus an RCA phono socket for the phase error voltage. It also provides access to the DC power socket.

RS-232C data

The RS-232C data from the GPS receiver module emerges on the yellow lead and is connected (via the IDC line socket) to pin 2 of CON7. From there, it's fed through inverting buffer IC14e to the RB1 input (pin 7) of PIC microcontroller IC1, which is used to process the serial data.

Similarly, the RS-232C serial input for the GPS receiver module is its blue lead and this goes to pin 1 of CON7. As a result, initialisation commands from the micro's serial output (RB2, pin 8) are fed to the module via inverting buffer IC14d.

The phase error pulse from IC7 is also fed to the RB3 input (pin 9) of IC1, so that the micro is able to monitor whether or not the PLL is maintaining lock.

Display circuit

The display circuit (Fig.3) interfaces to the main circuit via connector CON9 and includes the 2-line × 16-character LCD module – which is directly driven by microcontroller IC1 – plus its contrast control VR2.

In addition, there are the four control switches (S1 to S4) plus three status indicator LEDs (LED1 to LED3), in turn driven by transistor switches Q2 to Q4. Note that Q2 and Q3 (and thus LED1 and LED2) are controlled by the micro itself (via RA1 and RA2), whereas Q4 (LED3) is driven by the 1Hz pulses from the GPS module via IC11b. The microcontroller also scans the switches. As stated, S1 to S3 are pressed to display specialised data on the LCD, while S4 initialises the GPS receiver module.

Parts List: GPS-Based Frequency Reference

1 PC board, code 706 (Main), size, 142 x 123mm
1 PC board, code 707 (Display), size 144 × 58mm
(Both boards are available as a set from the *EPE PCB Service)*

1 ABS instrument case, size, 158 × 155 × 65mm
1 Garmin GPS 15L GPS receiver module
1 external active GPS antenna to suit – see text
1 2-line × 16 character alphanumeric LCD display module
2 TO-220 finned heatsinks, PC-mount
3 SPST PC-mount snap-action pushbutton switches (black) (S1-S3)
1 SPST PC-mount mini pushbutton switch (S4)
2 10MHz quartz crystals, HC-49U package (X1, X2)
4 PC-mount BNC sockets (CON1-CON4)
1 PC-mount 2.5mm concentric DC socket (CON5)
2 16-pin IDC line sockets
2 PC-mount 16-pin IDC header plugs (CON6, CON9)
1 10-pin IDC line socket
1 PC-mount 10-pin IDC header plug (CON7)
1 PC-mount RCA phono socket (CON8)
1 Panel-mount BNC-BNC male-male adapter
2 8-pin IC sockets, high quality machined pin type
4 14-pin IC sockets, machined clip type
5 16-pin IC sockets, machined clip type
1 18-pin IC socket, machined clip type
1 20-pin IC socket, machined clip type
3 M3 × 15mm tapped spacers
2 M3 × 6mm machine screws, round head
7 M3 machine nuts
3 M2 × 25mm machine screws, round head
4 M2 × 12mm machine screws, round head
7 M2 machine nuts
7 M2 flat washers and star lockwashers
1 7×2 length of DIL pin header strip
7 1mm PC board terminal pins
1 35mm film canister, 34mm dia. × 34mm long
2 cable ties

Semiconductors
1 PIC16F628A microcontroller programmed with GPSFrqRF.hex (IC1)
1 LM311 comparator (IC2)
2 74HC04 hex inverters (IC3,IC14)
2 74HC160 synchronous decade counters (IC4,IC5)
1 74HC73 dual flipflop (IC6)
1 74HC4046 phase comparator (IC7)
2 74HC161 synchronous 4-bit counters (IC8,IC9)
1 LM335Z temperature sensor (IC10)
1 74HC14 hex Schmitt trigger (IC11)
1 74HC374 octal D-type flipflop (IC12)
1 LM358 dual op amp (IC13)
1 7805 +5V regulator (REG1)
1 BD136 PNP power transistor (Q1)
3 PN100 NPN transistors (Q2-Q4)
1 5mm green LED (LED1)
1 5mm red LED (LED2)
1 5mm orange/yellow LED (LED3)
4 1N4004 diodes (D1,D5-D7)
3 1N4148 signal diodes (D2-D4)
1 BB119 varicap diode (VC1)

Capacitors
1 1000µF 16V radial elect.
4 10µF 16V radial elect.
1 10µF 25V tantalum
1 4.7µF 25V tantalum
11 100nF ceramic
1 2.2nF metallised polyester
1 1nF metallised polyester
2 100pF NPO ceramic
2 33pF NPO ceramic
1 22pF NPO ceramic
1 15pF NPO ceramic
1 4.7pF NPO ceramic
1 3pF to 10pF N470 trimcap, white (VC2)

Potentiometers
1 5kΩ mini trimpot, horizontal (VR1)
1 10kΩ mini trimpot, horizontal (VR2)

Resistors (0.2W 1% metal film)

5 1MΩ	1 2.2kΩ
1 68kΩ	1 2kΩ
1 47kΩ	3 1kΩ
2 33kΩ	1 680Ω
1 22kΩ	3 330Ω
9 20kΩ	2 180Ω
10 10kΩ	4 100Ω
1 6.8kΩ	1 68Ω
1 4.7kΩ	1 33Ω
2 3.3kΩ	

Power supply

Power for the circuit is derived from an external 12V DC supply (eg, a plugpack rated at 500mA or more). This is applied via power connector CON5 and diode D1, which provides reverse polarity protection.

Diodes D5 to D7 provide a supplementary voltage drop to reduce the power dissipation in 3-terminal regulator REG1, which delivers a regulated +5V rail to power most of the circuit. The only sections driven directly from the unregulated +11.4V input are comparator IC2 and heater transistor Q1 in the mini oven.

Other signals

That's about it for the circuit description, except to note that various useful signals (in addition to the main 10MHz and 1MHz outputs) are brought out of the frequency reference to allow its operation to be monitored.

First, the very accurate 1Hz GPS pulses are brought out via IC11d and CON3. Second, an inverted version of the phase error pulse from IC7 is brought out via IC11f and CON4.

Finally, the unfiltered DC error voltage from IC13a is brought out via CON8. Either of the last two signals can be used for logging the reference's operation.

That's all we have space for this month. Next month, we'll show you how to build it and describe the setting up and adjustment procedures. ***EPE***

Light In The Gloom

TechnoTalk

Mark Nelson

A recent breakthrough by Cambridge University researchers could well turn out to be the turning point for low-cost LED lighting in homes and offices. The scientist who developed this 'holygrail' claims the new bulbs are more eco-friendly than the hated compact fluorescents in use now and could be on the market in five years. Mark Nelson investigates the claims.

As well-informed people know, today's version of low-energy lighting, using compact fluorescent lights (CFLs), is the wrong technology. The products are relatively cheap to buy, but they have a number of practical disadvantages, as well as significant ecological problems in their production and disposal. Although they are evidently the wrong solution, up to now the right way to go has been too expensive for domestic use.

Brighter future

The brighter future is the light-emitting diode or LED. Based on a far more efficient light source and producing a purer white light, the affordable LED lamp bulb is seemingly within our reach at last. According to Prof Colin Humphreys of Cambridge University's Centre for Gallium Nitride, the new breed of LED lamp bulbs will last 60 years and could slash the proportion of electricity used for lighting from 20 to just five per cent.

In Britain, this could eliminate the need for eight power stations. Even better, the new bulbs do not contain mercury and they are dimmable.

Says Humphreys, "We are very close to achieving highly efficient, low-cost white LEDs that can take the place of both traditional and currently available low-energy light bulbs. This could well be the holy grail in terms of providing our lighting needs for the future. That won't just be good news for the environment; it will also benefit consumers by cutting their electricity bills".

New recipe

LED lamps are not new by any means and they are already used widely in torch bulbs, camera flash units, vehicle lights and display lighting in shops, to mention just a few applications. But for 'general lighting service' (that's ordinary lamp bulbs to you and me), the production costs are too expensive for widespread use in homes and offices.

Colin Humphreys' breakthrough at Cambridge University has been to make the new LEDs from Gallium Nitride (GaN), a man-made semiconductor that emits a brilliant bright light but uses very little electricity. His team has developed a new way of making GaN that could produce LEDs for a tenth of current prices.

The new technique grows GaN on silicon wafers, which achieves a 50 per cent improvement in cost and efficiency on previous approaches employing expensive wafers of sapphire, used since the 1990s. The idea is that commercially-produced versions of Humphreys' LED will be in use around homes and offices within five years.

Fine tuning

Demonstrating a concept in the lab is one thing, but refining it for mass production is another. The light produced by most 'white' LEDs tends to have a blue-ish cast, which is not suitable for domestic lighting. The 'golden yellow' LEDs are not ideal either. Humphreys says that by applying a phosphor to the LED, it can produce a more agreeable white light.

Another stumbling block to overcome is turning point sources of light into a bulb or globe that radiates in all directions. LEDs used in torches, spotlights and vehicle head and tail lights tend to be focused in a single direction. This glare is unwelcome in homes and offices, where people prefer a more omnidirectional and diffuse light source.

The team at Cambridge is also carrying out research into more specialist but equally vital applications for GaN light. They want to see how these could mimic sunlight to help three million people in the UK with Seasonal Affective Disorder (SAD). Ultraviolet rays produced from GaN lighting could also aid water purification and disease control in developing countries, identify the spread of cancer tumours and help fight hospital 'super bugs'.

On the right lines

One field where existing LED technology is making rapid inroads is aboard trains, even though you might not have noticed. Here, ruggedness, low maintenance and reduced power consumption outweigh the initial installation cost of retro-fit LED lighting. The figures work out well, as this example from British firm Dialight proves.

A typical fluorescent-tube lighting install-ation on a commuter train requires 2kW of electricity to achieve adequate brightness for reading. LED fixtures can achieve the same lighting level from 500W, reducing the number of voltage converters from 52 to just four. Reflectors control the direction of light across the carriage ceiling via a range of optical beam patterns, rather than bouncing it straight down to the floor. With lights left on in trains for 16 hours a day, it's obvious that significant energy savings are possible.

Another British firm actively involved in exploiting the market for 'lighting class' LEDs is Zetex, which employs more than 750 people worldwide. If the name doesn't ring a bell, let me just mention that Zetex is the semiconductor division of the Ferranti company of lengthy heritage. Its ZXLD1362 switching LED driver operates from input voltages of 6V to 60V at up to 95 per cent efficiency. The smallest of its kind at this current rating, it can drive up to 16 high-power LEDs with an adjustable output current of up to 1A.

The race is on

With the world's nations determined to develop their way out of the recession and also reduce energy consumption, the race is on to develop more efficient methods of solid-state lighting. Cambridge University's breakthrough in white LEDs could lead to mass manufacture in the UK. Prof Humphreys is well aware of the technical difficulties of growing LEDs on a silicon substrate, but is optimistic nevertheless.

He told trade paper *Electronics Weekly*: "We have only been working for a year or so and we are still on a steeply rising curve. [Nevertheless] our way is so much cheaper, I think it is probably commercially viable even now". His team is working with QinetiQ, formerly known as the Defence Evaluation & Research Agency, and the German manufacturer Aixtron to turn its science into a commercial production process.

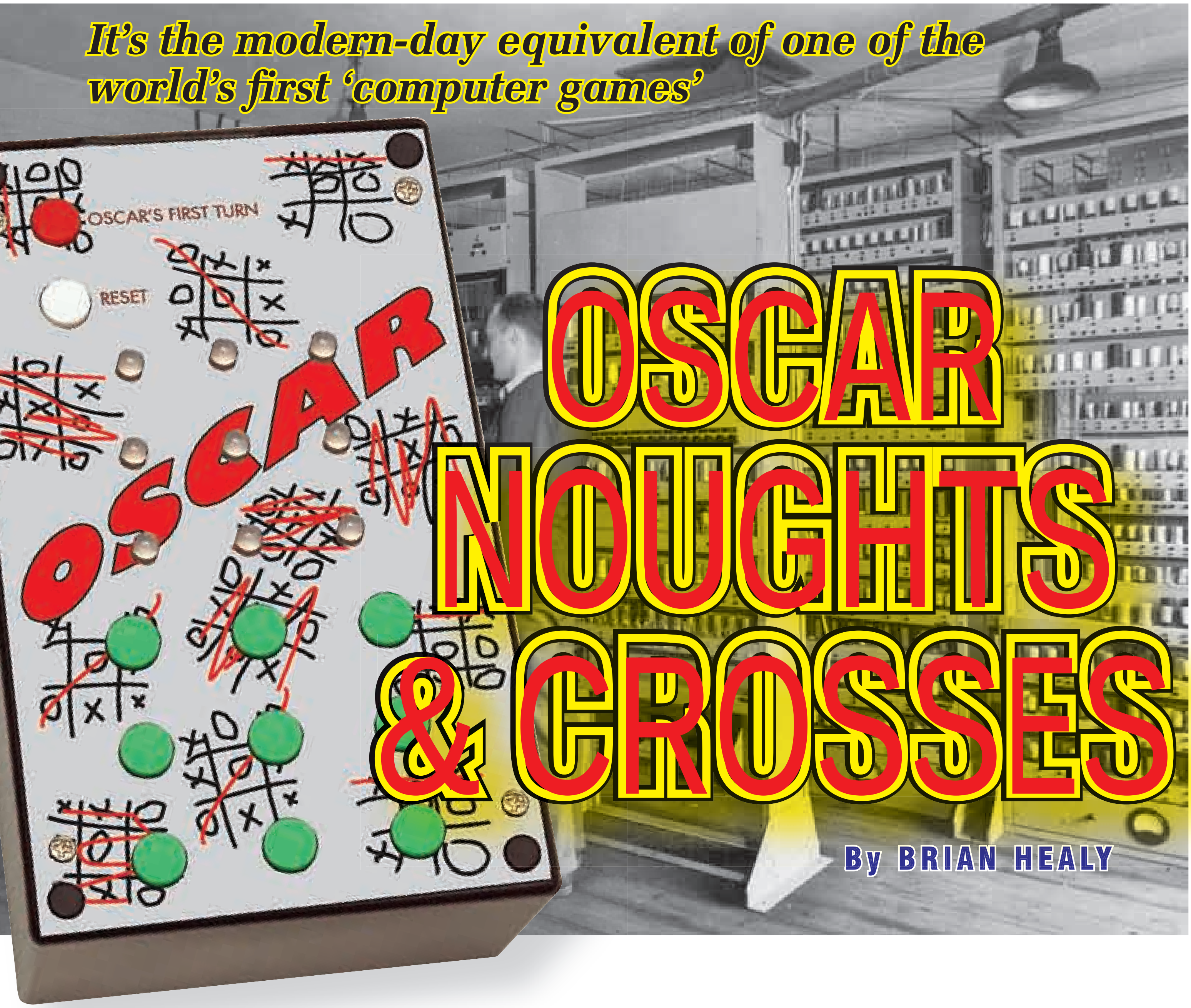
The US government is also backing the LED lighting revolution, with an $18.5 million five-year award to the Smart Lighting Engineering Research Center at Rensselaer Polytechnic Institute in Troy, New York. A recent study authored by RPI professors Fred Schubert and Jong Kyu Kim issued 'a call to arms for scientists and engineers', stating that over the next 10 years savings of more than $1.8 trillion will eliminate the need to burn almost a billion barrels of oil in power plants that would otherwise produce 10 gigatons in carbon dioxide emissions.

Declared Prof Jong Kyu Kim, "Such enormous savings will result from replacing 80 per cent of traditional lighting with LEDs over the next 10 years. And besides replacement, there are also new capabilities possible in this lighting revolution".

One of the most interesting applications under development at RPI is spectrum control, which they say will enable the colour of lighting to be altered during the day to influence the mood of workers positively, as well as curing certain medical problems that are caused today by poor lighting conditions.

It's the modern-day equivalent of one of the world's first 'computer games'

OSCAR NOUGHTS & CROSSES



By BRIAN HEALY

Noughts and crosses may rate quite poorly among young gamers of today, but in the late 1960s, a machine, more often called an electronic brain than a computer, playing noughts and crosses against a human opponent, was quite a sensation.

THE FIRST COMPUTERS were built during World War II to decode German coded military signals. From this early work sprung 'EDSAC' (Electronic Delay Storage Automatic Calculator), the first truly programmable computer. It was built at Cambridge University in 1949.

This computer, shown in the background above, was used by mathematicians for research and learning. It contained 3000 valves and consumed an astonishing 12kW of power.

History was made in 1952 by A.S. Douglas, a young PhD student, when he used it for another purpose: he programmed it to play noughts and crosses. The computer used a cathode ray tube to display its output, which means this was the very first video game in the world.

In the mid-1960s, both Sydney and Melbourne technical museums in Australia attracted large crowds with a 'computer' which played noughts and crosses against a human opponent.

In 1968, when the author was aged 24, he and a friend built a machine using 70-odd telephone relays and a uniselector to play the game.

A uniselector, by the way, is a rotary, solenoid driven, 50-position switch. They were commonly used in automatic telephone exchanges at the time and were even found in some older exchanges until quite recently, before first solid-state devices and then microcontrollers took over. In a busy telephone exchange, the noise of the uniselectors switching back and forth following the numbers dialled on a phone perhaps 10 kilometres or more away was quite deafening!

Oscar on hire

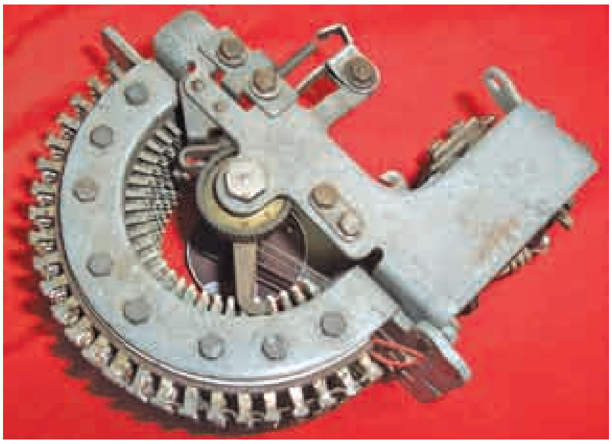
Our machine was as large as a refrigerator and about twice as heavy! We called him 'OSCAR' and he worked very well. When you pressed a button for your turn, the machine started whirring loudly (the sound coming from the uniselector), a row of lights flashed, relays clicked in and out and finally it all stopped as it brought up its reply. It was very impressive.

We hired it out to retailer David Jones and a new shopping centre called 'Westfield' in Wollongong (a large city south of Sydney, Australia) where it attracted large crowds.

It must be very difficult for people who did not come through that era to understand such a reaction, so I will try to explain.

It was akin to the crowds who gathered on pavements outside electrical retailers a decade or so earlier to watch that new-fangled invention, television, playing in the windows.

In 1968, very few people had ever seen a computer 'in the flesh'. They may have seen one in a film, where typically it would be in an almost sacred situation, a series of large metal cabinets, some with large tape spools rotating. All attended by well groomed, bespectacled technicians, wearing white lab coats, hovering over it like nurses over a new-born baby. What the computer actually did was a complete mystery, and there was no way you were ever going to be able to get close enough to touch one.



This is a Uniselector, a 50-way solenoid-driven switch. Every automatic telephone exchange used these in their thousands – now they are virtually a museum piece. The Uniselector was used as the basis for the original 'Oscar' built by the author back in the 1960s.

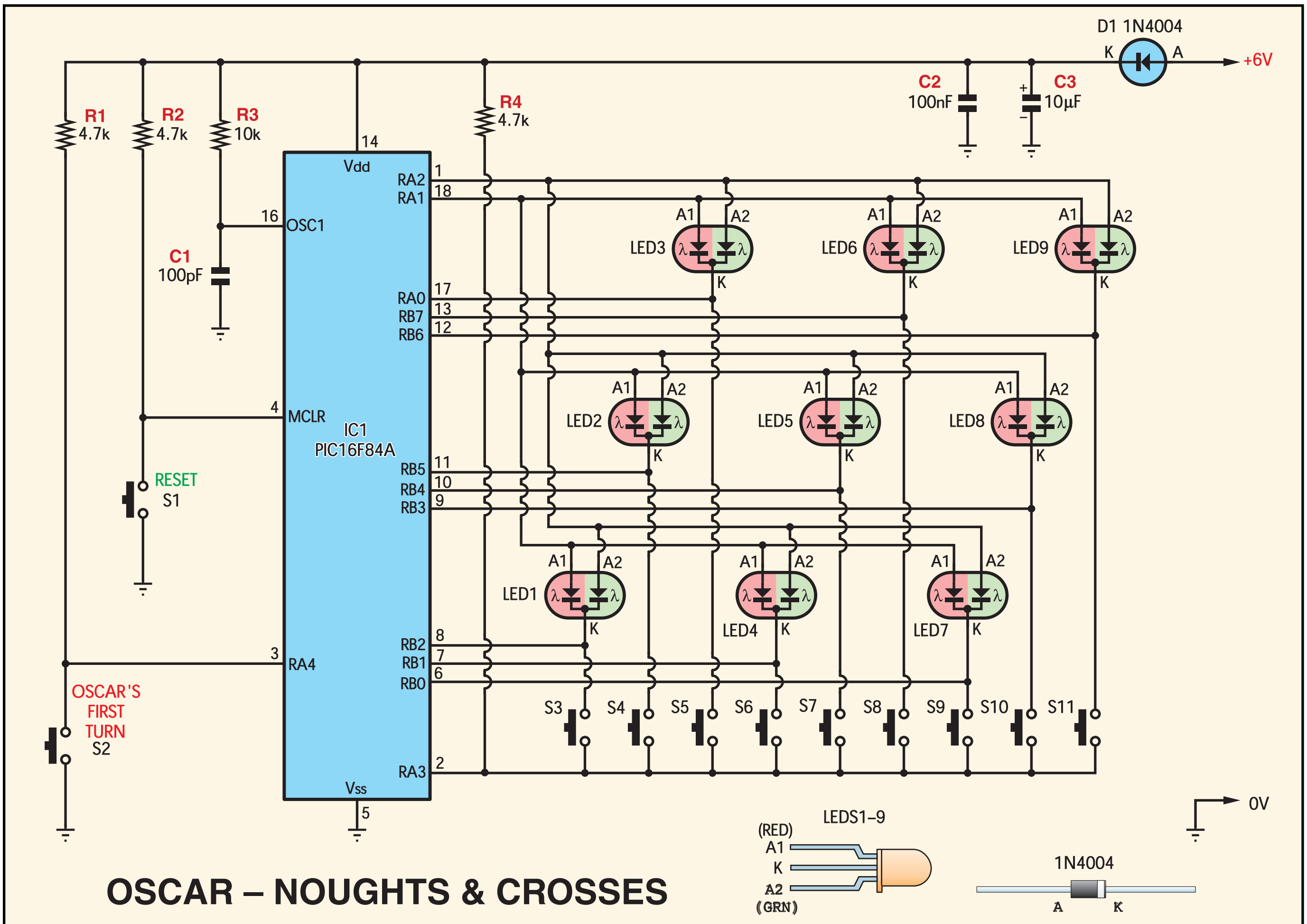


Fig.1: not a Uniselector in sight (or even hidden!). The PIC chip does all the work of the mechanical monster of 40 plus years ago – and this OSCAR is much easier to build.

This clipping, believed to be from the *Wollongong Mercury* around 1968, shows the original fridge-sized Oscar noughts and crosses machine. No, those aren't LEDs in the display – they were very expensive back in '68.

So, if suddenly you were able to have contact with a computer, to challenge it at a game that you understood well, this was very exciting. Lots of my older friends still remind me about Oscar.

We initially did not know even how to start to build such a machine. We eventually worked out that the machine had to go through a logical series of steps, in sequence. We never called it a program, but of course, it *was* a program.

I have never forgotten the sequence, so now that PICs have become available, I set out to put the exact same program from the 1968 Oscar into a PIC16F84A.

New OSCAR

The new OSCAR is a tiny fraction of the size of the original. And instead of requiring a lot of power to operate, it will run for months on a couple of batteries. It has nine green buttons in a 3 × 3 array and nine bicolour LEDs, also in a 3 × 3 array – see photos.

When you press a button, to take your first turn, the corresponding LED illuminates green. Oscar now 'thinks' for a second or two and then has 'his' move, illuminating his position in red. It is then your chance to have your second move – and I think you know the rest.

If Oscar wins, which is pretty common, the winning row of three red LEDs flashes, calling attention to the player's loss(!) and the game is halted. You cannot continue when you have been defeated.

The first version of the software was written so that Oscar never lost a game. However, that quickly becomes boring and so the software was later reworked to give its opponent a chance to win approximately one in 10 games. If you do win, your three green LEDs will flash to indicate success.

There are two more buttons. The white button is to reset Oscar for a new game and the red button is to allow Oscar to have the first move in the game. It is polite and fair to give him the first turn at least sometimes. He is very clever here, as the square he chooses for his first move is truly random.

Generating truly random numbers is difficult for a PC and very difficult for a PIC, but Oscar employs a useful trick here.

At the end of a game, following a reset, Oscar is not just sitting there doing nothing – not at all. He is repeatedly counting rapidly from one through to nine at high speed, until you press a key to start the game, at which time he stops counting. The number that he stops on will be the square he chooses if you give him first turn.

How it works

If you glance at the circuit (Fig.1), you will see that it is quite simple and does not use any active components apart from the PIC.

The circuit is powered from four AA batteries, housed in a plastic battery box. The maximum voltage for the PIC is 6V, so don't be tempted to install a 9V battery.

This PIC, a 16F84A, can have various oscillators, but in this case we are using a resistor/capacitor circuit on pin 16 of the chip. With the values chosen, the circuit oscillates at around 700kHz. The RC oscillator is a little cheaper and somewhat slower than a crystal, making delay loops easier.

You can see the 700kHz triangular waveform on pin 16 with a 'scope and high impedance probe. The PIC divides this by four to become the system clock and you can see the resulting 175kHz square-wave on pin 15.

Multiplexing

Because we are connecting so many devices to the PIC, we need to do some multiplexing. The PIC has only 13 input/output connections available, but we have nine position buttons, nine red LEDs, nine green LEDs and a couple more buttons.

If you have a look at the circuit you will see that for each of the nine locations, the common cathode (K) of the green/red LED and one side of the pushbutton switches are all connected together. So we have a common

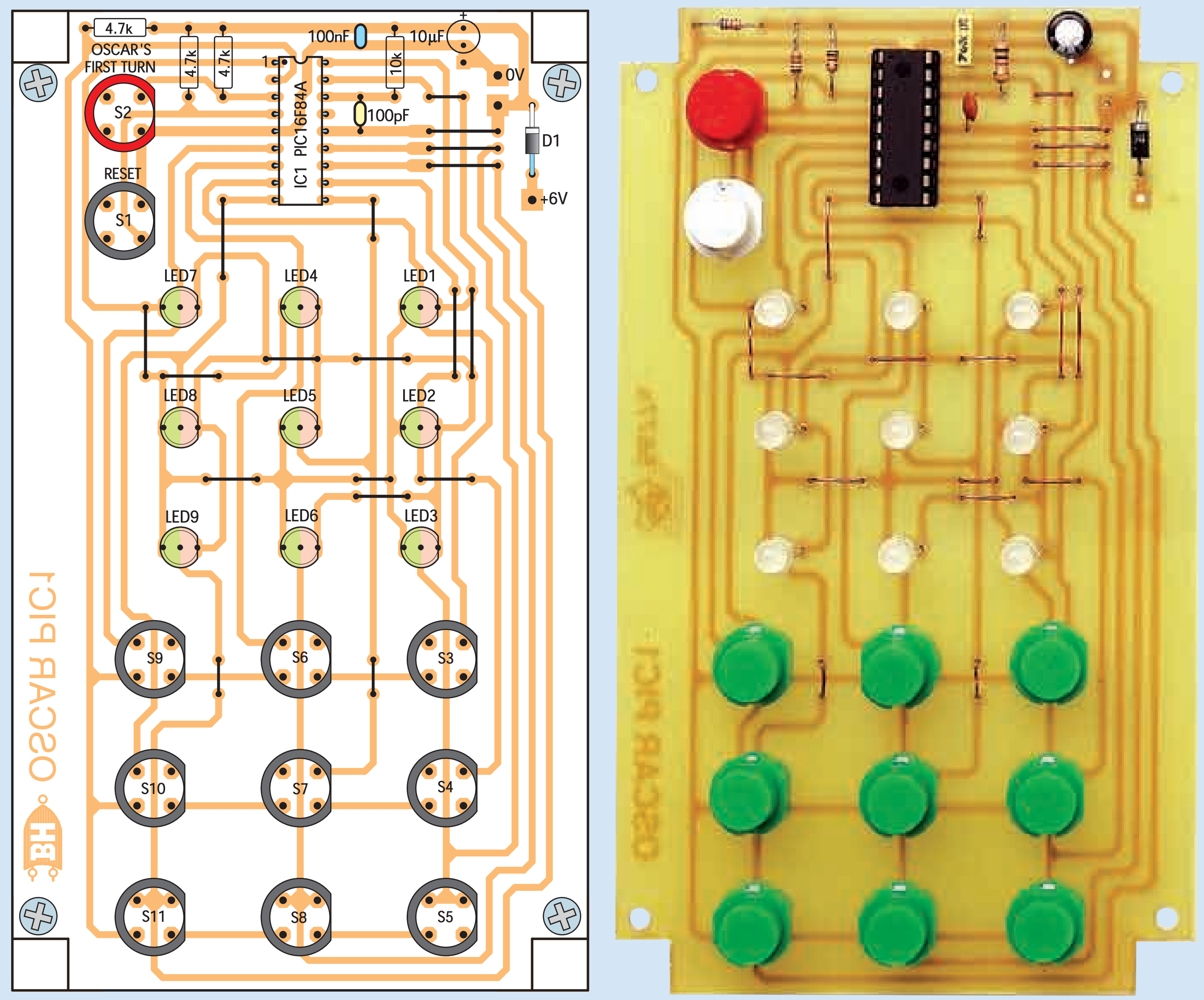


Fig.2: follow this parts layout diagram and the accompanying photo to assemble the unit. In the prototype, ordinary copper wire was used for the links, but we suggest tinned copper wire to prevent oxidisation.

connection for the button, red LED and green LED, and of course there are nine separate common points.

The PIC holds these lines high at 5V and then, one at a time, drops the line to 0V for around one millisecond, then pulls it back up to +5V and drops the next one to zero for one millisecond and so on. So, the PIC is relentlessly scanning from one to nine, regardless of the state of the game.

Let's now look at pins 1 and 18 of the PIC. These pins are configured as outputs and are normally held low by the PIC. Pin 1 connects to all the green LED anodes and pin 18 connects to all the red LED anodes.

If, during the scanning, the PIC needs to illuminate, let's say, green LED number six, it waits until the scanning reaches position number six and then, just for one millisecond, while the cathode (K) is held low, it raises the anode (A) via pin 1 of the PIC to 5V. Only that LED will light because it is the only one with power on one end and 0V on the other end.

In this way, the PIC lights the LEDs one at a time at high speed, so you are unaware that they are actually flashing rapidly. It will never light both green and red for the one location, as that situation never occurs.

The common sides of the pushbutton switches are all connected to pin 2 of the PIC. This pin is configured as an input and is normally held high by a 4.7kΩ resistor (R4). However, if you press a button, this pin will be pulled low when the scanning reaches that position.

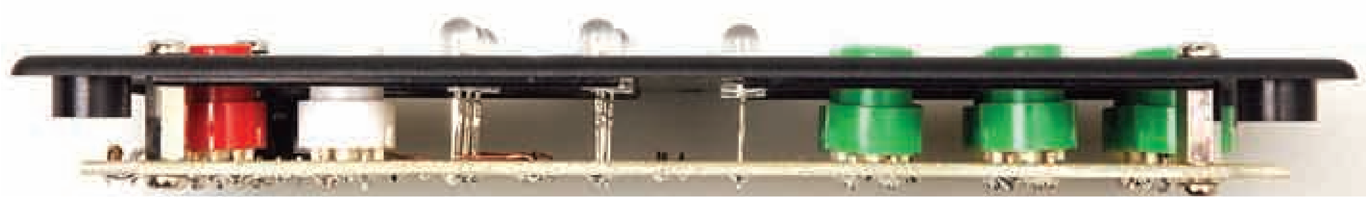
During an actual game, as the PIC is scanning each position, then for the one millisecond when the common point is pulled low, pin 1 will be switched high if the LED should be green. Similarly, if the LED should be red, pin 18 will be switched high.

If the position is not occupied (no red, no green), then (and only then) the PIC looks at pin 2 to see if a button has been pressed. This means that if the player presses the button for a position already occupied, it is ignored.

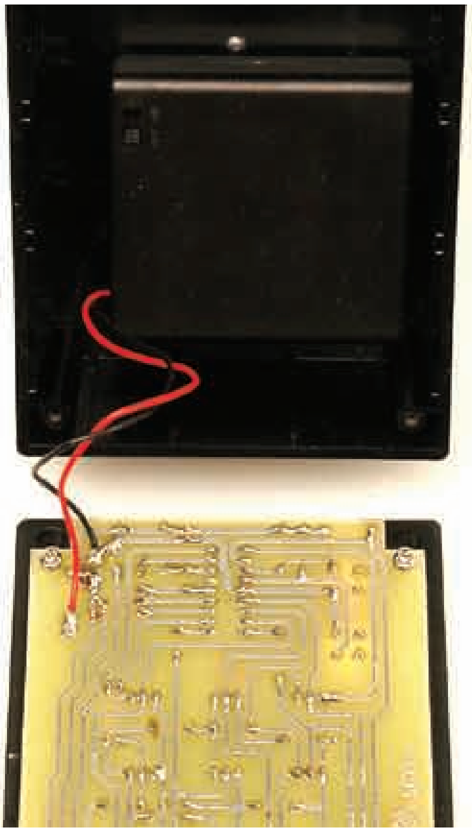
Game logic

Let's ignore the housekeeping software and just look at the game's logic itself.

When you press a button, the green LED is illuminated immediately, and



These two shots give a good idea of how OSCAR fits together. The PC board screws to the box lid via standoffs with the switches and LEDs poking through. The battery holder is fixed to the bottom of the box.



then there is a deliberate delay of one to two seconds so that Oscar appears to be 'thinking'. Then the PIC very rapidly goes through four separate procedures, looking for a response. As soon as a response is indicated, the PIC executes it and quits any further procedures until it's time for the next move.

The first procedure, called 'Win for Sure' is to test every position to see if in any row of three LEDs, there are two red LEDs lit and the third position blank. If it finds one, it of course puts a red LED there, stops the game and declares a win.

The second procedure is called 'Prevent Win' and is similar to the first. Its job is to test every row to see if there are two green LEDs in a row and a third position blank. If it finds one it puts a red LED there to prevent defeat.

The third procedure is the most difficult. It is called 'Tactics'. It goes through quite a few algorithms and tries to do something intelligent.

The fourth procedure, if the first three produce nothing, is simple: just find an empty position and go there. There is more software for responding when the player lets Oscar have first turn and also to highlight the winning row of three red LEDs by making them flash.

Software

The software files are available for download via the *EPE* Library site, access via **www.epemag.com**. Pre-programmed PICs are available from Magenta Electronics – see their advert in this issue for contact details.

Assembly

The whole circuit is built on one PC board, which mounts inside the lid of a UB1-type box. This board is available from the *EPE PCB Service*, code 705.

The most difficult part of the construction process is the precise drilling of the lid. Photocopy or cut out the front panel art and use it as a template – see Fig.3. Tape it to the box lid and drill a small pilot hole for each marked spot. That done, increase the size of the drill bit, being careful to keep the drill perpendicular to the lid at all times.

Check that the LEDs will fit into the holes easily and that the switch buttons have about 1mm clearance all around. If the switches get caught on the hole edges and jam on, the project won't work!

Assemble all the components onto the board except the LEDs. This is important – leave the LEDs until later.

It's best to use a socket for the PIC in case you need to remove it. The end of the socket with the notch in it is near the edge of the board. Leave the PIC out for the moment.

Fit all 18 wire links on the PC board (we suggest using resistor and capacitor lead cut-offs, as these are

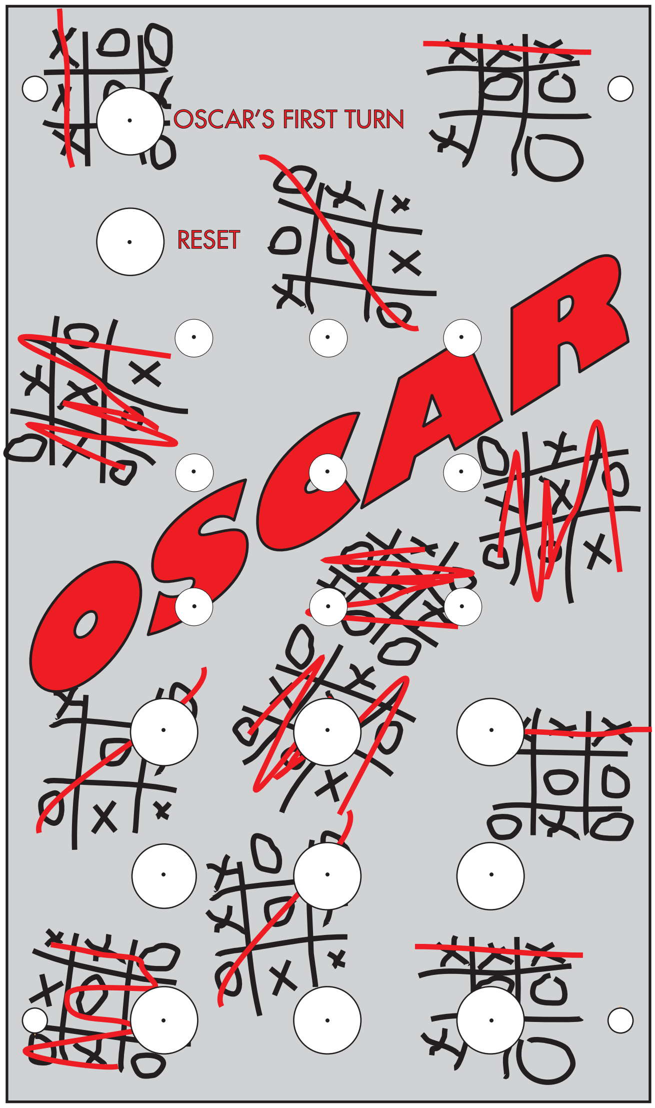
Parts List – Oscar Noughts & Crosses Game

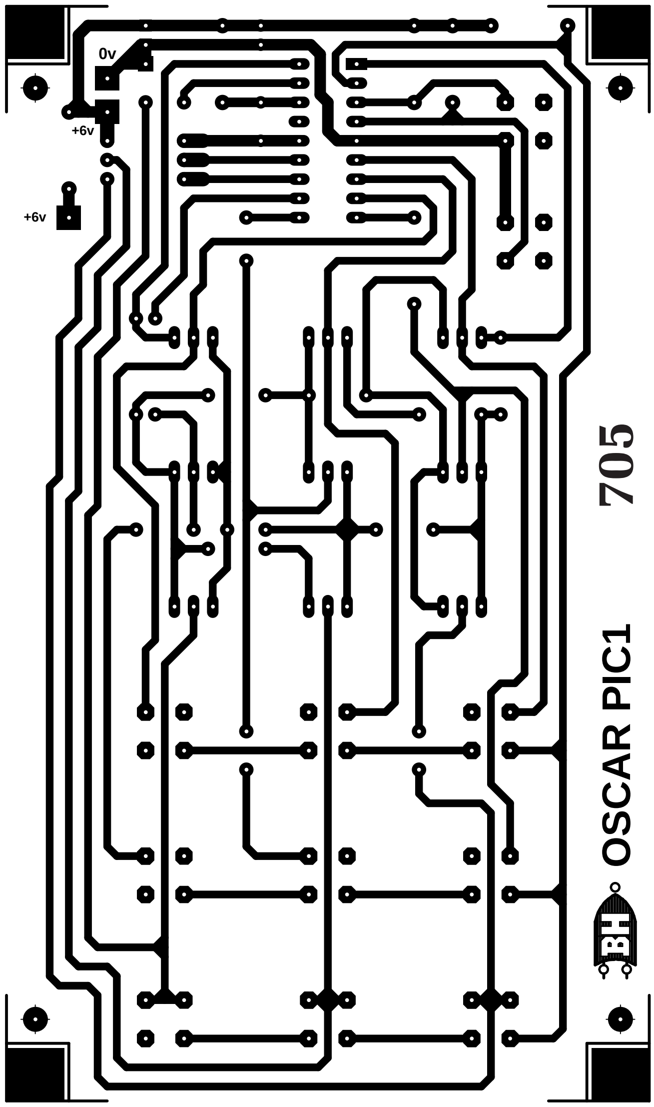
1 OSCAR PIC1 PC board, code 705, available from the *EPE PCB Service*, size 145 × 86mm
1 UB1-type plastic box, size 158 × 95 × 53mm
1 4 × AA battery holder
4 AA batteries
9 green SPST PC-mount tactile round PC-mount pushbutton switches; push-to-make, release-to-brake
1 red PC-mount pushbutton
1 white PC-mount pushbutton
1 18-pin IC socket
4 M3 ×10mm tapped metal or nylon stand-offs
8 M3 × 6mm screws

Semiconductors
1 PIC16F84A preprogrammed with OSCARv2.hex (IC1)
9 red/green 3-pin LEDs (LED1 to LED9)
1 1N4004 400V 1A rect. diode (D1)

Capacitors
1 10µF 16V radial electrolytic.
1 100nF miniature polyester
1 100pF ceramic capacitor (code 101 or 100p)

Resistors (0.25W, 5% carbon film)
1 10kΩ
3 4.7kΩ





Figs.3 and 4: full-size artwork for the front panel (which can also be used as a drilling template) and the PC board foil master, viewed from the copper side. Note the four cutouts required in the corners of the PC board so that it can clear the pillars in the box.

invariably tinned copper wire) and the four resistors.

The small electrolytic capacitor is polarised. Install the four 10mm metal standoffs to the PC board. Test fit the board to see how well you have drilled the holes for the switch buttons; file or ream the holes a little if necessary.

When you are happy with the fit of the buttons in the holes, fit all nine LEDs into their holes in the circuit board, taking great care with their polarity (flat side is on the anode 1 (red) leg), but don't solder them just yet.

Now mount the board on the case lid using the standoffs and fit the screws to both ends, so that the board is in its correct position. That done, push the LEDs one at a time hard into their corresponding holes in the lid. Make sure each LED is fully pressed into its hole, then solder its leads. Repeat until all the LEDs have been soldered in place.

If you have done this well, all the LEDs will be protruding through the lid by the same amount (around 3mm).

The battery box can be attached to the bottom of the box with double sided tape. Finally, fit the PIC into its socket, install the batteries, switch on and give it a go.

Faultfinding

If you have trouble with any of the functions you can check out the board as follows.

First, power off and remove the PIC, then make a short jumper out of a single strand of telephone wire. Put one end in pin 14 of the socket and the other end in pin 18.

Put one end of a 220Ω resistor in pin 5 and the other into pin 6. The first LED should light red. Swap the resistor end from pin 6 to pin 7 and the second LED should light red. Keep going into pins 8, 9, 10, 11, 12, 13 and 17 and each LED should light red in turn.

To check the green LEDs, change the jumper linking pins 14 and 18 to pins 14 and 1. Repeat as above with the 220Ω resistor and again, each LED should light (green) in turn.

If you have an LED in backwards it will light green when it should have lit red, and vice versa.

If these checks are OK, then it is highly likely that you have a faulty PIC or a PIC that has not been programmed or is programmed incorrectly. *EPE*

Versatile 4-In

. . . with tone controls and a b

This low-cost 4-input mixer features low-noise input preamps, each of which can be configured to suit a wide range of signal sources: microphones, guitar pick-ups, tape decks, synthesisers or CD players. Other features include a built-in equaliser with bass, midrange and treble controls, along with a monitoring amplifier which can drive stereo headphones.

By JIM ROWE

nput Mixer

uilt-in headphone amp!

Specifications

Input sensitivity (for 2.0V RMS output, each main preamp configuration):

- Dynamic mic, low impedance .... 2.6mV RMS
- Electric guitar .... 28mV RMS
- Tape deck .... 145mV RMS
- CD player .... 463mV RMS

Frequency response .... –3dB at 23Hz and 40kHz, –1dB at 40Hz and 22kHz (with tone controls flat; see Fig.4)

Maximum output .... 3.2V RMS (9V p-p) before clipping; see Fig.6

Output noise level (with respect to 2V RMS output, maximum gain and volume, tone controls flat, inputs terminated with 1kΩ, unweighted 22Hz-22kHz bandwidth)

- CD player input .... –92dB unweighted; –96dB A-weighted
- Tape deck input .... –92dB unweighted; –96dB A-weighted
- Guitar input .... –85dB unweighted; –89dB A-weighted
- Low-Z mic input .... –67dB unweighted; –70dB A-weighted

Total harmonic distortion (THD) .... Less than 0.01% up to 3.2V RMS output

Graphic equaliser

- Bass .... +13dB and –12.5dB at 100Hz, ±18dB at 40Hz, ±0.5dB at 1kHz
- Mid-range .... ±11dB at 1kHz, ±1dB at 100Hz, ±2.5dB at 10kHz
- Treble .... ±10.5dB at 12kHz, ±1dB at 1kHz, ±11.5dB at 15kHz

Headphone amplifier

- Output voltage before clipping .... 590mV RMS into 2 x 33Ω loads
- THD for 500mV RMS into 2 x 33Ω loads 0.8%

Supply voltage .... 12V DC (nominal) – see text

Maximum current drain 45mA

IT IS MANY, many years since we published a design for a low-cost four-input guitar mixer module for small bands and groups. Although it was very popular, it apparently wasn't quite as flexible as many users wanted, particularly in terms of its ability to configure the input preamps for signal sources other than guitar pick-ups – eg, for dynamic mics, tape decks, CD players and synthesisers. It also didn't include a built-in headphone amplifier for monitoring.

These shortcomings have been addressed in this design. There's now more flexibility in configuring the input preamps, together with a built-in headphone amplifier.

Block diagram

The block diagram for the Versatile 4-Input Mixer is shown in Fig.1. It provides four inputs, each with its own preamp stage and gain control. Each of the four input preamps can be configured by the user to provide the appropriate gain and input impedance values to suit a wide range of signal sources – from the millivolt or two of a low-impedance dynamic mic to the 1V to 2V signals of a CD/MP3 player or keyboard synthesiser. This makes the unit very versatile.

Following the input gain controls, there's a standard mixer stage, to allow the signals to be combined in whatever proportions you wish. The resulting composite audio signal is then fed to a 3-channel 'mini equaliser' stage, where three tone controls (bass, mid-range and treble) allow you to adjust the tonal balance.

This equaliser stage is basically an expanded version of a standard 'Baxandall' feedback tone control, with three controls instead of two.

From there, the output of the equaliser stage is passed to the master volume control and finally to the output jack, via an output buffer amplifier operating with a gain of 2.2.

The headphone amplifier (shown above the output buffer) allows the output audio signal to be monitored via a pair of standard stereo headphones.

The mixer circuit operates from a single 12V DC supply. This can be provided either by a mains plugpack or a 12V battery, making the unit suitable for portable and mobile use. The current drain is less than 50mA.

All components are mounted on a single PC board for ease of assembly and although the board is a little on the large size, we've made it just the right size to fit snugly into a 225 × 165 × 40mm low-profile plastic instrument case.

Circuit details

The full circuit diagram for the Versatile 4-Input Mixer is shown in Fig.3. It's quite easy to relate each circuit section to its corresponding block in Fig.1.

At the far lefthand side are the four signal input jacks CON1 to CON4, each connected to its own preamp stage and gain control. These preamps each use one section of an LM833 low-noise dual op amp IC – ie, two ICs are used (IC1 and IC2).

Although the four preamps shown in Fig.3 all have exactly the same circuit configuration, some of the components in each stage do not have specific values. Instead they have symbolic values like Rm, Rin, Rza, Rzb, Rf and Cf, to indicate their basic function rather than their value. This is because their values need to be chosen when each preamp is configured to suit a particular signal source.

Specifically, Rm, Rin, Rza and Rzb are given values to provide the appropriate input impedance for the source, while Rf and Cf are given values to provide the appropriate gain and/or signal handling capability. The inset table in the circuit diagram gives the values for each of the various input sources.

As the mixer is a mono device and there is a good chance that stereo devices may be connected to it (eg, an MP3 or CD player) all four channels have the capability of being 'summed' to mono via Rma and Rmb – again, the values are shown in the inset table.

Some devices, such as microphones, are generally mono, so Rma and Rmb may be substituted with links and/or omitted completely. Yes, we know there are stereo microphones out there, but these are the exception, not the rule.

For example, to configure a preamp for an electric guitar input, Rin, Rza and Rzb are 1MΩ (giving an input impedance of 330kΩ), while Rf is 22kΩ (to give a gain of 19 times, or about 25dB). Finally, Cf is given a value of 100pF to ensure stability.

Similarly, to configure a preamp for the much higher stereo output from a CD player or synthesiser keyboard, Rza

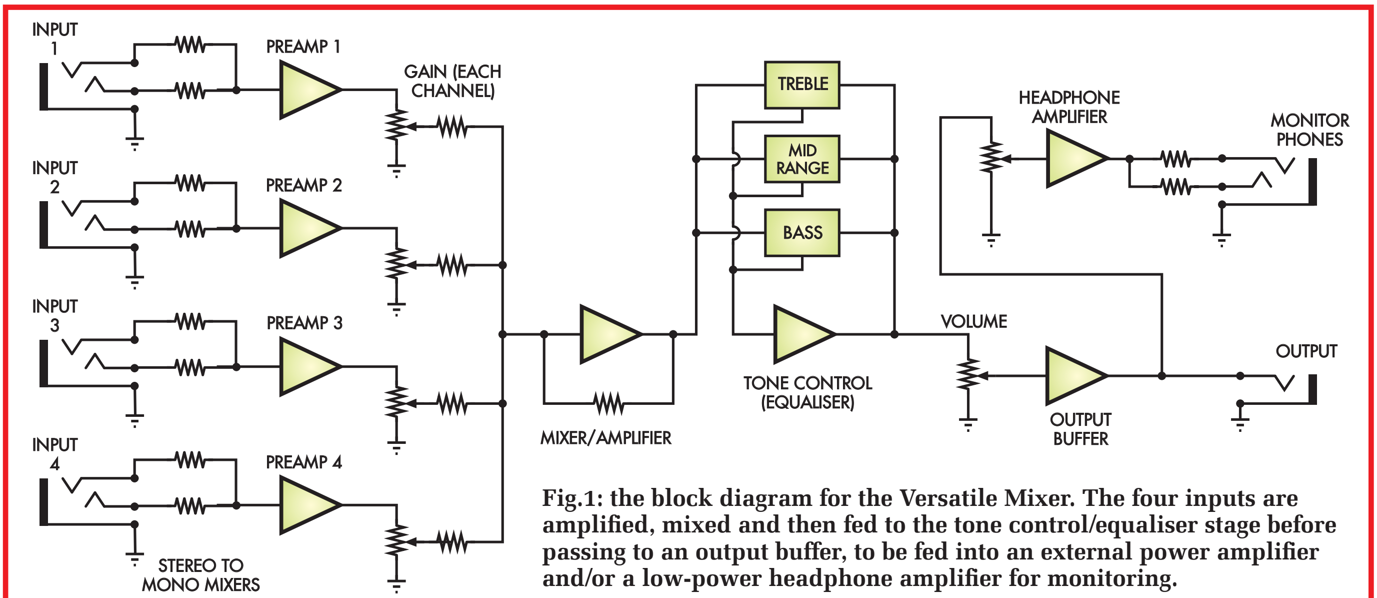
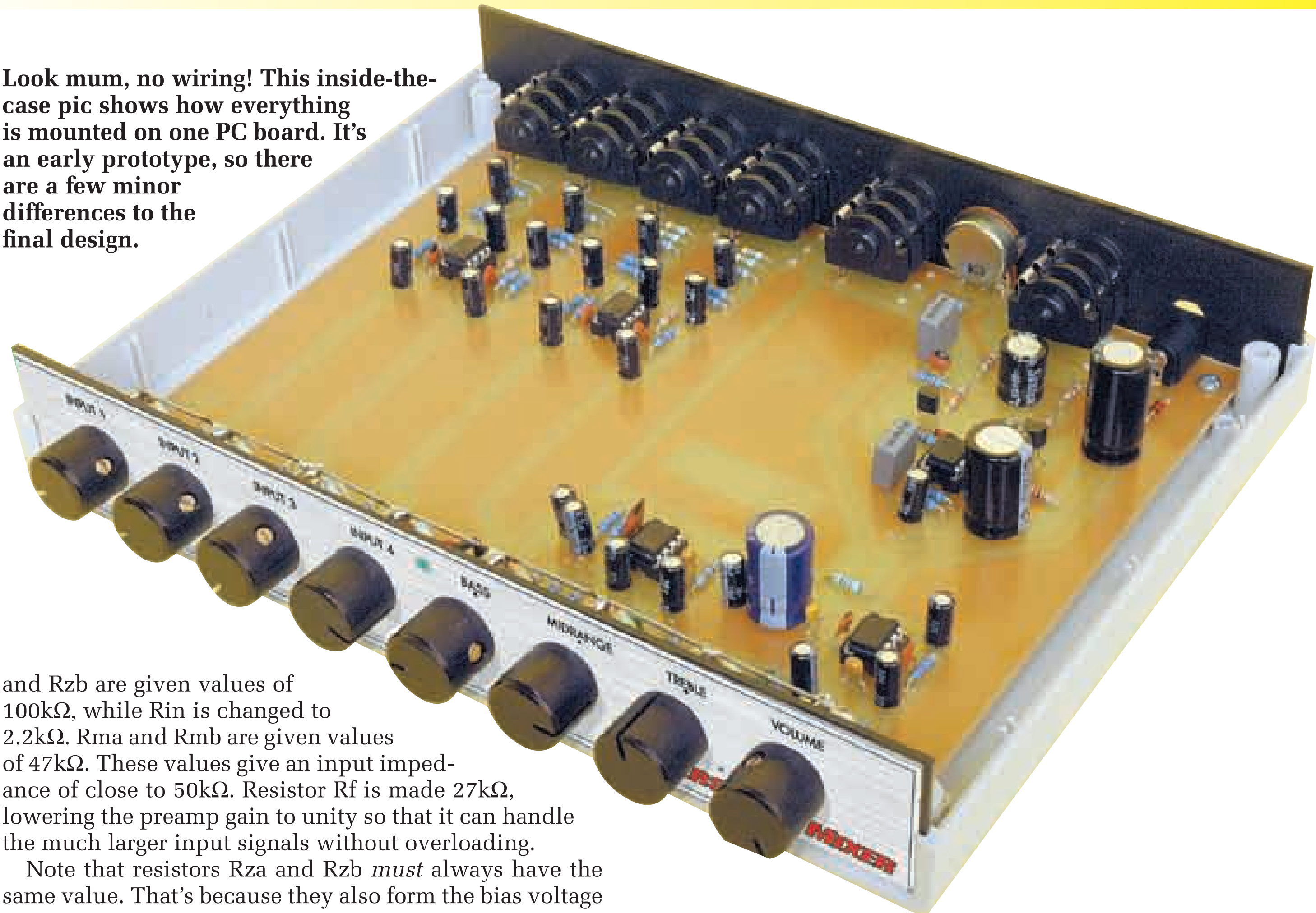


Fig.1: the block diagram for the Versatile Mixer. The four inputs are amplified, mixed and then fed to the tone control/equaliser stage before passing to an output buffer, to be fed into an external power amplifier and/or a low-power headphone amplifier for monitoring.



Look mum, no wiring! This inside-the-case pic shows how everything is mounted on one PC board. It's an early prototype, so there are a few minor differences to the final design.

and Rzb are given values of 100kΩ, while Rin is changed to 2.2kΩ. Rma and Rmb are given values of 47kΩ. These values give an input impedance of close to 50kΩ. Resistor Rf is made 27kΩ, lowering the preamp gain to unity so that it can handle the much larger input signals without overloading.

Note that resistors Rza and Rzb *must* always have the same value. That's because they also form the bias voltage divider for the preamp concerned.

No provision has been made for powering electret microphones, but in a permanent installation this could be easily achieved through the use of a suitable bias resistor (10kΩ is commonly used) from the nominal 12V line to the 'hot' input of the electret.

Preamp outputs

The outputs from the preamp stages are fed via 2.2µF electrolytic capacitors to gain control potentiometers VR1 to VR4. The signals at the wipers (moving contacts) are then fed, via 47kΩ mixing resistors and a 2.2µF capacitor, to pin 2 input of mixer/amplifier stage IC3a.

IC3a operates as a standard inverting amplifier with a gain of –2 (100kΩ/47kΩ) for each of the four inputs. It also provides a low 'virtual earth' input impedance, to ensure that there is no interaction between the four gain controls (VR1 to VR4).

A half-supply rail bias (+6V) for IC3a is provided by op amp IC3b. This is connected as a voltage follower with its pin 5 input set at +6V by a voltage divider consisting of two 47kΩ resistors across the supply rail. The resulting +6V bias voltage from pin 7 of IC3b is applied to pin 3 of IC3a via a 100kΩ resistor. It's also used to bias op amps IC4a (pin 3) and IC4b (pin 5).

Tone control stage

The heart of the tone control/equaliser stage is IC4a. As mentioned previously, this is an extended version of the standard Baxandall feedback tone control configuration – ie, it has three controls instead of the usual two. The operation is exactly the same though, with each pot (VR5, VR6 and VR7) acting as a gain control for signals within a set frequency range.

In operation, the pots vary the effective negative feedback ratios for their respective frequency bands.

Fig.2 shows a simplified scheme for the bass control. When the pot is in its centre position, IC4a has equal input and feedback impedances for the frequencies in its control range, thus giving it unity gain for those frequencies.

However, when the pot is turned to the 'maximum boost' (fully clockwise) position, the ratio of the feedback and input impedances increases to 11:1 (110kΩ/10kΩ), so the stage gain for those frequencies increases to 11 times or +21dB.

Conversely, when the pot is turned to the 'maximum cut' (fully anticlockwise) position, the ratio of feedback and input impedances reduces to 1:11 (10kΩ/110kΩ). As a result, the stage no longer amplifies those frequencies but

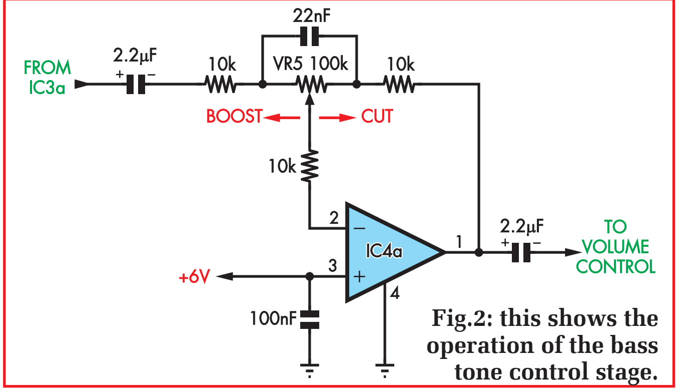
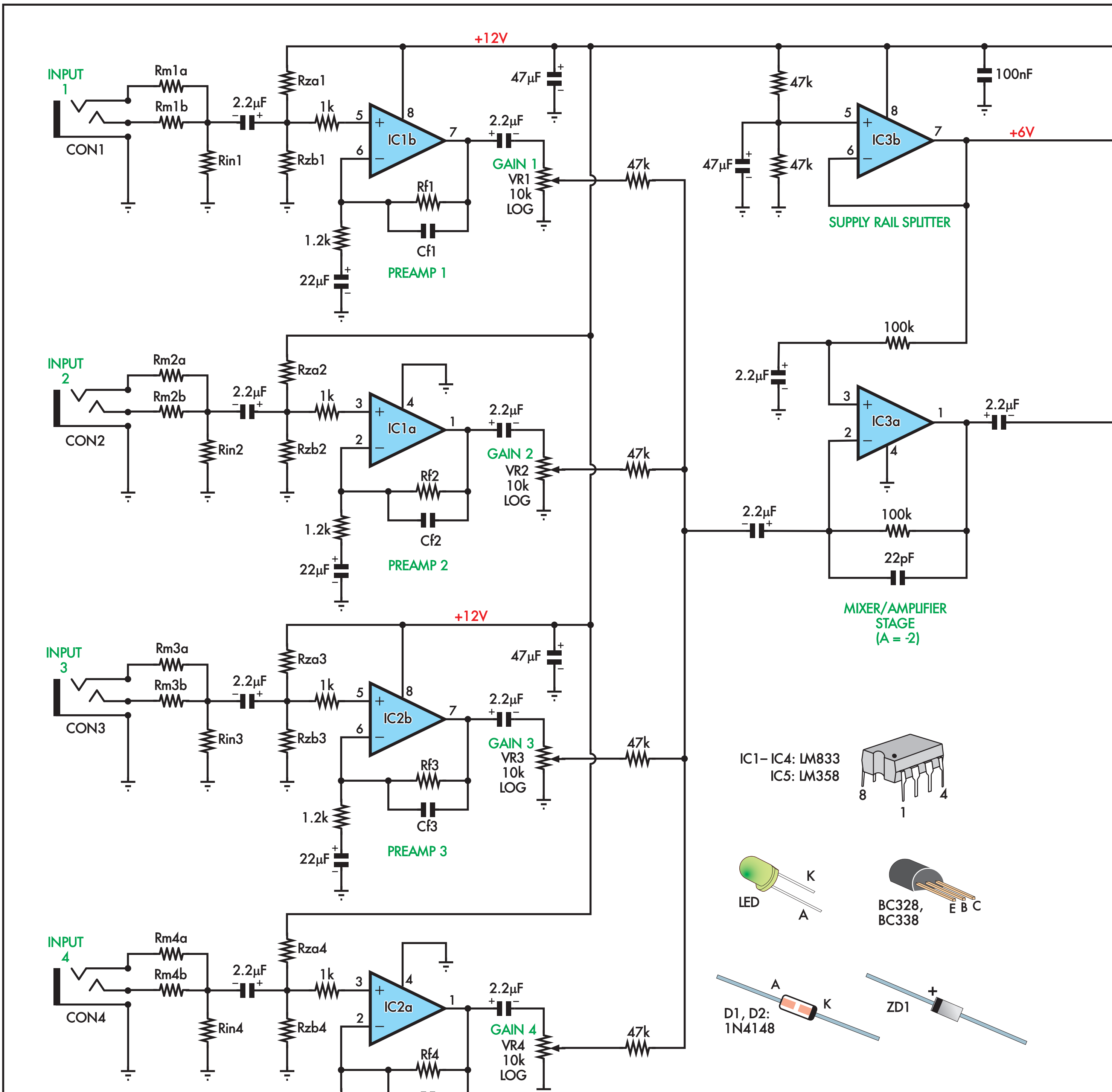


Fig.2: this shows the operation of the bass tone control stage.



PREAMP COMPONENT VALUES FOR VARIOUS INPUTS

INPUT	Rma	Rmb	Rin	Rza,Rzb	Rf	Cf
ELECTRIC GUITAR (50mV)	(OMIT)	LINK	1M	1M	22k	100pF
DYNAMIC MIC (Mono, Lo-Z)	(OMIT)	LINK	680Ω	10k	220k	12pF
DYNAMIC MIC (Mono, Hi-Z)	(OMIT)	LINK	1M	100k	120k	18pF
TAPE DECK (Stereo, 300mV)	47k	47k	2.2k	100k	82k	22pF
CD PLAYER/SYNTH (St, 2V)	47k	47k	2.2k	100k	27k	82pF

VERSATILE FOUR INPUT MIXER

attenuates them instead – ie, by about 11 times, or –21dB.

Going back to Fig.3, all three tone controls act in this same way, but each covers its own range of frequencies, as determined by the values of the various capacitors in the feedback networks.

IC4a's output appears at pin 1 and is AC-coupled to VR8, which is the master volume control. This controls the signal level fed to output buffer stage IC4b, which is configured as a standard inverting amplifier with a gain of 2.2 (22kΩ/10kΩ). Its output is in turn fed to output jack CON5 via a 2.2µF DC blocking capacitor.

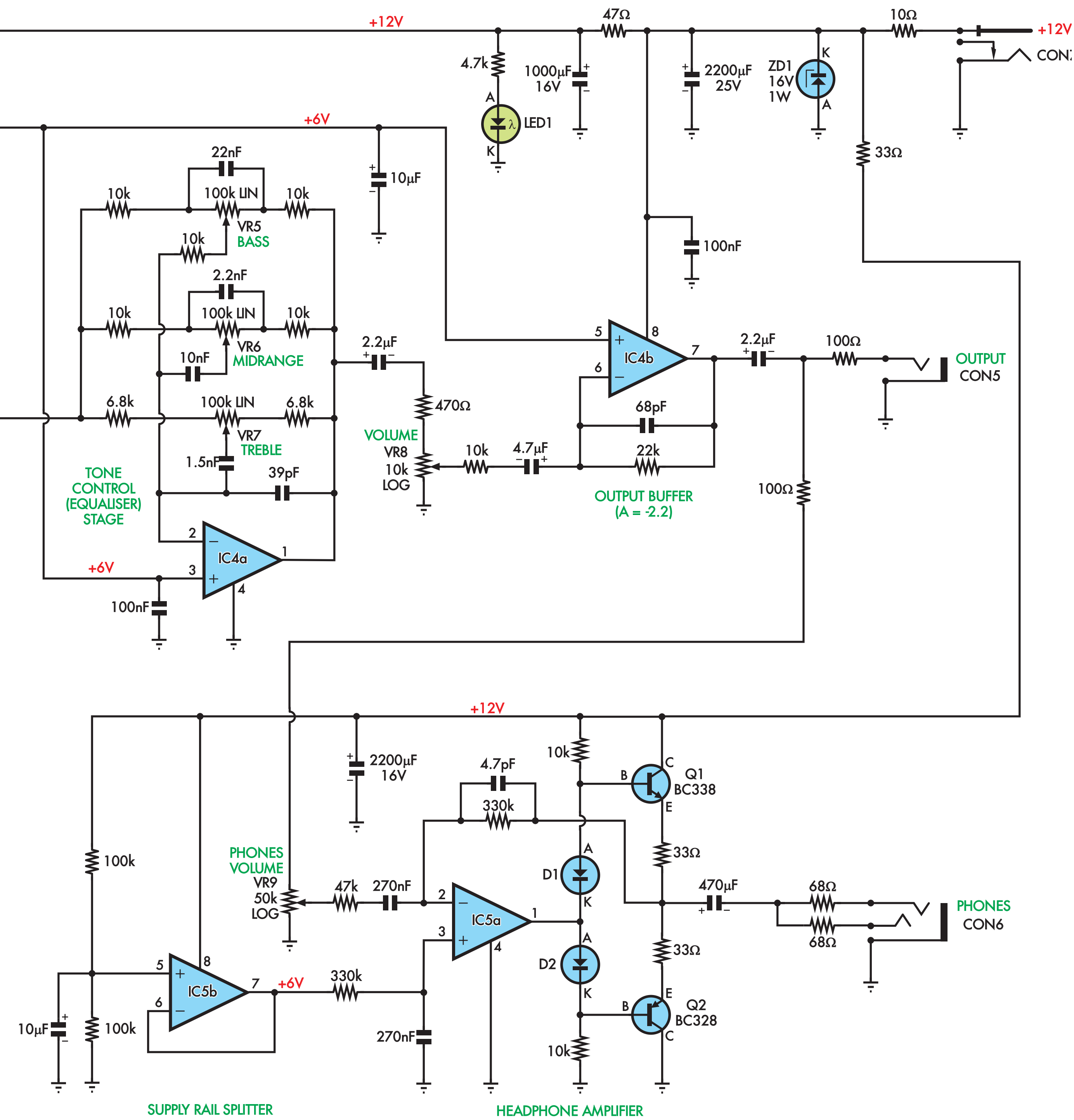


Fig.3: don't be daunted by the size of the circuit diagram – it really is quite an easy project to understand (especially when you compare it to the block diagram). And the good news is it's even easier to put together because all components mount on a single PC board. No wiring should mean no mistakes.

Headphone amplifier

The output signal at CON5 is also used to feed the headphone amplifier (IC5a), via a 100Ω isolating resistor and potentiometer VR9 (the headphone volume control). The headphone amplifier itself is based on IC5a, which is half of an LM358 low-power dual op amp. IC5b is wired in a similar manner to IC3b (ie, as a voltage follower) and is used to bias pin 3 of IC5a to +6V.

Transistors Q1 and Q2 are used to boost the output current capability of IC5a, to provide sufficient drive for both sides of a standard low-impedance stereo headphones/ear buds (33Ω per earpiece). These transistors are configured

Fig.4: this complex frequency plot is the result of five frequency sweeps with different tone control settings. The green trace ➊ is taken with maximum bass boost, mid-range flat (centred) and maximum treble cut. The yellow trace ➋ is taken with all tone controls flat (centred). The red trace ➌ is taken with maximum bass cut, mid-range flat (centred) and maximum treble boost. The purple trace ➍ is taken with bass and treble controls flat and maximum mid-range boost while the pink trace ➎ is taken with bass and treble controls flat and maximum mid-range cut. Note that the tone controls do interact with each other.

as complementary emitter followers, with diodes D1 and D2 setting their quiescent bias levels.

Negative feedback for the stage is taken from the junction of the two 33Ω emitter resistors and applied to pin 2 of IC5a via a 330kΩ resistor, ie, transistors Q1 and Q2 are inside the feedback loop. This reduces the distortion level of the headphone amplifier and also flattens its frequency response. The 4.7pF capacitor across the 330kΩ resistor rolls off the response above 100kHz to ensure stability.

Power supply

To make it as versatile as possible, power for the mixer is derived from either an external 12V DC regulated plugpack supply or from a 12V battery. This is applied via connector CON7 and powers all the mixer circuitry.

Reverse polarity protection is not provided by a series diode, but instead by a 10Ω series resistor and Zener diode ZD1, which also protects the circuit from over-voltage damage. If you connect a plugpack with the wrong polarity (ie, centre negative instead of the more usual centre positive) the 10Ω resistor should burn out, cutting power from the circuit.

A single 3mm ‘power on’ high-brightness LED connects across the 12V supply via a 4.7kΩ current-limiting resistor.

The 2200µF electrolytic capacitor across ZD1 decouples and filters the supply rail, while the rail to the headphone amplifier is further decoupled using a separate 33Ω resistor and 2200µF capacitor. This is done to prevent unwanted interaction between the headphone amplifier and the rest of the circuit due to supply rail fluctuations.

Additional supply decoupling for the +12V rail to the LM833 op amps is provided by a 47Ω resistor and 1000µF capacitor. This eliminates any possibility of low frequency ‘motor-boating’ when high gain is used on all the input channels, together with maximum bass boost.

It also makes it possible to use an unregulated 9V DC plugpack at a pinch – hum will be higher, but at least it might get you out of trouble if the specified regulated 12V DC plugpack is unavailable.

Self-contained battery power?

We know it’s going to be asked, so we will answer the question: can you make the mixer portable and run it from internal batteries – say a couple of 9V alkalines?

The answer, with a couple of reservations, is yes, it is possible – because the op amps set up the half-supply rails.

The two batteries could occupy the vacant real estate in the middle of the PC board. (You’d obviously need to fix these in position on the PC board, but that shouldn’t be difficult, given the amount of earth track in this area).

A couple of riders though: the mixer draws about 20mA *without* the headphone amplifier being used, so even new alkaline 9V batteries are only likely to give you a few hours operation at best. If you use the headphone amp, expect even less. But that period might be long enough for your application. And to use an 18V supply, you would need to change the 16V Zener to a 22V type. You would also probably want to fit a small power on/off switch.

Construction

Another of the major features of this design, one that we haven’t mentioned earlier, is the fact there is no wiring to be done! Everything – including the input/output sockets and control pots – is mounted on the single PC board. This makes building this mixer very easy.

This PC board is coded 704, measures 198 × 156mm and fits neatly inside a standard low-profile ABS instrument case measuring 225 × 165 × 40mm. The printed circuit board is available from the *EPE PCB Service* – see page 70.

As can be seen from the photos, all but one of the control pots are mounted along the front of the board, the exception being the headphone volume control pot (VR9). There simply wasn’t enough room for it on the front, so it was mounted adjacent to headphone jack (CON6) on the rear panel.

Note that the board has been designed to suit standard low-cost switched 6.35mm jack sockets for CON1 to CON6, but the board will also accept the unswitched stereo type. The reason we use switched stereo sockets is so that unused inputs are shorted to ‘earth’, thus minimising noise.

Fig.7 shows the parts layout on the PC board. Begin construction by carefully inspecting the PC board for etching defects, then start the assembly by fitting the six wire links.

Follow these with the resistors. You will have to decide how you wish to configure each input and then choose resistors Rma, Rmb, Rin, Rza, Rzb and Rf from the table on the circuit diagram accordingly. We’ve shown the resistor colour codes (and capacitor codes) but you should also check the resistor values using a digital multimeter, as some colours can be difficult to decipher.

The non-polarised capacitors can go in next. Again, the feedback capacitors (Cf1 to Cf4) will have to be selected from the circuit diagram inset table. The polarised electrolytics can now be fitted, taking care to ensure they go in with the correct polarity.

Next, fit the sockets for the five ICs, making sure you orientate them with their ‘notched’ ends as indicated in Fig.7. Follow these with diodes D1 and D2, Zener diode

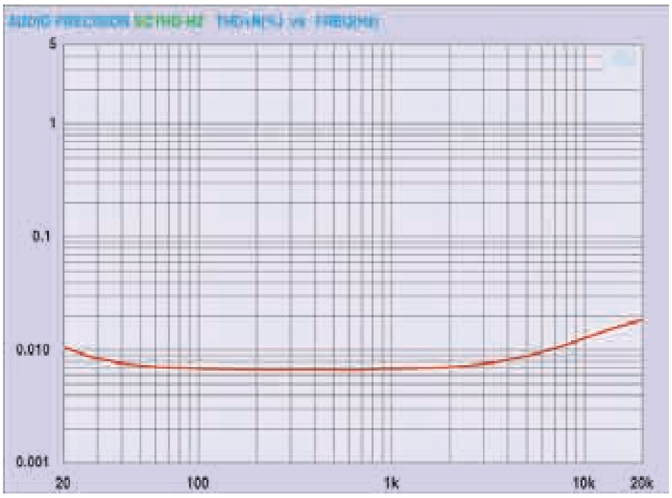


Fig.5: this graph shows total harmonic distortion versus frequency at an output of 2V RMS. The measurement bandwidth is 22Hz to 80kHz.

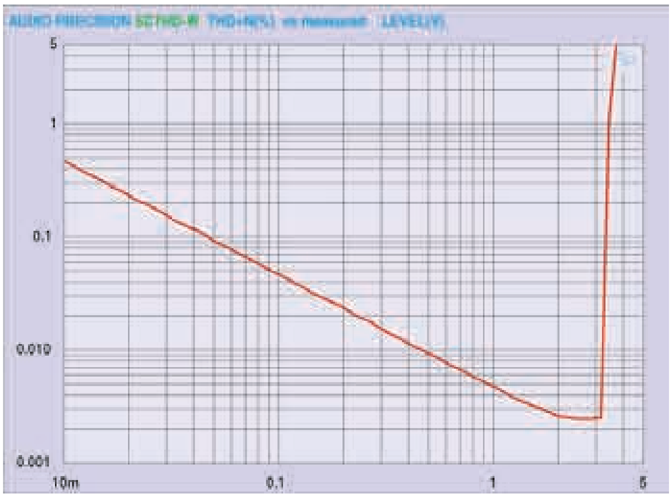


Fig.6 shows total harmonic distortion versus output level at a frequency of 1kHz. The measurement bandwidth is 22Hz to 22kHz. The rising value at lower signal levels is solely due to the residual noise at around –92dB with respect to 2V. Since the residual noise is fixed, it results in higher THD values as the signal level is reduced. In reality, the harmonic distortion is less than 0.003% at 1kHz, for all signal levels up to 2V RMS.

ZD1 and transistors Q1 and Q2, again making sure they have the correct orientation.

Potentiometers VR1 to VR9 can now be fitted. Before doing so, cut each pot's spindle to a length of 10mm using a small hacksaw and then use a small file to remove any burrs. This step will not be necessary if you use 'metric' pots with 10mm long splined shafts and matching splined knobs.

Note that the three 100kΩ linear units (usually marked B100K) must be fitted in the VR5, VR6 and VR7 positions along the front of the board. The five 10kΩ log pots (probably marked A10K) go in positions VR1 to VR4 and VR8, while the remaining 50kΩ log pot (marked A50K) is fitted as VR9 at the rear.

It's just a matter of pushing each pot as far down as it will go onto the board and soldering its pins. Once they're all in, scrape or file away some of the plating at the top of each of the VR1 to VR8 pot bodies and

Parts List – Versatile 4-Channel Mixer

1 PC board, code 704, size198 × 156mm. This board is available from the *EPE PCB Service*.
6 6.35mm switched stereo jack sockets, PC board mounting (CON1-6)
1 2.5mm concentric DC socket, PC-mount (CON7)
9 16mm diameter aluminium knobs
5 8-pin DIL sockets (for IC1-IC5)
1 200mm length of 0.25mm tinned copper wire
1 Low profile ABS instrument case, size 225 ×165 × 40mm

Semiconductors
4 LM833 dual low-noise op amp (IC1-IC4)
1 LM358 dual op amp (IC5)
1 BC338 *NPN* transistor (Q1)
1 BC328 *PNP* transistor (Q2)
1 16V 1W Zener diode (ZD1)
1 3mm high-brightness LED (LED1)
2 1N4148 signal diodes (D1,D2)

Capacitors
2 2200µF 25V radial electrolytic
1 1000µF 25V radial electrolytic
1 470µF 25V radial electrolytic
3 47µF 16V radial electrolytic
4 22µF 16V radial electrolytic
2 10µF 16V radial electrolytic
1 4.7µF 16V radial electrolytic
13 2.2µF 16V radial electrolytic
2 270nF MKT metallised polyester
3 100nF multilayer monolithic
1 22nF metallised polyester
1 10nF metallised polyester
1 2.2nF metallised polyester
1 1.5nF metallised polyester
1 68pF disc ceramic, NPO
1 39pF disc ceramic, NPO
1 22pF disc ceramic, NPO
1 4.7pF disc ceramic, NPO
4 ceramic caps, selected values (Cf1-Cf4)

Resistors (1%, 0.25W)

2 330kΩ	4 100kΩ	7 47kΩ	1 22kΩ	8 10kΩ
2 6.8kΩ	1 4.7kΩ	4 1.2kΩ	4 1kΩ	1 470Ω
2 100Ω	2 68Ω	3 33Ω	1 47Ω	1 10Ω

Up to 8 47kΩ input mixer resistors, (Rma1-4 and Rmb1-4) [omit for mono sources and use some links instead]
4 input resistors, selected values (Rin1-Rin4)
8 bias divider resistors, selected values (Rza1-Rza4 and Rzb1-Rzb4)
4 feedback resistors, selected values (Rf1-Rf4)

Potentiometers
5 10kΩ log pots, PC-mount 16mm (VR1-VR4,VR8)
3 100kΩ linear pot, PC-mount 16mm (VR5-VR7)
1 50kΩ log pot, PC-mount 16mm (VR9)

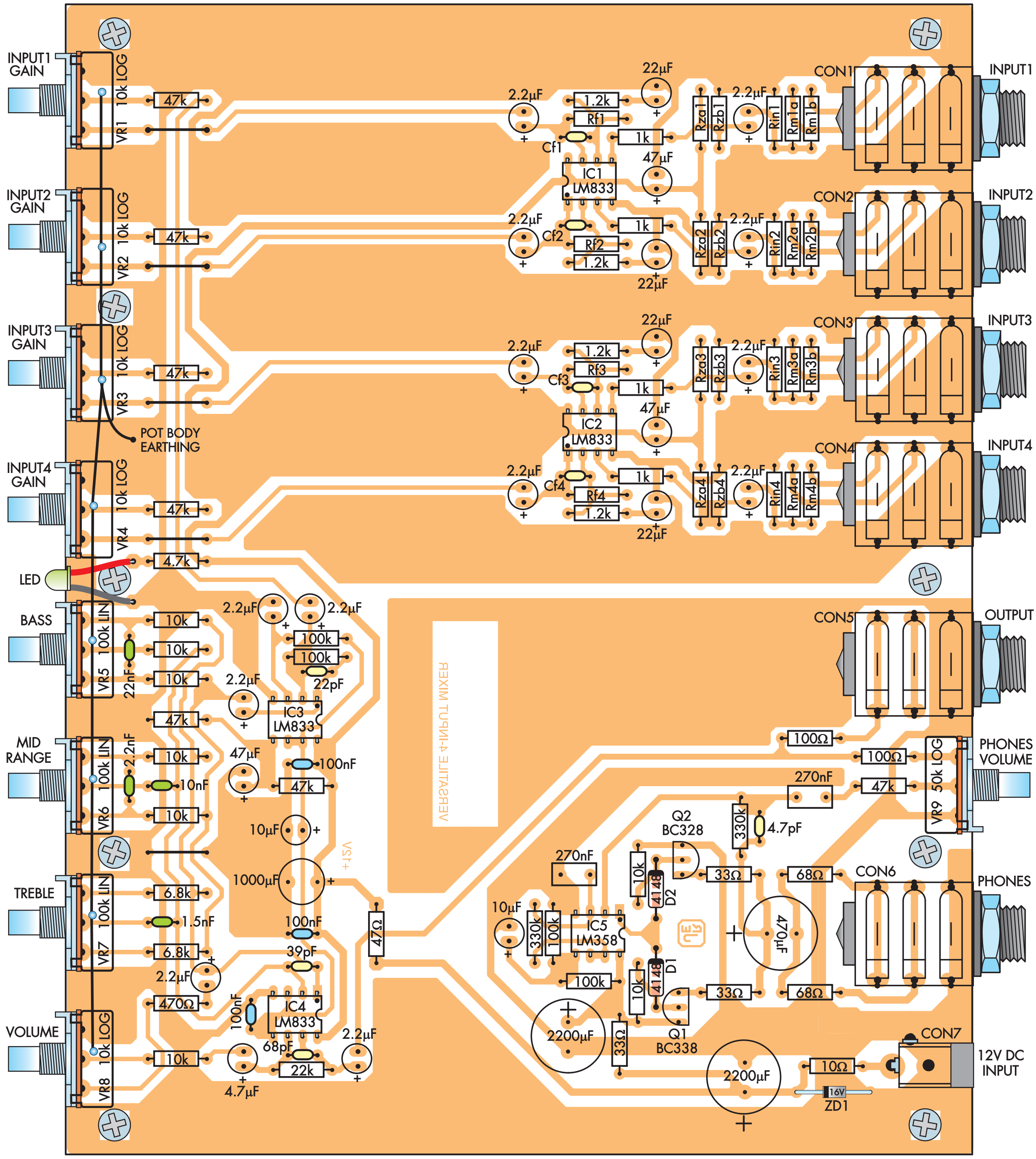


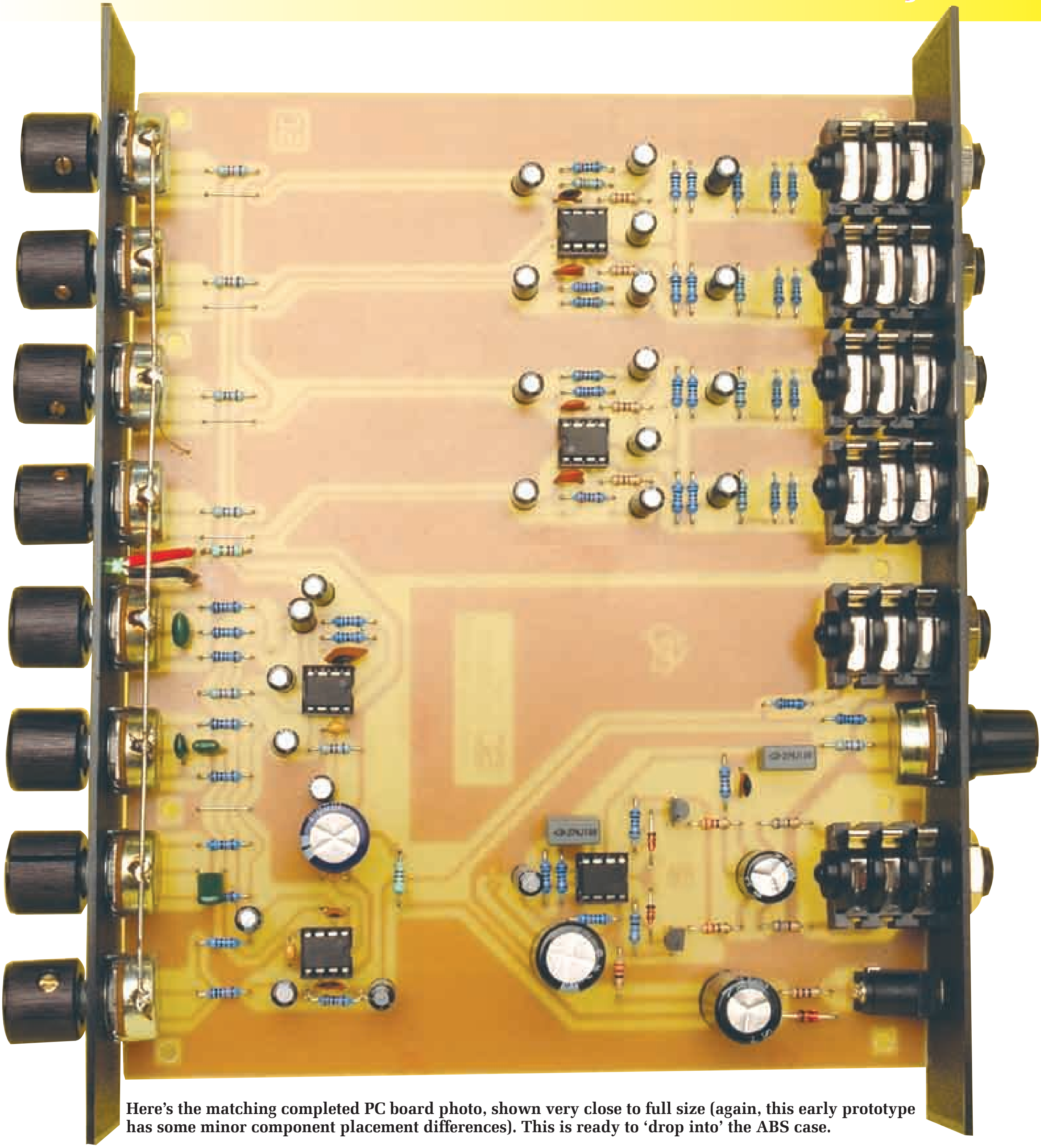
Fig.7: here's how it all goes together. Don't worry about all that PC board real estate with not much on it – the size is basically dictated by the pot spacing and the availability of suitable cases!

solder them together using a 170mm length of tinned copper wire. A second length of tinned copper wire is then used to connect VR3's body to an adjacent earth point on the PC board – see Fig.7. This step earths the pot bodies to prevent hand capacitance effects as the controls are adjusted.

The seven 6.35mm jack sockets CON1 to CON7 can now be fitted along the rear in much the same way, except there is no earth wire to be soldered on.

Once the sockets have all been fitted, the next step is to attach the rear panel to them (and to VR9). This simply involves passing the threaded ferrules through their matching panel holes and then fitting the washers and nuts. Don't tighten the nuts fully yet though – just leave them 'finger tight' for the time being.

The front panel is fitted in exactly the same way, this time over the threaded ferrules of VR1 to VR8. Again, leave the pot nuts finger tight – they're not fully tightened until the assembly is fitted into the case.

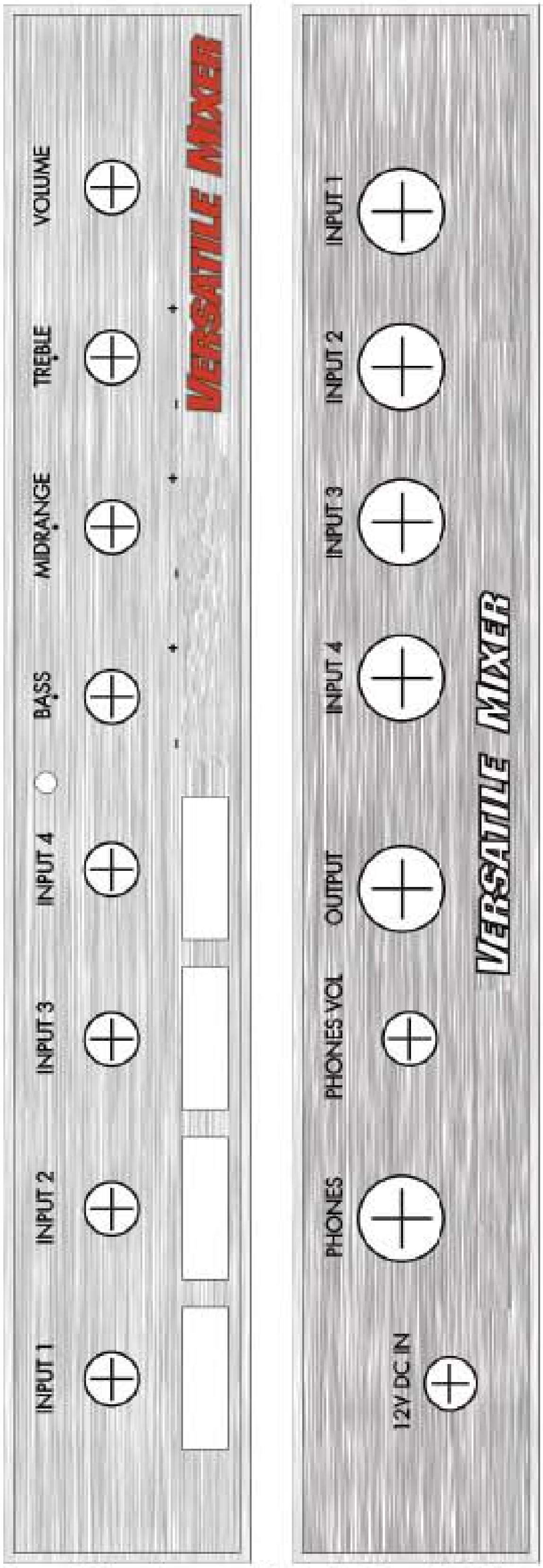


Here's the matching completed PC board photo, shown very close to full size (again, this early prototype has some minor component placement differences). This is ready to 'drop into' the ABS case.

Once this has been done, you're now ready to slide the completed board/panel assembly down into the lower half of the case, with the panel ends mating with the front and rear case slots. That done, the PC board can be fastened to the integral standoffs on the base of the case using nine of the small self-tapping screws provided.

The connector and pot mounting nuts can now all be carefully tightened with a small spanner. Don't tighten them too forcefully though, otherwise you'll strip their threads. Just nip them up tight enough to ensure they don't loosen with use. That done, you can fit the control knobs to the pot spindles.

The 'power on' LED mounts so its front is flush with the front panel – a tiny dob of super glue is enough to hold it in place. The LED leads will probably not be long enough to reach down to their respective holes on the PC board, so use some resistor lead cut-offs to lengthen them.



Front (left) and rear panels for the Versatile Mixer. The white panels underneath each input pot are used for writing on the input source (using a fine felt-tipped pen) – especially if your mixer is not permanently installed (and even if it is). Instantly knowing which input is which can save a lot of embarrassment when you need to adjust levels.

If there is any danger of shorting the LED leads to the potentiomenter earthing wire, you can slip some short lengths of insulation over the leads.

There's now just one more step to complete the construction and that's to plug the five ICs into their sockets. Be sure to fit the LM358 into the IC5 position and take care to ensure that they are correctly orientated (IC1 and IC2 face in one direction, while IC3, IC4 and IC5 face in the opposite direction).

Checking it out

There are no circuit adjustments to be made, but you should give it a quick visual check-out to make sure everything is in the right place and you haven't, for example, put any of the ICs, other semiconductors or electrolytic capacitors in back-to-front.

If it all checks out, you should make a simple current check before pronouncing it ready for use. This is easy to do – you actually do it by measuring voltage!

First, turn control pots VR1 to VR4, VR8 and VR9 fully anticlockwise and set VR5 to VR7 to the centre of their ranges (ie, at the top).

That done, connect a 12V DC power supply to the mixer's power socket. Make sure the power supply plug's centre pin is positive, otherwise the 10Ω resistor will let its smoke out and the mixer will definitely not work.

Now turn on the power supply and make sure the front panel LED comes on. That's a pretty good clue that everything is working properly. But it's not foolproof!

Set your multimeter to its lowest voltage range, and connect it across the 10Ω resistor at the DC input socket on the PC board. It should read somewhere between 200mV and 300mV (200mV across the 10Ω resistor means that the mixer is drawing 20mA).

If so, you can be reasonably confident your mixer is working properly. However, if the reading is higher than 300mV, switch off immediately because this indicates that there's some kind of error. At least you can be assured that it isn't a wiring error because there is no wiring!

So what is wrong?

There are quite a few fault possibilities – you may have connected the DC power lead with reversed polarity, fitted one of the ICs, transistors, diodes or electrolytic capacitors the wrong way around, or accidentally shorted adjacent tracks or pads on the PC board with solder. (Kit suppliers tell us that 99% of problems are due to poor soldering.)

In that case, it's a matter of going over your work and carefully checking everything until you find the problem.

As we mentioned earlier, if you have reversed the power supply polarity, the odds are that the 10Ω resistor at the input (ie, between the power input socket and the Zener diode) will have said 'too much' and given up the ghost.

Assuming that the voltage across the 10Ω resistor is correct (at 200-300mV), switch the multimeter to a suitable DC voltage range (eg, 0V to 20V) and use it to check the voltage at various key points in the circuit.

The easiest way to do this is to connect the meter's negative lead to the wire earthing at the pot bodies and then use the positive lead to probe the key voltages. Remember that you have many identical stages to compare voltages.

First, check the voltage at the rear centre pin of CON7 – it should read 12V, or whatever your battery or power supply is delivering. That done, check that pin 8 of either IC4 or IC3 is about 1V lower.

You should also find this voltage at pin 8 of IC1 and IC2 as well. Now check the voltage at pin 8 of IC5. This will be slightly lower again – something like 11.8V or so, if you're using a 12V source.

If everything seems OK so far, check the voltages at pin 7 of IC5 and at pin 7 of IC3. In both cases, you should get a reading of about 5.5V, because these pins are the outputs of the 'half supply rail' splitters. If these voltages are correct as well, your mixer is almost certainly working correctly.

It's just about finished!

The last check is to wind down the headphone volume pot to minimum, connect a set of headphones and then slowly increase the level to maximum. Depending on the headphone sensitivity, at maximum you will probably hear some hiss or noise, but not much else.

Plug in a suitable signal source (taking into account what components you have selected for the various inputs) and make sure that the input level pot for that source varies the level from zero to maximum.

Check all four inputs in a similar way with other audio sources and also make sure that there is an output at the output socket by connecting it to an amplifier.

All that remains is to fit the top half of the case and fasten everything together using the four countersink machine screws supplied. Your mixer is now complete and ready for use. *EPE*

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This inside view from the back shows the input and output sockets, headphones volume control, DC input plus the internals of the front panel.

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	330kΩ	orange orange yellow brown	orange orange black orange brown
❑	4	100kΩ	brown black yellow brown	brown black black orange brown
❑	7	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	8	10kΩ	brown black orange brown	brown black black red brown
❑	2	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	4	1.2kΩ	brown red red brown	brown red black brown brown
❑	4	1kΩ	brown black red brown	brown black black brown brown
❑	2	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	2	68Ω	blue grey black brown	blue grey black gold brown
❑	3	33Ω	orange orange brown brown	orange orange black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown

Capacitor Codes

Value	μF code	EIA Code	IEC Code
270nF	0.27μF	274	270n
100nF	0.1μF	104	100n
22nF	.022μF	223	22n
10nF	.01μF	103	10n
2.2nF	.0022μF	222	2n2
1.5nF	.0015μF	152	1n5
68pF	NA	68	68p
39pF	NA	39	39p
22pF	NA	22	22p
4.7pF	NA	4.7	4p7

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Recycle It!

BY JULIAN EDGAR

A £5 2-Channel Vibration Sensor

Want to make a vibration sensor for just a few pounds? All you need is an old cassette deck and a couple of loudspeakers!

THIS 2-Channel vibration sensor costs almost nothing to make, but is sensitive enough to detect a cat walking past on a wooden floor!

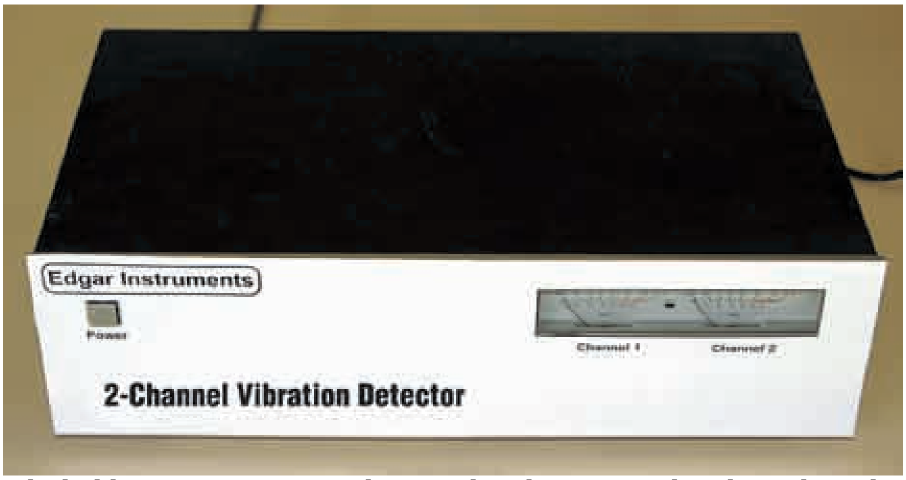
To make it, you'll need a discarded (but still working) cassette deck that has VU meters (these can be either analogue or digital) plus a couple of loudspeakers, which can be easily salvaged from an old stereo TV. If you can't score that lot for under £5.00, you're not really trying.

High-gain preamplifiers

The unit takes advantage of the fact that a cassette deck uses two high-gain preamplifier stages that work with very small signals. Normally, these signals are read off the tape by the tape heads, but what we do here is feed in new signals that are derived from coils of wire moving in a magnetic field. And since loudspeakers have very strong magnets, coils with lots of windings and very small internal clearances, they make ideal sensors for our vibration detector.

If the speaker basket (or frame) is firmly attached (face down) to the ground and a vibration occurs, then the basket and the cone will tend to move at different rates. For example, if there is a sudden movement upwards, the inertia of the cone means that it gets left behind for a moment. As a result, the magnet will move in relation to the coil (which is attached to the cone) and a small voltage will be generated.

This voltage is amplified and displayed on the cassette deck's VU meters. The greater the needle deflection, the greater the amount of vertical vibration that has occurred.



It looks like a £1000 instrument but costs less than £5 to make. This 2-channel vibration detector is actually based on a slightly modified cassette deck and uses conventional loudspeakers as vibration sensors. It's sensitive enough to detect a cat walking past on a wooden floor.

Building it

At its simplest, the vibration detector will take only a few minutes to make. First, make sure that the power cord is disconnected from the mains supply and then take the cover off the cassette deck. Now trace the leads (they'll be shielded) that connect the PC board to the tape heads. There will be six conductors in all – a common, play and record signal feed for each head.

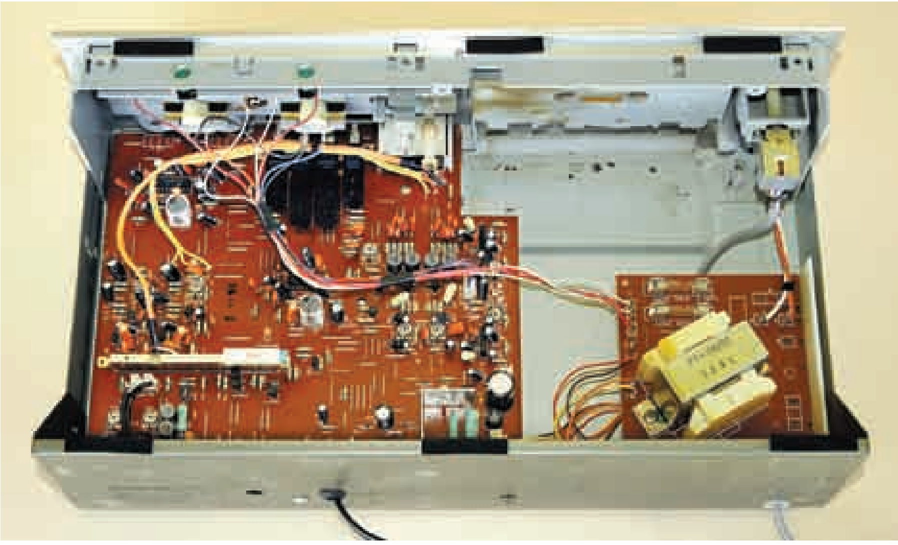
Cut these wires and feed them out of the case. That done, replace the case lid, power-up the deck, press the 'Play' button and then connect a speaker across the wires for one channel, trying various combinations until you find a pair which causes a VU meter to strongly react to any speaker movement.

Now do the same for the other channel. You may need to extend these leads and in our case, we used the cables that came with the deck.

While we were at it, we also stripped the cassette deck of surplus parts. For example, the complete tape mechanism was removed. Why? Well, the DC motor, drive belts and springs can find a use in another project, as can the tape counter. There's no need to leave them inside the 'unit'.

Of course, if you take this approach, you'll need to activate the same switches that pressing the 'Play' button normally does. For example, if a single switch is closed when 'Play' is pressed, the wires leading to that switch will need to be connected together. On the other hand, you may find that when the cassette mechanism is removed, the unit is effectively always in 'Play' mode.

Note too that different speakers will give different sensitivities. We



We chose to remove the internal bits and pieces that were no longer needed – the cassette mechanism, tape transport buttons, access door and so on. This allows these parts to be used in other projects and gives a much lighter unit.

The loudspeakers detect vibration and generate a small voltage as the magnet moves past the voice-coil in each unit. The larger the speakers, the more sensitive the instrument.

tried a variety and found that the larger the speaker, the more sensitive the unit became.

The speakers shown here (100mm diameter units salvaged from a stereo TV) were used in the author's unit and give a noticeable reading when anyone walks anywhere in the house.

As I type this, the unit is on my desk; with each normal force keystroke, the display meters are reading just under full-scale!

New faceplate

To make the unit look less like a cassette deck and more like a classy vibration detector, you can make a new faceplate. If the original faceplate is removable (most are), take it off and scan it into your PC. You can then use image manipulation software to construct the new visuals, putting on whatever labels you want.

That done, print it out at full-size on heavy stock, gloss paper and affix it to the original faceplate. The label can then be protected using clear contact adhesive film or a couple of strips of broad adhesive tape.

Another option is to replace the scale behind the VU meters. You can make the scale read anything you like, but in the case of the unit shown here, we elected to keep the original scales.

Rat It Before You Chuck It!

Whenever you throw away an old TV (or VCR or washing machine or dishwasher or printer) do you always think that surely there must be some good salvageable components inside? Well, this column is for you! (And it's also for people without a lot of dough.) Each month we'll use bits and pieces sourced from discards, sometimes in mini-projects and other times as an ideas smorgasbord.

And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you salvage the high-quality bearings from VCR heads. Or perhaps you've found how the guts of a cassette player can be easily turned into a metal detector. (Well, we made the last one up but you get the idea . . .)

If you have some practical ideas, write in and tell us!

Changing the sensitivity

If the sensitivity of the unit is too great, simply reduce the size of the speaker. Adding weights to the cone also alters the response.

When exploring the use of different speakers, be aware that a typical house is full of background vibrations. The compressor in the fridge can cause sufficient vibration to swamp other signals, while a PC cooling fan can also cause clearly visible room vibration.

So, to be able to watch earth vibrations caused by (say) visitors walking up to your front door, you'll need to remotely mount the speaker sensor away from this house-borne noise – but note that the sensitivity will be reduced if the cable is too long. Screwing the sensors to the floor, however, will improve sensitivity.

Logging the output

Finally, if you want to feed the output signal into a logging system or drive an external display, line-level output voltages will be available on the normal RCA phono outputs at the rear of the cassette deck.

INTERFACE

By Robert Penfold

USING HANDSHAKE OUTPUTS AS POWER SOURCES

THE two previous *Interface* articles considered the use of RS232C handshake lines as a means of controlling user add-ons. The RS232C serial port can be a standard type or it can be provided by a USB-to-serial converter.

Once installed properly and integrated into the Windows operating system, a USB-to-serial converter is used in the same way as a normal serial port, and it is treated in exactly the same way when writing the control software. As explained in the previous *Interface* articles, two handshake outputs (DTR and RTS) are under direct software control when using the SerialPort component of Visual BASIC 2008.

Unfortunately, no other lines can be controlled directly, and there is no easy way of controlling the Transmitted Data output line on a simple true/false basis. Direct control of this line might be possible using more roundabout methods, but it does not appear to be a feature of the SerialPort component.

There is an even bigger omission in that it is not possible to directly read any of the input lines either. This is a pity, as it would provide a quick and easy means of providing basic information from add-on devices. Instead, all information has to enter the port as normal asynchronous serial data. Since hardware handshaking is not normally required, due to the relatively slow data rates involved, the handshake inputs are therefore superfluous.

Supply difficulties

One problem in using a serial port with user add-ons is that there is no supply output of any kind. When using a USB-to-serial converter there is a +5V supply output on the USB port, but this is not available from the serial port.

It is likely that there is a fair amount of unused supply current available from the USB port, but it could be difficult to find a neat way of accessing it. In fact, it would almost certainly be easier to use a second USB port to provide power for the main circuit. Other options are to use a battery supply, or a battery eliminator.

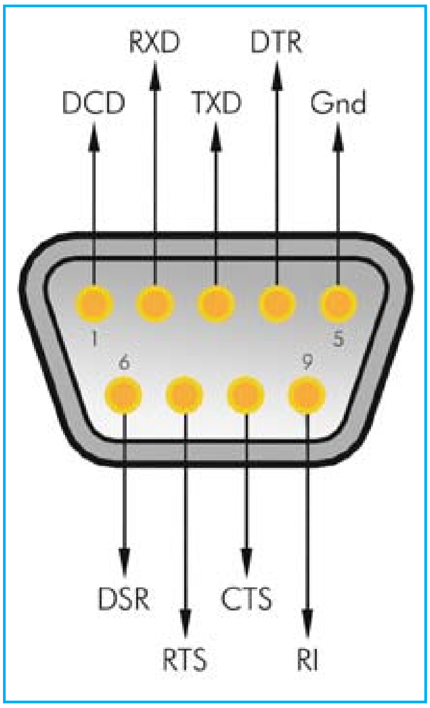


Fig.1. Connection details for a PC 9-pin serial port. A 9-pin female D connector is needed to make connections to the port

Another possibility is to use the handshake outputs as power sources. Of course, this is only a practical proposition if they are not being used for other purposes, which they will probably not be if the port is only being used to read data, or the transmitted data is being sent in asynchronous form via the Transmitted Data output. It will not be possible if the handshake outputs are being used to send synchronous data using the method outlined in the previous *Interface* article.

Of course, the amount of current that can be drawn from an RS232C handshake output is not very great. The nominal output potentials are ±12V, but the actual voltage under no loading varies enormously. A typical PC serial port provides unloaded output potentials that are slightly higher than these nominal levels, while a USB-to-serial converter is likely to fall a couple of volts short of them.

Presumably, the USB converters have voltage doubler circuits that give nominal output levels of ±10V from the 5V supply of the USB port. Many laptop PCs have unloaded output potentials of around ±5V, which is two volts higher than the bare minimum needed to conform to the RS232C standard, but it makes them of little use as supply outputs.

Current limiting on all outputs is a requirement of the RS232C standard, and this is done to prevent any damage if two outputs should be connected together by accident. This is unfortunate in the current context, as it severely limits the maximum supply current that can be drawn from each handshake output.

Short circuiting a handshake output to ground is unlikely to produce a current flow of much more than about 10 milliamps, and in some cases the short-circuit current is a bit less than this. The output current is usually limited by a series resistor rather than some form of semiconductor limiting circuit, and the practical consequence of this is that the output voltage starts to fall as soon as you start to draw any current.

Balanced view

Because of the series resistor, it is usually necessary to add a voltage regulator in order to use a handshake line as a power source. One possible exception is where it is necessary to have dual balanced supplies in order to power an analogue signal processing circuit based on operational amplifiers. With this type of circuit it is not normally necessary for the supply lines to be well stabilised, noise-free, or accurately balanced. Operational amplifiers and the circuits in which they operate are normally designed to be largely oblivious to any irregularities in the supply lines.

On the face of it, no circuitry is needed other than the usual supply decoupling capacitors. In practice, this is fine, provided the two handshake outputs are set to the correct states prior to the add-on being connected to the serial port.

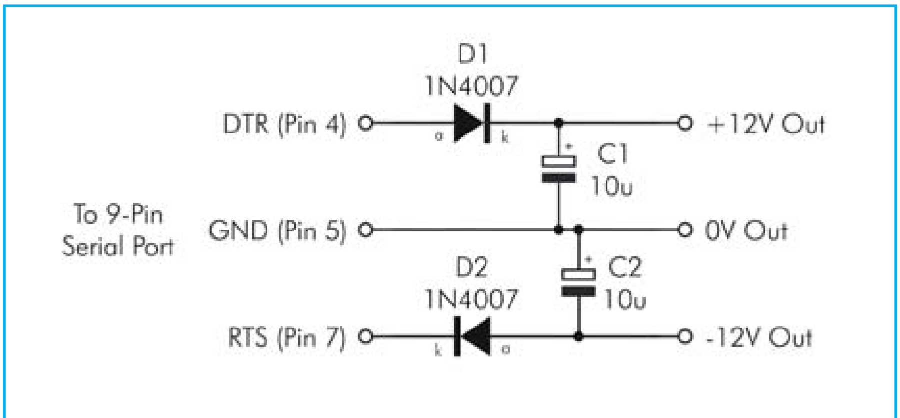


Fig.2. A simple circuit that provides dual balanced supplies from the two handshake outputs of an RS232C port. The DTR and RTS lines must be set to true and false respectively

Since it is likely that the add-on will often be connected to the computer at switch-on, and the correct starting levels for the two output lines are unlikely to be correct by default, it is advisable to include protection diodes (see Fig.2) to ensure that the circuit cannot be fed with supplies of the wrong polarity. The voltage drop of about 0.6V or so through each diode is unwelcome, but is unlikely to be of any great significance in practice. The voltage drop could be minimised by using Schottky diodes instead of an ordinary silicon type. Each output voltage would then be reduced by about 0.2V.

The supply voltages obtained are something that is dependent on the particular RS232C port in use, and the current consumption of the circuit. Using a circuit based on two or three ordinary operational amplifiers, it is likely that the actual supply potentials would only be about half their nominal levels of ±12V.

This might be sufficient, but where possible it is probably best to use low current consumption operational amplifiers, such as the TL061CP. Four of these will typically consume less than one milliamp and place minimal loading on the supply lines. Typical supply potentials of around ±8V to ±10V could then be achieved.

Drop-out generation

It is possible to obtain stable 5V supplies of either polarity, or both, but the maximum output current will still be quite low even at this reduced output voltage. Also, it is necessary to use something other than 'bog standard' voltage regulators in order to obtain a worthwhile output current. All that is needed in order to obtain a regulated 5V supply is a low-power regulator chip added at each handshake output. In the example of Fig.3, the two handshake outputs are fed to separate regulator chips, with IC1 providing a positive supply, while IC2 provides a negative one. Of course, as with all the supply circuits featured here, the two handshake lines must be set to the appropriate output levels in order to get the circuit to function properly.

Ordinary regulator chips will not provide particularly good results in this application, with the supply probably sagging below 5V if more than a milliamp or two of output current is drawn. Clearly, the limitations of the power sources prevent very much more than this from being obtained, but the maximum output current is still less than one would probably expect.

One reason for the apparent shortfall is that the regulator chip itself requires a small but significant supply current. The actual current consumed is quite low, at around four milliamps, but the available output current is reduced by this amount.

The other cause of the problem is the drop-out voltage of the regulator, which is the minimum input voltage needed in order to maintain the output at 5V. For a small 5V regulator this potential is normally about 7V to 8V. The regulator ceases to function properly when the handshake line is pulled down to this level, and not when it reaches 5V. This reduces the maximum available output current by a significant amount.

The solution to the problem is to use a modern regulator chip that has reduced current consumption and a low drop-out voltage. In component catalogues these are usually referred to simply as LDO (low drop-out) regulators.

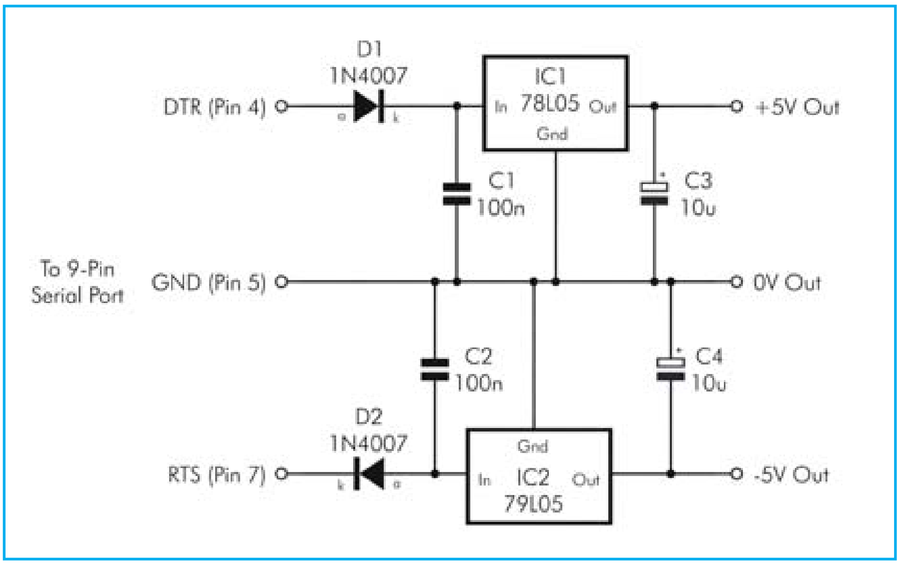


Fig.3. This circuit provides stabilised supplies of plus and minus 5-volts. It is necessary to use LDO regulators in order to obtain worthwhile maximum output currents

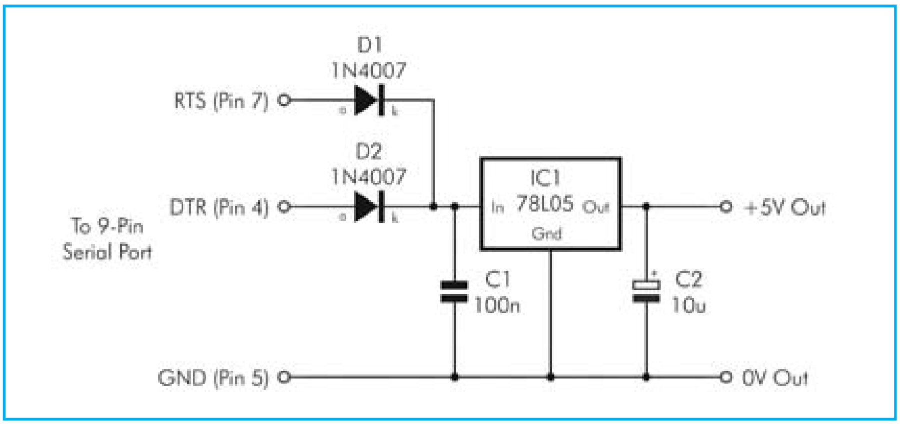


Fig.4. Using two handshake outputs in parallel enables a higher maximum output current to be achieved

As an example of one of these chips, the LE50CZ positive voltage regulator has a dropout potential that is typically just 0.2V higher than the output voltage, together with a typical current consumption of just 0.5mA. Using a modern regulator chip such as this, it should be possible to obtain a properly regulated output potential with output currents of up to about 7mA or 8mA with most RS232C ports.

Doubling up

While an output current of this order is still very low, it is actually sufficient to power many modern circuits. However, it is possible to obtain higher output currents provided only a single supply is required. The basic technique is to drive the voltage regulator from two handshake outputs, as in Fig.4. In this case, the two outputs must both be set at +12V (true).

The two diodes (D1 and D2) form a simple mixer that enables the two outputs to drive the regulator chip, but prevents one line from driving any output current into the other one. The mixing process requires a series resistor in each handshake output line, but there is no need to include these in the circuit. The built-in current limiting of each handshake line effectively provides this resistance.

Using two handshake lines, Schottky diodes, and a good LDO regulator it should be possible to obtain something in the region of 12mA to 15mA from most serial ports. This is still fairly low, but it is sufficient to drive many modern circuits. After all, there are plenty of modern logic devices and analogue circuits that have minute power consumptions.

Driving a few LED indicator lights should be no problem, since it is now possible to obtain devices that require a supply current of only one or two milliamps for effective operation. Being realistic about things, it would not be possible to accommodate higher current devices such as most relays, filament bulbs, and the like.

There is a third output on a serial port in the form of the Transmitted Data output (pin 3). This can be used as a supply output if it is not being used to output data, but as explained previously, there is no simple way of directly controlling the output level of this line.

It normally goes to –12V under standby conditions, so it can be used to provide a negative supply. Unfortunately, it cannot be used to provide a positive supply, or to boost the other two lines and provide an augmented +5V supply with output currents of up to around 20mA or so.

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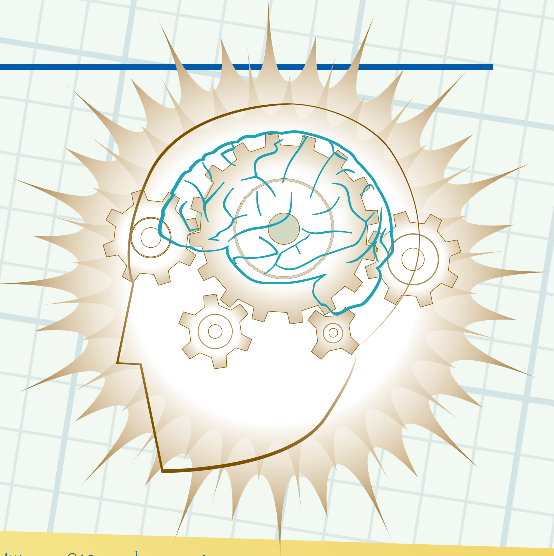

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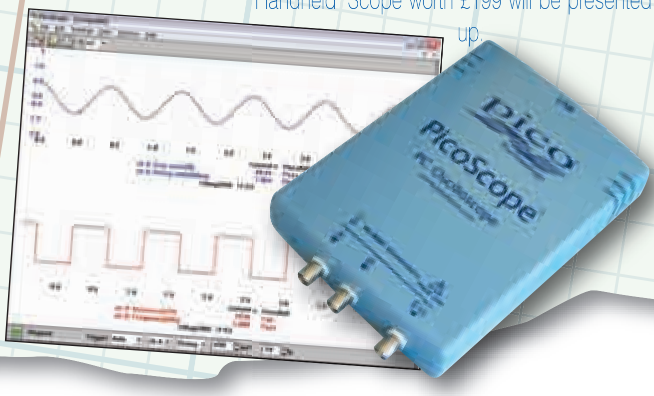

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Wind-Water Speed Indicator – *Revolutionary*

The circuit of Fig.1 shows a simple Wind-Water Speed Indicator. The 'star attraction' is motor M1, which is a 'garden variety' quartz clock motor, as found in any quartz clock on a supermarket shelf. This has a miniature stepper motor, which creates one complete AC waveform with each revolution.

Note that this means that this motor is ideal for counting revolutions. But that is not all. A quartz clock motor (apart from its spinning magnet) can easily be completely waterproofed in epoxy resin, which means that it will also turn underwater, to measure water speed. Further, by fixing a suitable axle to the motor's magnet (with a propeller), it will spin with almost no friction at all. Consequently, unlike most electric motors, it is able to turn at the slightest puff of wind or movement of water. It is, of course, also a fairly cheap motor.

The electronics are based on CMOS hex inverter IC1, which is used principally in its analogue mode. IC1a is DC coupled to IC1b, is AC coupled to IC1c via capacitor C2, with the input of IC1c being DC biased via preset potentiometer VR1. Capacitor C2 must be non-polarised (two 470n non-polarised capacitors may be wired in parallel if desired). Preset VR1 must be a multiturn component, in the interests of precision adjustment. IC1c is DC coupled to IC1d.

With the circuit having a very high gain throughout, IC1d provides a binary output which is ideal for plugging into a 12V counter circuit. Resistor R1 is used as the ballast resistor limiting the current through LED D1. As shown, D1 will indicate as little as one revolution per second, and less. LED, D1 should be an ultrabright device.

The circuit should ideally be powered off a 12V regulated power supply since its current consumption is relatively high (about 20mA), and a regulator will guarantee stability. The circuit is adjusted by means of preset VR1. This is turned carefully until D1 just fades and extinguishes. The circuit is then 'ready to go'.

Thomas Scarborough, Cape Town, South Africa

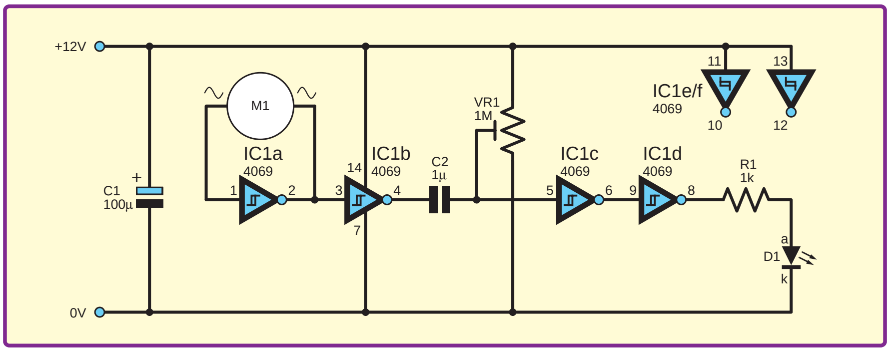


Fig.1. Simple Wind-Water Speed Indicator circuit diagram

Alternators as Servos – *Remote control*

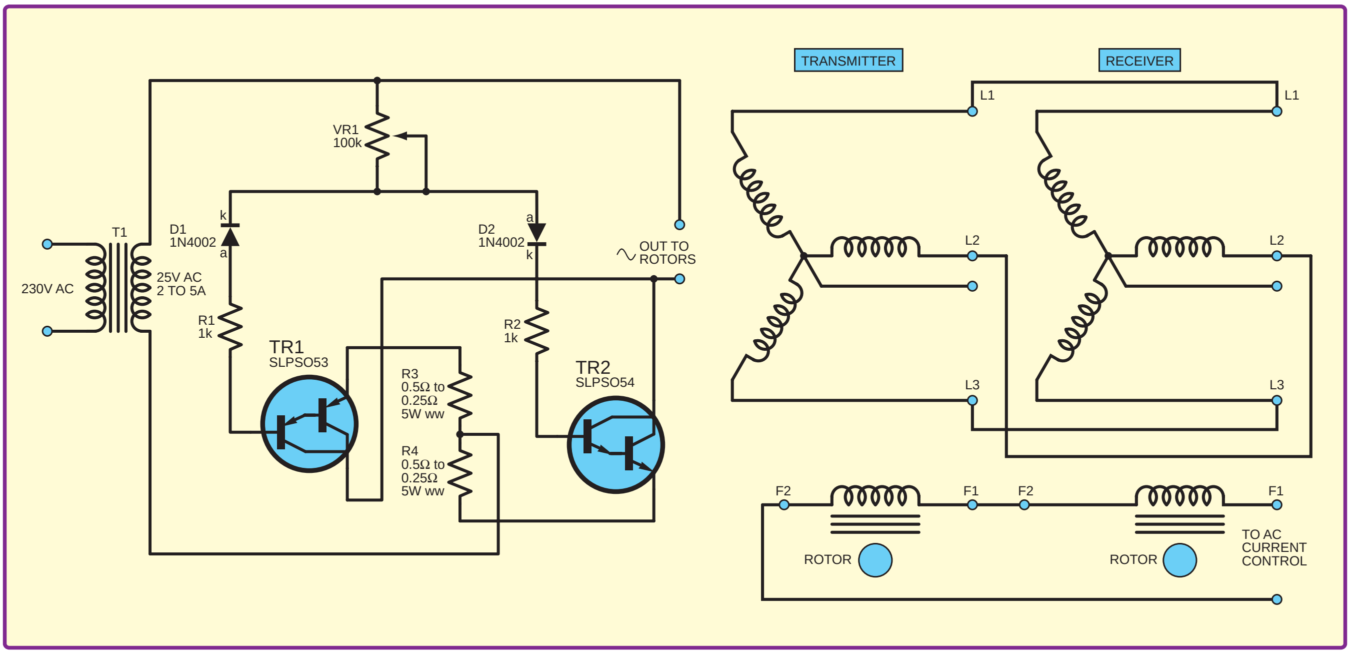


Fig.2. Remote motion control using alternators as servos. Note resistors R3 and R4 are wirewound types

Normally a car's alternator is used to generate AC, which is rectified to DC, and then used to power various items in the car and to charge the battery. But, with a little ingenuity, you can use it as half of a servo pair to produce remote motion in a distant place. The circuit details are shown in Fig.2.

First, you have to use a pair of identical alternators. Start off by removing the four bolts from the corners of each alternator. It is best to work on one alternator at a time. After the bolts are removed, gently pull it apart. It will be in two halves, one will be the stator section, and the other will be the rotor. There will also be a regulator that controls the DC current in the rotor field; remove it completely. Next remove the three-phase bridge rectifier.

Run the field and rotor wires externally. The same with the stator wires. Remember, connect L1 to L1, L2 to L2, L3 to L3. You will need at least a 4- or 5-wire cable, capable of carrying the current of the fields and rotors.

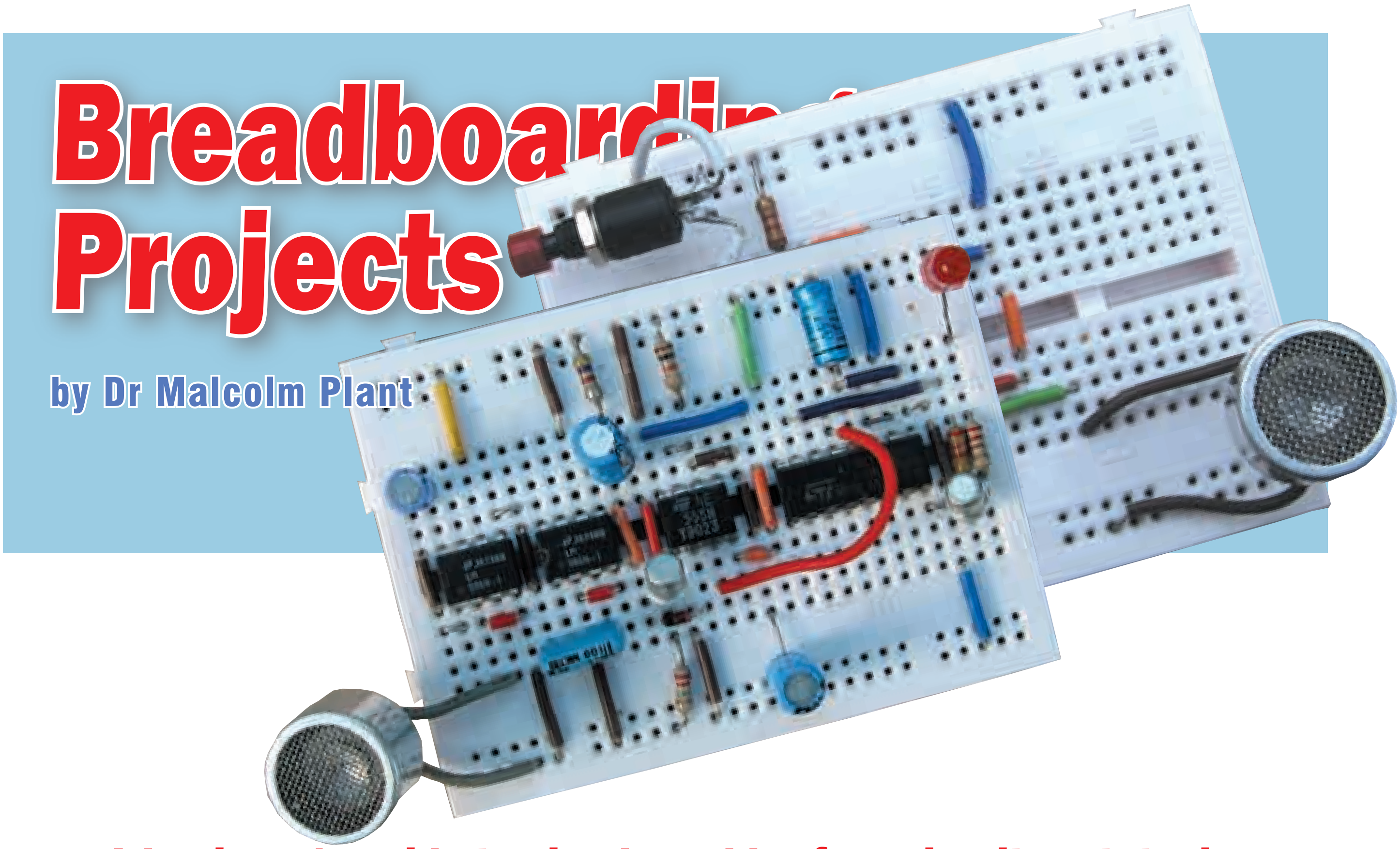
After this is completed you will have to put it back together – but this can be tricky. The two brushes must be set on the slip-rings again. In most cases, a simple piece of stiff wire can be used. It first must go through the hole in the back of the alternator frame and through the two brush holders, one on each side. Push down on the brushes, and slide the wire through the back frame over the top of the brushes and into the hole on the end. If this is done correctly you will see the wire sticking through the back of the alternator over the top of the brushes and into the end hole. When successful, put the rotor back in.

Before you push it together, align up the bolt holes. You may have to rotate it back and forth until it is lined up. Once this is done drop the bolts in and tighten it up. Do this for both alternators. Now wire up.

You will have to find some place to put the transformer and AC current controller. This can be in a small box, also providing access to AC power. Use a heatsink for transistors TR1 and TR2. Do not forget to remove the stiff wire from the back of the alternators after you put it back together again.

Using old alternators that have been converted into servos is far cheaper than getting a servo pair ready-made. By scrounging used alternators at your local junk yard, you may get them for almost nothing!

Craig Kendrick Sellen, Carbondale PA, USA



Breadboarding Projects

by Dr Malcolm Plant

A beginner's guide to simple, solder-free circuit prototyping
Part 7: Ultrasonic Remote Control

Two circuits are needed for this month's project, comprising a transmitter that generates pulses of ultrasonic sound waves and a separate receiver that processes received ultrasonic pulses to switch a relay on and off.

Project 12:
Ultrasonic Transmitter

THE Ultrasonic Transmitter circuit shown in Fig.7.1 generates ultrasonic sound waves at a frequency of 40kHz. The key component is a 555 timer, IC1, which is wired as an astable to produce an output frequency of 40kHz. This stream of electrical signals drives the ultrasonic transmitter transducer TX1.

Potentiometer VR1, used as a variable resistor, enables you to make fine adjustment to the frequency when setting up the control system to ensure that TX1 is resonating at its optimum natural frequency, thereby ensuring maximum range. This adjustment is described in the 'synchronising' section at the end of the receiver section.

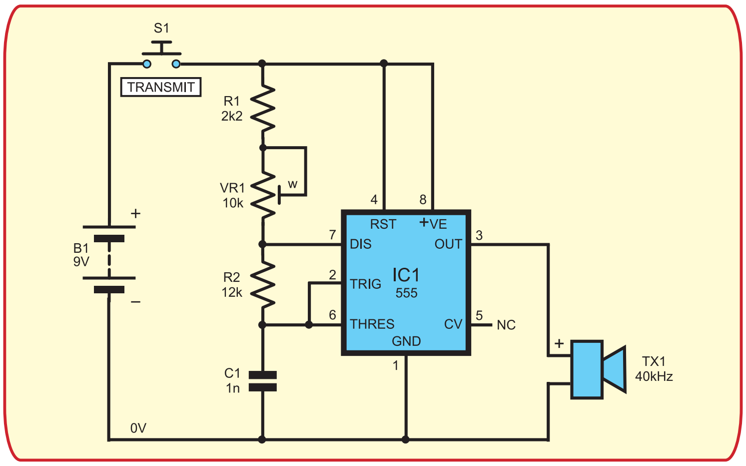


Fig.7.1. Circuit diagram for the Ultrasonic Transmitter

Breadboard

The Protobloc component layout for the Ultrasonic Transmitter is shown in Fig. 7.2. Connections to S1 and TX1 and LS1 are also shown in Fig.7.2, which requires wires to be soldered to their terminals for insertion into the breadboard.

When soldering the leads to the transducer connecting pins, be as quick as possible, as it does not take kindly to excessive heat. Note that

Component Info

IC1, type 555 timer IC

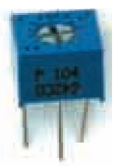
PIN 1

Viewed from the top, an indented dot and a 'half-moon' shape at one end indicates pin one. The pins are numbered anti-clockwise ending at pin 8 opposite pin 1.

TX1, 40kHz ultrasonic transmitter transducer

One pin is connected to the case and this must be connected to the 0V supply. Make sure it is the transmitter device and not the receiver. A 'T' will be printed on it.

VR1, potentiometer



This is a preset type that can be inserted directly into the Protobloc and its value adjusted with a small screwdriver

S1 , pushswitch

push-to-make, release-to-break

Components needed...

Ultrasonic Transmitter

Integrated circuit, IC1: type 555 timer
Ultrasonic transducer, TX1: 40kHz transmitter. (Usually only sold as a 'matched pair', ie transmitter and receiver).
Potentiometer, VR1: 10kΩ miniature preset type
Capacitors, C1: value 1nF polystyrene
Resistors, R1 and R2: values 2.2kΩ (R1); 12kΩ (R2). *Both 0.25W 5% carbon film.*
Pushswitch, S1: push-to-make, release-to-break type
Battery, B1: 9V and connecting leads
Protobloc and wire links

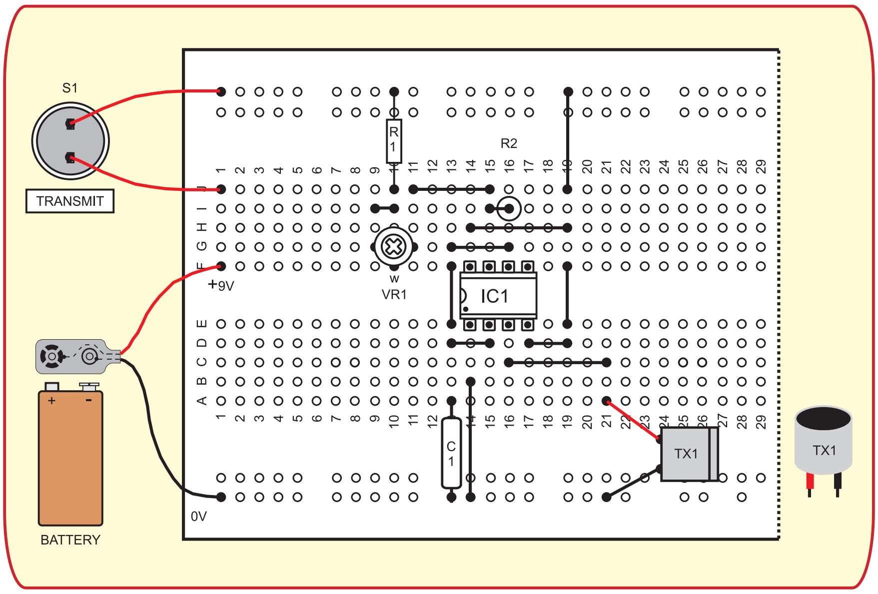


Fig.7.2. Assembly of the Ultrasonic Transmitter on Protobloc

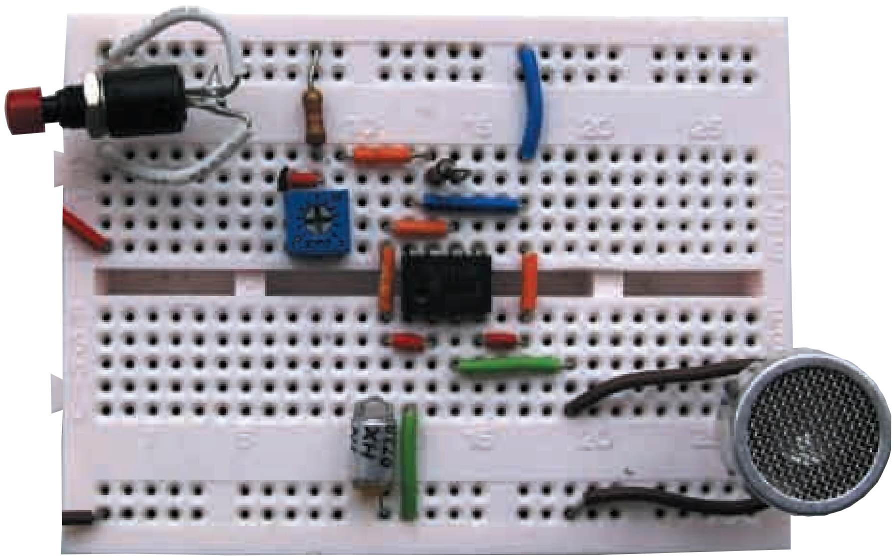
one pin is also connected to the case of the transducer, so make sure this lead is connected to the board 0V line.

Notes

● The component values listed should be used to ensure that the circuit can be tuned to generate 40kHz sound waves. The author used an oscilloscope to check that the circuit was driving the ultrasonic transmitter at 40kHz.

However, if an oscilloscope is not available, you can fine tune the system by trial and error as described below, once the receiver is assembled. More information later.

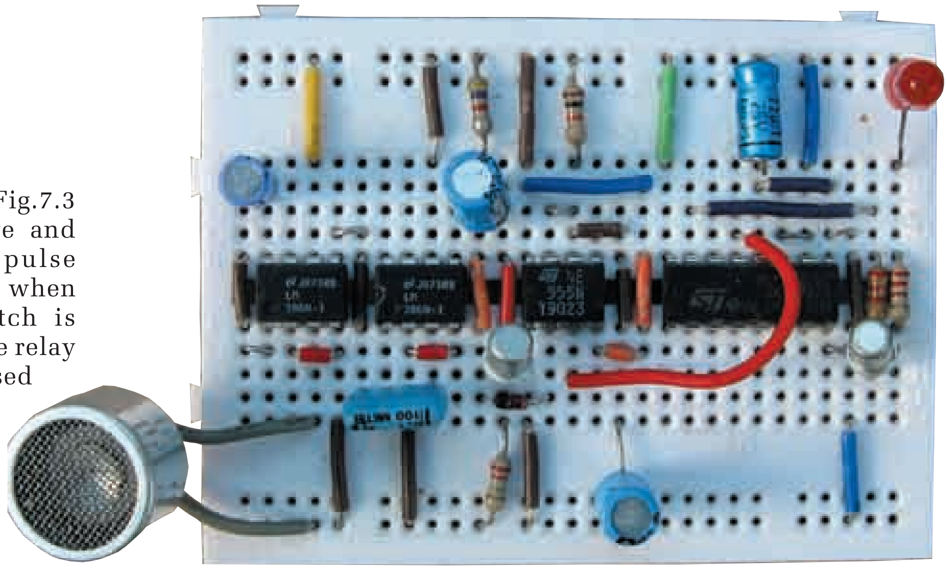
● A brief press of the pushswitch generates a short burst of ultrasonic sound for transmission to the receiver.



ULTRASONIC RECEIVER

Project 13:

Ultrasonic Receiver



THE circuit shown in Fig.7.3 is designed to receive and process the 40kHz pulse of sound waves generated when the transmitter's pushswitch is pressed. On the first push the relay is energised, and de-energised on the next push, enabling an electrical device to be switched on and off via the relay contacts. The Receiver circuit comprises the following building blocks:

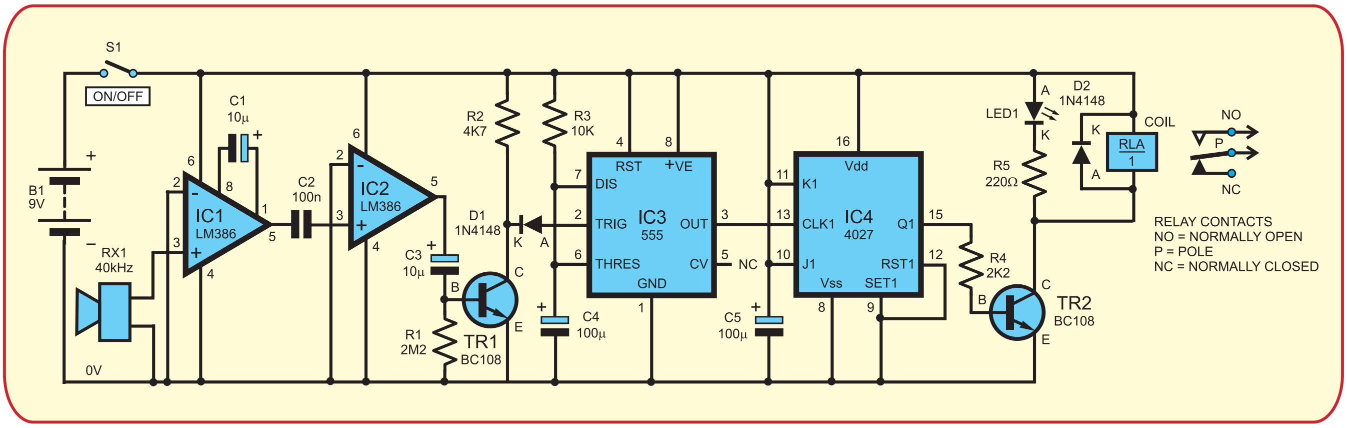


Fig.7.3. Ultrasonic Receiver circuit diagram

Integrated circuits IC1 and IC2, which together amplify the ultrasonic sound waves received by sensor RX1 from the transmitter. Just like the *Bat Detector* project (Part 6), two coupled amplifiers are used to boost the voltage gain and ensure remote control over a useful range of around 25 metres.

The amplified 40kHz pulses are fed to the base (B) of *NPN* transistor TR1 via capacitor C3. When a burst of ultrasonic waves is received, the voltage at the collector (C) terminal of TR1 suddenly falls as current flows through resistor R2.

The sharp fall in voltage is transferred to the trigger pin 2 of IC3, which is a 555 timer connected as a monostable circuit. Once triggered it produces a short pulse from its output terminal (pin 3) of about one second duration. This pulse triggers flip-flop IC4 via its clock input pin 13, each successive pulse 'toggling' the output (pin 15) between logic high and logic low.

Components needed...

Ultrasonic Receiver

Integrated circuits, IC1 to IC4: type LM386 low power audio amplifier (IC1, IC2); type 555 timer (IC3) and a 4027 CMOS dual JK master/slave flip-flop (IC4)

Transistors, TR1 and TR2: both type BC108 or similar in a T018 style package

Ultrasonic transducer, RX1: 40kHz receiver. (Usually only sold as a 'matched pair' with transmitter).

Light emitting diode, LED1: red, green or yellow – not blue

Diode, D1 and D2: both type 1N4148 signal diode

Relay, RLA: low voltage 6V type, single-pole changeover contacts

Capacitors, C1 to C5: values 10µF 16V radial elect. (C1, C3); 100nF polyester (C2); 100µF 16V radial elect. (C4); 100µF 16V axial elect. (C5)

Resistors, R1 to R5: values 2.2MΩ (R1), 4.7kΩ (R2), 10kΩ (R3), 2.2kΩ (R4) and 220Ω (R5). All 0.25W 5% carbon film.

Switch, S1 (On/Off): single-pole, single-throw (SPST)

Battery, B1: 9V and connecting leads

Protobloc and wire links

The final stage is the relay driver using *NPN* transistor TR2. When a logic high is produced at pin 15 of IC4, the transistor switches on, energising relay RLA1 and turning on the optional LED1. The next burst of 40kHz sound waves sets the output of IC4 to logic low, switching off the transistor and denergising the relay and LED1.

Breadboard

The Protobloc component layout for the Receiver is shown in Fig. 7.4. The electrolytic capacitors **must** be inserted on the board with their positive (+) leads positioned as indicated.

Transducer RX1 has one pin connected to its case and this pin must be connected to 0V. These pins require short lengths of 0.6mm insulated wire to be soldered to them so that they can be inserted into the Protobloc.

When soldering the leads to the transducer pins, be as quick as possible, as it does not take kindly to excessive heat.

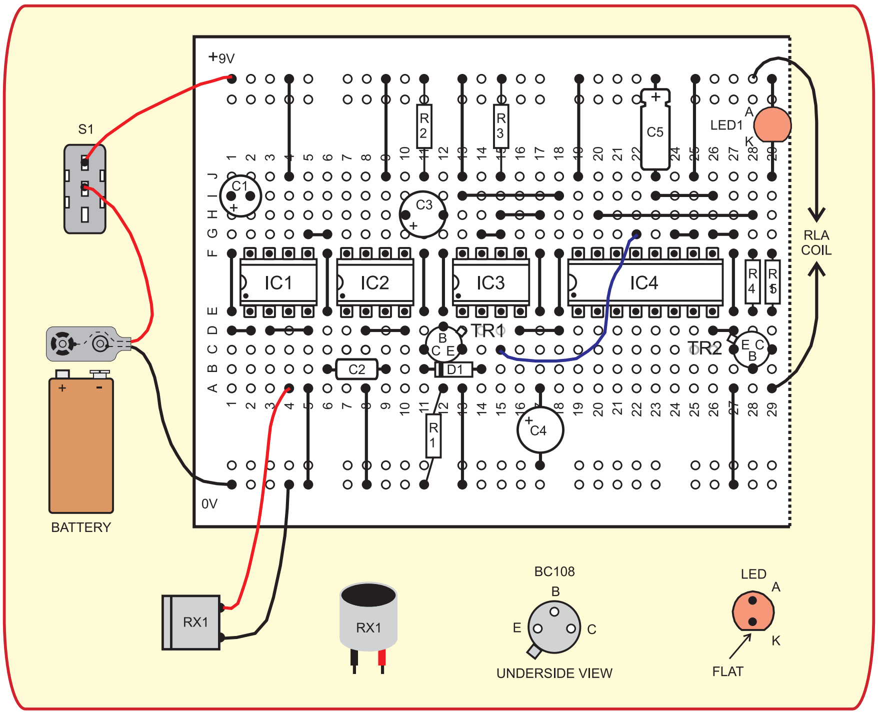
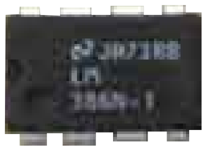


Fig.7.4. Ultrasonic Receiver assembly. Note that protection diode D2 is soldered directly across the relay coil contacts: cathode (banded) lead to the positive supply

Component Info

IC1, IC2, type LM386 audio amp
IC3, type 555 timer IC



pin 1

Viewed from above, an indented dot and 'half-moon' shape at one end indicates pin one. Once pin 1 has been identified, pins are numbered 1 to 8 going anticlockwise, ending up at pin 8 opposite pin 1.

IC4, type 4027 JK flip-flop

PIN 1

Once pin 1 has been identified, pins are numbered 1 to 16 going anticlockwise.

Notes

- **Never** use the relay to control power from the AC mains supply. If you want to use it for controlling mains-operated devices you must seek the help of a qualified electrician.
- Do not omit capacitor C5, as it helps to stabilise the power supply voltage to the circuit.

X1, 40kHz ultrasonic receiver transducer

One pin is connected to the case and this must be connected to the 0V supply. Make sure it is the receiver device and not the transmitter. An 'R' will be printed on it.

RLA, relay 6V energising voltage.

This has single-pole changeover switching contacts for switching on and off a separate circuit from the electronic one. **It must not be used to switch mains-operated devices**

Synchronising the system

The transmitter needs adjusting so that it generates ultrasound at a frequency of 40kHz. This is easy if you have an oscilloscope or frequency counter handy. If you do not have one, proceed as follows.

Make sure the transmitter is connected to the 9V battery and its sensor is pointing towards the receiver placed about a metre away and also connected to its 9V battery. LED1 should be on or off depending on whether the output of IC4 is high (on) or low (off) when powering up the circuit. Now it's a matter of trial and error!

Press and release pushswitch S1 on the transmitter while watching LED1 on the receiver. Make small adjustments to preset VR1 on the transmitter until repeatedly pressing and releasing S1 causes LED1 to go off and on. Gradually increase the distance between the transmitter and receiver to 20 metres and continue to make fine adjustments to VR1. If the receiver is to be used to switch on and off an electrical device, a relay needs to be connected in parallel with LED1 and R5, as shown, and its switching contacts used to control the device in a separate circuit.

Next Month: Motion Detector and Moisture Monitor Mk.2.

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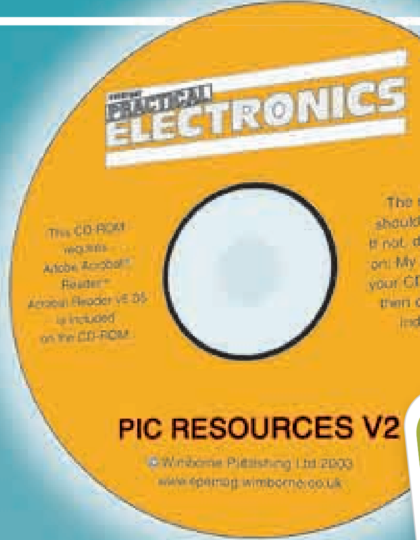

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Selecting op amps

EPE Chatzones (**chatzones.co.uk**) contributor ***nielsejner*** recently posted the following question about op amps:

Dealing with logic ICs seems to be easy, they have a circuit symbol that tells how they act.

When it comes to op amps I am less experienced and have difficulties comparing one to another if I need to substitute. From my view they all look alike – a triangle (see Fig.1) – and then I have to look into several datasheets to find a replacement.

Is there somewhere on the internet where they are listed in groups, categories or in a way so that it is easy to find a replacement?

For John Becker's Mains Monitor *of Aug '08, I am looking for an LM6462, which is totally unknown on the internet. But then the text says it is a dual rail-to-rail op amp, so would a TS912 do?*

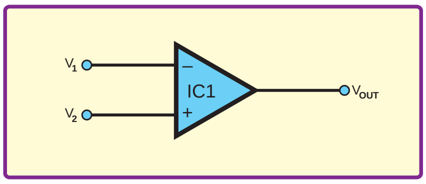


Fig.1. The op amp schematic symbol does not tell you anything about its characteristics

Datasheet googling

At first I was surprised that Nielsejner had claimed that the LM6462 is 'totally unknown on the internet', and it seemed that Google provided plenty of hits when searching for 'LM6462 datasheet'.

However, it quickly became evident that these results were not very useful and it soon became clear that the reason was that the correct name for the device is LMC6462. The 'C' seems to have been dropped from LMC6462 in the *Mains Monitor* article (*EPE* August '08). (John confirms that it should be an LMC6462.)

If you search for an IC datasheet using Google, or any other general internet search engine (for example search for 'LMC6462 datasheet') you tend to get lots of hits from sites that archive or catalogue datasheets, and from distributors selling the devices. It may be more useful to do an 'advanced search' and set the file type to PDF (for example, search 'LMC6462 datasheet filetype:pdf' on Google) as almost all datasheets are distributed in PDF format. Then scroll down the list and see if you can spot the domain name of a well known manufacture like Analogue Devices, Texas Instruments, or National Semiconductor.

You may well find the datasheet you want on one of the archiving sites, but it is better where possible to search directly on the manufacturer's site. This will have the most up-to-date revision of the datasheet and often other information such as application notes, production status information (ie, whether the device is still being made) and sometimes suggestions for alternative or similar devices.

A search for LM6462 on National Semiconductor's website (**national.com**) found the 'LMC6462 Dual Micropower, Rail-to-Rail Input and Output CMOS Operational Amplifier' as the first hit, despite the incorrect code. Manufacturers' own search engines are likely to be more aware of the structure and possible variations of device codes, and, of course, there is far less irrelevant material to obscure what you are looking for.

Manufacturer's prefix

The clue to the manufacturer is in the first few letters of an IC's code – known as the manufacturer's prefix. There are a number of sites on the internet which list IC prefixes and link these to the manufacturers that use them. One example is **wikibooks.org/wiki/Practical_Electronics/Manufacturers_Prefix**.

Some manufacturers no longer exist, or have been taken over by other companies, and some prefixes are used by multiple manufacturers, but such lists give you a good starting point for a search.

Device needs

To select an op amp for a particular design you need to know what the circuit and hence what the op amp needs to achieve. This will give you a minimum specification for the device, or help you identify which of the many op amp characteristics are most important.

For example, if your application is an audio amplifier, then it would be sensible to use a low noise op amp, but offsets may not be so important. On the other hand, if you were amplifying the signal from a temperature sensor then the offset (DC accuracy) and its temperature stability may be very important.

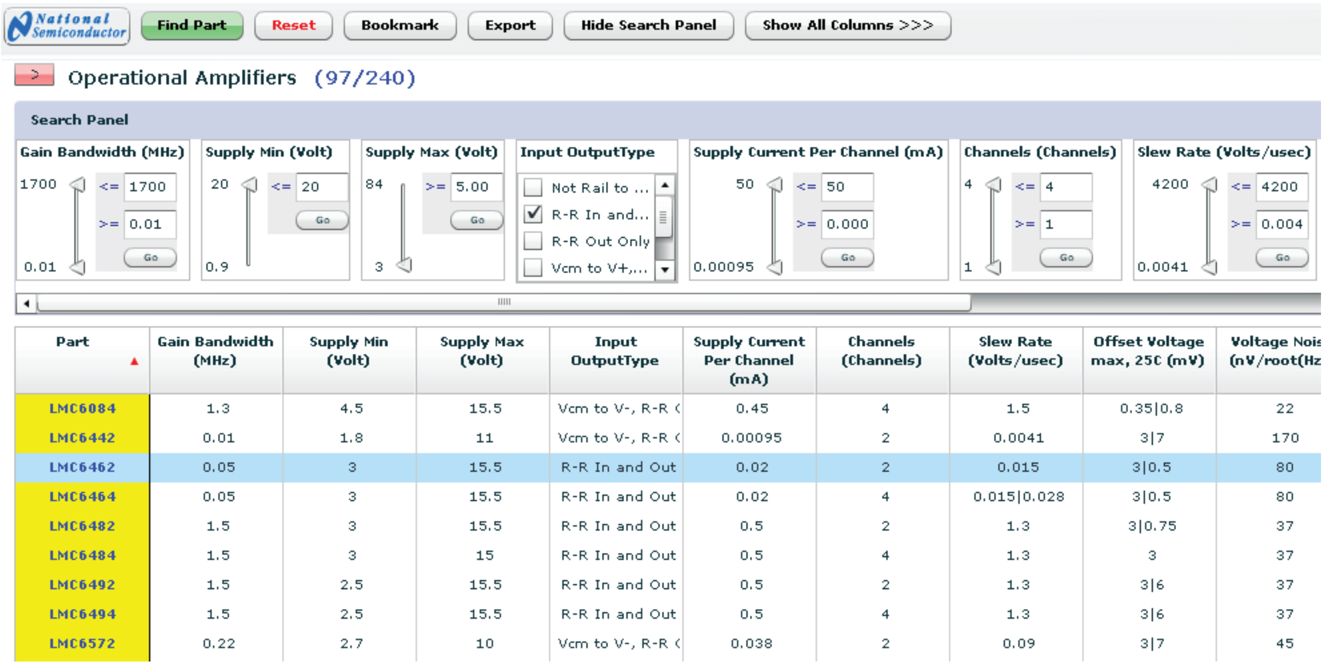
For some applications, the choice of op amp will not be very critical (these applications often suit 'general purpose' op amps). However, in other cases the choice of op amp can make the difference between a circuit functioning properly or not.

To find a possible replacement or alternative device look at the headline characteristics or 'features' on the datasheet or manufacturer's website, and match or better the relevant ones with the substitute device. Also, make sure that electrical ratings such as supply voltages are compatible in the substitute.

It is possible that not every feature was important when the device was originally chosen – a look at the circuit may help narrow this down. For example, in the case of the *Mains Monitor* (which is mains powered) the 'micropower' capabilities of the LMC6462 are probably less important than its 'rail-to-rail' input and output capabilities.

Table 1: Manufacturers op amp application grouping

- ***General-Purpose*** – suitable for a wide range of applications requiring moderate amplifier performance
- ***Low Noise*** – guaranteed very low noise for applications such as sensitive measurement and signal processing where noise from the op amp must be within known bounds
- ***Low-Power/Micopower*** – suitable for use in systems, such as mobile equipment, where power consumption is critical
- ***Wideband/High Speed*** – suitable for applications such as pulse circuits and video where accurate reproduction of complex high frequency signals is required
- ***High-power/High Current*** – op amps with high current output stages capable of driving low impedance loads
- ***Low Drift/High Precison*** – amplifiers with minimal offset voltage, and where accuracy is preserved over a wide temperature range
- ***Low Bias/High Impedance*** – FET input op amps with very low input bias currents for use in buffer amplifiers or circuits with large external resistors



Part	Gain Bandwidth (MHz)	Supply Min (Volt)	Supply Max (Volt)	Input OutputType	Supply Current Per Channel (mA)	Channels (Channels)	Slew Rate (Volts/usec)	Offset Voltage max, 25C (mV)	Voltage Nois (nV/root(Hz
LMC6084	1.3	4.5	15.5	Vcm to V-, R-R (	0.45	4	1.5	0.35|0.8	22
LMC6442	0.01	1.8	11	Vcm to V-, R-R (	0.00095	2	0.0041	3|7	170
LMC6462	0.05	3	15.5	R-R In and Out	0.02	2	0.015	3|0.5	80
LMC6464	0.05	3	15.5	R-R In and Out	0.02	4	0.015|0.028	3|0.5	80
LMC6482	1.5	3	15.5	R-R In and Out	0.5	2	1.3	3|0.75	37
LMC6484	1.5	3	15	R-R In and Out	0.5	4	1.3	3	37
LMC6492	1.5	2.5	15.5	R-R In and Out	0.5	2	1.3	3|6	37
LMC6494	1.5	2.5	15.5	R-R In and Out	0.5	4	1.3	3|6	37
LMC6572	0.22	2.7	10	Vcm to V-, R-R (	0.038	2	0.09	3|7	45

Fig.2. Interactive online op amp selection from National Semiconductor (www.national.com/cat/)

Op amp selection

Something that helps when selecting op amps is that manufacturers often group their op amps into types suited to different kinds of application and these can narrow down your search. Typical descriptions are outlined in Table 1.

Some op amps may belong to more than one of these categories, and different manufacturers may use different terminology.

Interactive tools

Manufacturers and distributors often provide interactive selection tools on their websites. These allow you to define the values of the op amp parameters you require to narrow down the list of possible devices. Fig.2 shows an example of one such selection system. This is a screenshot of National Semiconductor's 'Parametric Catalogue and Search' (**www.national.com/cat/**).

In this case, we have deselected all the options in 'Input Output Type' apart from rail-to-rail input and output. We have also set >=5.00 for 'Supply Max (Volts)' as the op amp in the *Mains Monitor* has a 5V supply. All other parameters are in the default settings. The op amps meeting these requirements (97 out of 240) are listed on the web page (as shown in Fig.2). Note that the LMC6462 is in the list, as would be expected.

The specifications given on op amp data sheets can be divided into electrical ratings (maximum voltages etc) and characteristics (gain, slew rate etc). Some of the key parameters are discussed below. When selecting or substituting an op amp, decide which of these characteristics is the most important – no op amp has brilliant performance in all areas.

Electrical ratings

Maximum and minimum power supply voltage (or supply voltage range): This ranges from less than 1V for minimum values up to several tens of volts for maximum values.

Make sure that your op amp matches the supply voltage you are using. Exceeding maximum supply voltages can cause permanent damage to ICs. Below the minimum the device simply will not operate properly or will have massively degraded performance.

Maximum differential input voltage: Typically, this is equal to the supply voltage or is a largish value such as ±40V. In a few cases it may be much lower, less than ±1V, for example.

You will need to take note of this if your application causes large differential inputs to occur, in many applications the differential input voltage is often very low due to the high gain of the op amp (if the differential input wasn't small the output would be at one of the rails).

Power dissipation: The product of supply current and supply voltage. Power dissipation will increase as the power supply voltage is increased and if higher output currents are demanded from the op amp.

For special low power (micropower) op amps the minimal amount of power consumed in typical operation is often quoted as the selling point.

Supply current used and maximum supply current: The current into the supply terminals under specified conditions. As with power dissipation, you need to distinguish between figures for typical, maximum and quiescent (no signal) conditions. Supply current is important in low power applications (eg, battery powered circuits).

Characteristics

Large signal gain (A) open loop voltage gain: This typically ranges from tens of thousands to millions. The gain specified is for low frequency operation and op amp gain is deliberately made to fall as frequency increases to prevent instability. Gain may be specified as a number, eg 100,000, as a ratio of voltages, eg 100V/mV, or in decibels, eg 100dB.

The precise value of the gain for individual op amps of a given type does not usually matter. This is because op amps are often used with negative feedback in circuits, where the gain of the circuit depends on the external components and not on the gain of the op amp, as long as the gain is very large.

Common mode input voltage range: In many circuits the small differential signal applied to the op amp will be biased around half the supply voltage range, which would be 0V for a split supply – this is easy for the op amp to deal with. More difficult to handle is a small differential signal on top of a large voltage common to both inputs, particularly if this is close to, or at, one of the supply voltages.

Not all op amps can work with input signals like this, but those that are described as 'rail-to-rail input', some even allow the common mode voltage to exceed the supply range by a small amount.

Unity gain bandwidth (fu) or gain bandwidth product (GBW): The range of frequencies for which open-loop gain is greater than one. Typical values for general purpose devices are in the range of tens of kilohertz to a few megahertz, but may be higher – into the gigahertz range for special high frequency/high speed devices.

Common mode rejection ratio (CMRR): The ability to reject signals common to both inputs – the op amp is a differential amplifier, so it should ignore signals which are the same on both inputs. Signals which are the same on both inputs are called *common-mode signals* and ideally should not affect the output, but in practice do to some extent.

CMRR affects gain accuracy in some configurations and determines the ability of the op amp to ignore noise common to both inputs. CMMR is measured in dB, 80dB to 120dB is typical, but lower and higher values occur.

Maximum peak-to-peak output swing: The maximum peak-to-peak output voltage that can be obtained without clipping the waveform. For many devices this is very close to the power supply voltages (referred to as 'rail-to-rail output'). At high frequencies, the op amp can still produce these voltages, but distortion occurs as it cannot change the output fast enough (see slew rate).

Slew rate: The maximum rate of change of output (closed loop). Slew rates are often quoted in volts per microsecond. For example, a value of 2V/μs would mean that the time that the op amp's output took to change from 0V to 5V due to a step change at the inputs would be 2.5μs.

Typical slew rates for general-purpose devices are from a few hundred millivolts to a few volts per microsecond, but much faster devices are available. A fast device with a slew rate of 3000V/μs could change its output from 0V to 5V in 1.7ns.

Supply voltage rejection ratio: This is the ability to prevent changes in supply voltage from causing changes in the output voltage.

Changes in the supply current due to circuit activity cause changes in supply voltage, which in turn may affect the output voltage. This is measured in decibels and is defined in a similar way to CMRR.

Input resistance/impedance: Common-mode input impedance is the effective impedance from either input terminal to ground and is ideally infinite. Differential input impedance is the apparent impedance between the inputs (also ideally infinite).

The input impedances will have both capacitive and resistive components. FET input op amps have particularly high input resistance, eg 10^{12} ohms.

Input offset voltage: Ideally, with a differential input of zero the op amp's output should also be zero, but in real op amps there will typically be a non-zero output.

The offset voltage is defined as the DC voltage, which must be supplied between the inputs to force the quiescent (zero input signal) open-loop (no feedback resistors) output voltage to zero. The offset is typically small, but will be amplified by the circuit and may cause significant problems.

Temperature coefficient of input offset voltage: Specifies how input offset voltage changes with temperature. As we noted above, offset changes with temperature and this parameter tells you by how much.

Input bias current: Bipolar op amps require bias (base) currents for the transistors connected to their inputs, and op amps with FET inputs have leakage currents at the inputs. The input bias current tells you how large these currents are and is defined as the average current into the two inputs with the output at zero volts.

This can vary greatly for different types of op amp, from femtoamps (10^{-15}A) to tens of microamps, with bipolar op amps having larger input bias currents than FET input op amps.

Input offset current: The difference between the bias currents into the two inputs with the output at zero volts. Ideally, these currents will be equal, but in practice they are not, so the offset will be non-zero.

The input currents have to flow through the external circuitry and if different will cause offsets even if the impedances connected to the two inputs are equal.

Temperature coefficient of input offset current: Specifies how input offset current changes with temperature.

Input referred voltage noise: Voltage noise is defined as the voltage fluctuations at the input of an otherwise noise-free amplifier with shorted inputs. This is usually specified in terms of voltage noise density in nV/μHz. The noise figure is 'input referred' so there is no need to take the amplifier's gain into account.

Noise is potentially a problem in all electronic circuits, but is particularly important in applications such as microphone preamps, strain gauges, and most RF/wireless front-ends.

Input referred current noise: Current noise is the current fluctuations at the input of an otherwise noise-free amplifier with open inputs. Like voltage noise it is specified as noise density, typically in pA/μHz.

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Video from a PIC

In last month's article we concluded a subject that was close to the author's heart – embedded Ethernet. This month, we look at another of his pet subjects, generating video from a PIC, in a format suitable for driving a standard TV.

Now, you might think that this is about hooking a PIC processor up to a complex video controller IC and a large SRAM IC, but in fact, we are going to look at generating video from an absolutely minimal system – a single PIC processor and a few passive components that can be built in an evening on stripboard.

The goal of the next two articles is to create a simple electronic and software system that can be easily adapted to uses of your own, without requiring extreme skill in programming or a detailed knowledge of video technology. This means we need to develop a simple video library that consumes a modest percentage of your processor's available bandwidth, but which you can essentially forget about, allowing you to concentrate on your own application.

Frame buffer

To achieve a clear separation of video generation and application software we will use an old standard design concept, the *frame buffer*. The frame buffer is nothing more than an area of RAM that is used to store the data representing the image that you would like to see displayed on the screen. One section of the program continually reads this data and outputs it to the screen; another part of the program is responsible for filling or changing the contents of the frame buffer.

The frame buffer provides an interface between the two parts of the program – other than that, the two need to know nothing about each other. This makes our life much simpler, since the video generation software can be developed first and completely independently of any application that uses it.

Also, the development approach to the two is very different: video generation requires a knowledge of complex video waveforms, and very accurate signal generation, but is otherwise quite simple; potential applications will be far less time critical, can vary greatly and be as simple or complicated as you wish. Having a video library made available to you means you can relax and experiment with different applications and ideas.

So, beyond the novelty value, what would we actually use this for? Some of the obvious examples are classic old arcade games like Pong, or perhaps Tetris. With additional minor circuitry you could use it to overlay information onto an existing video signal, announcing important messages while you are watching your favourite TV show. You might also consider experimenting with more complex video signals such as Teletext – more on *that* in a later article. We have even seen examples of a PIC with an RS232 interface fitted which allows the television to become a simple dumb terminal.

Video generation

As we have mentioned, video generation from a PIC is not a new idea; it was first demonstrated on a simple PIC processor in the 1990s, and the link to the details on the Internet is listed at the end of this article. All of the examples that can be found on the Internet share common characteristics: they are very clever, complex, timing critical applications. The authors have invested considerable effort in squeezing the maximum performance out of their chosen processor to achieve the results.

Changing the application to your own applications would be very difficult. An excellent book by Lucio di Jasio, titled *Exploring the PIC32*, gives a wonderful example of a video generation library that is isolated from the application via a frame buffer, but that solution uses a complex PIC processor that is only available in a fine pitched surface mount device. Our objective is a solution on a simple, easy-to-solder processor, but with a simple, easy-to-use video library. So we must 'roll our own'.

This is going to be an unusual series of articles. Unlike previous ones, the outcome of this series is not necessarily going to be success. Video generation offers some challenging problems to overcome, and the outcome will only really be known when we try it out for real. That's not something to be disheartened by, however. This is one of those projects where the journey is likely to be as entertaining as the final solution!

So lets make a start by examining how video signals are generated.

Video signals

Video broadcast signals conform to one of several incompatible standards, the main ones being PAL, SECAM or NTSC. NTSC video generation, the American standard, has been widely covered on the Internet and in published media, so the author will look at PAL. The fact that he lives in the UK where PAL is the standard has a certain influence on the decision too!

PAL (phase alternating line) is really a standard for how colour is encoded into the broadcast signal, but most definitions cover all aspects of the video signal. There are a number of sub-standards within AL;

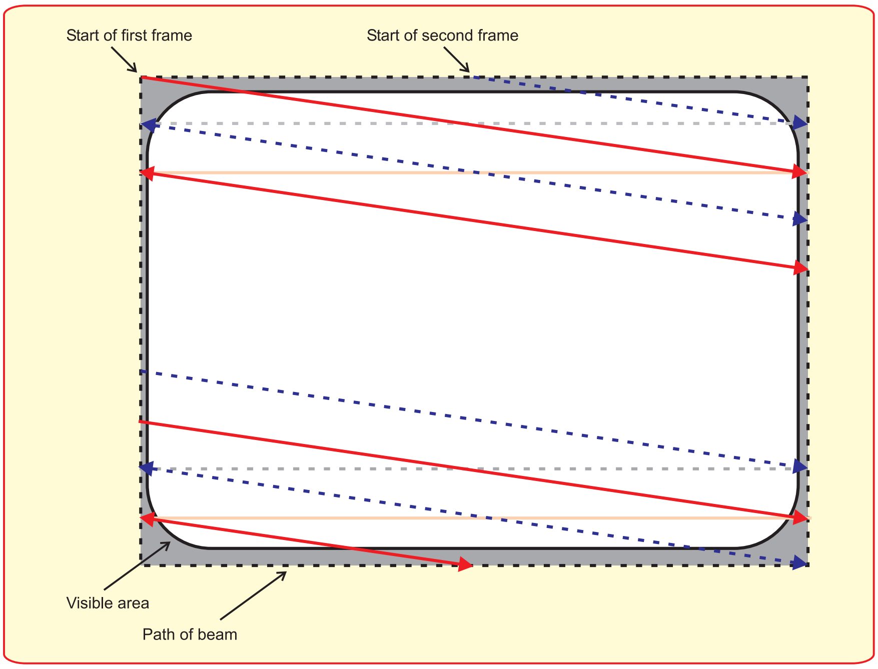


Fig.1. Interlaced frames

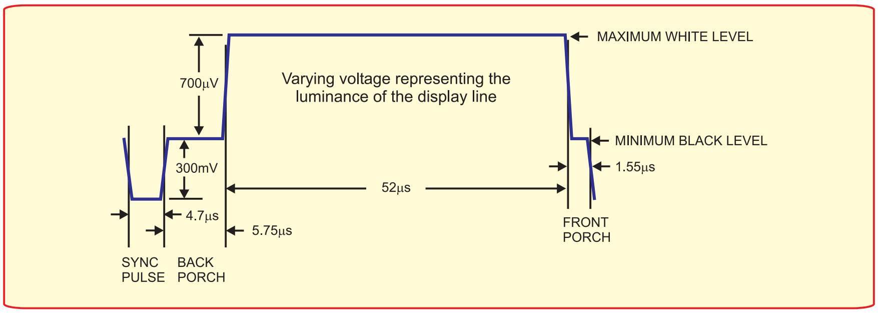


Fig.2. A video line (without colour)

once again, due to the location of the author, we will look at the UK standard PAL I.

Despite the differing standards, the software that will be presented in next month's article can be altered to work with all of them, with minor modification. That is left as an exercise to the reader, unless anyone would like to supply the author with a suitable television set, and return postage!

PAL standard

The PAL standard includes the definition of how colour is included in the video signal. It became clear quite early on in our investigation that generating colour signals in PAL would be just too complicated for a simple PIC, and so we will ignore colour completely. Doing so means that our images will be black and white only, but that's enough of a challenge for now. We can address colour when we look at teletext generation in a later article.

The PAL standard is designed to draw 625 lines on the screen, with an update rate of 50 times a second, matching the frequency of the UK AC mains power supply. Each 'screen full' of lines is called a *frame*. To reduce the bandwidth of the broadcast signal (ie, to enable more television channels to fit within a given frequency range) only half of the 625 lines are drawn for each pass of the frame, with alternate pass of lines being interlaced with the previous ones (see Fig.1). This technique relies on the persistence of vision inherent in our optic nerves to 'average out' the images, resulting in what appears to be a continuously updated 625-line display, when in fact the screen is being updated 25 times a second. The more you study video standards, the more you come to appreciate how smart the inventors were.

625 lines drawn 25 times per second means that each displayed line takes 64μs. That's the first important parameter that our software will need to cope with.

Remember that video standards were set in the days when cathode ray tubes were the only means of displaying a picture. The magnetic fields generated in coils around the tube deflected an electron beam to sweep out the picture; these magnetic fields had a certain amount of 'inertia' and could not instantaneously move from the end of a line back to the beginning. Therefore, the video signal for each line included a 'fly back' period to allow the electronics to set up the appropriate magnetic field, and that can be seen in the video standard.

Video lines and frames

In Fig.2 is shown the video signal for a single displayed line. Only 52μs of the 64μs period is available for picture content; the rest (sync pulse, front porch and back porch) allow for the electronics within the television to reposition the electron beam.

Notice in Fig.2 that the video signal has a range of only 1V, with the sync pulse being between 0V and 300mV, and the video data itself lies between 300mV and 1000mV. If we are only interested in generating a black and white image, we only need to generate two voltages: 300mV and 1000mV. That's another point to remember for our hardware and software design.

Not only did the video standard have to take into account the time required for the electron beam to return back to the start of the next line, it also had to account for the time required at the end of the display for the electron beam to return back to the top left of the display, and recognise the difference between the alternating frames. This was handled by changing the format of some of the display lines at the beginning and end of the 625-line set to provide 'markers' for the television, and to allow the circuits to settle back to normal levels.

Once again, it is clear that the designers of the video standard anticipated the limitations of the electronic circuits that would be used to render the video signal. Fig.3 shows how individual lines differ, depending on where they are in the transmission of a frame.

In each sweep of the display, rendered 25 times a second, a number of 64μs time slots are used to provide image synchronisation rather than to actually display any data. These time slots do not conform to the standard line format – they contain no video data, and in some cases include additional sync pulses. This forms another requirement for our system: although the data for a screen consists of 625 lines, some of these are for syncronisation and will require special handling in our software.

Looking closely at Fig.3, it is possible to see where the distinguishing parts of a display's frame are, in the subtlety of the post-equalisation pulses. In common with many other implementations, we are going to make a simplification: we will not create alternating, interlaced lines. This will result in a small gap appearing in each line displayed, but for now at least, this is considered an acceptable compromise. We can always enhance the video driver at a later date to handle full interlacing.

From Fig.3 it is also clear that 25 out of the 625 lines of data drawn to the display do not contain any visible data; this is referred to as the *blanking period* and amounts to 1.6ms. In addition to this, there are a number of display lines that are not visible on the screen, which are now used for transmitting Teletext or caption information. Many computer games rely on this period to update the frame buffer memory, so that partially updated images are not shown. This is unlikely to be an issue for us, but we should include in our design some means of indicating to the application that the blanking period is active.

Next month

This is a highly simplified, software engineer's view of the PAL video system. We are glossing over the fine detail – but hopefully not too much! – and we shall find out next month, when we try to turn this into a practical solution, if we have simplified too much. If any of you video experts out there would like to comment or make suggestions, feel free to let us know.

Next month, we will look at the practicalities of realising a video interface, and hopefully present a video library that you can use yourself. The library will be presented in 'C' using the free Microchip C30 compiler, but you will be able to write your own applications in assembler if you wish.

For those of you interested in trying out the video experiment, we will be using the PIC24HJ32GP302 28-pin DIL processor, with an 8MHz crystal oscillator. The remainder of the circuit will be a few resistors and capacitors. The circuit operates at 3.3V from an external regulated power supply.

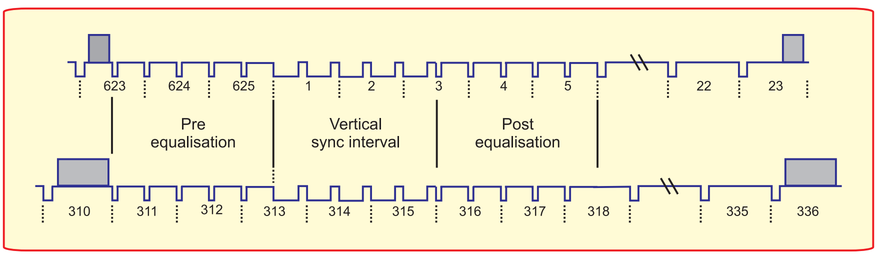


Fig.3. Frame signals

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ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

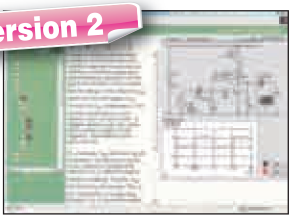
Logic Probe testing

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

Electronics Circuits & Components V2.0 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 and 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.

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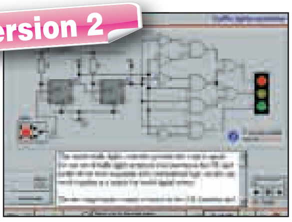
Sections on the CD-ROM include: ***Fundamentals*** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). ***Op Amps*** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. ***Amplifiers*** – Single Stage Amplifiers (8 sections), 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* (above), 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.

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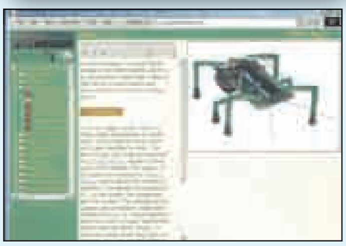
Analogue Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to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

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.

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

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Institutional (Schools/HE/FE/Industry)	£99	plus VAT
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PICmicro TUTORIALS AND PROGRAMMING

HARDWARE

VERSION 3 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 from the 12, 16 and 18 series PICmicro ranges. 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 – 16 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
- USB programmable
- Can be powered by USB (no power supply required)

£155 including VAT and postage, supplied with USB cable and programming software

£40 OFF Buy the Development Board together with any Hobbyist/Student or Institutional versions of the software CD-ROMs listed below and take £40 off the total (including VAT) price.

SOFTWARE

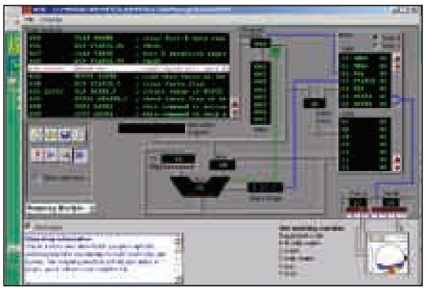
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro 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 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

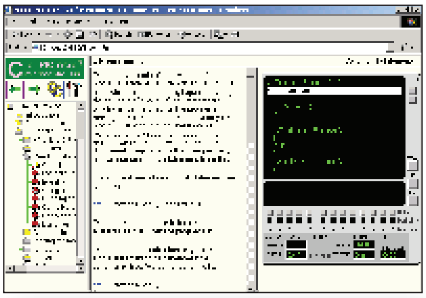


'C' FOR 16 Series PICmicro Version 4

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

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

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



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space. Flowcode will run on XP or later operating systems

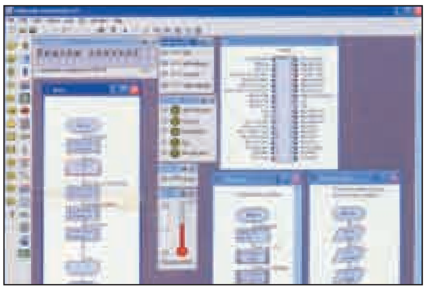
FLOWCODE FOR PICmicro V3

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A Powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and l.c.d.'s. The use of macros allows you to control these devices without getting bogged down in understanding the programming.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols ● Full on-screen simulation allows debugging and speeds up the development process.

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



PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

Hobbyist/Student	£44	inc VAT
Institutional (Schools/HE/FE/Industry)	£99	plus VAT
Institutional/Professional 10 user (Network Licence)	£300	plus VAT
Site licence	£599	plus VAT
Flowcode 10 user (Network Licence)	£350	plus VAT
Flowcode 50 user (Network Licence)	£699	plus VAT

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SPECIAL PACKAGE OFFER

TINA Pro V7 (Basic) + Flowcode V3 (Hobbyist/Student)

TINA Analogue, Digital, Symbolic, RF, MCU and Mixed-Mode Circuit Simulation, Testing and PCB Design

£50.00 inc. VAT and p&p

TINA Design Suite is a powerful yet affordable software package for analysing, designing and real time testing analogue, digital, MCU, and mixed electronic circuits and their PCB layouts. You can also analyse RF, communication, optoelectronic circuits, test and debug microcontroller applications.

Enter any circuit (up to 100 nodes) within minutes with TINA's easy-to-use schematic editor. Enhance your schematics by adding text and graphics. Choose components from the large library containing more than 10,000 manufacturer models. Analyse your circuit through more than 20 different analysis modes or with 10 high tech virtual instruments. Present your results in TINA's sophisticated diagram windows, on virtual instruments, or in the live interactive mode where you can even edit your circuit during operation.

Customise presentations using TINA's advanced drawing tools to control text, fonts, axes, line width, colour and layout. You can create, and print documents directly inside TINA or cut and paste your results into your favourite word- procesing or DTP package.

TINA includes the following Virtual Instruments: Oscilloscope, Function Generator, Multimeter, Signal Analyser/Bode Plotter, Network Analyser, Spectrum Analyser, Logic Analyser, Digital Signal Generator, XY Recorder.

***Flowcode V3** (Hobbyist/Student) – For details on Flowcode, see the previous page.*

This offer gives you two seperate CD-ROMs in DVD style cases – the software will need registering (FREE) with Designsoft (TINA) and Matrix Multimedia (Flowcode), details are given within the packages.

Get TINA + Flowcode for a total of just £50, including VAT and postage.

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An Interactive Guide to Circuit Design

Over 150 pages
Over 600 images

An interactive CD-ROM to guide you through the process of circuit design. Choose from an extensive range of input, process and output modules, including CMOS Logic, Op-Amps, PIC/PICAXE, Remote Control Modules (IR and Radio), Transistors, Thyristors, Relays and much more. Click Data for a complete guide to the pin layouts of i.c.s, transistors etc. Click More Information for detailed background information with many animated diagrams. Nearly all the circuits can be instantly simulated in Crocodile Technology (not included on the CD-ROM) and you can customise the designs as required.*

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Runs in Microsoft Internet Explorer

All circuits can be viewed, but can only be simulated if your computer has Crocodile Technoloy version 410 or later. A free trial version of Crocodile Technology can be downloaded from: **www.crocodile-clips.com. Animated diagrams run without Crocodile Technology.*

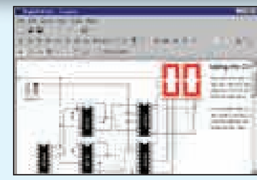
Single User £39.00 inc. VAT.

Multiple Educational Users (under 500 students) £59.00 plus VAT. Over 500 students £79.00 plus VAT.

(UK and EU customers add VAT at 15% to "plus VAT" prices)

Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98/NT/2000/ME/XP, mouse, sound card, web browser.

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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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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- ☐ Assembly for PICmicro V3
- ☐ 'C' for 16 Series PICmicro V4
- ☐ Flowcode V3 for PICmicro
- ☐ Digital Works 3.0

Version required:
- ☐ Hobbyist/Student
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- ☐ Institutional/Professional 10 user
- ☐ Site licence

- ☐ PICmicro Development Board V3 (hardware)

- ☐ TINA Pro V7 Basic + Flowcode V3 Hobbyist/Student
- ☐ Electronic Components Photos; Version 1.1
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Note: The software on each version is the same, only the licence for use varies.

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READOUT

Email: editorial@wimborne.co.uk

Matt Pulzer 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. The Atlas LCR automatically measures inductance from 1mH to 10H, capacitance from 1pF to 10,000µF and resistance from 1Ω to 2MΩ with a basic accuracy of 1%. www.peakelec.co.uk

★ LETTER OF THE MONTH ★

Dear EPE

I always read *Recycle it* with great interest, and as a regular SCR (skip content recycler) I relate closely to the spirit of the articles.

Your pressure switch article (*March '09*) highlighted a useful item, often discarded, but generally in good order with a multitude of potential uses. My point about these pressure switches is that I have found they are not particularly reliable for long-term monitoring of water levels.

If you think about how they work in a typical washing machine or dishwasher, effectively they are 'reset' after every wash. This happens because the water level falls below the level of the sensing tube, the water drains out and the diaphragms and switches return to their neutral settings.

At the start of a new wash, the water is pushed up the pipe, pressurising the air and operating the switches.

If the switches are left in a pressurised state for long periods, then creep can occur due to leaks, however small, in the pipe or diaphragms. This will relieve the internal air pressure and can lead to false switching. Also, if it is used in turbulent water with lots of air bubbles, then any air entering the tube may affect the switch points.

Craig Taylor, by email

An excellent point Craig – recycling is fun, cheap and a small step away from needless pollution, but it is always important to check that devices are being used safely and sensibly.

Dear EPE

Many thanks for the great Microchip PICkit2 offer (*Feb '09*). It arrived a couple of days after ordering. At first, it seemed a slightly confusing loading procedure – but all is now working OK.

Since the start of my adventure into PICs and assembler programming I have gone from a simple parallel port programmer running on a DOS-486 to a David Tait homebrew set up using FPP and on to a Velleman programmer kit with MPLAB. *EPE* articles have been a great source of ideas, information and interest – so, thanks again.

Is there any chance of getting Microchip to 'special offer' the little 44-pin 16F887 demo board, it makes a great piggyback controller for stripboard projects.

Les Clarke, by email

Many thanks Les, and I'm pleased to hear that our latest offer arrived promptly and is up and running, it was a very popular offer. We will check with Microchip to see if they can do an offer on the 16F887 demo board.

EasyPC/Class A amp project

Dear EPE

Like John Becker, I still have a DOS version of EasyPC but, unlike John, I can't seem to get it to work as a window in XP (despite tinkering with the various EMS and XMS settings). Could John find a minute to pass his settings on? I couldn't find any reference to these in the *Chat Zone*.

The authors of the Class A amp recommend tinning the conductors before putting them into the terminal blocks. I used to do this and also some manufacturers used to tin the mains cable strands in the days when you had to fit your own 13A plug.

However, I found that these connections could go slack due to creep of the solder over time. I therefore discontinued this practice and even used to cut off the tinned ends of pre-tinned wires when making up 13A plugs.

Dave Reeves, Sutton Coldfield

John tells me that in fact he doesn't run EasyPC fully successfully under XP, so for now he doesn't have any reliable settings to pass on.

It's an interesting point about tinned leads – we'd welcome further insight on this effect, especially as it could be a safety issue when used with the mains.

Stripboard layout

Dear EPE

I read with interest Mark Nelson's *TechnoTalk* article (*Dec '08*) on using a schematic editor to create (using freeware), a working stripboard layout. I have tried this out to a degree, but believe there maybe a better alternative.

First, after creating a netlist file from my Altium (Protel) schematic editor, I had lots of difficulty importing the netlist into VeeCAD (one of the software packages mentioned), as it only accepts numeric pin designators, not letters. Diode designators, for example in Protel, are either 'K' or 'A' – not 1 or 2.

The compiler alerts the user to where the problem is by giving you the line number. Since the lines of the output are not numbered, this makes life a bit difficult when trying to locate and edit that piece of code (netlist). Also, in general, the software prefers all through-hole components to surface mount ones, and if your project has a lot of ICs, then you are going to be placing a lot of 'X's, which is the software mark for cutting a track.

Nowadays, there are many good evaluation boards (some populated, some not) on the market. They are typically competitively priced and expertly made by component manufacturers such as Microchip or Analog Devices. Often, these boards can be easily connected to other 'daughter boards'. Microchip's PICDEM 2 PLUS board I have found extremely useful for linking a differential sensor board to another I purchased from National Semiconductor.

As a consequence, before anyone goes down the path of populating a working stripboard project, created from the netlist, created from their schematic editor, I suggest they first search for a complimentary evaluation board, preferably with a working 'prototype', area attached.

Peter Barrett MIEAust, by email

Thank you Peter – does anyone else have experience of using a schematic editor to create a working stripboard layout?

IF YOU HAVE A SUBJECT YOU WISH TO DISCUSS ON THIS PAGE PLEASE EMAIL US AT:

editorial@wimborne.co.uk

Net Work

Alan Winstanley

This month's *Net Work* continues on the theme of mobile Internet applications. We hope that readers visit the *EPE* Online website (**www.epemag.com**) where more bonus articles and updates, screenshots and a list of this month's clickable links are provided. In the March online update you can read about the new RF remote control for the truly brilliant PURE Evoke Flow wifi radio, more details of Easy WiFi Radar, plus some details of BT's I-Plate broadband accelerator. Did the I-Plate work for me? Check *EPE* Online to find out!

Previously, I described my practical experiences of using mobile Internet based on my HTC Windows smartphone. I can now monitor POP3 incoming emails by either using wifi or GPRS, and I can send emails through AuthSMTP, my preferred outbound email supplier. (All relevant hyperlinks are available in my *EPE* Online *Net Work* monthly blog.)

Always prepared

Looking at my motley collection of IT hardware gathered over the years, experience has taught me the value of not taking technology entirely for granted. I usually work on the basis that one day, something somewhere in my system will break down at the worst possible time and proceed to drop me in deep, deep trouble. Given that much of Britain's communications infrastructure seems to be on a knife-edge (my telephone exchange building is actually a small wooden hut near a village duck pond), it is amazing that Internet technology works at all, but somehow it does – most of the time.

As a result of some very bitter lessons learnt in the past, I try, as a policy, to implement multiple layers of backups, not only to protect data (using backup external drives, a Netgear RAID network drive, the odd DVD backup and a 'last gasp' online backup in the shape of Carbonite) but also backing up communications and hardware, trying to cover contingencies as far as possible. I live by a digital version of the Scout Movement's maxim: '*be prepared*'.

As far as Internet access goes, I have had my fair share of disasters. Some years ago a truck delivering to a neighbour's house managed to slice through our overhead phone lines, taking my broadband with it. The temporary workaround was to use a Nokia mobile phone as a painfully slow modem, hooked to a laptop. But this would not have been possible unless I had purchased a suitable USB modem cable from my local Maplin store – and installed and tested it first. The local electricity board subsequently decided to raise the height of the telegraph poles (brilliant!) which resulted in more Internet down-time.

Even today, though, I still retain a legacy Nokia mobile phone with batteries and chargers, and I have a spare SIM card, USB modem cable and Windows driver disk – just in case – because I still don't entirely trust technology. As the very unsympathetic AEG customer service agent said when I complained about my dishwasher blowing up yet again, "parts can fail at any time", in case I did not already know.

Going off the rails

Apart from good old copper wires, fibre optics and microwave links are used to transmit data around our shores. Optical fibres can be strung alongside high voltage overhead power lines, in a good example of lateral thinking. They are also, as I recently found, routed alongside railway lines that carve their way across our country. There I was, studiously dealing with emails and generally surfing around when the broadband connection suddenly went dead. The telephone line still worked, so the outage was something of an enigma.

Regular *Net Work* readers will know by now that some basic tests can be run to help isolate such a problem. I usually try a Tracert from the DOS prompt (Start/Run/cmd/tracert), tracing **www.ebay.co.uk** because it's quick to type. If the DNS lookup fails then either the computer network is disconnected or the network is down. Can other websites be accessed in the browser? Can emails still be sent or received? Then try powering down the router for a few minutes, and reboot the PC at the same time. Wiggle the Ethernet connectors to ensure they are still mated. It is very surprising how often a simple check solves the problem.

In the case of my broadband outage, I had no such luck and the ADSL connection was resolutely not responding. A quick phone call to my small, independent ADSL supplier revealed the cause, namely that railway workers who were maintaining the tracks somewhere near Sheffield had sliced through a fibre optic. Not satisfied with their endeavours, they did the same 100 metres further up the line, so the entire length of optical fibre would need replacing which would take a day. A week or so later, and I am not kidding, they did exactly the same thing again, this time near Leicester.

The result was several days without any broadband connection, but this time I had a weapon in my arsenal in the shape of my mobile phone. Since I had no ADSL, my wifi router was redundant, but I could still check email directly using the phone's GPRS tariff. This was more than adequate to keep email-related aspects ticking along.

As a challenge, I then spent a few hours grappling with the mysteries of Bluetooth, as I decided to try hooking the phone to my laptop wirelessly. My Sony Vaio does not have Bluetooth, but a tiny Belkin thumbnail-sized dongle from a supermarket soon overcame that problem. Admittedly after much hair-pulling, I am still not clear how I managed to pair the two devices together, nor am I sure that I could repeat the exercise, but I configured a virtual COM port that enabled my laptop to reach out onto the Internet through my mobile phone. The dongle's flickering blue LED ensured that business kept moving, and I felt quite smug that my dainty Bluetooth dongle had got one over those railway workers and their shovels.

EPE Online Library

Hopefully, regular readers are now finding their way around our all-new website, which is your first port of call for downloading monthly files, PIC source codes and more besides. The *EPE* issue month and year are key to locating files, as they are sorted in date order. If you have any difficulties in locating files, especially older ones, the best way of asking for help is via the online Contact Us form and we will update the site and/or email any files to you directly.

As we have previously stated, this site runs best in Internet Explorer 7 or Firefox, and users of IE6 or earlier should really upgrade straight away. Without exception, all IE6 users in difficulty confirmed that any problems disappeared as soon as they upgraded. It is also worth ensuring that your version of Adobe Flash Player is up to date, as the website launches a small flash-based animation on each page. One user confirmed an improvement in performance once he fetched the current version of Flash Player.

On my bonus *Net Work* blog, at *EPE* Online (**www.epemag.com**), I'll offer a few more practical pointers about using a mobile phone to obtain Internet access, and I'll update you on my Grand Linux Trial. In next month's *Net Work*, I'll be trying to fix a Registry bug on my PC and investigating the murky world of so-called Windows 'Registry Cleaners' sourced from online suppliers.

Do email and let us know what topics you would like to see covered in future *Net Work* columns. You can email me at **alan@epemag.demon.co.uk**.

DIRECT BOOK SERVICE

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

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Electronics Teach-In + FREE CD-ROM

Mike Tooley

A broad-based introduction to electronics – find out how circuits work and what goes on inside them. Plus 15 easy-to-build projects. The 152 page A4 book comes with a free CD-ROM containing the whole *Teach-In 2006* series (originally published in *EPE*) in PDF form, interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC.

In addition to the Teach-In series, the book includes 15 CMOS-based simple projects from the *Back-To-Basics* series by Bart Trepak, these are: Fridge/Freezer Alarm, Water Level Detector, Burglar Alarm, Scarecrow, Digital Lock, Doorchime, Electronic Dice, Kitchen Timer, Room Thermometer, Daily Reminder, Whistle Switch, Parking Radar, Telephone Switch, Noughts and Crosses Enigma and a Weather Vane. There is also a MW/LW Radio project in the Teach-In series.

152 pages + CD-ROM — **Order code ETI** — **£8.50**

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PROJECT CONSTRUCTION

IC 555 PROJECTS
E. A. Parr

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are over 70 circuit diagrams and descriptions covering basic and general circuits, motor car and model railway circuits, alarms and noise makers as well as a section on 556, 558 and 559 timers. (Note. No construction details are given.) A reference book of invaluable use to all those who have any interest in electronics, be they professional engineers or designers, students or hobbyists.

167 pages — **Order code BP44** — **£5.49**

POWER SUPPLY PROJECTS
R. A. Penfold

This book offers a number of power supply designs, including simple unstabilised types, and variable voltage stabilised designs, the latter being primarily intended for use as bench power supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits. The information in this book should also help the reader to design his own power supplies. Includes cassette PSU, Ni-Cad charger, voltage step-up circuit and a simple inverter.

91 pages — **Order code BP76** — **£5.49**

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers and crystal calibrators.

104 pages — **Order code BP267** — **£5.49**

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

Temporarily out of print

TEST EQUIPMENT CONSTRUCTION
R. A. Penfold

This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

The following designs are included:-

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This book explains how to use your PC on the Internet and covers amongst other things: Choosing and setting up your computer for the Internet. Getting connected to the Internet. Sending and receiving emails, photographs, etc., so that you can keep in touch with family and friends all over the world. Searching for and saving information on any subject. On-line shopping and home banking. Setting up your own simple web site.

228 pages — **Order code BP600** — **£8.99**

RADIO

SETTING UP AN AMATEUR RADIO STATION
I. D. Poole

The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.

Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

86 pages — **Order code BP300** — **£4.45**

EXPERIMENTAL ANTENNA TOPICS
H. C. Wright

Although nearly a century has passed since Marconi's first demonstration or radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour.

The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc.

Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.

72 pages — **Order code BP278** — **£4.00**

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AN INTRODUCTION TO RADIO WAVE PROPOGATION
J.G. Lee

Radio wave propogation is one of the more important discoveries made in the early 20th century. Although technology lagged behind early experimenters pursued this newly discovered phenomenon eagerly for, in understanding the physics of propagation, they were discovering more about our Universe and its workings.

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This book has been written with the average electronic hobbyist in mind. Technical language and mathematics have been kept to a minimum in order to present a broad, yet clear, picture of the subject. The radio amateur, as well as the short-wave listener, will find explanations of the propagation phenomena which both experience in their pursuit of communications enjoyment.

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THEORY AND REFERENCE

BEBOP TO THE BOOLEAN BOOGIE
Second Edition
Clive (call me Max) Maxfield

This book gives the "big picture" of digital electronics. This in-depth, highly readable, guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate.

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Clive (Max) Maxfield and Alvin Brown

CD-ROM

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Martin Bates

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Explore in detail microcontroller interfacing techniques using the popular PIC 16F877. Work through step-by-step examples interactively using circuit simulation software, supplied as assembly source code.

Interfacing PIC Microcontrollers provides a thorough introduction to interfacing techniques for students, hobbyists and engineers looking to take their knowledge of PIC application development to the next level. Each chapter ends with suggestions for further applications, based on the examples given, and numerous line drawings illustrate application of the hardware.

Step-by-step examples in assembly language are used to illustrate a comprehensive set of interfaces, and these can be run interactively on circuit simulation software, used to aid understanding without the need to build real hardware.

A companion website includes all examples in the text which cam be downloaded together with a free version of Proteus's ISIS Lite.

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GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

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Ian R. SInclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

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R. A. Penfold

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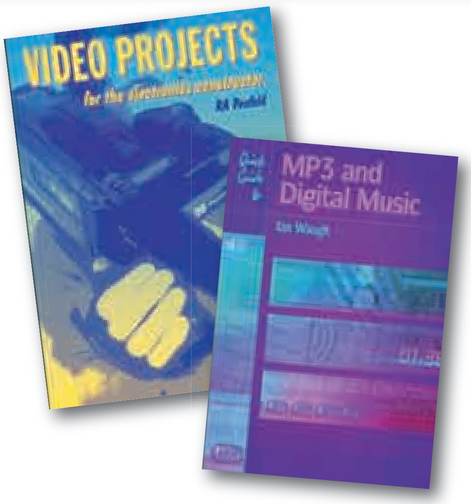

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Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer,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

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FAULT FINDING, CIRCUITS AND DESIGN

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BOOK + CD-ROM

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For Editorial address and phone numbers see page 7

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