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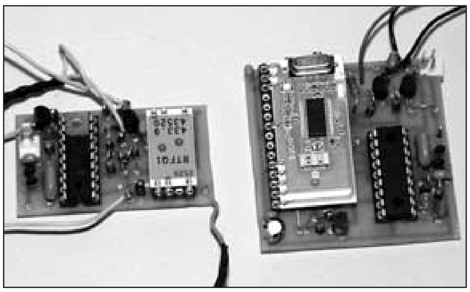
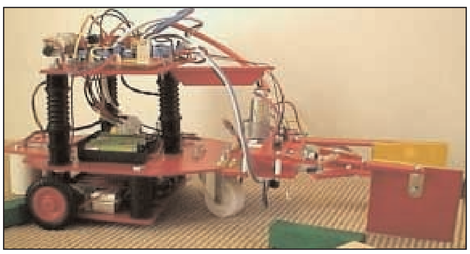




Projects and Circuits

Series and Features

Regulars and Services

Our March 2005 issue will be published on Thursday, 10 February 2005. See page 75 for details

NEXT MONTH

CAT FLAP

A versatile detector that will sense the presence of a magnet worn by the cat at a distance of around 20cm. The design can then be used to trigger a deterrent for strays and/or unlock the cat flap for the magnet-wearing moggy.

A simple design employing an easily constructed coil with a Faraday shield plus a handful of p.c.b. mounted components.

PIC BINGO

Most people will have played Bingo or similar lottery style games since their early years. Methods abound for the selection of random numbers – usually between 1 and 90 – ranging from wooden balls in bags to the washing-machine like Lotto creations as seen on television. This project applies modern PIC-based electronics to the traditional game, resulting in a gadget that is completely fair, requires no set-up time and, most importantly in family circles, removes all arguments about who should be the "caller."!

PIC Bingo provides for manual and automatic number generation. In automatic mode, a number is generated automatically after a pre-programmed delay of up to 99 seconds. A "rewind and replay" function is also provided, as is the ability to change the range for which numbers are generated – useful for other games – and to check the numbers on the winning card.

The project also demonstrates and applies a number of techniques previously featured in EPE *projects, including large seven-segment l.e.d. displays and, most fun of all (and very useful for school/club bingo evenings), the enormous seven-segment displays described in the* PIC Big Digit Display *article from May 2002. These devices are driven from an expansion p.c.b. enabling constructors to customise the project to their specific requirements.*

TK3 SIMULATOR AND PIC18F UPGRADE

Describing the latest facilities that have been added to the EPE PIC Toolkit TK3 *PIC assembly and programming software, now released as version V3.00.*

The first addition is a quite sophisticated Mini Simulator through which your own software routines can be put through initial testing procedures, allowing potential bugs to be eliminated prior to downloading the code to a PIC.

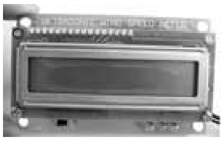
The second enhancement is the expansion of the assembly, programming and disassembly routines to allow members of the recently introduced PIC18Fxx2/xx8 family to be handled. These devices have more commands and abilities than the more familiar PIC16Fxx devices, but have significantly different assembly and programming requirements.

MARCH 2005 ISSUE ON SALE THURSDAY, FEBRUARY 10

Hot New Kits This Summer!

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

NEW! EPE Ultrasonic Wind Speed Meter



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

Specifications

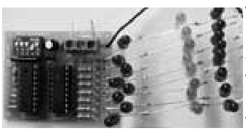
- Units of display: metres per second, feet per second, kilometres per hour and miles per hour
- Resolution: Nearest tenth of a metre
- Range: Zero to 50mph approx.

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

NEW! Audio DTMF Decoder and Display

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

NEW! EPE PIC Controlled LED Flasher



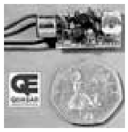
This versatile PIC-based LED or filament bulb flasher can be used to flash from 1 to 160 LEDs. The user arranges the LEDs in any pattern they wish. The kit comes with 8 superbright red LEDs and 8 green LEDs. Based on the Versatile PIC Flasher by Steve Challinor, *EPE* Magazine Dec '02. See website for full details. Board Supply: 9-12V DC. LED supply: 9-45V DC (depending on number of LED used). PCB: 43 x 54mm.
Kit Order Code: 3169KT – **£10.95**

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

FM Bugs & Transmitters

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

MMTX' Micro-Miniature 9V FM Room Bug

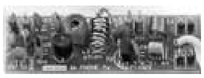


Our best selling bug! Good performance. Just 25 x 15mm. Sold to detective agencies worldwide. Small enough to hide just about anywhere. Operates at the 'less busy' top end of the commercial FM waveband and also up into the more private Air band. Range: 500m. Supply: PP3 battery.
Kit Order Code: 3051KT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

HPTX' High Power FM Room Bug

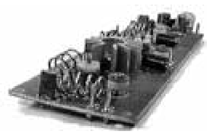
Our most powerful room bug. Very Impressive performance. Clear and stable output signal thanks to the extra circuitry employed. Range: 1000m @ 9V. Supply: 6-12V DC (9V PP3 battery clip suppied). 70 x 15mm.
Kit Order Code: 3032KT – **£9.95**
Assembled Order Code: AS3032 – **£17.95**

MTTX' Miniature Telephone Transmitter



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

3 Watt FM Transmitter



Small, powerful FM transmitter. Audio preamp stage and three RF stages deliver 3 watts of RF power. Can be used with the electret microphone supplied or any line level audio source (e.g. CD or tape OUT, mixer, sound card, etc). Aerial can be an open dipole or Ground Plane. Ideal project for the novice wishing to get started in the fascinating world of FM broadcasting. 45 x 145mm.
Kit Order Code: 1028KT – **£22.95**
Assembled Order Code: AS1028 – **£34.95**

25 Watt FM Transmitter

Four transistor based stages with a Philips BLY89 (or equivalent) in the final stage. Delivers a mighty 25 Watts of RF power. Accepts any line level audio source (input sensitivity is adjustable). Antenna can be an open dipole, ground plane, 5/8, J, or YAGI configuration. Supply 12-14V DC, 5A. Supplied fully assembled and aligned – just connect the aerial, power and audio input. 70 x 220mm.
Order Code: 1031M – **£124.95**

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3143KT – 10W Stereo Amplifier £10.95
1011-12KT – Motorbike Alarm £12.95
1019KT – Car Alarm System £11.95
1048KT – Electronic Thermostat £9.95
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3126KT – Sound-Activated Relay £7.95
3063KT – One Chip AM Radio £10.95
3102KT – 4-Ch Servo Motor Driver £15.95
3155KT – Stereo Tone Controls £8.95
1096KT – 3-30V, 5A Stabilised PSU £32.95
3029KT – Combination Lock £6.95
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3130KT – Infra-red Security Beam £12.95
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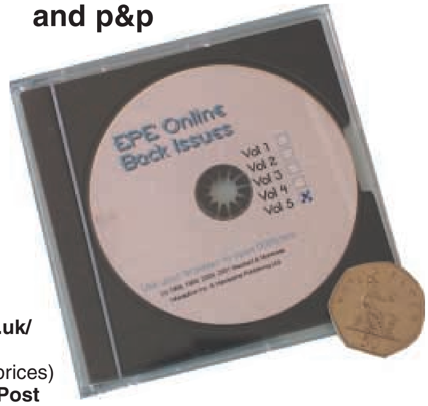

A great way to buy *EPE* Back Issues – our mini CD-ROMs contain back issues from our *EPE Online* website plus bonus articles, all the relevant PIC software and web links. Note: no free gifts are included. All this for just £14.45 each including postage and packing.

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VOL 6: BACK ISSUES – July 2001 to December 2001

VOL 7: BACK ISSUES – January 2002 to June 2002

VOL 8: BACK ISSUES – July 2002 to December 2002

VOL 9: BACK ISSUES – January 2003 to June 2003

VOL 10: BACK ISSUES – July 2003 to December 2003

VOL 11: BACK ISSUES – January 2004 to June 2004

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All volumes include the *EPE Online* editorial content of every listed issue, plus all the available **PIC Project Codes** for the PIC projects published in those issues.

Note: Some supplements etc. can be downloaded free from the Library on the *EPE Online* website at **www.epemag.com**.
No advertisements are included in Volumes 1 and 2; from Volume 5 onwards the available relevant software for *Interface* articles is also included.

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DID YOU MISS THESE?

OCT '03

PROJECTS ● RC Car Wars ● Serial Interface for PICs and VB6 ● Practical Radio Circuits–5 (Super Regen. Receiver) ● Spooky Bug.
FEATURES ● PIC Breakpoint ● Ingenuity Unlimited ● Interface ● Techno-Talk ● New Technology Update ● Net Work – The Internet Page.

NOV '03

PROJECTS ● PIC Random L.E.D. Flasher ● Cardboard Clock ● Practical Radio Circuits–6 (S.S.B. and Direct Conversion Receiver) ● Anyone At Home?
FEATURES ● Teach-In 2004 – Part 1 ● Ingenuity Unlimited ● Practically Speaking ● Techno Talk ● Circuit Surgery ● New Technology Update ● Net Work – The Internet Page.

DEC '03

PROJECTS ● PIC Nim Machine ● Practical Radio Circuits–7 (Superhet Tuner) ● PIC Virus Zapper Mk2 ● Christmas Cheeks.
FEATURES ● Teach-In 2004 – Part 2 ● Electrotherapy ● Circuit Surgery ● Ingenuity Unlimited ● Techno Talk ● High-Speed Decimal To Binary For PICs ● Interface ● Network – The Internet.

JAN '04

PROJECTS ● Car Computer ● Practical Radio Circuits–8 (Dual-Conversion SW Receiver) ● Bedside Nightlight ● PIC Watering Timer.
FEATURES ● GPS to PIC and PC Interface ● Practically Speaking ● Teach-In 2004 – Part 3 ● Ingenuity Unlimited ● Techno Talk ● Circuit Surgery ● New Technology Update ● Net Work – The Internet Page.

FEB '04

PROJECTS ● PIC LCF Meter ● Sonic Ice Warning ● Jazzy Necklace ● PIC Tug-of-War.
FEATURES ● Surface Mount Devices ● Circuit Surgery ● Teach-In 2004 – Part 4 ● Interface ● Ingenuity Unlimited ● Techno Talk ● Net Work – The Internet Page.

MAR '04

PROJECTS ● Bat-Band Convertor ● Emergency Stand-by Light ● MIDI Health Check ● PIC Mixer for RC Planes.
FEATURES ● Teach-In 2004 – Part 5 ● New Scientist CD-Rom Review ● Circuit Surgery ● Techno Talk ● Ingenuity Unlimited ● Practically Speaking ● Net Work – The Internet Page.

APRIL '04

PROJECTS ● EPE Experimental Seismograph Logger 1 ● Infra-Guard Monitor ● Loft Light Alarm ● PIC Moon Clock.
FEATURES ● USB To PIC Interface ● Ingenuity Unlimited ● Teach-In 2004 Part 6 ● Interface ● Techno Talk ● Circuit Surgery ● New Technology Update ● Net Work – The Internet Page ● Pull-Out – Semiconductor Classification Data.

MAY '04

PROJECTS ● Beat Balance Metal Detector ● In-Car Laptop PSU ● Low-Frequency Wien Oscillator ● EPE Experimental Seismograph Logger–2.
FEATURES ● Coping With Lead-Free Solder ● Teach-In 2004 – Part 7 ● Ingenuity Unlimited ● Techno Talk ● Circuit Surgery ● Practically Speaking ● Pic-N'-Mix ● Net Work – The Internet Page.

JUNE '04

PROJECTS ● PIC Quickstep ● Crafty Cooling ● MIDI Synchronome ● Body Detector Mk2.
FEATURES ● Clinical Electrotherapy ● Ingenuity Unlimited ● Teach-In 2004 – Part 8 ● Interface ● Circuit Surgery ● Techno Talk ● PIC-N'-Mix ● Net Work – The Internet Page.

JULY '04

PROJECTS ● Portable Mini Alarm ● Bongo Box ● Hard Drive Warbler ● EPE PIC Magnetometry Logger–1.
FEATURES ● Making Front Panel Overlays ● Practically Speaking ● Teach-In 2004 – Part 9 ● Ingenuity Unlimited ● Circuit Surgery ● Techno Talk ● PIC-N'-Mix ● Net Work – The Internet Page.

AUG '04

PROJECTS ● EPE Scorer ● Keyring L.E.D. Torch ● Simple F.M. Radio ● EPE PIC Magnetometry Logger – 2.
FEATURES ● PIC To PS/2 Mouse and Keyboard Interfacing ● Techno Talk ● Circuit Surgery ● Teach-In 2004 – Part 10 ● Interface ● Ingenuity Unlimited ● PIC-N'-Mix ● Net Work – The Internet Page.

SEPT '04

PROJECTS ● EPE Wart Zapper ● Radio Control Failsafe ● Rainbow Lighting Control ● Alphamouse Game.
FEATURES ● Light Emitting Diodes – Part 1 ● High Speed Binary-To-Decimal For PICs ● Practically Speaking ● Ingenuity Unlimited ● Techno-Talk ● Circuit Surgery ● PIC-N'-Mix ● Network – The Internet Page
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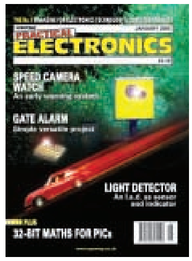
OCT '04

PROJECTS ● EPE Theremin ● Smart Karts – Part 1 ● Volts Checker ● Moon and Tide Clock Calendar.
FEATURES ● Light Emitting Diodes – 2 ● Circuit Surgery ● Interface ● Ingenuity Unlimited ● Techno Talk ● PIC-N'-Mix ● Network – The Internet Page ● ROBOTS – Special Supplement

NOV '04

PROJECTS ● Thunderstorm Monitor ● M.W. Amplitude Modulator ● Logic Probe ● Smart Karts - 2.
FEATURES ● Light Emitting Diodes-3 ● Floating Point Maths for PICs ● Ingenuity Unlimited ● PE 40th Anniversary ● Circuit Surgery ● Techno Talk ● PIC-N'-Mix ● Net Work – The Internet Page.



DEC '04

PROJECTS ● Super Vibration Switch ● Versatile PIC Flasher ● Wind Direction Indicator ● Smart Karts - 3.
FEATURES ● Light Emitting Diodes-4 ● Ingenuity Unlimited ● Circuit Surgery ● Interface ● PIC 'N' Mix ● Techno Talk ● Net Work – The Internet Page ● INDEX Vol. 33.

JAN '05

PROJECTS ● Speed Camera Watch ● Gate Alarm ● Light Detector ● Smart Karts - 4.
FEATURES ● Practially Speaking ● 32-Bit Signed Integer Maths for PICs ● Ingenuity Unlimited ● Circuit Surgery ● Techo Talk ● PIC 'N' Mix ● Picoscope 3205 Review ● Net Work – The Internet Page

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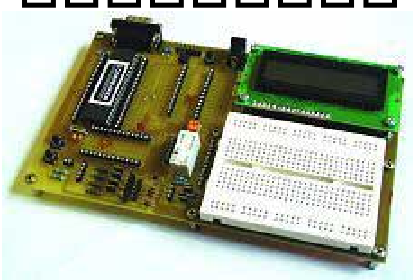

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- Works with MPASM assembler

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Historic Bunkum

The more we investigate the past the more we realize that much of the history of technology that has been popularly accepted over the last 100 years or so is actually pure bunkum! Take for instance the invention of the transistor by Bell Labs in 1947 – they in fact repeated existing technology – see Andy Emmerson's *Who Really Invented The Transistor* article published in our January 2003 issue. Or the "invention" of radio by Marconi when in fact Tesla had demonstrated remote control by radio in 1893. See the article *Nikola Tesla – Overlooked Radio Pioneer* by Lorin Knight G2DXX in our sister publication *Radio Bygones* in the August/September 2002 issue.

Maybe you thought Edsison invented the voice recording system in 1877 – not so, a French scientist called Leon Scott invented a recording machine twenty years earlier. See Andrew Emmerson's reply to a letter from a reader in the USA in this issue.

In the past we have also looked at the "invention" of the computer and at present our article on *The Life And Works of Contrad Zuse* (available as an extra on our Back Issue CDROMs) perhaps describes the earliest working computer – unless of course you know different?

Putting It Right

Suffice to say that we are always keen to update the record on such inventions – I was going to use the term "set the record straight" but who knows if what I have indicated above are the final definitive versions of events? Time will tell if further previous "inventions" come to light.

How we get such information into mainstream teaching, public awareness and update the history books and encyclopedias is, of course, another challenge. But the more people we tell the better chance we have. So next time you find a quiz answer or book reference with the "wrong" answer why not take the trouble to inform the perpetrators that, whilst their answer conforms to popular belief, it is in fact basically incorrect.

We live and learn!

Mike Kenward

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All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.
A number of projects and circuits published in *EPE* employ voltages than can be lethal. **You should not build, test, modify or renovate any item of mains powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.**

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers (see *Shoptalk*). **We advise readers to check that all parts are still available before commencing any project in a back-dated issue.**

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Constructional Project

PIC Electric MK2

John Becker - Part 1

Monitor the cost of running your mains electrical appliances

PIC-ELECTRIC Mk2 is a considerably more sophisticated version of a design published in *EPE* about nine years ago. Whereas the original basically monitored the cost of running a single mains a.c. electrical appliance in real-time, the Mk2 provides data logging facilities for two appliances, each independently connected to its own logging path. It has the features shown in the panel opposite.

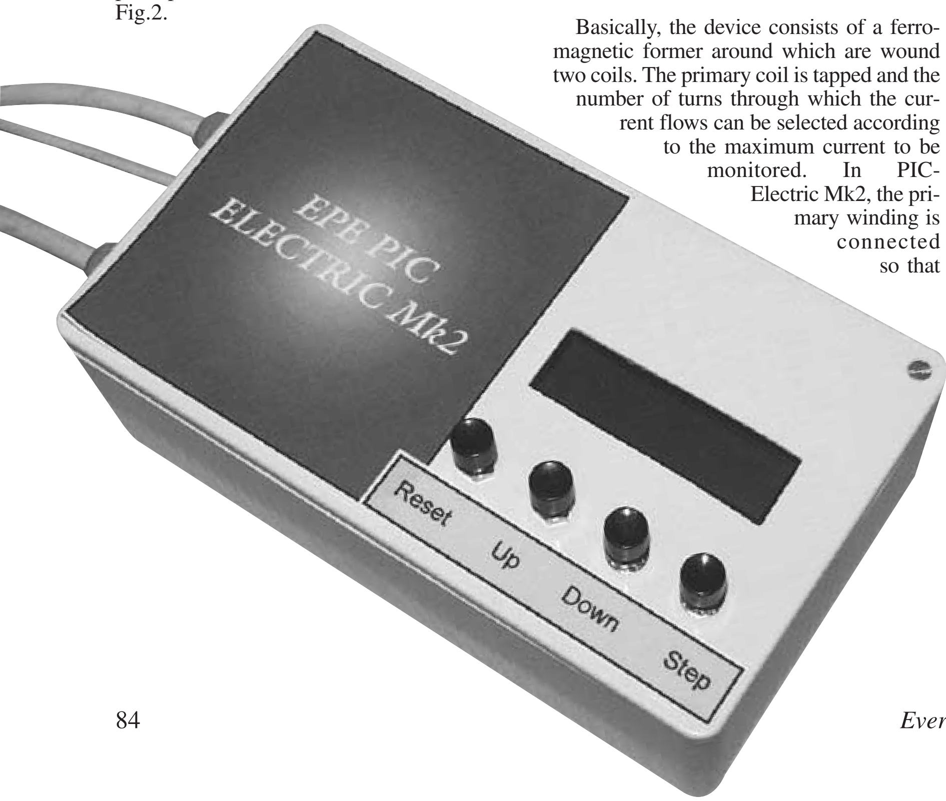
It must be noted that this design should only be built by those who are suitably qualified or supervised. Mains electricity can kill!

Features

- PIC16F876 microcontrolled
- 230V/110V 50Hz/60Hz compatible
- 2-channel monitoring – second channel optional
- L.C.D. display of real-time values for:
  Mains a.c. voltage, up to 250V a.c., including 110V a.c.
  Appliance load current, up to 25A per channel
  Appliance power consumption, up to 6kW per channel
  Cumulative cost since start of monitoring, to 999.99 units
  User selected cost per kWh value, any decimal currency
  Elapsed time since unit's power-up
- Optional on-board serial logging memory for:
  Mains a.c. voltage
  Appliance load current, 2 channels
- Logging capacity approximately 68 hours at 1-minute sampling rate
- Cyclic recording, 0 to maximum memory, roll-over to 0, continue, etc
- Output of recorded data to PC-compatible computer, Windows 95 upwards
- Specially written PC program for data storage to disk for subsequent display and analysis
- Stand-alone program, written in Visual Basic 6, but does not need VB6 to be installed on PC
- Data files compatible with Windows Excel graphing and analysis software

Current Sensors

As with the original *PIC-Electric*, Hall Effect current transducers are used in this design, notated as X1 and X2 in Fig.1 (you may omit X2 if you do not want two channels). With these transducers, alternating current (a.c.) measurement is carried out by measuring the magnetic field that is generated by a current-carrying conductor. The schematic drawing illustrating the principle is shown in Fig.2.



Basically, the device consists of a ferro-magnetic former around which are wound two coils. The primary coil is tapped and the number of turns through which the current flows can be selected according to the maximum current to be monitored. In PIC-Electric Mk2, the primary winding is connected so that only one coil turn is used, allowing a theoretical maximum of 25A to be drawn through the sensor.

Within the gap between the legs of the magnetic former is a Hall Effect semiconductor device. This is placed at right angles to the magnetic field generated by current passing through the primary coil. The resulting voltage generated across the semiconductor is linearly proportional to the magnetic field, and hence to the current flowing in the circuit.

The device can be used to measure alternating or direct currents (a.c. or d.c.). Its output does not depend on a changing magnetic field, only on the instantaneous strength of the field. The bandwidth of the device is from d.c. to 150kHz.

The voltage generated across the semiconductor is processed by an internal amplifier and fed through the secondary winding of the transducer, generating an output current. An output current of 25mA is generated by a 25A primary current flowing through the sensor, to within ±0·6%. By feeding the current through a known-value resistor, typically 100Ω to

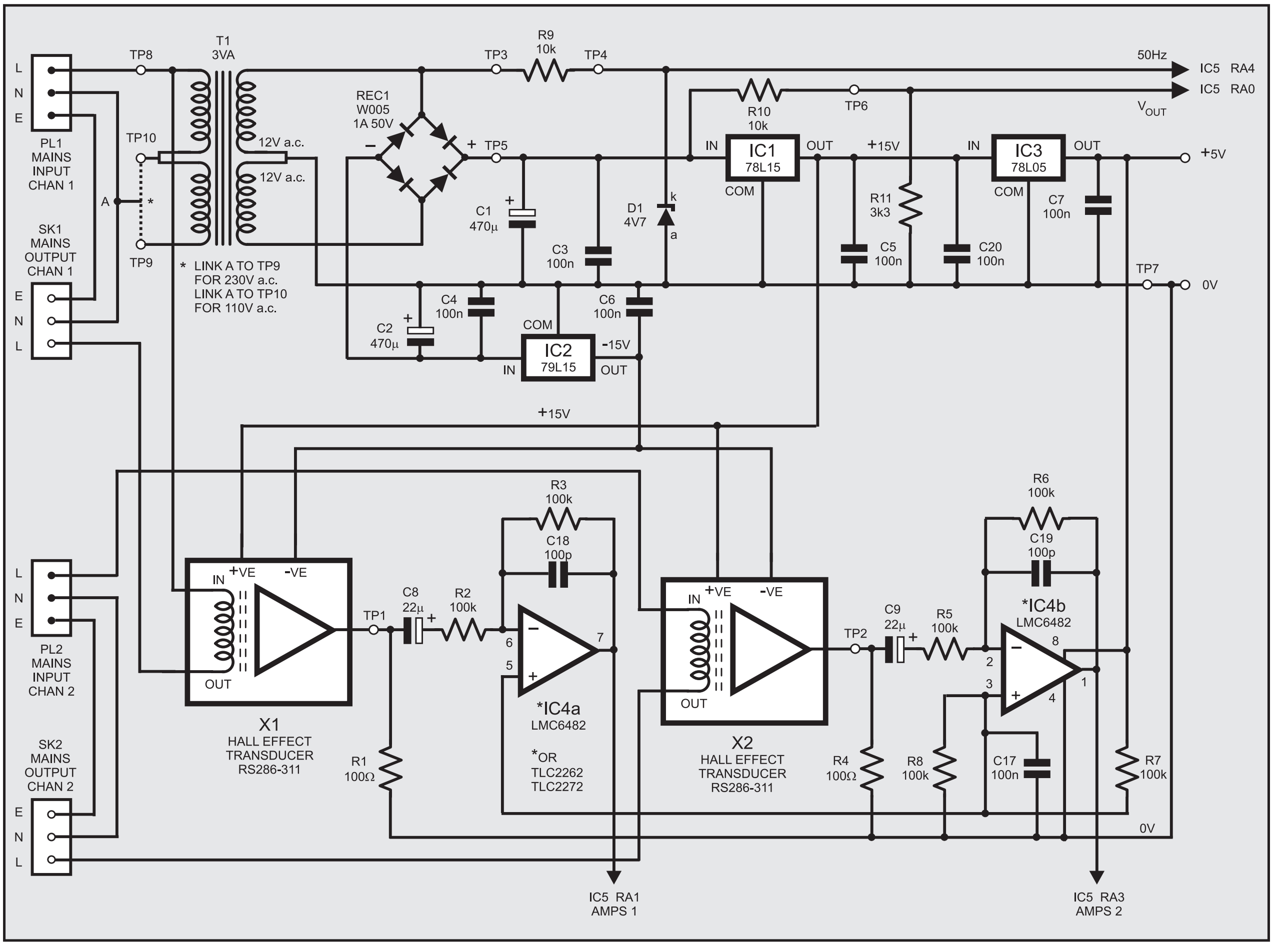


Fig.1. Circuit diagram for the PIC Electric Mk2 power supply and current sensors.

190Ω, the current can be converted to an equivalent output voltage.

When connected for 25A maximum current, the resistance of the primary coil is only 0·3 milliohms, and so imposes very little insertion loss between the mains power source and the appliance being monitored. The isolation between the primary coil and the sensor's output is 2.5kV r.m.s. at 50Hz for one minute.

The sensor also requires a dual d.c. supply voltage of ±15V, consuming about 10mA, plus the output current.

Power Supply

Referring to Fig.1, mains a.c. electrical power is brought into the circuit via a standard mains plug and cable.

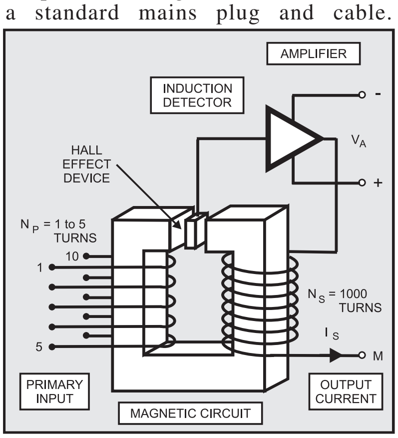


Fig.2. Hall effect current sensor and transducer functional diagram.

Initially it powers transformer T1, and may be 230V a.c. or 110V a.c., depending on which primary windings of the transformer are used. The twin secondary windings each output a nominal 12V a.c. This is bridge rectified by REC1 to provide a dual-rail supply of about ±18V d.c.

Capacitor C1 smooths the positive rail voltage, which is then regulated down to +15V by IC1. The negative rail is smoothed by C2 and regulated down to −15V by IC2. This ±15V supply is required to power the current sensors, X1 and X2. Capacitors C3 to C6 help to maintain the "quietness" of the supply rails.

The nominal 12V a.c. output on one secondary winding is also attenuated by resistor R9 and Zener diode D1 to provide a 0V to 4·7V peak-to-peak output signal. This is used as a synchronisation signal by the control circuit (Fig.3, IC5 pin RA4).

From capacitor C1, the rectified but unregulated voltage is also fed to the potential divider formed by resistors R10 and R11. The d.c. voltage at their junction is that used by the controller to assess the equivalent mains a.c. voltage (via IC5 pin RA0) – any change in the latter will cause an equivalent change in the rectified voltage.

The +15V output from IC1 is regulated down to +5V by IC3 for use by the control circuit, with decoupling provided by capacitors C7 and C6.

Sensing Circuits

The two mains a.c. live (L) lines are fed to the inputs of the two transducers, X1 and X2. Their outputs are connected separately to the live terminal of the appliances being monitored, via connectors SK1 and SK2 respectively.

Taking sensor X1 as the example, current drawn by the appliance causes an output current to flow from the sensor's output, as described above. Resistor R1 provides the load across which the equivalent sensor output voltage is generated. The maximum a.c. voltage that can be developed here is approximately ±2·5V for a 25A appliance current.

Because the PIC operates from a 0V/5V supply, the a.c. voltage from the sensor, which swings above and below 0V, is capacitively coupled to the op.amp stage around IC4a. A rail-to-rail op.amp is used, powered from the +5V supply line. In the presence of an output signal from the sensor, the op.amp's output swings above and below the midway level of 2·5V, as set by resistors R7 and R8. As discussed presently, the upper and lower peaks of the waveform are synchronously monitored for amplitude by the PIC.

Sensor channel two, comprising X1 and IC4b, functions in the same way as channel one.

Control Circuit

The main control circuit is shown in Fig.3. At its heart is the PIC16F876 microcontroller IC5, which is operated

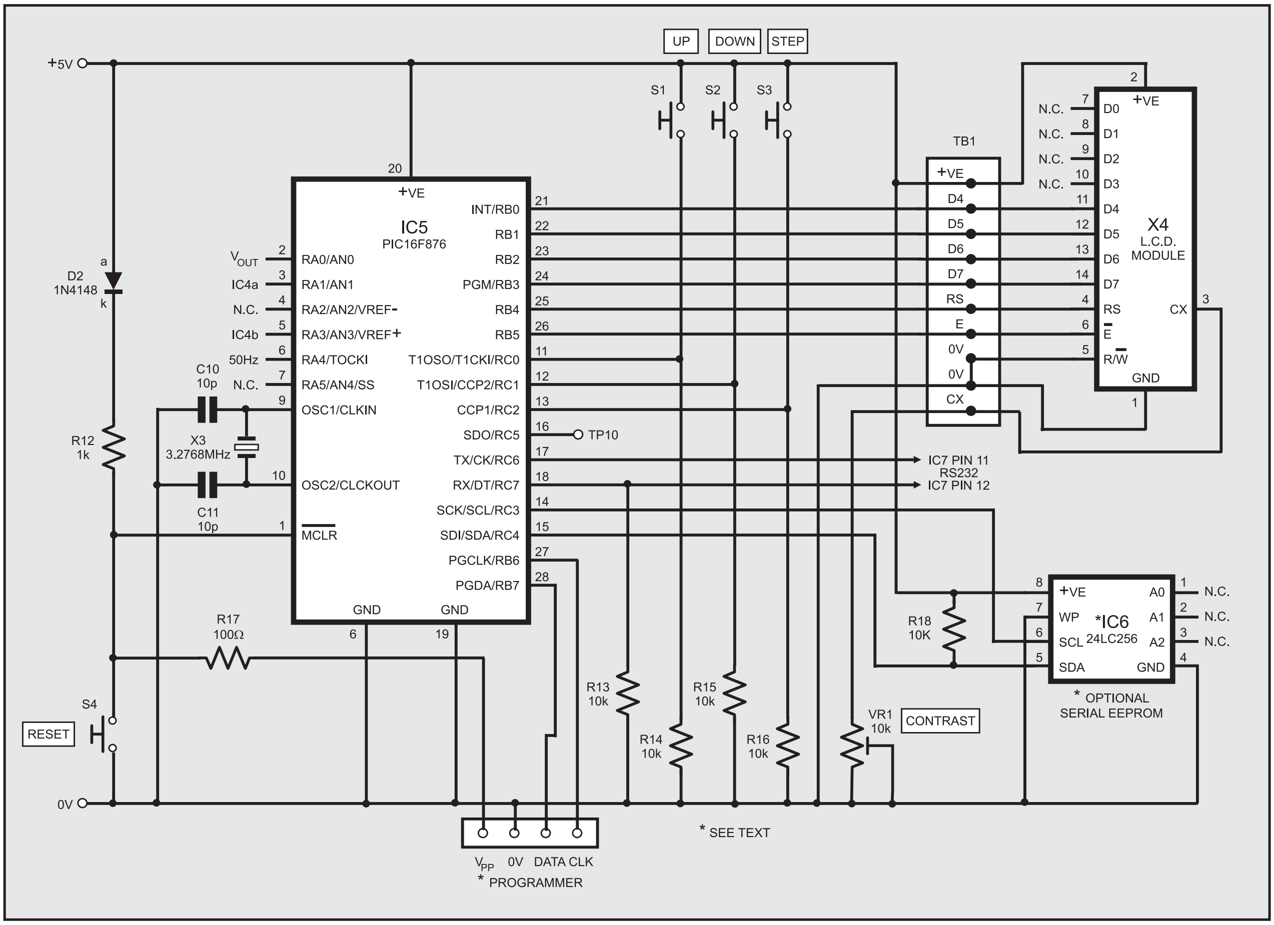


Fig.3. Main control diagram for PIC Electric Mk2.

at 3·2768MHz as set by crystal X3. Via Port B, the PIC controls the 2-line by 16 characters per line alphanumeric liquid crystal display (l.c.d.) X4, which is used in standard 4-bit mode. Its screen contrast is set by preset VR1. The switches, S1 to S4, will be discussed at relevant points later in the text.

PIC pins RA0, RA1 and RA3 are used in analogue-to-digital conversion (ADC) input mode. Pin RA4 is used as a Schmitt trigger digital input, into which is fed the 50Hz (or 60Hz) mains frequency signal via R9/D1 in Fig.1.

The rising edges of the mains frequency waveform trigger a clock counter. Every one second (50 or 60 pulses, depending on mains frequency) a clock counter (hours, minutes, seconds) is updated. At this point the PIC synchronously reads the analogue voltage levels on the three allocated inputs, converting each to a 10-bit digital value. The value on RA0 represents the equivalent voltage present at the mains supply. The values on RA1 and RA3 respectively represent the appliance current detected by the sensors.

At this moment, however, these values are just numbers as generated by the PIC's ADC conversion. Correction factors are then applied which convert the numbers to meaningful voltage and current values.

The three resulting values are then further processed to establish the wattage values that the current and voltage readings represent. From this value a cost factor in relation to the wattage is calculated, according to the value previously entered via switches into the PIC's non-volatile memory (EEPROM – electrically erasable read-only memory). This value is the cost per kilowatt-hour (kWh) as charged by your local electrical supply company.

These results are then processed in relation to the elapsed time (from the clock counter) since the unit was connected to the mains power, and "running cost" totals determined.

Results are output to the l.c.d., which is used in 2-screen mode, i.e. there are two display screens available for viewing, as selected by switch S3.

The first screen displays both appliance current values at the left, channel 1 on line 1, channel 2 on line 2, each suffixed with "A" for amps. Both values are followed by the prevailing wattage values, suffixed with "W". At the top right of line 1 is shown the present equivalent a.c. mains voltage value and below it the letter "V".

Screen 2 displays the real-time running cost for each channel, respectively on lines 1 and 2. At the right of line 2 is shown the elapsed time since monitoring started, counting up at one-second intervals. The clock's maximum hours count display is 999, after which it rolls over to zero and counts up again.

At the right of line 1 is shown the present address count of the optional external memory, discussed next.

Examples of several screen displays will be shown next month in Part 2.

External Memory

PIC Electric Mk2 has been provided with a data recording facility for those who would like to keep track of facts and figures. It is stressed, however, that the design *does not need* to be used as a logger. It is perfectly suited to using on its own as a "here and now" monitor for use around the home from time-to-time.

A single serial non-volatile memory chip is provided for data logging, IC6 in Fig.3. It is a Microchip type 24LC256, as used in several previous *EPE* logging designs. It has 256 kilobits (32-kilobytes) of 8-bit memory.

In other designs, eight of these memories can be run in parallel, with a 3-bit address value determining which one is to be accessed in response to coded commands from the PIC. In this application, the memory is used on its own and its address-setting pins (A0 to A2) are left unconnected (they are biased low within the device).

The memory is controlled by PIC pins RC3 (clock) and RC4 (data). Data is transferred serially in response to the clock signals. The data pin is bidirectional (read/write) and is provided with a pull-up resistor (R18) for use during data read.

Data is recorded to the memory at one-minute intervals, in blocks of eight bytes at a time, allowing 4096 (4K) sample groups to be recorded, just over 68 hours-worth of samples. The memory is accessed cyclically, recording to memory bytes from 0 to 32K, then rolling over to zero, and then recording over the previous memory locations, up to 32K again, and so on.

To maintain program simplicity in respect of the rollover point, the number of bytes used for each sample has been set at the "round" binary number of 16, which divides evenly into 32768 (32K). At each minute interval two bytes for the voltage are recorded, two bytes each for both current channels, with two bytes left over. To one of these is recorded a "flag" which indicates at what point in the memory count the unit has been switched on. The other is set to zero and ignored.

When each batch of samples is recorded at one minute intervals, the present memory count is also recorded to the PIC's own internal non-volatile memory. This memory, and the main 32K serial memory, retain data even after power has been disconnected.

Each time power is re-applied, the PIC's internal memory is read for various correction values, and also for the latest memory address from which to continue the recording count. The above marker "flag" is set at this point.

When the serial memory is downloaded to a PC (which may be done at any time), the screen displays waveforms relative to the recorded volts and amps values, and also shows marker lines indicating the start of each powered session, as recorded by the "flag".

Also, when the memory is downloaded, the current memory address count is copied to the PC so that the data can be shown in the correct time sequence – oldest data first, newest last (at screen right).

RS232 Interface

The RS232 serial interface circuit is shown in Fig.4. This circuit's components may be omitted if the logging facility provided by IC6 is not required.

The interface allows the logged data to be copied to a PC computer, according to the industry-standard RS232 protocol and voltage levels. It is used in bidirectional mode to allow the PIC and PC to exchange handshake signals to main the correct data synchronisation. Data exchange is set at 9600 Baud, 8-bits, no parity.

Resources

Software, including source code files, for the PIC unit and PC interface is available on 3.5inch disk from the Editorial office (a small handling charge applies –see the *EPE PCB Service* page) or it can be downloaded *free* from the *EPE* Downloads page, accessible via the home page at **www.epemag.co.uk**. It is held in the PICs folder, under PIC-Electric Mk2. Download all the files within that folder.

This month's *Shoptalk* provides information about obtaining pre-programmed PICs.

The PIC program source code (ASM) was written using *EPE Toolkit TK3* software (also available via the Downloads page) and a variant of the TASM dialect. The run-time assembly is supplied as an MPASM HEX file, which has configurations embedded in it (crystal XT, WDT off, POR on, all other values off).

The PC interface software was written under Visual Basic 6 (VB6), but you do not need VB6 to be installed on your PC in order to run it.

Whether or not VB6 is installed, copy *all* of the PIC-Electric files (except the PIC files if you prefer) into a new folder called **C:\PIC Electric Mk2**, or any name of your choosing, on Drive C (the usual hard drive letter).

If you do not have VB6, you also need three other files, **comdlg32.ocx**, **Mscommctl.ocx** and **Msvbm60.dll**, held on our 3.5inch disk named Interface Disk 1, and in the Interface folder on our Downloads page (they are also included with the *TK3* software, in Disk 2). These files must be copied into the same folder as the other PIC-Electric Mk2 files.

These three files are not supplied with the PIC-Electric software as they are common to several *EPE* VB6 projects and amount to about 1MB of data.

Additionally, the VB6 source code makes use of Joe Farr's excellent *Serial Interface for PICs* (Oct '03) software. In order to access (and perhaps modify for your own purposes) the PIC-Electric VB6 source code files, you need to have Joe's software installed on your PC as well (see his published text). This is also available via our Downloads page.

Without Joe's software installed, if you try to access the PIC-Electric source code, it will crash.

Note that you should not attempt to "instal" the PIC-Electric VB6 files via Explorer or other similar PC facility. Use Windows' own normal Copy facility.

Construction

There are two printed circuit boards for this design – one for the power supply and sensors, and one for the control circuit.

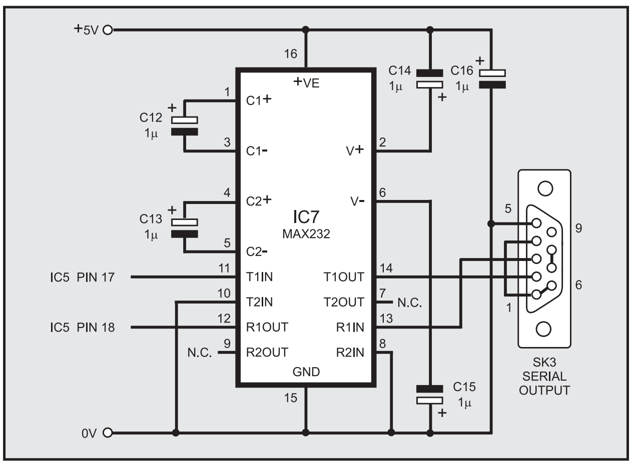


Fig.4. Optional serial interface circuit.

COMPONENTS

Resistors

R1, R4, R17	100Ω (3 off)
R2, R3, R5 to R8	100k (6 off)
R9, R10, R13 to R16, R18	10k (7 off)
R11	3k3
R12	1k

All 0·25w 5% carbon film

See SHOP TALK page

Potentiometer

VR1	10k preset, round

Capacitors

C1, C2	470µ radial elect. 25V (2 off)
C3 to C7, C17, C20	100n ceramic disc, 5mm pitch (7 off)
C8, C9	22µ radial elect. 16V (2 off)
C10, C11	10p ceramic disc, 5mm pitch (2 off)
C12 to C16	1µ radial elect. 16V (5 off) – see text
C18, C19	100p ceremic disc, 5mm pitch

Semiconductors

D1	4V7 400mW Zener diode
D2	1N4148 signal diode
REC1	W005 1A 50V bridge rectifier
IC1	78L15 +15V 100mA regulator
IC2	79L15 –15V 100mA regulator
IC3	78L05 +5V 100mA regulator
IC4	LMC6482 dual op.amp, rail-to-rail
IC5	PIC16F876 micro controller, pre-programmed (see text)
IC6	24LC256 serial EEPROM (optional – see text)
IC7	MAX232 RS232 interface (optional – see text)

Miscellaneous

S1 to S4	min s.p. push-to-make switch (4 off)
T1	min. mains transformer, 2 x 120V a.c. primaries 2 x 12V secondaries, 1·5VA per secondary, p.c.b. mounting
X1, X2	Hall effect current transducer RS286-311 (X2 optional - see text)
X3	3.2768MHz crystal
X4	2-line x 16-character (per line) alphanumeric l.c.d.

Printed circuit boards, available from the *EPE PCB Service* code 487 (Control) and 488 (Sensor); metal case, minimum 190mm x 110mm x 60mm; 8-pin d.i.l. socket (2 off); 16-pin d.i.l. socket; 28-pin d.i.l. socket; mains screw-terminal block strip, to suit; mains cables, plugs and sockets, to suit; connecting wire; solder, etc.

Approx. Cost Guidance Only **£75**

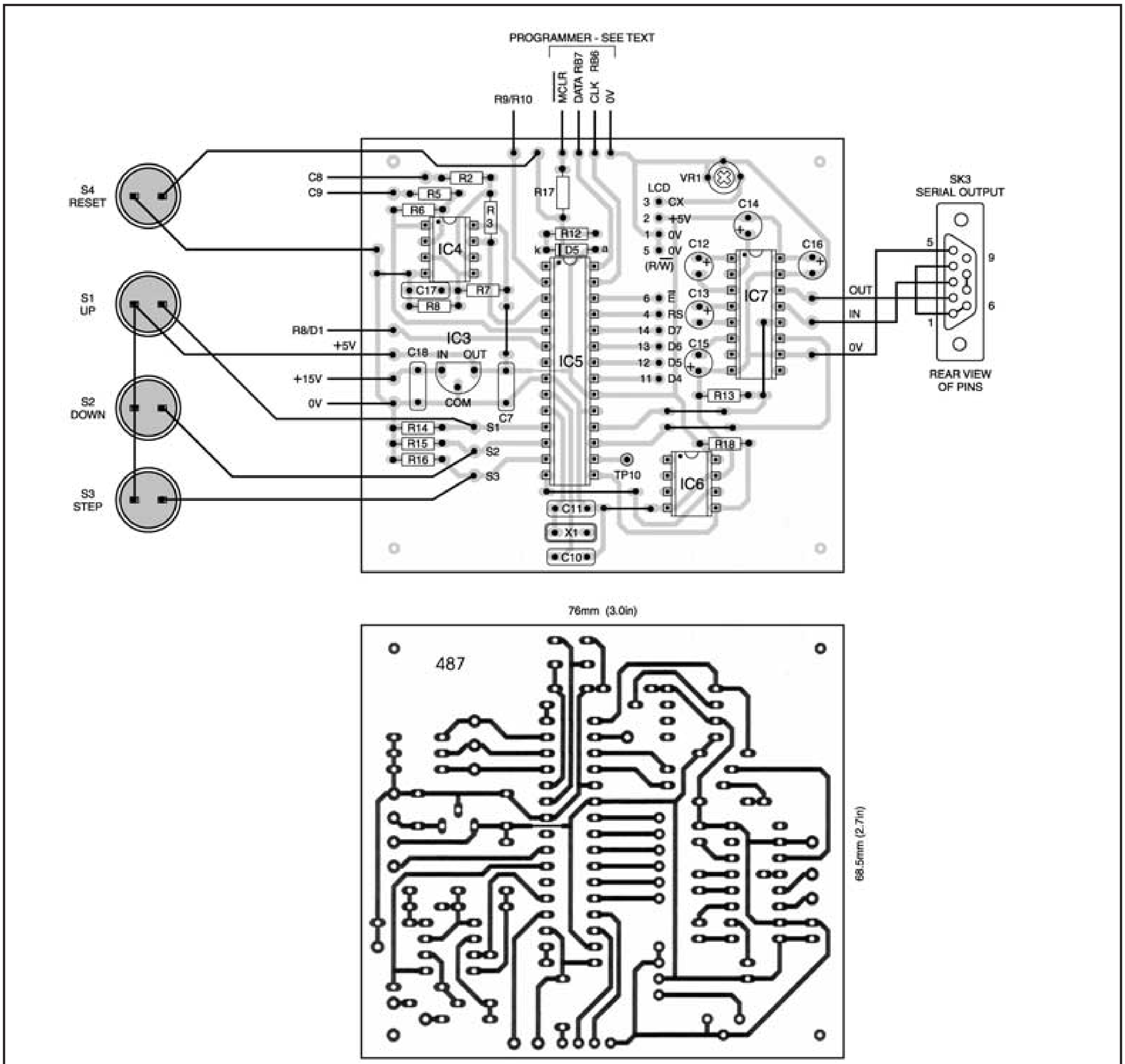


Fig.5. Component layout and master track pattern for the main Control board.

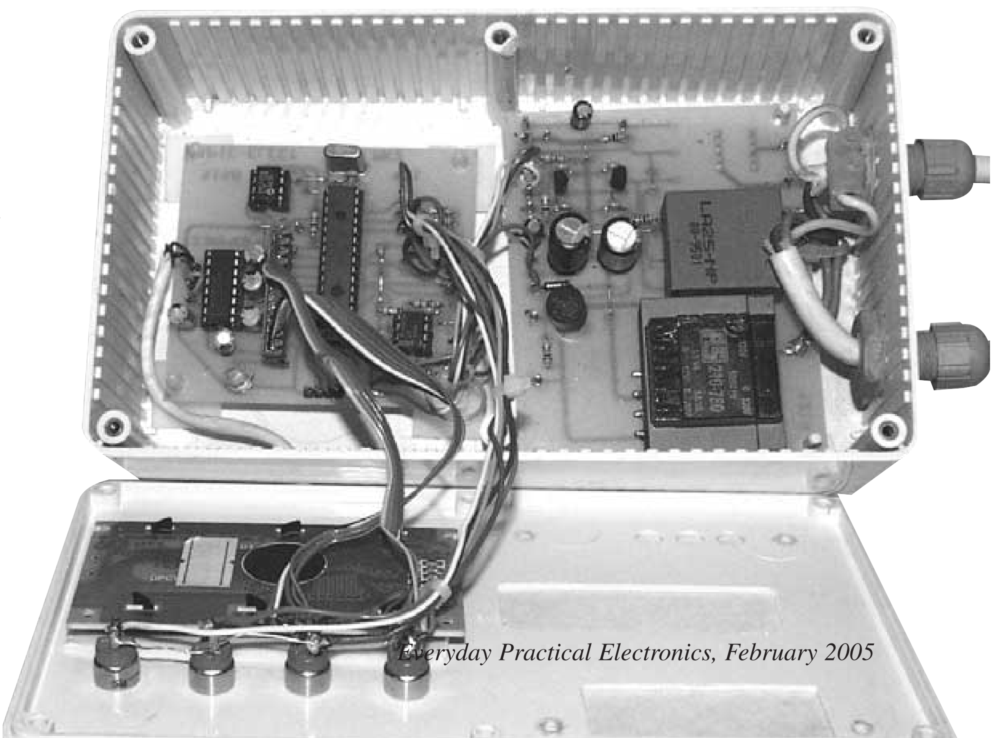
These boards are available as a pair from *EPE PCB Service*, codes 487 (Control) and 488 (Sensor). Their component and track layout details are shown in Fig.5 and Fig.6.

It is again stressed that this mains powered design should only be built by those who are suitably qualified or supervised.

As usual, assemble the boards in order of ascending component size, starting with the few on-board link wires. Correctly observe the polarity of electrolytic capacitors and semiconductors. Do not insert the dual-in-line (d.i.l.) i.c.s into their sockets, or insert sensors X1 and X2, or connect the l.c.d., until valid operation of all aspects of the power supply has been proved.

Enclosure and Wiring

The unit should be housed in a good-quality metal box suitable for enclosing mains powered circuits. Locking cable grommets should be used for the mains input and output cable holes, drilled at one



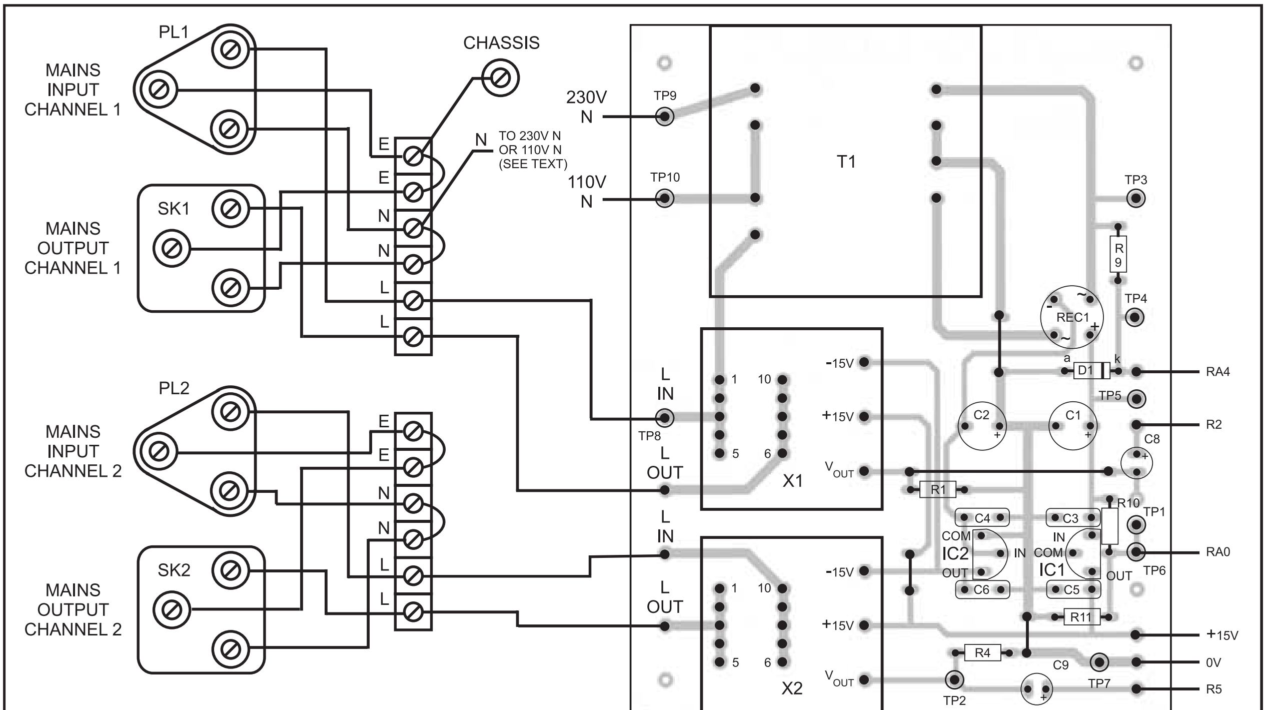
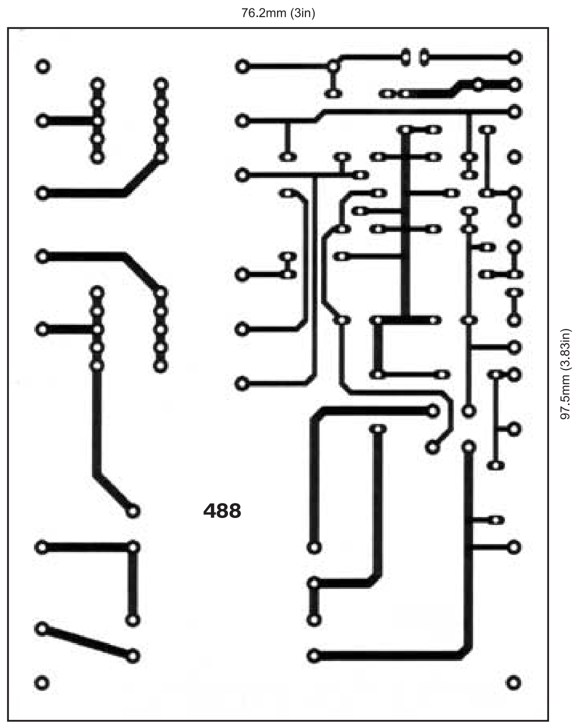


Fig.6. Component layout and master track layout pattern for the Sensor board



end of the case. A slot needs cutting in the lid for the l.c.d. and holes drilled for the switches. The serial connector SK3, if used, should be mounted at the opposite end of the case to the mains cables.

Ventilation holes were not found necessary with the prototype, but if they are preferred, ensure that they do not allow objects to be inserted that could come into contact with the mains connections. The latter should also be covered with insulating tape to prevent inadvertent electrical contact with them.

The mains power cables should be of a size appropriate to the current which they are expected to carry. Although the sensors are capable of monitoring 25A of current, the limit for normal domestic power cables and connectors in the UK is 13A. The plugs and sockets used with the cables should be chosen to suit the supply standard of the country in which this design is to be used. Use suitably-rated terminal strip connectors on the inside of the case.

The neutral (N) connection to the p.c.b. for channel 1 should be made to the point designated for the supply voltage rating in your locality. The metal box **must** have a wired connection between it and the earth (E) lead of the mains input cable for channel 1.

Note that the mains-carrying tracks on the p.c.b. should be reinforced with suitably-rated solid connecting wire to allow the maximum permissible current to be conducted through them.

Power Supply Test

Normal mains safety procedures must be observed with all the tests now described. The power must be disconnected when making changes to the assembly.

With the sensors, d.i.l. i.c.s and l.c.d. omitted, apply power to the unit. Monitor the output voltage at regulators IC1, IC2 and IC3, which should respectively be at +15V, −15V and +5V (within a few per cent) with reference to the 0V line. DO NOT take any readings with reference to mains neutral or mains earth unless specifically stated.

Additionally check that the voltage at test point TP6 is below the maximum allowable limit of +5V. If an oscilloscope is available, check that the 50Hz (or 60Hz) waveform at TP4 is swinging between 0V and about 4·7V.

If any voltage readings are incorrect, immediately disconnect the power and find out why.

When the power supply has been proved, the sensor(s) may be inserted and soldered into position. As said above, reinforce the p.c.b. tracks to suit the maximum current expectation.

With power re-applied, but without an appliance being monitored, check that the ±15V supply lines are still correct.

Next Month

In Part 2 next month we conclude by describing PIC Electric's testing, alignment and optional use with a PC and customised software.

TECHNO-TALK ANDY EMMERSON

PIE IN THE SKY?

Look to the sky - is it a bird or a plane? It's certainly not Superman but a new wireless Internet service using tethered balloons and circling aeroplanes as antenna platforms. According to Andrew Emmerson it's pure science fiction and another example of ignoring the lessons of history.

LAST December saw the announcement that £2.1 million from the European Union's Framework Programme was to be devoted to a hare-brained scheme to make broadband Internet available to all by means of solar powered aircraft. Had the announcement's date been the first of April, I would have smiled at this wizard wheeze but sadly these mischief makers are for real.

Stratospheric Broadband

Their project goes by the name of Capanina and brings together some 13 partners from across Europe and Japan. Under the banner "stratospheric broadband", the declared intention is to develop broadband capability from aerial platforms as a cost-effective solution and viable alternative to cable and satellite.

The Capanina proposal is based around aircraft or airships operating as "High Altitude Platforms" (HAPs) located permanently in the sky. Placing these HAPs at an altitude of 20 kilometres – well above the flight path of normal aeroplanes but below satellites – will, the proponents claim, provide a cheaper and more efficient solution than those currently available, as HAPs do not require underground cabling or masts.

The fact that most countries are already well provided with cabling and antenna structures is ignored in their sales pitch, which instead concentrates on their goal of delivering broadband connections to rural areas across Europe – the areas where there is least demand for this service – within the next four years.

"The opportunities offered by HAPs are exciting as they could deliver broadband connections which are 2,000 times faster than a traditional modem and 200 times faster than today's 'wired' ADSL broadband", says Peter Walters, FP6UK National Contact Point for the programme. "Demand for fast communication is increasing all over the world, and this technology offers an innovative way of delivering broadband inexpensively to people at home, in the office or on the move."

Failed Projects

Innovative it may be but convincing it's not. In fact there's nothing in the programme to demonstrate either a commercial case or practical feasibility. The roster of failed sky-platform projects is not exactly short either. In 2003 York-based telecomms firm SkyLINC declared it would build a network of base stations for delivering broadband to rural communities from tethered balloons 1·5km up.

A year previously a startup company in the USA called SkyTower Telecommunications announced it would launch solar-powered "Helios" unmanned aeroplanes that would circle for six months, transmitting bargain-priced broadband Internet, 3G cellular and high-definition TV service.

Before this, Angel Technologies (1992), SkyStation International (1996), Platforms Wireless International (1996), RotoStar (1997) and Space Data Corporation (1997) all announced similar schemes involving helium blimps or high-altitude aircraft. And surprise, surprise, not one of these has come to fruition.

Lost in Space

The money sunk and lost without trace on all those projects belonged to private investors, who presumably could afford to throw good money after bad. What makes the Capanina project different from all previous incarnations of the same idea is that public money is involved. And £2.1 million is not exactly small change.

Worse, not one of these schemes demonstrates that its proponents have researched the practicalities. Tethered balloons – aerostats to give them their "technical" name – require, well, tethering and the height at which they must fly (but not fly away) means you will need some pretty strong guy wires to keep them in place. Mechanical problems to overcome arise from megalightning, gales and icing, both on the ropes and on the aerial platforms (blimps or drones).

Even if these hurdles are not insuperable, the hazard to aircraft trying to avoid the tethers will be far more difficult to overcome. Whilst costs per customer may be lower than satellite or landline connection, it is only fair to say that these schemes will need many more balloons or aircraft than they would satellites for the same coverage and they will find the stratosphere a harsher environment than outer space.

There is plenty of case history to demonstrate the impracticality of these schemes too; the idea of transmitting from airborne platforms such as aeroplanes or tethered balloons has never found much favour. There have been some remarkable plans in the past (see panel), even a few successful experiments, but generally the schemes have never really fulfilled the expectations of their architects.

Stratovision

The only successful projects of transmitting from aeroplanes have been American, first "Stratovision" transmitting educational TV to schools in the 1950s and then over Vietnam with televisual entertainment to troops during the ill-fated war of the 1960s. Radio Caroline proposed commercial television over northern England but it never managed to get off the ground. Technically these schemes were feasible but also very expensive.

Success with tethered balloons has been far more patchy and about the only scheme that worked has been TV Marti, beaming propaganda television from an aerostat over Cudjoe Key (Florida) to the Cubans (whose government has been very successful at jamming the signal in the Havana area, using both helicopter-borne jammers and scores of small units mounted on utility poles).

Other schemes have turned out complete failures; probably the most recent attempt to use sky-hooks was the ill-fated "pop pirate" radio ship *Laser 558*, anchored off the British coast in the North Sea. A tethered balloon intended to hold aloft the antenna wires lasted only a short while; the motion of the ship and arc currents from the aerial soon put paid to this ingenious scheme.

The last word just has to go to Internet commentator Lloyd Wood, who likens the whole concept to the secret Cloudbase headquarters of children's telefantasy series Captain Scarlett; the truth is always less believable than fiction!

A Brief History

Britain's balloon came first! After the last war there was great pressure to extend the previously London-only television service to the rest of the country. Unfortunately there was neither sufficient finance nor manufacturing or manpower resources to achieve this by conventional means.

Arthur C. Clarke had already described his scheme for broadcasting using artificial satellites, however, and it may have been this which inspired the Post Office's scheme for an aerial suspended from a tethered balloon! Conceived in 1947, the most direct inspiration may have been the sight of the wartime balloon barrage of the London skyline during the war years.

The designer, John Bray, died only recently and in his memoirs he wrote: "The proposal was to use frequencies above 1000MHz (at which useful gain and directivity could be achieved by aerials of practicable size). Full coverage of the whole of the United Kingdom could have been provided by six such systems at heights of about 5,000ft. Since the aerial system was wholly passive and could have a wide frequency bandwidth it could be used simultaneously for broadcasting and for picking up signals from a similar system up to about 150 miles away, or from mobile units for outside broadcast purposes."

News . . .

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

Oyez, OLED TV Screening Shortly!

An alternative to LCD screens is imminent, and partly thanks to printer company Epson. Barry Fox reports

EPSON is now promising that OLED TV screens, made from Organic Light Emitting Diodes, can be made for half the price of an LCD screen of the same size – and be ready for sale by 2007. The surprise claim came out of the European Business and Technology Forum in London hosted by Seiji Hanaoka, Executive Vice President and Chief Technology Officer of the Seiko Epson Corporation.

Epson's Strategy

With press flown in from around Europe, the promise was to "present Epson's business strategy and vision of digital imaging in tomorrow's world." Much of the event was little more than a sales pitch for Epson's ink jet printers and LCD projectors, because 80% of all LCD projectors use Epson panels – with 0.9in (2.29cm) projector panels promised for May 2005.

The LCD screen market is sewn up by Philips, Samsung, LG, Sony and Sharp. So Shoichi Iino, General Manager of the OLED Development Division, was not undermining Epson's current business by promising big things from OLEDs. "It is the display technology of the future" said Iino confirming that LCD development would continue, with Epson and Sanyo now in partnership.

"OLED is thin, beautiful and affordable. OLED has superior speed, contrast and viewing angle to LCD". The colour chemicals are applied as lines of spots by an inkjet printer – with ±15 micron accuracy, to give 200 pixels per inch. OLED target lifetime is 10,000 hours, with end of OLED lifetime defined as a brightness loss of 20%.

"We will hit that target by 2007," claimed Iino. "We have built a 40in (101.6cm) XGA panel and its lifetime is 2,000 hours. OLED panels can be thin, and large or small. They are thinner and simpler than LCD or plasma. The cost will theoretically be 50% less than LCD because there is no backlight or polarizing panels."

Moving Greetings

A slide suggested that OLEDs will be used to make greetings cards with moving pictures – but there was no practical demonstration. Iino also regretted that he could not show the 40in prototype because "it was too big to fit in my suitcase". But transport problems had not prevented Epson from bringing in many more prototype products, including a miniature 12.3gm helicopter robot controlled by Bluetooth, and three smaller OLED screens.

Nick Butler, MD Epson UK, promised OLEDs for home entertainment by 2007, but small screens only. A working 2.1in (5.3cm) OLED Active Matrix screen with 262,144 colours and power drain of 150mW, looked very impressive, with bright pictures and good colours, and no smear on moving video. A 5.5in (14cm) version with similar specification and drawing 2W looked equally impressive.

A 12.5in (31.7cm) screen was housed in a case, which vibrated slightly to the touch suggesting the presence of a fan inside. There were no specification details for this larger screen. The 12.5in pictures were equally impressive, though, even on a sequence showing fireworks against a dark sky. But the prototypes were very obviously prototypes, with ribbon cables attached.

Future Confident?

Says Sarah Carroll of market analysts Understanding & Solutions: "OLED does offer significant cost savings. However the life of the product is still a very significant issue and they themselves are talking about commercial introduction in 2007, which is a lifetime in this business – and allows LCD and plasma to gain further ground."

Subwoofers for Audiophiles and Savings

B.K. Electronics, whose colour ads have graced our back covers for many years, have told us that their XLS200 subwoofers are now offered direct to the public, and that savings of up to £300 can be made compared to similarly specified subwoofers.

B.K. have manufactured at least 100,000 award winning and highly acclaimed subwoofers for OEMs (original equipment manufacturers) such as Rel Acoustics and Rega etc. It is with this depth of experience in designing and building quality subwoofers that B.K. now offer the XLS200 to the public.

The XLS200 uses a Peerless XLS10 drive unit that is amongst the world's best and highly regarded drive units, coupled with the BSBP200 sub-bass amplifier to give precise control and flexibility. There are two versions available to suit most tastes, the XLS200 which is forward firing, and the XLS200-DF which is downward firing.

Further information on these subwoofers can be found on B.K.'s website at **www.bkelec.com/new/**. The company's other contact details are, B.K. Electronics, Dept. *EPE,* Unit 1, Comet Way, Southend-on-Sea, Essex. Tel: 01702 527572. Fax: 01702 420243.

Watching While Training

Train delays should now be a lot easier to bear. British company Goodmans is now selling a vest pocket video player that lets people watch movies on the move without the need to carry a DVD player.

The £200 GPDR1 uses MPEG-4 compression to record two hours of video in a 256MB memory card at 320Kbps. The video can be copied from a TV set, VCR or DVD. Goodmans believe that because the device only makes a temporary recording to solid state memory, and can only show video on its own 6.4cm l.c.d. colour screen, it does not need to incorporate the copy protection circuitry used in video disc or tape recorders, to stop them recording movies.

Because there is no disc to spin – as in an iPod or portable DVD player – rechargeable batteries last at least two hours.

The GPDR1 also records 10 hours of MP3 music or shows over 3000 JPEG still pictures. If the train is really late, it works as a dictation machine for recording many long angry letters.

Barry Fox

MAPLIN FOR BIG BOYS?

Maplin is now rivaling the Innovations catalogues for enticing hyperbole. A recent Big Boys Toys catalogue offers a "full function calculator with a dark secret", for £20. The calculator comes with a pair of wireless headphones. Put the calculator on a conference table, or living room table, go into another room and listen on the headphones to whatever is being said.

What intrigues most, however, is a whole gaggle of "Shocking" gismos. Previously Maplin had sold a fly swatter, like a tennis racket, that fries insects with a high voltage spark. Now a pen, cigarette lighter and Roulette wheel all have one thing in common; they contain a hidden electric shock coil. The pen, which is "great fun for the office", shocks when you press the top; the lighter delivers a belt when the flame lights; and the Roulette wheel rewards the unlucky loser with a nasty surprise.

Each of these Shocking Big Boys Toys comes with the same warning: "This is not a toy – do not play if you suffer from epilepsy, a heart condition or any similar related illness". So it will pay to be wary of anyone in the home, pub or office who casually asks you about epilepsy or heart disease – or generously offers a free calculator.

Barry Fox

Crystal Cold Audio

Here's an intriguing innovation, as outlined in a press release recently received, which says:

With the never-ending search for a purer quality of sound with the music and Hi-Fi Industry, the technological boundaries are being pushed as never before. Rising to the challenge for crystal clear sound, Crygenic Treatment Services ... are proving a specialist cryogenic process for improving the performance of cables, circuit boards and other electronic equipment.

Although relatively new to the music and Hi-Fi Industry, the cryogenic treatment of cables and circuit boards is gradually being considered by many as an important factor in assisting with the reproduction of a pure and transparent sound signal.

For more information contact Cryogenic Treatment Services Ltd, Dept EPE, Mansfield i-Centre, Hamilton Way, Mansfield, NG18 5BR. Tel: 01623 600830. Web: www.195below.co.uk.

Constructional Project

Sneaky

by Mike Boyden

A covert communication system for magicians and spies

FOR a number of years the author has used simple magical tricks to entertain friends at parties and gatherings. The art of confounding an audience is a unique pleasure and all the more fun when the audience is in close proximity to the deception and the group is still unable to work out how the trick works. The author is also interested in electronics and as a consequence of combining these two hobbies, Sneaky was developed.

Sneaky is basically a two-unit one-way radio communication system. One unit, the Slave, is worn by the magician and the other unit, the Master, is worn by the assistant. The transmission path is unidirectional, that is, data can only be passed from the Master to the Slave. Exactly how the Sneaky pair are used in front of an audience is explained later.

Experimenting

Initial experiments were conducted using widely available low-power radio links, operating in the UHF band. The devices at first appeared to fit the overall design requirements being physically small, having low electrical power needs, requiring no operating licence and obtainable at a reasonable price.

Although these units can operate over distances of approximately 100m, the initial results were disappointing, due to reliability issues. It was only when these units were given an improved signalling system, overseen by a PIC microcontroller, that a fully functional system became a practical proposition. The final system has been tested at a number of gatherings and found to work reliably, whilst remaining undetected.

Sneaky Master

The circuit diagram for the Master transmitting unit is shown in Fig.1. It comprises a 433MHz low-power f.m. transmitter, IC2, coupled to a PIC16F628 microcontroller, IC1, operating at 4MHz, as set by crystal (or ceramic resonator) X1. Using a crystal-controlled frequency helps to maintain good synchronisation between the asynchronous transmissions.

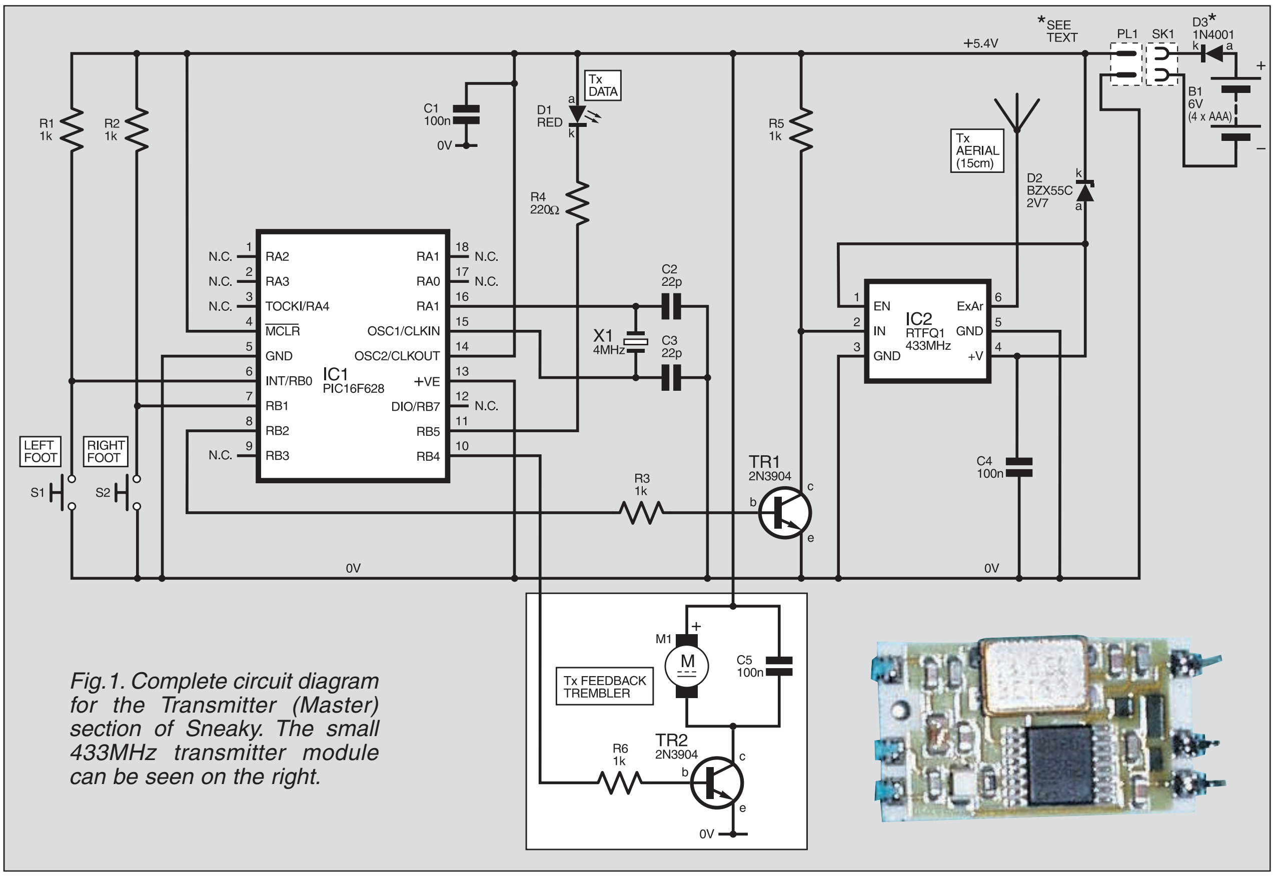


Fig.1. Complete circuit diagram for the Transmitter (Master) section of Sneaky. The small 433MHz transmitter module can be seen on the right.

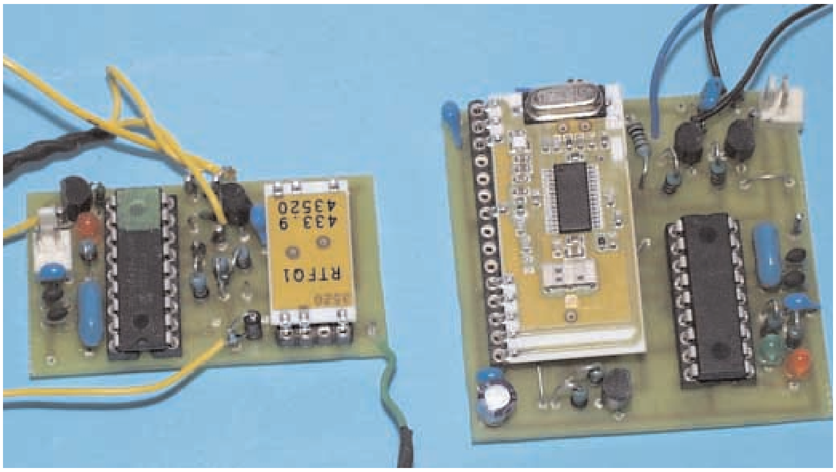
Covert signalling is accomplished by means of pushbutton switches, S1 and S2. These are operated by the assistant's right and left feet and coupled to the PIC by thin wires passing inside the assistant's trousers.

When the PIC detects a switch press, it outputs a coded stream of pulses from its pin RB2. The format of the pulse stream depends on which switch is pressed. The pulses are fed via buffer resistor R3 to transistor TR1, whose collector output feeds them to the transmitter module, IC2.

So that the assistant knows that a foot switch has been correctly pressed, a "trembler" is used as the covert signalling device. These units are simply small motors that vibrate when energised. When the PIC is outputting data to the transmitter, its pin RB4 turns on trembler motor M1 via transistor TR2. Resistor R6 buffers the PIC's output line, and capacitor C5 decouples the voltage across the motor.

While transmission is taking place, Tx Data l.e.d. D1 is turned on by PIC pin RB5. Resistor R4 is the l.e.d.'s ballast resistor.

The transmitter is powered at 3·3V, a voltage which *must not* be exceeded. In this design the battery-provided 6V supply is dropped to 3·3V by the insertion of Zener diode D2 between it and the transmitter.



The Prototype transmitter and receiver circuit boards that make up Sneaky

Sneaky Slave

The circuit diagram for Sneaky's Slave Receiver is shown in Fig.2. The 433MHz receiver module is notated as IC2. The data output pulses from IC2's pin 14 are first buffered by resistor R8 and transistor TR3, and then fed to pin RB1 of the second PIC16F628 microcontroller, IC1.

The PIC decodes the pulse train and, depending on the code, activates one of the two trembler motors, M1 or M2, via pins RA3 and RA4, resistors R1 and R2, and transistors TR1 and TR2. Resistor R3 is required to positively bias pin RA4 as this is an open-collector output. This PIC is also controlled at 4MHz, as set by crystal X1.

An important design requirement for the receiver is that any loss of signal is reported to the wearer immediately. This is one of the tasks managed by the PIC and two independent checks make sure that the loss of the r.f. (radio frequency) link or data transmission errors are quickly signalled.

The receiver module IC2 generates an output voltage (RXSL) at pin 13, relative to the received signal strength. This is fed to PIC pin RA2, which is used in comparator mode. The software monitors this input and compares it with a reference voltage at pin RA1, also used in comparator mode.

The reference voltage is set by preset potentiometer VR1. The voltage across VR1 is regulated at approximately 3·0V by Zener diode D1 and resistor R4. Preset VR1 is set so that the voltage at its wiper, and thus RA1, represents the minimum received signal strength below which the link quality is deemed to be unacceptable.

Tests showed that RXSL should be about 2·5V for a fully functional link, dropping to 1·0V for an unacceptable link. Consequently, setting a voltage of approximately 1·5V at the wiper of VR1 includes a safety margin before a "signal loss" error is indicated. Should the RXSL voltage fall below the reference voltage, then the error condition is signalled by fully turning on both the right and left tremblers whilst the fault condition persists.

When data is *not* being received, Rx Error l.e.d. D2 is turned on by PIC pin RB5, ballasted by resistor R5. When it is being correctly received, Rx Data l.e.d. D3 is turned on by RB4, ballasted by R6.

Power Supply

To eliminate the possibility of a unit becoming inadvertently turned off, there are no power switches in the prototypes.

The battery power leads are connected directly to the p.c.b.s by means of locking plugs. Each power lead also contains a diode (D3 and D4 in Fig.1 and Fig.2) respectively, which is used to reduce the 6V supply to approximately 5·4V.

Magical PICs

Although there are two boards, each PIC uses the same software (see later). PIC pin RB7 on each PIC is used to detect into which board the device is plugged, and this

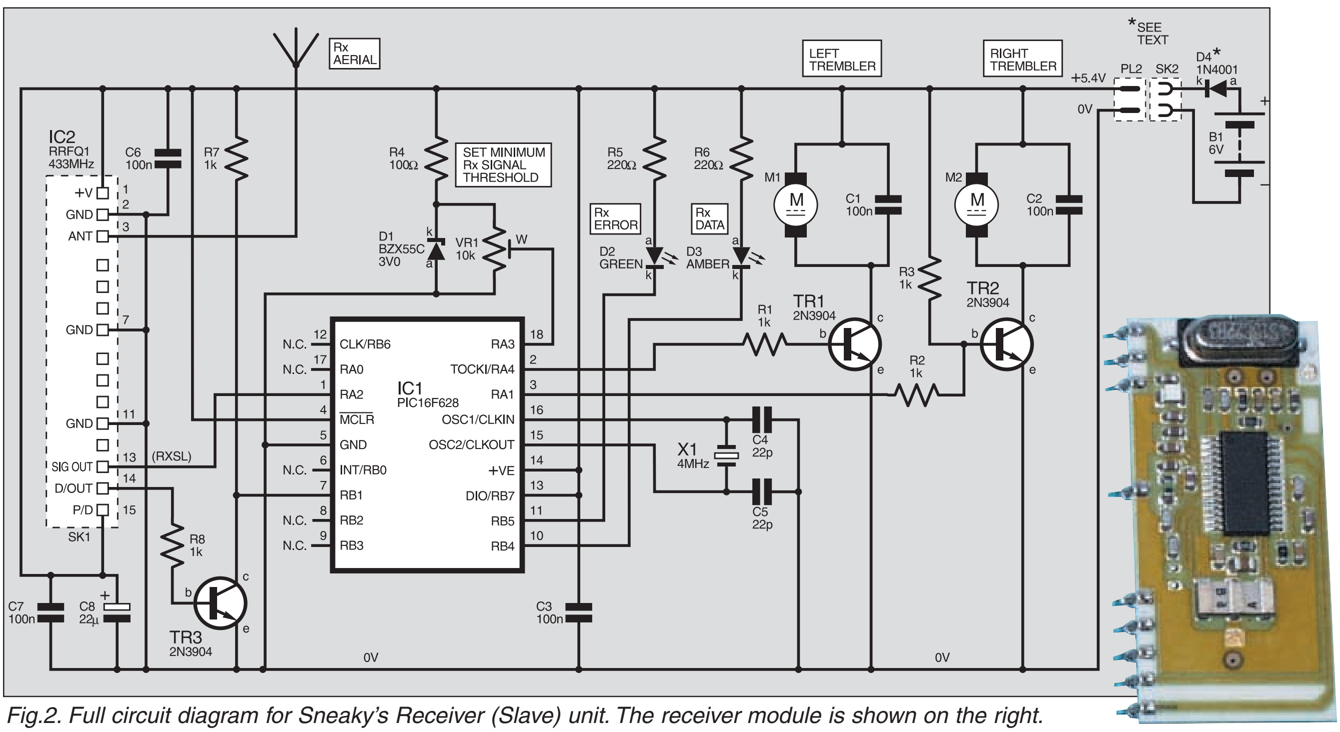


Fig.2. Full circuit diagram for Sneaky's Receiver (Slave) unit. The receiver module is shown on the right.

enables the relevant code routine to be automatically executed.

When power to the transmitter unit is switched on, the PIC initialises itself for asynchronous communication at 2400 Baud. It then continuously sends the ASCII code for letter “Z”, see Fig.5, unless a footswitch press is detected. This continuous transmission can be thought of as the system’s “heartbeat” and is used by the receiver to check the presence of the transmitter.

If footswitch activation is detected, then the switch closure is debounced and either the ASCII code for “A” or “B”, is transmitted, indicating which switch was pressed.

COMPONENTS

TRANSMITTER (MASTER)

Resistors — See **SHOP TALK** page

R1 to R3, R5, R6	1k (5 off)
R4	220Ω

All 0·25W 5% carbon film or better.

Capacitors

C1, C4, C5	100n ceramic disc, 5mm pitch (3 off)
C2, C3	22p ceramic disc, 5mm pitch (2 off)

Semiconductors

D1	5mm red l.e.d.
D2	BZX55C 2V7 Zener diode
D3	1N4001 rectifier diode
TR1, TR2	2N3904 *npn* transistor (2 off)
IC1	PIC16F628 micro controller, preprogrammed (see text)
IC2	RTFQ1 433MHz transmitter module

Miscellaneous

S1, S2	single-pole normally-open click switch (2 off)
M1	6V d.c. trembler motor (see text)
X1	4MHz crystal (or ceramic resonator)
PL1/SK1	2-way, p.c.b. mount ing, keyed pin-header (male) and matching 2-pin (female) socket
B1	6V battery pack (4 x AAA)

Printed circuit board, available from the *EPE PCB Service*, code 485 (Trans); 18-pin d.i.l. socket; s.i.l. socket strip for TX module; metal case, size and type to choice; multi-strand connecting wire, including 15cm piece for aerial; heatshrink sleeving; solder pins; solder etc.

Approx. Cost Guidance Only **£18**

Excl. case & batteries

On receipt of characters “A” or “B”, the appropriate trembler is activated for about one second. Invalid switch combinations, e.g. both pressed together, are ignored.

Once the letters “A” or “B” are sent then the repetitious “heartbeat” character transmission is resumed. Its receipt is continually verified by the receiver’s PIC and any unexpected absence triggers a fault alarm condition. This alerts the wearer that a loss of communication with the master has occurred, and a move to a better location to recover the link can be made.

Construction

Component and track layout details for the Transmitter and Receiver are shown in Fig.3 and Fig.4 respectively. These boards are available from the *EPE PCB Service* codes 458(Trans.) and 486(Rec.).

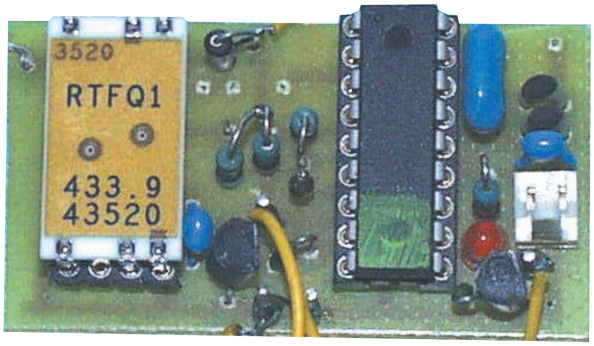
Assemble the boards in the suggested order of ascending component size. Use sockets for both PICs, the transmitter and the receiver. A single-in-line (s.i.l.) socket cut to length is suitable for the latter devices. Do not insert any of these four devices on their boards until after the assembly has been fully checked. Observe the correct orientation of all polarity-sensitive components, such as the electrolytic capacitors and all semiconductor devices.

The tremblers in the prototype were originally adapted from 3V cassette recorder motors. A blob of solder placed onto the brass motor shaft, created the necessary eccentric rotation and hence vibration. However, a source of commercial tremblers is given in *Shoptalk*, but the connections to these units need to be made more rugged.

Once the solder connections have been made and tested, the entire trembler unit should be enclosed in 20mm heatshrink sleeving, with the wires trapped underneath. By applying heat, the sleeve will shrink tightly around the trembler and wires, thereby improving durability.

First Test

As previously said, the transmitter sup-



Completed prototype Transmitter board.

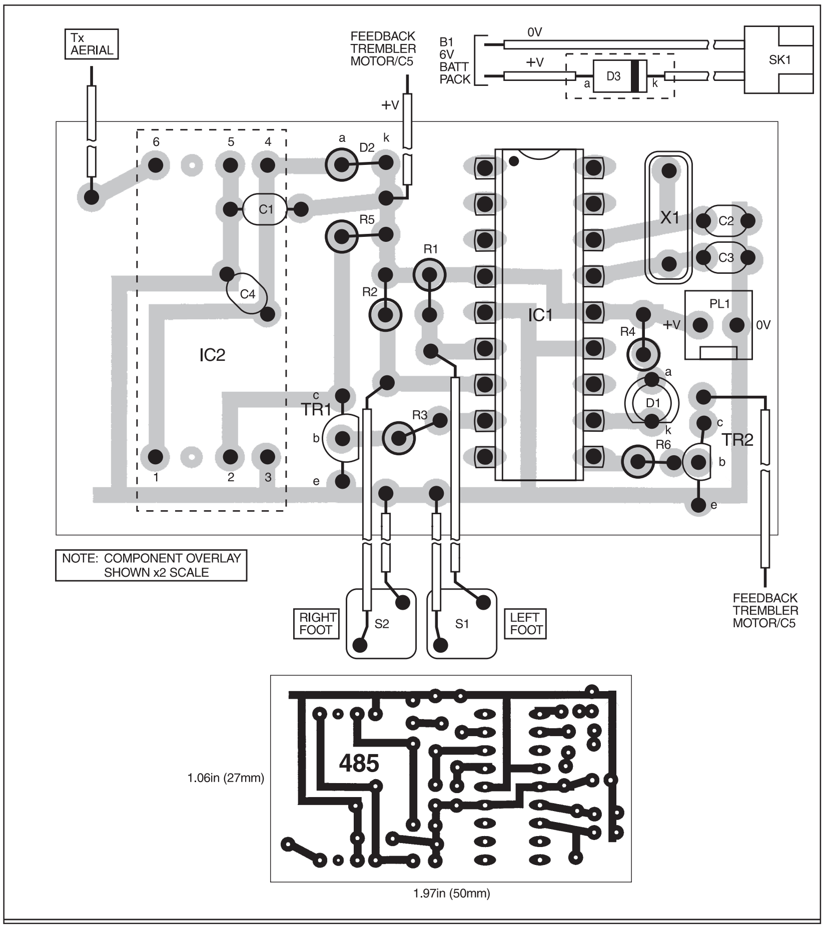
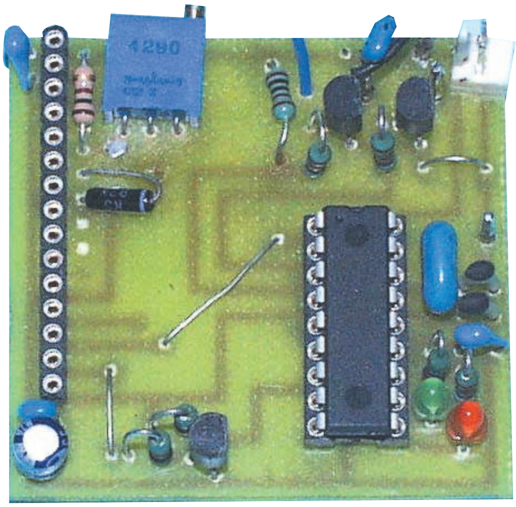
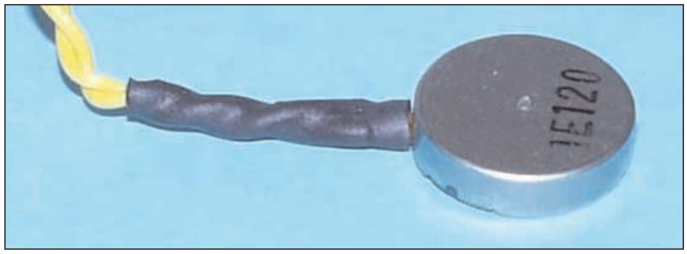


Fig.3. Printed circuit board component layout (shown twice size), wiring and full-size underside copper foil master for the assistance (Master) transmitter.



(Left) Prototype receiver circuit board. Preset VR1 and Zener diode D1 have been laid flat to make room for the receiver module



One of the trembler motors

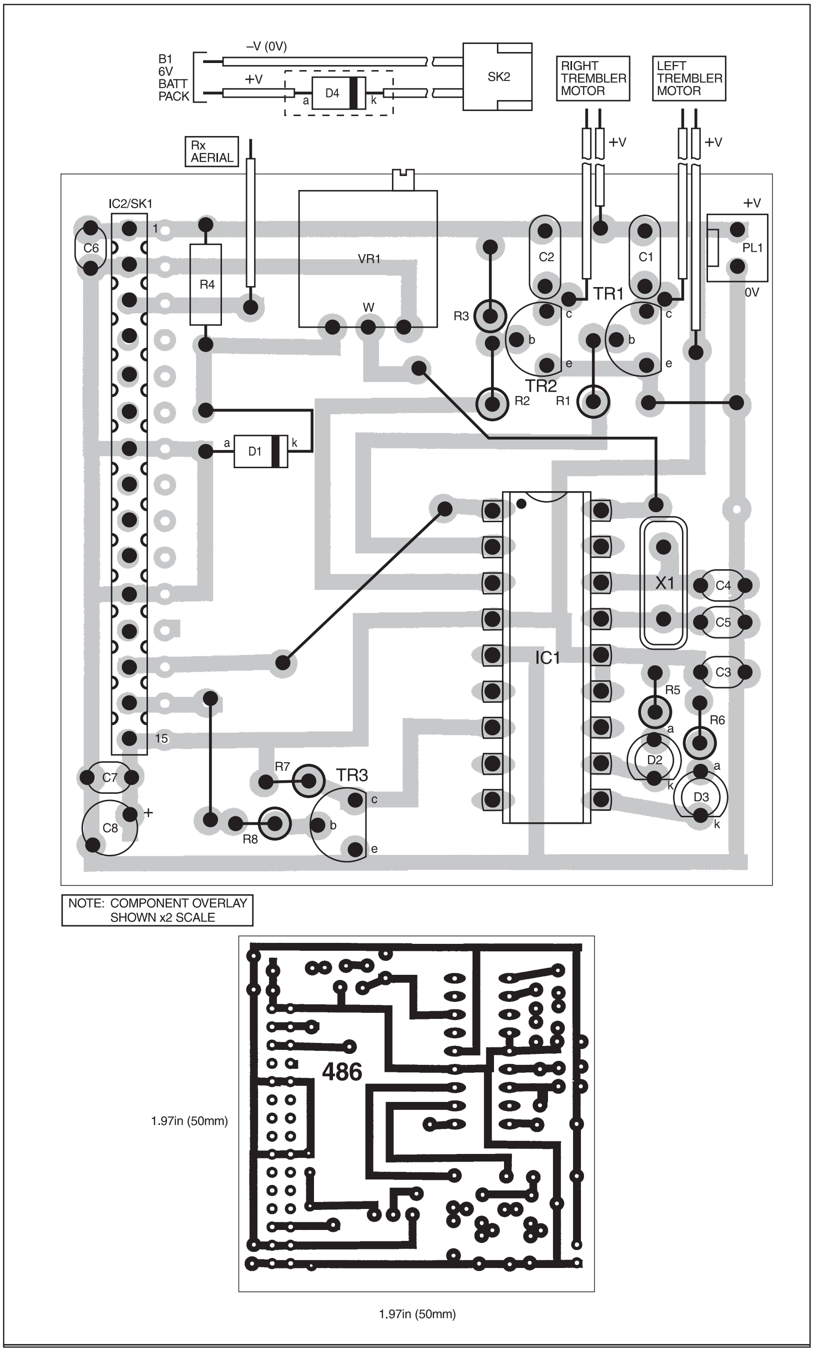


Fig.4. Slave (Magician) receiver printed circuit board component layout (twice size), wiring and full-size copper foil master. The receiver module (IC2) is plugged into s.i.l. socket SK1.

COMPONENTS

RECEIVER (SLAVE)

See SHOP TALK page

Resistors

R1 to R3, R7, R8	1k (5 off)
R4	100Ω
R5, R6	220Ω (2 off)

All 0.25W 5% carbon film or better.

Potentiometer

VR1	10k 18- to 25-turn cermet preset, top adjust

Capacitors

C1 to C3, C6, C7	100n ceramic disc, 5mm pitch (5 off)
C4, C5	22p min. ceramic, 5mm pitch (2 off)
C8	22µ radial elect. 16V

Semiconductors

D1	BZX55C 3V0 Zener diode
D2	5mm green l.e.d.
D3	5mm amber l.e.d.
D4	1N4001 rect. diode
TR1 to TR3	2N3904 *npn* transistor (3 off)
IC1	PIC16F628 microcontroller, preprogrammed (see text)
IC2	RRFQ1 433MHz receiver module

Miscellaneous

M1, M2	6V trembler motor (2 off)
X1	4MHz crystal (or ceramic resonator)
PL1/SK1	2-way, p.c.b. mounting, keyed pin-header (male) and matching 2-pin (female) socket
B1	6V battery pack (4 x AAA)

Printed circuit board, available from the *EPE PCB Service*, code 486 (Receiver); 18-pin d.i.l. socket; s.i.l. socket strip for Rx module; metal or plastic case, size and type to choice; multistrand connecting wire, including 15cm piece for aerial; heatshrink sleeving; solder pins; solder etc.

Approx. Cost Guidance Only **£19**

Excl. case & batteries

ply voltage of 3·3V must not be exceeded. Before inserting the transmitter module, temporarily connect a 1kΩ resistor between the allocated p.c.b. pads for the transmitter's pin 5 (+VE) and pin 4 (0V). If the voltage at the junction of this resistor and the anode (a) of Zener diode D2 exceeds significantly 3·3V (i.e. greater than say 3·5V), the fault must be traced and corrected – the most likely reason is that the diode is inserted the wrong way round.

When satisfied with all checks of the boards, insert the preprogrammed PICs, transmitter and receiver modules. Ensure that the pins of the latter modules tally with the p.c.b. pads to which tracking is connected. The module should be inserted *gently* as the ceramic substrate is brittle and will not withstand physical abuse.

The receiver module should be *carefully* bent over slightly to reduce the overall height. The component side should appear uppermost.

Enclosures

The test models were enclosed in two ancient tobacco tins, but modern enclosures can be used! Whilst the Receiver can be built into a plastic case, the Transmitter should be built into a metal one and an earth wire taken from a 0V point on the p.c.b. and securely connected to the case. This connection will enhance the transmitter's effectiveness. Its aerial should pass through a generous hole in the case and hang to a length of about 15cm.

Clearly mark the pushbuttons and tremblers so as to avoid the channels becoming inadvertently swapped over when Sneaky is being fitted at a later date.

Setting Up

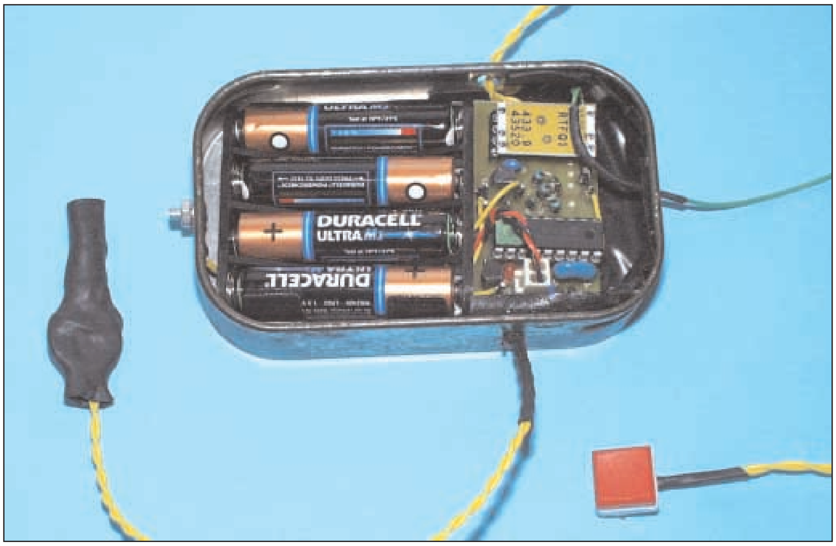
Sneaky's receiver should be the first unit to be set up. Apply power and adjust preset VR1 to give approximately 1·5V at its wiper (and at PIC pin 18). The receiver tremblers should be activated, signalling an error condition (no "heartbeat" detected and poor signal strength). Also, Rx Error l.e.d. D2 should be on.

Next, apply power to the transmitter and place it about 2m away from the receiver. The tremblers should stop trembling and the Rx Error l.e.d. turn off. This demonstrates that the "heartbeat" is being correctly detected and the received signal level is acceptable.

Pressing the transmitter pushswitches should flash the transmitter Tx Data l.e.d. and activate the transmitter's feedback trembler. At the receiver, the Rx Data l.e.d. should flash and the respective receiver trembler should turn off for about 0·5 seconds. The Rx Error l.e.d. should be off.

A little testing will establish under what conditions Sneaky will provide reliable communications. On the prototype, the voltage range of receiver signal strength recorded was 1V with transmitter turned off and 2·5V with the transmitter placed 2m away from the receiver, and 2V at a range of about 16m.

This voltage difference is an indication of the safe working range of the two units and should be set with some margin of safety included. The prototype operated reliably over a distance of up to about 16m, through four household walls, which is an excellent result, given the less-than-ideal aerial arrangements.



Component positioning inside the prototype transmitter's metal case. A trembler motor, encased in heat shrink sleeving, is shown on the left and a "toe/foot" switch on the right.

When used in very close proximity (less than 1m), the received signal strength error warning would sometimes trigger, so very close proximity of magician and assistant should be avoided.

Art of Deception

The prototype units are retained against the body by means of 4cm elastic bands sewn to small cotton pockets. The pockets should be designed to retain the units against the natural curves of the body, while at the same time being comfortable.

Suitable locations were found to be either behind the calf muscle or at the base of the spine. The tremblers were simply pushed underneath the retaining elastic band, see Fig.5. The aerial is allowed to hang down, disguised inside the trouser. Female magicians may favour locating the unit at the base of the spine and concealing the aerial in the waistband.

The pushbutton switches can be secured to the ball of a big toe with a little p.v.c. tape, as the sock is pulled over the foot. If the "click" of the button cannot be felt, then the toe of the sock can be cut away, thus improving the feel of the button against the sole of the shoe. If two-channel signalling is required, then the wire to the other button is passed across the trousers at the waist band and down the left leg to the left foot.

Being sneaky, Sneaky will work best when it is thought of as a part of a performance that is used to entertain an audience and all performances are more pol-

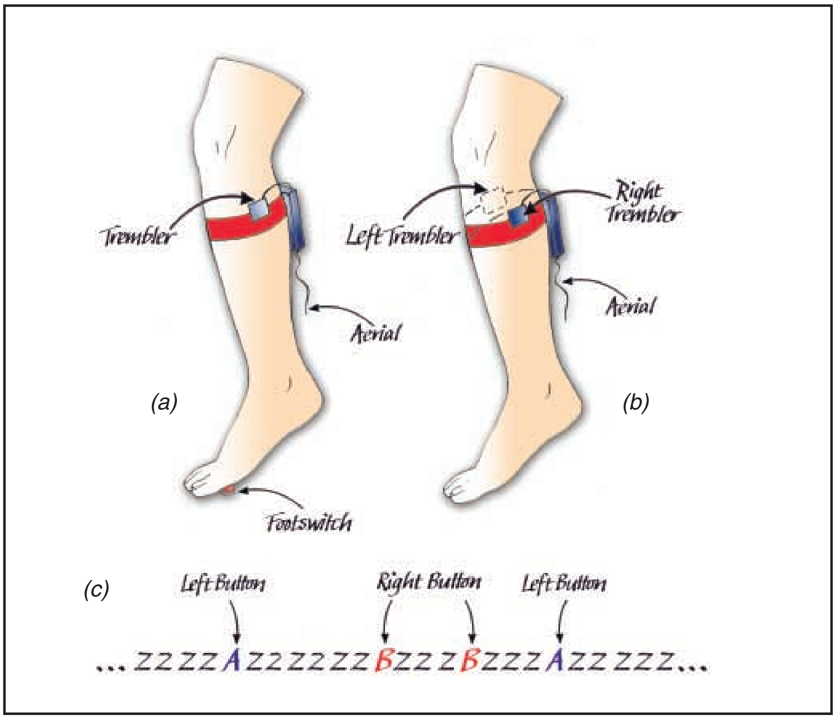
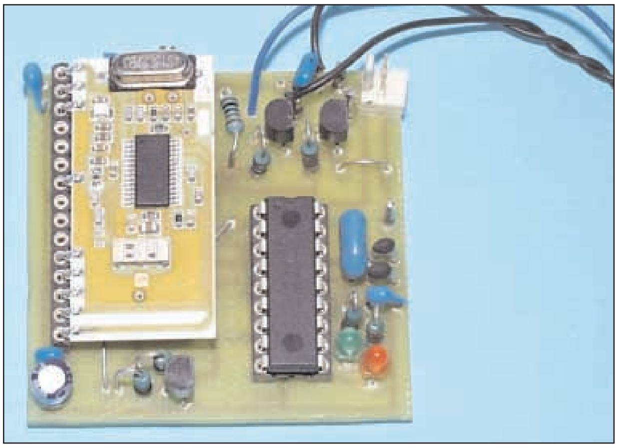


Fig.5. One suggestion for concealing the two units and tremblers: a)Master (assistant) and b) Slave (Magician). The "heartbeat" sequence transmission code is shown at c)



Layout of components on the receiver circuit board. The pins of the receiver module have been carefully bent to reduce the overall height of the board.

The receiver and transmitter p.c.b.s housed in ancient tobacco tins. The tins should be lined with insulation tape to avoid any "short circuits" across the copper tracks.

ished if they are well rehearsed. Magicians will emphasise the importance of planning when entertaining an audience – after all, your audience don't know what is going to happen or how the trick is done, so the initiative is with the magician and assistant.

Have a number of signals prearranged with a variety of meanings, so that there is no obvious communication between magician and assistant. If things go wrong, have a distraction plan already devised.

The following describes a method by which Sneaky has been used, but the variations are endless and will provide great fun for trickster and audience alike (with apologies to *The Sting*):

...The Set Up

The trick is set up between two people, namely the magician (who wears the slave unit) and the accomplice (who wears the master unit). The magician and accomplice should preferably arrive at the venue at different times and appear not to know each other.

The units should be turned on and a number of tests carried out to check range and reliability. Checks should be made inside and outside the venue – the importance of this will become apparent later.

...The Hook

The magician can show off some little tricks and make it known that he/she is quite the amateur entertainer. Later on in the evening, four objects are placed on a table in one room and the magician is allowed to view the selection. The items are given a number by the magician, say a vase is number 1, a pencil is number 2, a pepper pot is number 3 and a shoe is number 4.

The magician now goes to the next room. He declares that if a person points to an object on the table, he will "read the mind" of that person and state which object was pointed at. The assistant stands in the room where the objects are being selected.

...The Shut-Out

A few people are asked to try their luck, but no attempt is made by the assistant to signal the selection to the magician. The eager audience, previously built up by the magician will slowly lose interest, but just as the audience fades away, it is time to pull them back, but very gently at first.

...The Sting

When all appears to have gone flat, a person is finally selected in "desperation". The assistant watches the selection made and now signals this to the magician by means of Sneaky. One pulse indicates object 1, two pulses object 2, and so on.

Slowly, it will become clear that this person must have the right "mental telepathy" as he/she is getting it correct 100 percent of the time. People will start to call their friends to witness a remarkable event.

To maintain audience interest, the items for selection can be changed to, say, four cards – Ace of Hearts, Ace of Diamonds etc, or the names of four people or symbols marked onto a piece of paper, i.e. square, circle, diamond etc. The variations on this trick are almost unlimited.

The wonderment in the audience will build up as people look for the deception. On one occasion, the author completely stopped a party with this trick and was instructed to "read the minds" of party goers from the house next door, where, of course the trick still worked because basic range checks had already been carried out with the assistant.

The duration of this trick should not be over extended, as one audience became increasingly suspicious and "frisked" the Magician, nearly detecting Sneaky.

One or Two Channels?

Signalling up to approximately six items can be made using Sneaky in the single channel configuration (i.e. right foot switch in the master and right trembler in the slave). Sending each pulse with a regular rhythm will assist the magician with counting, but anything more than six signals can lead to confusion for both sender and recipient.

It is therefore advised to use the two channels option for signalling, say, a playing card. In this situation the left foot can signal suit (Clubs = one pulse etc) and if the card is low (Ace to six = one pulse) or high (seven to King = two pulses). The right foot signals the card value. For example nine Clubs = one pulse followed by two pulses on the left foot, then three pulses on the right foot. Although this sounds cumbersome, reliable and speedy signalling was accomplished after only two weeks practice.

Continually pressing either of the buttons will result in a regular pulsating of the respective trembler at about 1Hz and this could be used as another category of signal.

This unit is suited to a simple "selection" type of trick, but really the variations are only limited by the ingenuity of *EPE* amateur magicians. But remember that this is a performance and, for all performers, the "buzz" of entertaining people is addictive and worth all the rehearsal time.

Never give away the secrets of your magic. This rule allows others to entertain (and be entertained) by a live performer – a rare thing in these days of recorded mass entertainment.

Resources

Software, including source code files, for the Sneaky is available on 3·5-inch disk from the Editorial office (a small handling charge applies – see the *EPE PCB Service* page). It can also be downloaded *free* from the *EPE* Downloads page, accessible via the home page at **www.epemag.wimborne.co.uk**. It is held in the PICs folder, under Sneaky. Download all the files within that folder.

This month's *Shoptalk* provides information about obtaining pre-programmed PICs, and the sourcing of components. ☐

PIC N' MIX ANDREW JARVIS

Our periodic column for your PIC programming enlightenment

Read the Script, Free Development Software!

THERE are few subjects that stir more passionate debate than the relative merits of your favourite programming language or development tool. If you enjoy putting together PIC projects, then it's likely you'll have a battle on two fronts – not only do you have to select the assembler (or compiler) of choice for the PIC device but, as many *EPE* projects demonstrate, there is often the PC side to consider as well.

Looking at PC software is actually a bit of a departure for *Pic N' Mix*, but while attempting not to stray too far off territory, I did want to share one particular technique that can be useful for rapid development. You may have noticed that numerous PIC designs published by *EPE* use Visual Basic for the PC application software. VB, as it is popularly known, is a favourite because it is powerful, yet simple to learn and has provided an acceptable migration path for BASIC lovers raised on earlier platforms.

One criticism levelled at VB is that it is difficult to know which version to get, or indeed how to get it. Then there's the .NET framework, which adds an unnecessary layer of complexity and some compatibility issues into the mix, so why bother at all?

The language debate usually reaches common ground where good software is offered at no cost. That is why assembly is so popular for the PIC – *TK3* supports TASM and MPASM, or alternatively there's the GPUTILS assembler and Microchip's own popular MPASM assembler and MPLAB IDE – all free. There are of course others, which you may know about.

What may be less obvious is that anyone using a Windows PC already has a free VB development system, of sorts. If you didn't know this, you've just discovered Visual Basic Script Edition (VBScript).

What's the Script?

For many people, VBScript is a language for scripting HTML to create dynamic web pages in the context of a Web browser. However, when combined with the Windows Script Host (WSH) integrated into most Windows platforms (or available for free download), scripts may be run natively within the OS, which to you and I means you can double-click them or run them at the command line. In turn, this opens up Windows Script as a viable testbed for PIC related development on the PC, and is a great introduction for those who are anxious about purchasing a more complete development system.

Just how viable is perfectly illustrated when VBScript combines with other components to create something altogether more useful. As an example, we'll demonstrate using scripting with the *EPE* Serial ActiveX control supplied with Joe Farr's October '03 article *Serial Interface for PICs and VB6*.

If you need to download or upgrade your scripting capability go to **www.msdn.microsoft.com/scripting** and choose Microsoft Windows Script 5.6 for your Windows platform. This will install the latest (at the time of writing) VBScript and WSH for you. It's unlikely you'll need to do this if you're running a more recent version of Windows like 2000 or XP.

Test Run

A quick test can be performed to be sure you are up and running properly before attempting anything more complex. Create a script (i.e. a new text file) with your favourite text editor and enter the following line:

WScript.Echo("Pic n' Mix Shows How!")

Save it with the extension **.vbs**, then double-click the file to see the message. If you prefer the command line, start an MS-DOS command prompt, change to the directory where you saved the script and enter "cscript", followed by the script name. (Alternatively, you can right-click the file and choose "Open in MS-DOS window".)

Incidentally, you may have realised by now that the "favourite programming language" debate is looming again. I could just have easily described this process with JScript (Microsoft's implementation of JavaScript), which is also supported by the WSH. Indeed, if your passion is for C, or C++ over VB then you will probably find this scripting flavour much easier to learn, and you can do most of everything described here with the different syntax and a file extension of **.js**.

Something for Nothing

Sample 1 from Joe's *Serial Interfacing* article (the simple loopback test) has been reconstructed as VBScript comprising two files, **EPESerial.wsf** and **Sample1.vbs** available from the usual Downloads click-link on the *EPE* website, via **www.epemag.co.uk**. To run it, be sure you have the Serial control installed (it's also available from the Downloads site if you don't already have it), and that you have the interface connected and set up correctly for Sample 1. Type the following at a Command Prompt in the directory to which you copied the scripts:

cscript //job:sample1 epeserial.wsf

If you get an error along the lines of "Cannot find the type library" then it is likely you haven't installed the Serial OCX.

The new sample is basically very similar to the original, but there are a few fundamental differences. VBScript has only one data type, the Variant, so you won't see the usual references to integral types like Integer and Boolean. This lack of strict type checking makes "Option Explicit" almost essential to stop the interpreter creating new variables when you inevitably misspell the name of one in your script files.

Also, the *EPE* Serial control is instantiated by using its textual programmatic identifier (ProgID) instead of by dragging the control onto a form as you would do using the Visual Basic IDE. The same "CreateObject" method also connects the Serial OCX events. The Windows Script File (***.wsf**) is required to allow the use of named constants like "sio19200". Error handling is largely different and has been omitted for simplicity.

Using the Serial control in this way is a tribute to the beauty of component based, language neutral, reusable software. It's yet another way of getting something for nothing – perhaps in the future *EPE* will release more controls of the calibre of the Serial OCX.

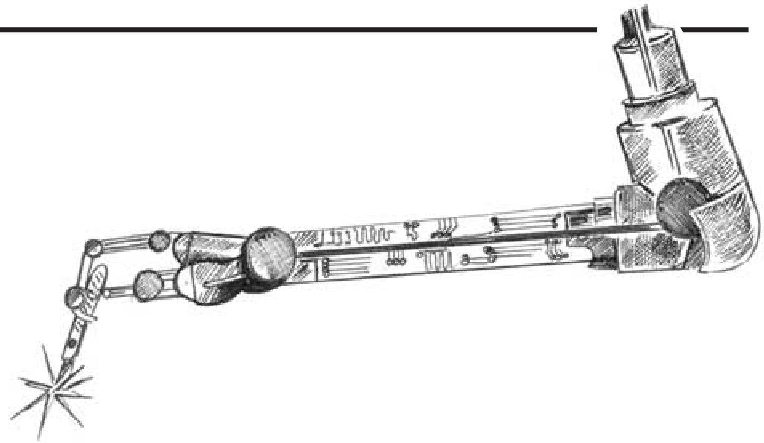
Scripture Lessons

Of course, VBScript is not limited just to readers who constructed the Serial Interface or installed the ActiveX control. Apologies to readers for whom this example has less value, but it is hoped that it's still a useful exercise to see how such scripts may be put together and adapted for your own projects. A free Script Debugger is also available from the Microsoft link given previously.

For more documentation on the script technologies and an extensive language reference for both VBScript and JScript, download "Microsoft Windows Script 5.6 Documentation" from the Microsoft address given earlier. A word of caution is merited, though, before you attempt anything too ambitious with scripting. VBScript is not a replacement for a powerful development system like VB6. It is an interpreted subset of the language with limited functionality for direct access to the operating system. You can't build and run the *EPE* projects with it, but it can be a useful tool, it is free, and most importantly, you might have some fun with it.

We'll continue this next month.

Circuit Surgery



Alan Winstanley and Ian Bell

We round off our brief introduction to the PC Universal Serial Bus, with a suggested circuit

OVER the last couple of months we have looked at some of the internal details of the Universal Serial Bus (USB), looking at pinouts and power requirements, plus the basic concepts behind USB data itself. Hopefully this has given some insight into how it works, at least at the electrical level.

There is a lot more to USB than we have described – in particular we have not discussed much about other aspects such as software drivers needed on the PC, nor the protocols via which communication between the PC and potentially several simultaneously active USB devices can be managed.

Even with our brief overview, you have probably realised that USB is complex and therefore building a USB compliant circuit from scratch is not easy. Unfortunately, applications and software such as a fully-worked USB-based PIC programmer go beyond the scope of *Circuit Surgery*. Does this mean the hobbyist has to give up on USB? Hopefully not, as there are a number of chips that can do most of the work for you.

One such chip is the surface-mounted FT232BM from Future Technology Devices International Ltd. (FTDI). The FT232BM device is a USB UART (Universal Asynchronous Receiver/Transmitter) which provides conversion between USB and basic serial data of the form used by RS232 (as used by the PC serial port). The FT232BM does not handle full conversion to RS232 – for this you need to need to add an RS232 level converter chip such as the Maxim MAX213CAI. Conversion to other serial standards such as RS422 and RS485 are also easy using appropriate level conversion chips.

Simple USB Circuit

For many possible USB projects, full conversion to RS232 will not be required because the FT232BM inputs and outputs serial digital data in a form that can be directly connected to a device such as a PIC using either a 3.3V or 5V supply, or powered via the USB bus. An example of a circuit like this is shown in Fig. 1.

Even though it is a surface mount device, this should not deter the experienced hobbyist or experimenter who is capable of p.c.b. design or soldering to a reasonable level of accuracy using a very fine soldering iron.

The PIC's on-chip UART (or other device) can connect directly to the UART in the FT232BM. Serial data from the PIC is then sent via USB to the PC. Similarly, data from the PC is

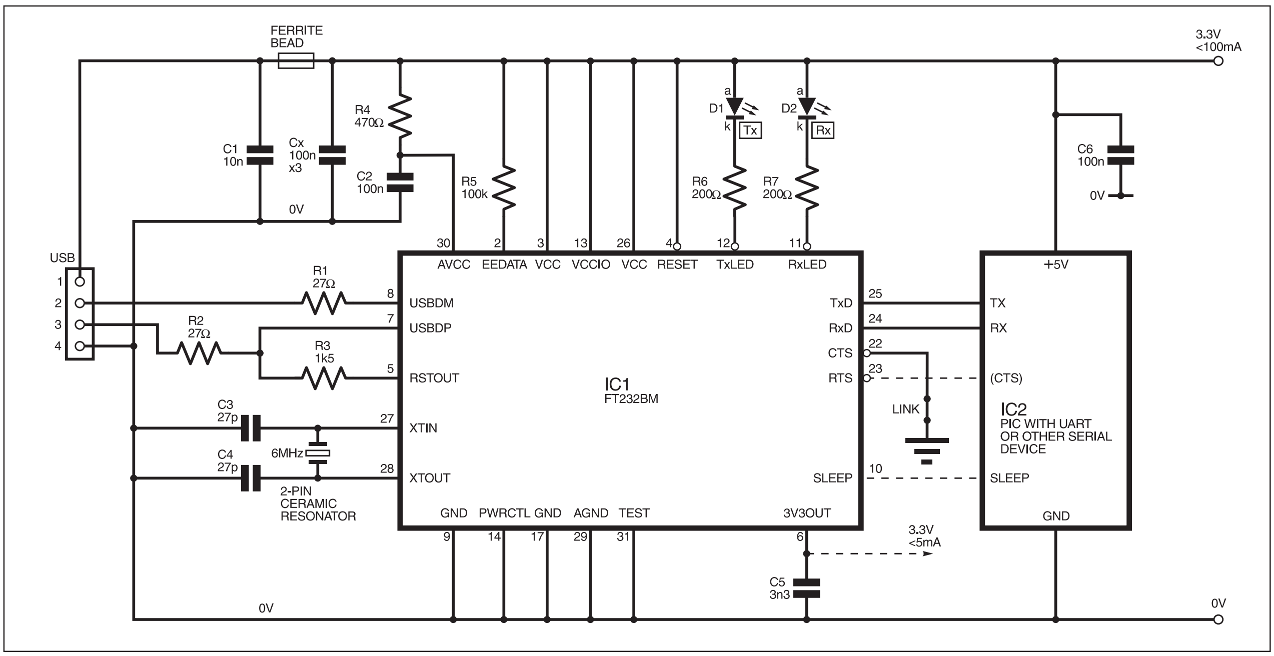


Fig.1. Basic bus powered USB circuit using the FT232BM to provide a serial interface to a device such as a PIC.

received on the USB link by the FT232BM and sent serially to the PIC or other device.

The simplest serial link can be implemented using just two lines, Receive (RXD) and Transmit (TXD), to and from the FT232BM and external device. The other (RS232) serial protocol signals Request to Send (RTS), Clear to Send (CTS), Data Terminal Ready (DTR), Data Set Ready (DSR), Data Carrier Detect (DCD) and Ring Indicator (RI) are all provided on separate pins of the FT232BM and can be used if required.

The FT232BM also provides an Enable Transmit Data output pin for RS485 protocol, and it provides two outputs which can directly drive l.e.d.s to indicate transmit and receive activity. They can drive separate l.e.d.s or they can be wired together to drive a single l.e.d.

The circuit in Fig. 1 shows the FT232BM configured for USB bus-powered operation. As we discussed in out first USB article, there is a limit to the amount of current available from the USB bus. Although USB can supply 500mA the basic circuit in Fig. 1 should not be used for supply currents above 100mA. This is because all USB devices should draw no more 100mA at initial connection.

Power Compliance

For high power bus-powered circuits it is necessary to use the PWREN output pin of the FT232BM to control power consumption. This pin goes low once the USB connection has been established, and can be used to enable the higher power circuitry. Also remember that a bus-powered hub can only supply 100mA to a device connected to it.

Another power requirement for strict compliance with the USB standard is that the USB device must be able to go into suspend mode in which it draws less than 500μA. This can be implemented using the SLEEP output pin of the FT232BM to suspend activity in the rest of the circuit (e.g. put a PIC into sleep mode, or power down an RS232 driver chip). The SLEEP pin goes low during USB suspend.

For projects that exceed a 500mA supply requirement, or have their own power anyway, the FT232BM can be configured for self-powered operation by a small change to the USB interface circuit, as shown in Fig. 2. Here the USB 5V pin is no longer connected to the circuit's supply.

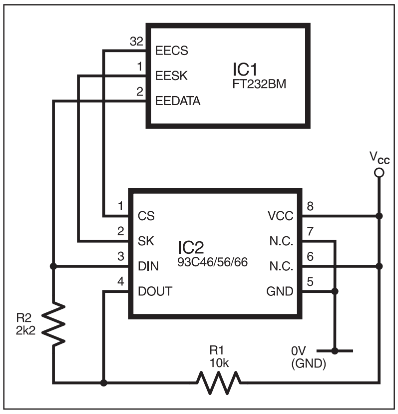


Fig.3. Using an EEPROM to configure the FT232BM.

The basic circuit in Fig. 1 will provide a working USB connection to a microcontroller, such as a PIC or other device. However, it does not make full use of all the FT232BM's features. In order to have full control over the configuration of the FT232BM you need to connect an EEPROM containing the configuration data as shown in Fig. 3. The EEPROM data includes Vendor Identifier, Product Identifier Serial Number and Power Description (required for high power devices).

Default USB data is provided by the FT232BM (to the PC) if no EEPROM is present, but without an EEPROM the FT232BM does not provide a serial number. This number allows multiple FT232BMs to be connected without causing conflicts, but means that the device's identification (from the PC's point of view) will change if it is plugged into a different port.

The EEPROMS used can be 93C46, 93C56 or 93C66. The latter two store more data than is required by the FT232BM and this spare space may be used by other parts of the circuit (e.g. a PIC) if access to the EEPROM is correctly controlled (this is explained in detail in the data sheet for the device).

The FT232BM has several power supply pins. There are two V_{CC} (4.35V to 5.25V) pins proving power to the chip core and non-UART interface pins. The V_{CCIO} pin (3.0V to 5.25V) supplies the UART interface (the Tx/Rx l.e.d.s must also be connected to this supply). There are two ground (GND) pins and also an analogue supply and ground AV_{CC} and AGND which power the internal clock multiplier, and finally there is a 3.3V ($3V3V_{OUT}$) output from an internal regulator. The main purpose of this regulator is to supply the USB transceiver, but a small current (<5mA) may be used by external circuitry.

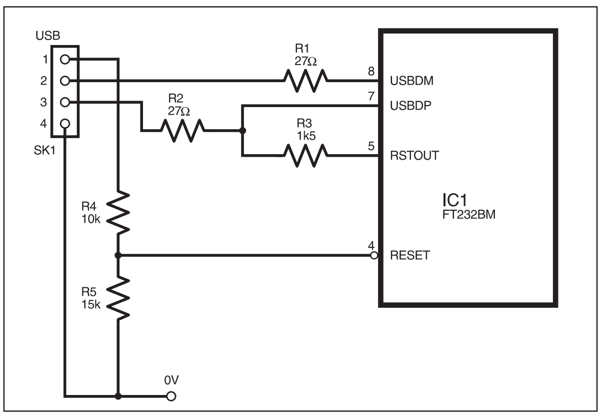


Fig.2. USB connections to the FT232BM for self-powered circuits

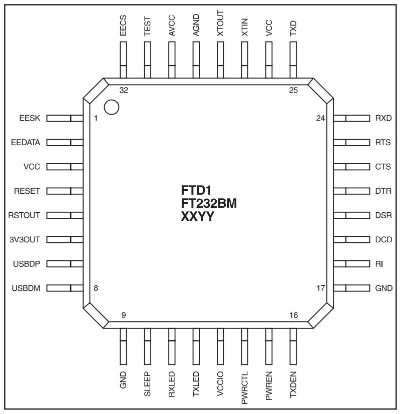


Fig.4. Pinouts for the FT232BM.

Software Drivers

In order to use the FT232BM, software drivers have to be installed on the PC. These are available from the FTDI web site (as are instructions on installation and usage)

To make use of the full features of the FT232BM use the “Direct Drivers” that allows the EEPROM attached to the FT232BM to be programmed with configuration data. You. can download a utility from FTDI that programs the EEPROM via the FT232BM over the USB link.

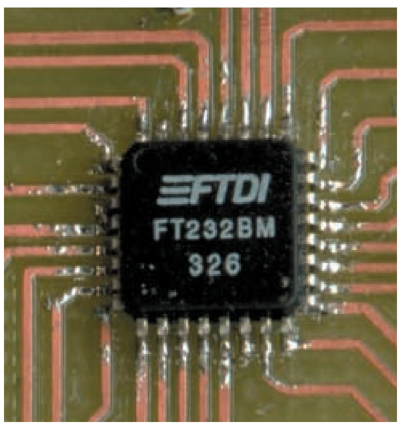
In their simplest form, the drivers create a virtual COM port which can then be used just like any other. So all the software you have written for old serial COMs ports should simply work – just set the COM port number to the virtual port created by the driver.

Similarly, the standard serial program HyperTerminal (found in Windows Communications programs) can be used to test small amounts of data transfer to and from your USB project (particularly if you use text-based data) without having to write any software first.

Resources

Further information can be found on the FTDI web site at **www.ftdichip.com**. The Site also has a link to FDTI’s worldwide sales network.

Hopefully I have given you a taste of what's involved and some useful pointers for further experimentation. I.M.B.



The FT232BM is a surface mount device in an LQFP-32 package with 0.8mm pitch pins. With care it can be soldered by hand, as was the example in this photo.

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Peak Power	1800W
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Stability	+/-10%
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Continuous Power	1000W
Peak Power	3000W
Output Voltage	230V AC
AC Frequency	50Hz
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★Output voltage and current are indicated by two high precision LED displays

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★Output voltage and current are indicated by two high precision LED displays

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READOUT

Email: john.becker@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

WIN AN ATLAS LCR ANALYSER WORTH £79

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

The Atlas LCR automatically measures inductance from 1μH to 10H, capacitance from 1pF to 10,000μF and resistance from 1Ω to 2MΩ with a basic accuracy of 1%.

★ LETTER OF THE MONTH ★

Electromagnetic Pulses

Dear EPE,

Mike Kenward's *Editorial* (Jan '05) brought back memories of a time when I was involved in the building and testing of an EMP (electromagnetic pulse) simulator. There is nothing secret or technical in the design, although I won't reveal the location where I worked. All countries that produce defence electronics will have a simulator of some sort. Size varies with application. The US have a massive bridge built entirely of wood (no metal fasteners) onto which they can roll B52 bombers. Another spans a cliff-lined inlet into which the largest aircraft carriers will fit.

The one I worked on would have been able to take a reasonable size truck. The method of producing EM pulses consisted of a high voltage generator/store which was triggered through an oil bath capacitor, onto an adjustable spark gap (built in a sealed container which was filled with SF6 gas). This then passed through a series of about 10 steel wires which fanned out and over the equipment to be tested, before converging back down to a large resistor network to earth. The voltage was only half a megavolt, larger systems run up to tens of megavolts. Although the voltage was modest, care had to be taken in construction in order to negate corona effect and its losses.

The tricky part comes in getting the speed of rise-time of the pulse. It is this that can kill electronics by beating protection responses. We were given a target of one nanosecond rise-time. After trying a couple of capacitors and varying the pressure of the SF6 gas and the spark gap, a calculated speed of 1.2 nanosecs was achieved. Had we more modern measuring equipment, the results may have been different. The capacitors took about a week to build and installing them meant the removal/replacement of about 2000 litres of transformer oil.

I know the system worked as my transistor radio got fried during one of the tests. I don't know a lot more about the subject other than the above. I joined another project shortly after and don't know if minimum rise-time was beaten. However, I do know how to switch one million amps!!

It's probably easier and cheaper to explode a nuclear device to produce a large EM pulse than find another method.

It has been some time since I last wrote. I have changed profession (I seem to do this every 16 or so years, so this should be the last) and have spent the last 13 months getting "up to speed". I now work as an electro-mechanical technician, servicing and repairing 650 volt generating and UPS (universal power supply) systems for the railway. This opportunity arose just as I was building an inverter system to run a three-phase lathe in my shed. They had to stop me when they asked if I knew anything about UPS systems! A lot of the information I gleaned from articles and projects in *EPE*. I'm forever grateful.

Graham Card, via email

How nice to hear from you again Graham, and with a fascinating tale to tell! Thank you. And you've also convinced me not to try generating EMPs with a PIC! Very best wishes with the new job.

Smart Karts

Dear EPE,

I was delighted to receive the October edition of *EPE* and find the *Smart Kart* article in it. I run Hobby Electronics courses for "mature age" students and we have been tinkering with simple mobile buggies using op.amps and 555 timers. But the *Smart Kart* will be our main construction project for next year. Many thanks for a great magazine.

Tony Lee, Old Reynella, S. Australia, via email

Thanks Tony, that's good to know. We expected that Owen Bishop's imaginative robot would find use in many educational ways. It really is a "fun" design as well.

Clear L.E.D.s

Dear EPE,

I would like to say how much I have enjoyed reading Anthony H. Smith's series of articles on l.e.d.s and related circuits (Sept '04 to Jan '05). Even though I have an HND in Electrical & Electronics Eng. (after many years of study at night-school) I often struggle to understand many articles on electronics, never having had the chance to work in the industry. However, I found Anthony Smith's articles refreshing and a model of clarity.

David R. Smith, via email

Thank you for your kind words David. We know that many readers have benefitted from Tony's excellent series.

Speed Camera Watch

Dear EPE,

Regarding Mike Hibbett's *Speed Camera Watch* (Jan '05), rather than spend time and effort on designing a device to alert himself of the presence of a camera, perhaps he might consider changing his driving habits and observe the speed limits.

I fear, however, that this is not likely to happen as he admits often to being unaware of his speed and many times in the same spot.

Cameras are placed so as to be easily visible (not near sharp bends) and are sign-posted and painted bright yellow to alert drivers in plenty of time, reminding us to obey the law or be prosecuted for behaving irresponsibly.

And I think your magazine is behaving irresponsibly in publishing this article which, despite its disclaimer, encourages the law-breaker.

Robert Talbot, Member of the Institute of Advanced Motorists, via email

Editor Mike replies:

I cannot see how this encourages the law breaker. No doubt you have never drifted over the speed limit but I am afraid that most of us are human and occasionally do so. As you say cameras are obvious to alert drivers in plenty of time, this device just adds to that time. I don't think Mike suggested that cameras were placed near sharp bends, simply that the unit could also remind you of a bend etc.

If this device helps to keep drivers within the law then it must be a good thing. Indeed, some Police forces have advocated the use of such detectors. As we said on the front cover, this is an early warning system. I guess our opinions must differ on this one but I certainly do not feel we have in any way acted irresponsibly.

Mike Kenward

Time-Warp?

Dear EPE,

I enjoyed the November issue as usual, but feel that a few comments are in order:

Andy Emmerson (*Techno Talk*) includes Abraham Lincoln in the list of individuals whose voices may be recovered from early recordings by the application of the latest digital technologies. Unfortunately, President Lincoln was murdered in 1865, twelve years before the first audio recording was made. Therefore, I suspect that Mr Lincoln's voice is still beyond the reach of our technology.

The story "News... Valve Centenary" suggests that Fleming's valve delayed the imminent development of semiconductor technology. But, is this assertion plausible? The 43 years between the valve's invention and the first transistor, produced an explosion of scientific and technical knowledge and skill.

Yet, in 1947 the Bell Labs team that developed the transistor was just barely able to make it work even though they had the best materials, the latest equipment, the brightest people, and buckets of money. In fact, they gave up on their first design, a field effect device, because they were unable to produce sufficiently pure semiconductor materials. The point-contact transistor was the best they could do.

More years of R&D, especially in materials science, were needed to produce the silicon junction transistor. And, still more years of R&D after that before semiconductors could handle a significant amount of power. Rather than impeding progress, Fleming's valve was the very development which opened the door and enabled all that followed.

Herman Respess, Shelby Township, Michigan, USA, via email

Editor Mike replied to Herman:

Thanks for your interesting response, which I have sent on to Andy Emmerson for his comments. On the subject of semiconductor development I take the points you have made but should also point out that "crystals" with three contacts were being used to "amplify" before Fleming invented the valve and no doubt development of that area of technology would have speeded up semiconductor electronics.

To which Herman replied:

I have seen some early crystal circuits (galena and cat-whisker) with three contact points. Some of them were called amplifiers or amplified output receivers. The ones I've seen so far were really voltage doublers. The crystals formed two diodes. Although true amplification did not occur, these circuits could provide significantly louder output than single diode circuits. The increased loudness sometimes gave the impression of amplification to early experimenters.

However, there are certainly many things in this world which I have never seen. Maybe this is an opportunity for me to learn something new. If you would point me to a source of information, I would appreciate it.

And Andy responded:

At first sight Mr Respess has got to be right; Lincoln did indeed die before Edison disclosed his tinfoil recording system. But Edison was by no means the first person to record sound, a fact that I didn't have space to mention in my article.

Under the heading "Sound recorded in 1857", a web page reports: "For years, a rumor has titillated enthusiasts of phonograph history – the speculation that Abraham Lincoln made a sound recording. Indeed, it is known that in 1857, a French scientist named Leon Scott invented a proto-phonograph that recorded, but could not play back, sounds. According to the Lincoln rumor, the 16th president spoke into a similar device in 1863. However, Lincoln fans shouldn't get too excited. For now, there's absolutely no proof that Lincoln actually took time off during the Civil War to speak into anyone's recording device, experts say."

Nevertheless, Scott is reputed to have recorded Lincoln in the White House on his Phonautograph and at this point in time, who is qualified to prove or disprove this? His machine certainly exists and is preserved in the Smithsonian Institution. If you follow the thread on this subject at **http://palimpsest.stanford.edu/byform/mailing-lists/arsclist/2004/07/msg00193.html** you will see that a working phonograph had already been constructed in 1791.

Very few devices were actually "invented" by the person who took the credit in history; they merely improved the prior inventions of others. Leon Scott's Phonautograph is described at **http://history.acusd.edu/gen/recording/scott.html**, where you can also see a photo of one of his machines.

As for Mr Respess' comment about "the 43 years between the valve's invention and the first transistor", I don't think he has read about Lossev's "oscillating crystals" nor seen my article on pre-1947 crystal triodes (*Who Really Invented the Transistor?* Jan '03). Working transistors were produced long before Bell Labs re-invented them and embezzled the credit for a pre-existing technology!

Andy Emmerson

Windication

Dear EPE,

Can I thank Mike Feather for his *Wind Direction Indicator* (*EPE* Dec 2004). It is always of interest to see how other designers approach a problem, and it is a relief to see a proper electronic design that doesn't rely on software in a PIC. There are a couple of comments I would like to make though.

Firstly, I don't think the suggested shaft encoder is going to last very long in a weather-exposed environment. I can find no specification for the switch contact plating, and at the price I don't think it's likely to be gold. If a sensor is going to be in service for the long term and not just a few months, a non-contact encoder is required (for example, brew your own optical encoder with a clear plastic wheel, some l.e.d.s, and a few phototransistors).

My other point is that the decode and display circuit can be reduced to one i.c.! While the use of a 74LS86 to convert Gray code to binary is very interesting and educational, it really isn't necessary. Just feed the Gray code directly into the binary inputs of the 74LS154 decoder, and sort it out by putting the l.e.d.s in Gray-code order around the display.

Ken Wood, via email

Thanks Ken, your comments are appreciated. Somehow, though, I suspect those switch contacts may remain functional for longer than you might think. Assuming that they are kept moving by the wind, there should be a degree of self-cleaning that takes place. On the electronics circuit board, though, it might be worth while coating it with "conformal" spray to protect it from moisture and possible degradation of tracks and joints.

In a wind sensor I did some 10 years back I did use opto-coupling, in conjunction with a linear optosensor chip that had been newly introduced at that time. It was, though, a more complex solution than Mike used. We liked the simplicity of what Mike achieved, whilst one chip could have been saved, it would have made the board more complex.

Shorting-Out DIY?

Dear EPE,

I hear that as from January nobody will be able to alter anything electrical like wiring in their own house without getting it checked and passed by a qualified jobsworth electrician. That is if you can find one of these rare individuals with the necessary bit of paper and who will even consider visiting at less than a £200 call out charge.

I have in my time had more than enough of the "you can't do that 'cos I say so" brigade to last me many lifetimes. If this is a fact then you may as well pull down the shutters on the mag 'cos sooner or later a clown will be accusing you of aiding and a betting.

George Chatley, via email

I don't know what implications this might have George, either in terms of what I do in my own home, or what significance it might have if any for EPE *and other mags in our field.*

For a start, how on earth do they enforce this restriction? Do they intend that DIY stores should stop selling electrical cable, sockets, junction boxes etc? Since buying my first house 40 years ago I have always made electrical changes and upgrades as I have seen fit, and without "professional" intervention, with one exception. That was when I had a heavy-current potter's kiln installed at one house. The electricity company came to approve my wiring for that before final connection was made. My recollection is that I called them for my own reassurance about safety.

Clowns or no clowns, I find it difficult to understand how this intended restriction can be made workable.

Toolkit TK3 V3.00

By the time you read this, a much updated version of my EPE Toolkit TK3 *PIC programming and assembly software, V3.00, should be on our Downloads site, via* ***www.epemag.co.uk.***

The most significant aspects of this version are that a Mini Simulator and facilities for PIC18F devices have been added. Note, though, that whilst much field testing for the 18Fs has been done, this extensive addition should be treated as a "beta" test version and feedback on any aspects will be much appreciated.

Both additions will be reported on in more detail in the March issue. Malcolm Wiles will also be introducing PIC18Fs to you formally in the April issue.

Reader Ian Stedman has also kindly contributed a TK3 *FAQ, which is also with* TK3*'s Folder.*

Constructional Project

Sound Card Mixer

Terry de Vaux-Balbirnie

Bring "Life" to your computerised live recordings!

HAVE you ever used your computer's sound card to make a live recording? Did you plug a microphone into the "microphone input" socket and were disappointed with the results? If so, read on!

The most common complaints from people doing this are of weak or distorted sound. One reason appears to be that there is no uniform standard set for this input. In many cases, it will have been designed for a computer microphone (say, for voice recognition purposes) rather than the general type used for music and voice recording. Even if the input is sufficiently sensitive to handle the very low signal from a good quality microphone, the on-board preamplifier is often of a low quality, resulting in distortion.

On the Level

Such problems may be overcome by using the sound card's Line input instead. This has more predictable characteristics and should be more or less the same for all makes and types of card. However, you cannot plug a microphone directly into this input and expect it to work properly. This is because it requires a signal of up to one volt to load it, rather than the few millivolts available from the microphone. A preamplifier is therefore necessary between the microphone and sound card to boost the signal.

One point worth noting is that the microphone input on a cheap sound card is sometimes a line level input anyway and the socket labelled "line input" appears to do nothing!

The Sound Card Mixer circuit described here provides the boost necessary to bring the microphone output to line level. However, while designing it, certain other issues were addressed to make it appeal to more readers. To this end, the finished device takes the form of a desktop unit which is connected to the sound card through a short length of cable. This avoids having to fumble behind the computer whenever connections need to be changed.

The new unit also provides additional inputs – for two stereo microphones (or four mono ones) plus a stereo line input. The latter allows a high-level device such as a CD player, tape deck or musical instrument to be connected. Of course not all the inputs need be used.

Six controls on the front panel allow the left and right channels of all inputs to be adjusted and mixed independently to provide a single pair of stereo outputs.

Extra Inputs

If the circuit is built in the specified case, there will be space for more sockets in addition to those described above. These could provide composite video input and output, for example, which might be used for video editing. These sockets would be connected directly to the computer, using their own cables – they would not really be part of the new circuit.

The unit is powered using an internal 9V battery pack consisting of six "AA" size alkaline cells. An On-Off switch and associated light-emitting diode (l.e.d.) "On" indicator are also fitted. The circuit draws some 40mA while operating, so the batteries may be expected to provide about 35 hours of service. Larger batteries could be used providing there is sufficient space inside the case to accommodate them (or you place them externally).

Another good method would be to use six nickel-cadmium or nickel metal hydride (rechargeable) batteries. Their 7·2V nominal output would be sufficient. It is not advisable to power the circuit from a mains-derived supply because there could be problems with mains induced hum.

Circuit Description

The full circuit diagram for the Sound Card Mixer is shown in Fig.1. IC1 to IC4 are identical low-noise dual operational amplifiers (op.amps). There are therefore eight op.amps altogether. All the "a" sections are associated with Right channels while the "b" ones are used for the Left.

Op. amps IC1a and IC1b are used for the first microphone input (MIC 1) while IC2 performs the same function for the other one (MIC 2). Op. amps IC3a and IC3b are associated with the Line Input. IC4a and IC4b are used as mixers which combine all the Right and all the Left signals obtained from IC1 to IC3.

The positive supply feed is via On/Off switch S1 and operates l.e.d. indicator D2

Completed Sound Card Mixer with author's mods (not described in this article).

COMPONENTS

Approx. Cost Guidance Only **£38** excl. case & batteries

Resistors

R1, R11, R21, R31	680Ω (4 off)
R2, R3, R6, R7, R12, R13, R16, R17, R22, R23, R32, R33, R42, R43, R52, R53	22k (16 off)
R4, R14, R24,R34	47k (4 off)
R5, R15, R25, R35, R41, R45, R51, R55	10k (8 off)
R8, R18, R44, R54	15k (4 off)
R9	560Ω

All 0.25W 5% carbon film or better.

See SHOP TALK page

Potentiometers

VR1, VR11, VR21, VR31	220k enclosed carbon preset, horiz. (4 off)
VR2, VR12, VR22, VR32,VR42, VR52	10k single-turn conductive plastic, 12mm square p.c.b. mounting (2·5mm pin spacing), log. or lin. (6 off)
VR3, VR13	10k enclosed carbon preset, horiz. (2 off)

Capacitors

C1, C11, C21,C31, C41, C51	4μ7 min. radial elect. 35V (6 off)
C2, C6, C12, C16,C22, C32, C42, C52	47μ radial elect. 16V (8 off)
C3, C7, C13, C17, C23, C33,C43, C53	22p ceramic disc, 5mm pitch (8 off)
C4, C5, C8, C9, C14, C15, C18, C19, C24, C25, C34, C35,C44, C45, C54, C55	10μ radial elect. 16V (16 off)
C20	220μ radial elect. 16V
Cx	220n ceramic disc, 5mm pitch (see text) (4 off)

Semiconductors

D1	1N4001 50V 1A rect. diode
D2	red l.e.d. indicator
IC1 to IC4	NE5532 dual low-noise op.amp (4 off)

Miscellaneous

S1	s.p.d.t. toggle switch
SK1 to SK4	3·5mm mono jack socket (4 off)
SK5, SK6	non-insulated phono sockets (see text) (2 off)

Printed circuit board, available from the *EPE PCB Service*, code 489; metal instrument case, 220mm x 170mm x 35mm (min. height) x 80mm (max. height); control knobs (6 off); rubber grommet; AA alkaline cells (6 off); PP3-type battery connector; materials for battery bracket; 8-pin d.i.l. sockets (4 off); small fixings; stereo screened cable; 3.5mm stereo jack plug; plastic p.c.b. spacers (see text); cable tie; connecting wire; solder etc.

via current-limiting resistor R9. Current also flows through diode D1 to charge capacitor C20. The capacitor provides a reserve of charge and maintains any momentary peaks of current which will be useful when the battery is nearing the end of its life.

The diode also provides reverse-polarity protection – if the supply were to be connected the wrong way round, the diode would fail to conduct and nothing would happen. This prevents damage to the other semiconductor devices. Note, however, that the l.e.d. indicator is not protected in this way.

Since the circuits based on IC1a/b and IC2a/b are identical, only a description of that centred around IC1a is required. The Right microphone input is connected to IC1a inverting input, pin 6, via capacitor C1 and input resistor R1 (the equivalent resistor in IC1b is labelled "R11" while in IC2a it is labelled "R21" and so on).

Capacitor C1 allows the a.c. signal to pass while blocking the d.c. path. The resistance of the microphone itself, therefore, does not affect the circuit following it.

Boost

The combined value of fixed resistor R4 and preset potentiometer VR1 in series (the feedback network) divided by that of R1 determines the gain (amplifying factor) of this section. In fact, this is *negative* (since it is configured as an inverting amplifier) but this does not affect the practical result.

With the values specified, the minimum gain is therefore −70 times and the maximum, −400 times approximately, depending on VR1 adjustment. This will be set at the end to match the sensitivity of the microphone used.

Low-value capacitor C3, connected in parallel with R4/VR1, has negligible effect at audio frequencies. This is because its impedance will be high compared with that of the resistors.

However, at frequencies higher than the audio range, its impedance becomes significant and this reduces the overall value of the feedback loop. The gain therefore "rolls off" and prevents any high frequency instability which might otherwise occur.

Bias

The non-inverting input (pin 5) of IC1a is connected to the potential divider consisting of equal-value resistors R2 and R3. This biases it to one-half of the supply voltage (nominally 4·5V). It allows processing of both the positive and negative parts of the input signal by allowing them to swing above and below this level.

However, as far as a.c. is concerned, capacitor C2 maintains the non-inverting input at 0V because it has a very low impedance at audio frequencies and effectively reduces the value of the lower "arm" of the potential divider.

The output signal appears at pin 7 and the a.c. (audio) signal flows, via capacitor C4 and the track of potentiometer VR2, to 0V. Potentiometer VR2 is one of the six panel-mounted mixer controls and it allows a fraction of the output voltage to be "tapped off" by the sliding wiper contact. This is fed, via capacitor C5 and resistor R5, to the Right channel mixer section based on IC4 and which will be described presently.

The above description applies not only to the other microphone channels but also to the line inputs. However, there are certain small differences.

Looking at IC3a (right line channel), the gain is fixed at 1·5 times by the ratio R44/R41. This is much less than the gain of the microphone channels because the signal is already at a high level. A small amount of boost is applied so that a suitable gain will be obtained when the sliding contact of mixer control VR42 is at some intermediate setting.

Mixing It

The right-hand channel signals (two microphone and one line) pass via capacitors C5, C25 and C45 and resistors R5, R25 and R45 respectively to IC4a inverting input, pin 6 (the right channel mixer input). The non-inverting input (pin 5) is biased using resistors R6 and R7 in the same way as for IC1/IC2/IC3.

The gain is the same for all channels and is set by the resistance of R8 divided by that of one of the input resistors (R5, R25 and R45) giving 1·5 times. Capacitor C7 rolls off the gain at high frequencies and promotes stability in the same way as with the previous sections.

The combined right-hand signal passes via capacitor C8 through the track of preset potentiometer VR3, whose sliding contact then "taps off" a fraction of this and the final output appears via capacitor C9. Mixing of the left-hand channels is carried out by IC4b in exactly the same way.

Preset VR3 and VR13 will be adjusted at the end to match the gain to the output requirements of the sound card, also to remove any imbalance that might exist between the right and left channels.

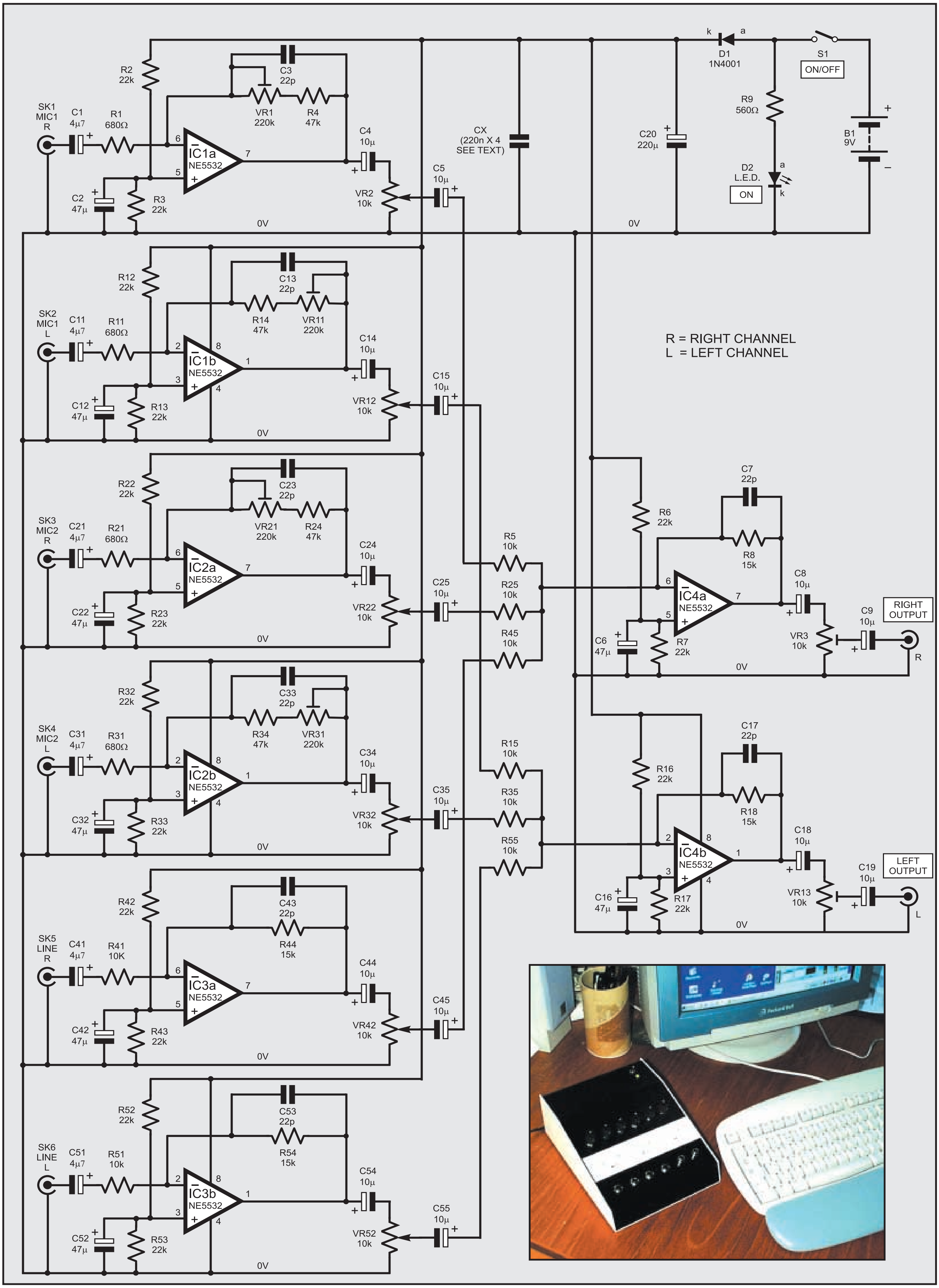


Fig.1. Complete circuit diagram for the Sound Card Mixer. Note that the author used jack sockets for the MIC inputs and un-insulated phono sockets for the Line inputs.

Construction

Construction of the Sound Card Mixer circuit is based on a single-sided printed circuit board (p.c.b.). This board is available from the *EPE PCB Service*, code 489. The component layout, interwiring and actual size copper foil master track pattern are shown in Fig.2.

Drill the five p.c.b. mounting holes in the positions indicated (they might not be needed but it is better to drill them at this stage just in case). Drill small holes in the positions indicated at the centre of each preset VR1, VR11, VR21 and VR31 position. This allows them to be adjusted through the p.c.b. when this is in position.

Solder the four 8-pin i.c. sockets and the link wire (near IC4) in place. Follow with all resistors (including the six presets) but not the mixer controls (VR2, VR12, VR22, VR32, VR42 and VR52). Add diode D1, taking care over its orientation. Next, solder the capacitors in position. Most of these are electrolytic types and must be soldered with the polarity as indicated.

Capacitor C20 should be mounted flat on the circuit board to present a low profile. There are four decoupling capacitors (all labelled Cx) – one across the supply rails of each i.c. Only one of these capacitors is shown in the circuit diagram but all four appear on the p.c.b. layout.

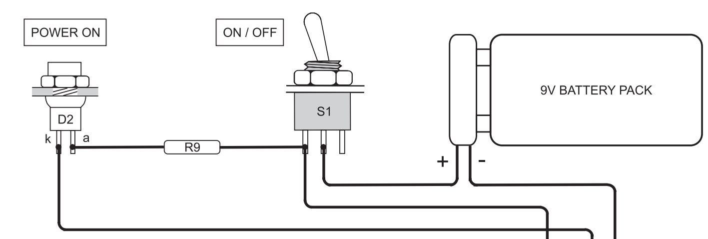
Next, solder the mixer potentiometers in place. It would be better if they were of the logarithmic type since these give a better physiological response (angle of rotation against perceived change in volume) but, in fact, ordinary linear controls would be perfectly adequate. The potentiometers are mounted flat on the circuit board so that the spindles point vertically upwards.

However, those used in the prototype were really intended for vertical mounting. If the units used are of this type, the connecting pins will need to be bent through right angles. Additional support should then be given to each potentiometer by a wire loop passing round the bush and soldered to the unconnected pad below its position.

Going Loopy

Prepare these loops using bare connecting wire (strip the insulation from ordinary single-strand wire). Using a suitable mandrel (say, the shank of a 10mm drill bit) twist the wire to make a loop at one end and solder the joint. Pass a loop over each bush, pull the wires tight and solder the ends to the free pads.

Adjust all six preset sliding contacts to approximately mid-track position. Check that the tops of all on-board components fall below the level of the potentiometer bushes and make any adjustments as necessary to make this so.



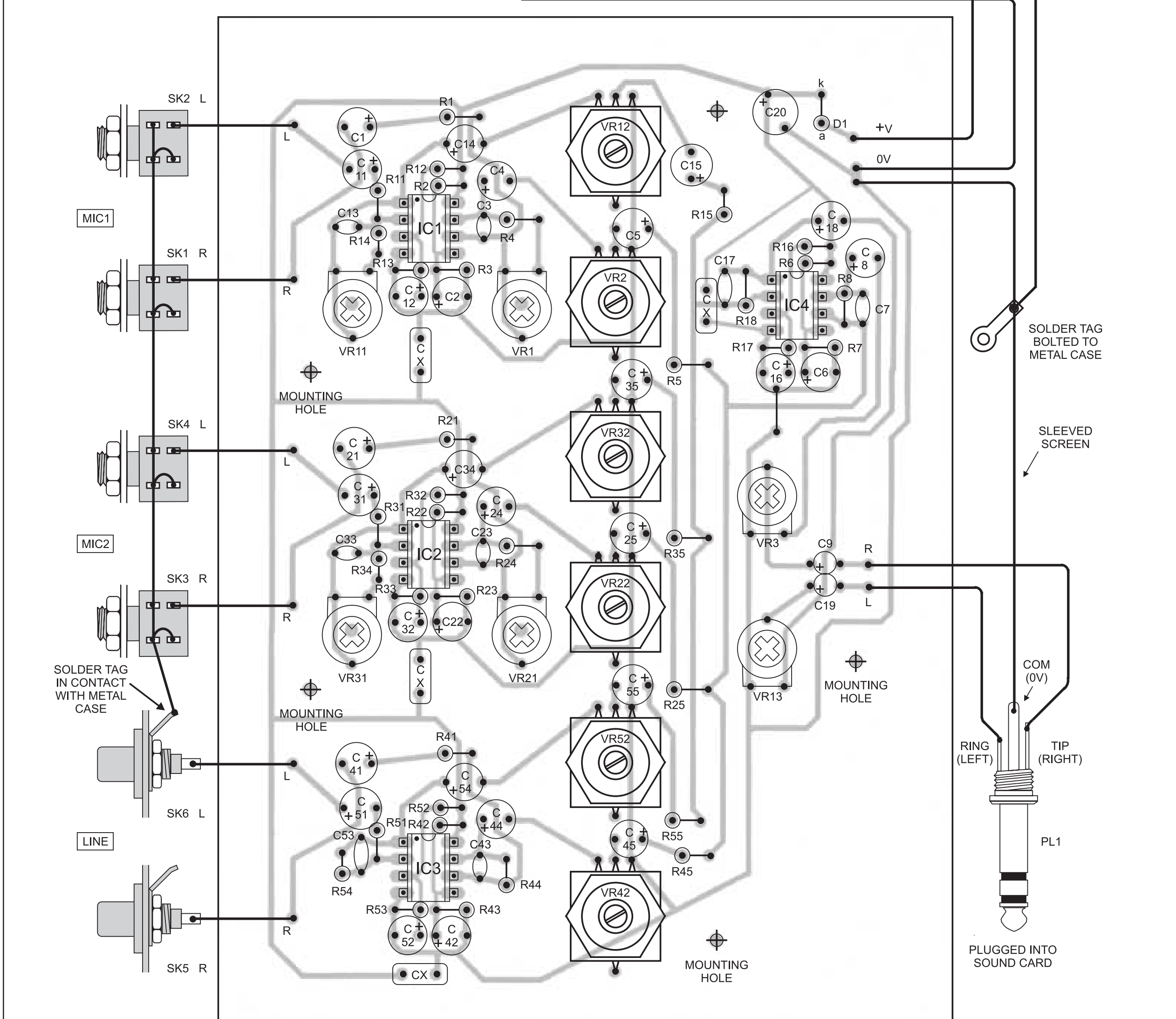


Fig.2. Sound Card Mixer printed circuit board component layout and interwiring. The full-size underside copper foil master is shown on the opposite page. The right and left outputs have been hard-wired to a stereo jack plug. Connections will, of course, have to match your own sound card set-up.

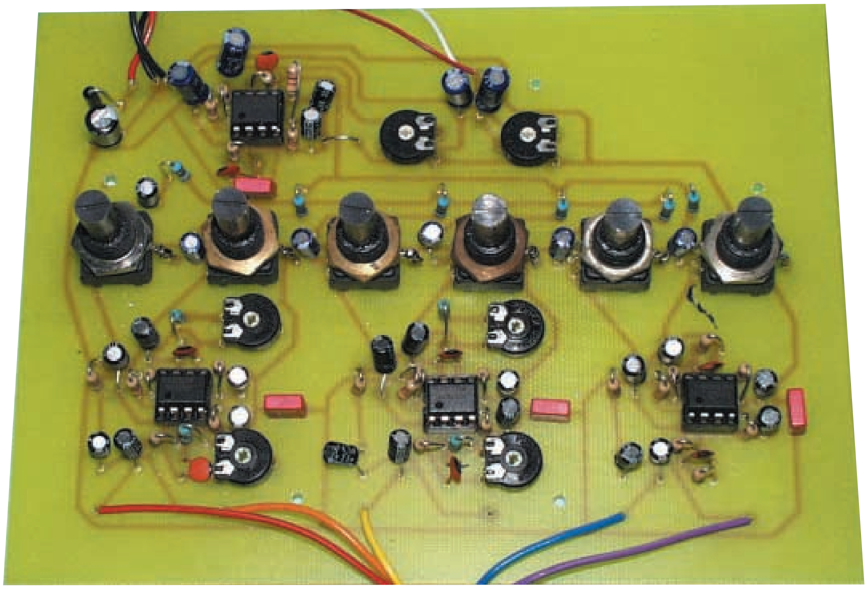
Boxing Up

An all metal box must be used for this project. This screens the circuit against possible hum pick-up which might otherwise be apparent in the final sound. The box should be large enough to accommodate all components and allow for any anticipated expansion with sockets for special purposes, etc.

Plan the layout of the front panel. This involves marking the positions of the potentiometer bushes, l.e.d. indicator, on-off switch and input sockets. Drill these holes through. In the prototype, 3·5mm mono jack sockets were used for the microphone inputs. In some cases, stereo sockets would be appropriate.

If the microphones have 6·35mm jack plugs fitted, adaptors are available to enable them to be plugged into 3·5mm sockets. Otherwise fit 6·35mm sockets if space permits. Whatever sockets are used, they should have switch contacts that open when a plug is inserted. These will be used to connect the "tip" to 0V ("earth") when a channel is left "open". This technique prevents hum that might be introduced by an unconnected input.

The Line inputs are made to a pair of phono sockets (SK5 and SK6). Mark out and drill a hole in the rear of the unit for the rubber grommet which will carry the output cable.



Component layout on the completed circuit board

Supply Arrangements

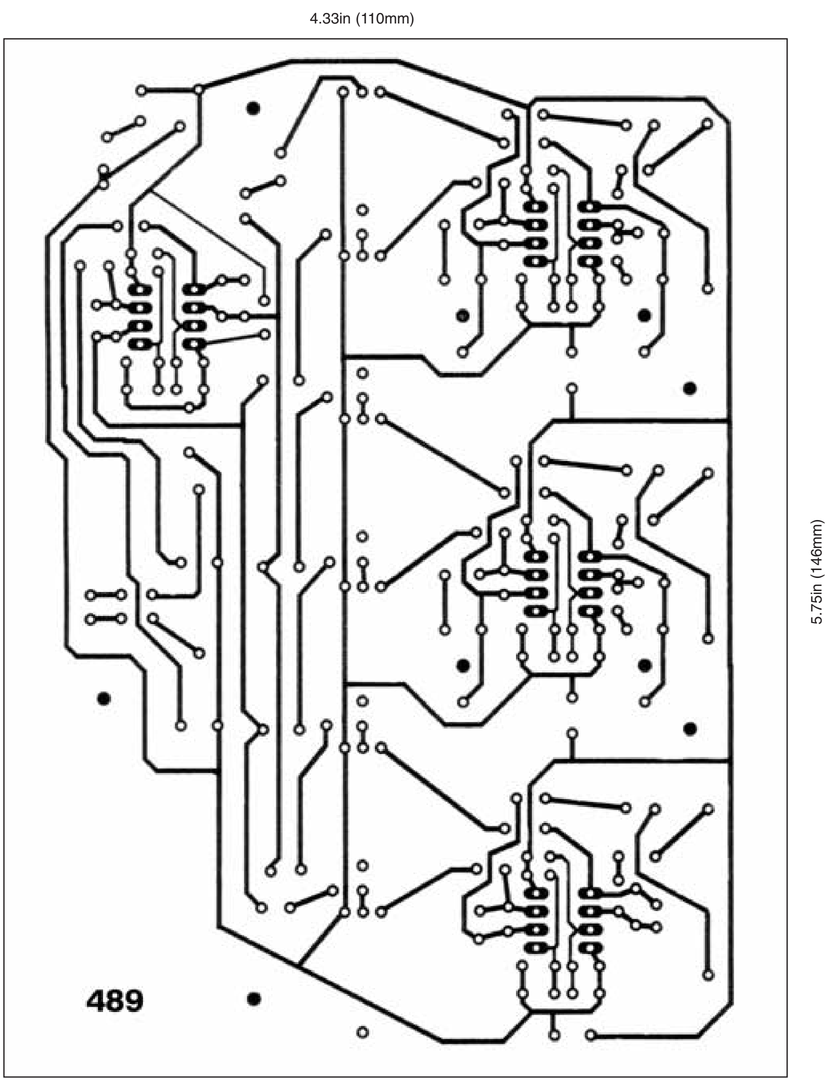
Decide where the battery pack is to be mounted and make a bracket to hold it. Drill the necessary attachment holes and a further one for a solder tag near the battery position. Fit these parts. Make sure the solder tag makes good electrical connection with the case by scraping off the paint around it.

It would be better if the batteries were attached to the lid section of the case rather than being placed on the bottom. This is because the wires will not be put under any strain when the lid is removed.

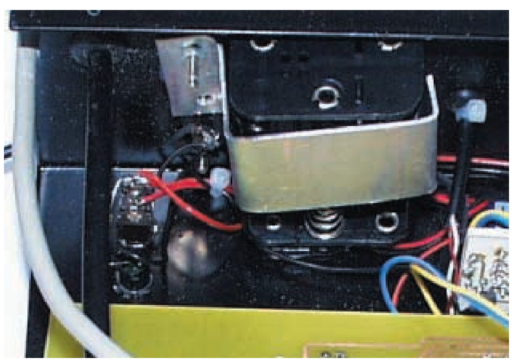
Check the fit of the p.c.b. Use washers (or spare nuts) on the potentiometer bushes so that as little as possible of them will protrude on the outside. This will provide a better fit for the control knobs (but do not attach these yet). With the arrangement used in the prototype, the potentiometer fixing nuts alone were sufficient to hold the panel securely – check this point.

If necessary, mark the positions of the p.c.b. mounting holes on the box, remove the p.c.b. and drill some or all of them through. Additional support may then be given by using thin bolts through these holes. If doing this, use stand-off insulators on the bolt shanks cut to the correct length. Mount the p.c.b. temporarily making sure that no on-board components are bent out of position or put under strain when the potentiometer nuts and any other fixings are tightened.

Mount the input sockets. If the phono sockets are of the "single hole fixing" non-insulated type as specified, scrape away the paint around the holes so that the "sleeve" connections make good metallic



Full-size underside p.c.b. copper foil master pattern.



Battery holder (6 cell) clamped to the side wall of the case.

contact with the case. Also, fit a solder tag (supplied with this type of phono connector) to the one nearest the microphone jack sockets. This is used as an "earth" (0V) point for all the jack socket sleeve and switch connections. If the phono sockets used do not make an automatic connection between the "sleeve" and the metalwork, a separate solder tag making good electrical contact with the case will be needed to do this.

Well Connected

Remove the p.c.b. again. Using pieces of stranded wire, make the connections to the input pads. Make similar connections to the supply and "solder tag" position. Using some form of colour code will help to avoid wiring errors. Fit the l.e.d. indicator (D2) and On/Off switch (S1).

Referring to Fig.2, complete the internal wiring. Note how resistor R9 is hard-wired in series with the l.e.d. The connections appropriate to the jack sockets used in the prototype are shown. Check that these are correct for the sockets used.

For the output cable, use twin (stereo) screened wire having a 3·5mm stereo jack plug on the end (or as appropriate for the sound card). This wire should be no longer than necessary, to avoid hum pickup. Fit a rubber grommet in the hole drilled in the rear panel, pass the wire through it and solder the ends to the output copper pads on the p.c.b.

The screening should be sleeved to prevent short-circuits and connected to the rear solder tag (the one near the battery position). Three wires need to be soldered here. Twist them all together and make the joint in one operation. Check that this work is sound. Apply some form of strain relief to the output wire (for example, by using a tight cable tie on the inside of the box) so that it cannot be pulled free in use.

Completed Sound Card Mixer. The knob on the top/back of the case is the Volume control for next month's Stereo Headphone Monitor.

Mount the circuit panel and tighten the potentiometer nuts. Do not do this too tightly because you may wish to remove the p.c.b. again later. Make sure no wires are trapped or left under strain. Insert the i.c.s into their sockets and fit the batteries.

Testing

If headphone monitoring is not already possible, you might like to construct the add-on Stereo Headphone Monitor (next month) before making any accurate tests.

Connect the output to the sound card's Line input (as stated previously, this might be the microphone socket!). Turn the Mixer controls to minimum and switch on the unit. The l.e.d. should glow.

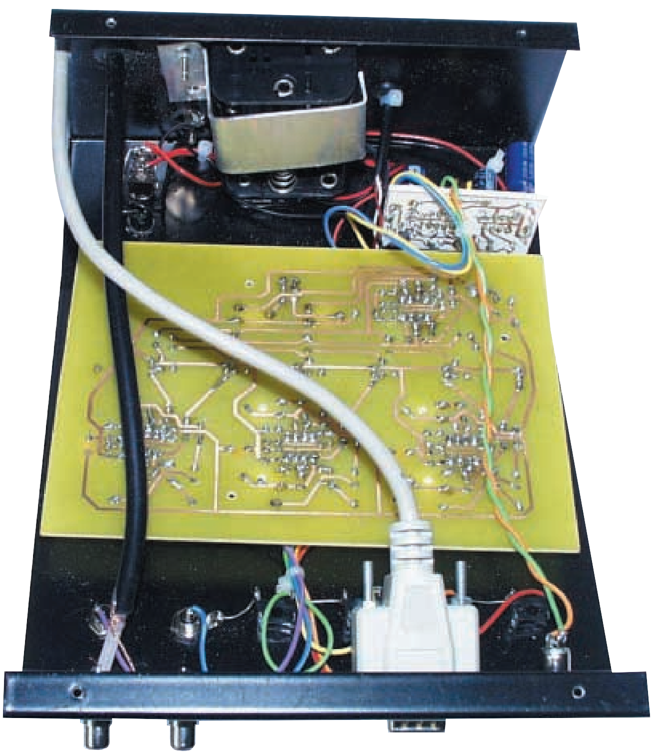
It is best to test the line inputs first. For this, you will need a device having a line-level output, such as a tape deck or the audio output from a camcorder. Make test recordings using both Left and Right channels. You will probably find that presets VR3/VR13 provide a satisfactory output level when left at mid-track adjustment.

If you do have to adjust them, the p.c.b. will need to be removed to allow this (unless you drilled the access holes in the p.c.b. as mentioned earlier). If one channel is louder than the other, adjust VR3/VR13 slightly to restore the balance.

Now, plug a microphone into each channel in turn and speak into it while slowly advancing the corresponding mixer control. The sound should be recorded clearly. Adjust the microphone gain presets (VR1, VR11, etc) to obtain a good level and a satisfactory balance between the microphone and line channels.

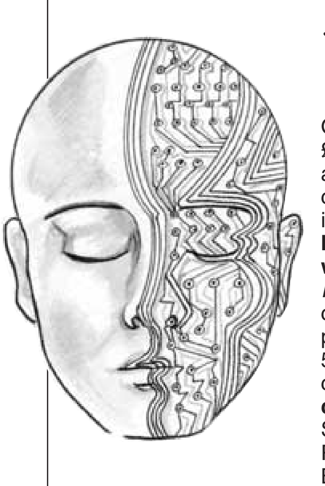
If the final level is much too high or too low despite adjusting VR3/VR13, you will need to alter the gain of the mixer. If it needs to be increased, raise the value of resistors R8 and R18 equally. Conversely, if it needs to be reduced, lower the values.

It only remains to tighten the potentiometer nuts, fit the control knobs, make a label and attach self-adhesive plastic feet to the base of the box. During operation, you will know when the batteries will need to be replaced when the "power on" l.e.d. indicator becomes dim and the sound quality deteriorates. □



Layout of components mounted on the inside of the metal case cover. The sockets on the front edge are the author's additions plus the stereo socket (front right) for next month's Stereo Headset Monitor.

Next Month: Build an add-on or stand-alone Stereo Headphone Monitor



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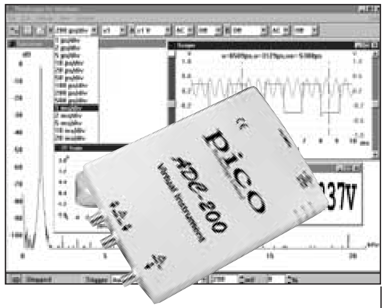

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Digital Stop Clock – On The Count

THE Digital Stop-Clock circuit diagram shown in Fig.1, opposite, was designed and built to help in the production of audio tapes for sight-impaired people. It is much easier to see and use than a small stopwatch.

The circuit is powered by a plug-in mains adaptor giving a 12V a.c. output at a minimum of 200mA. The 12V a.c. is rectified by the standard full-wave bridge arrangement (D1 to D4), and is then regulated down to 5V d.c. by IC1. Capacitors C1, C2 and C3 provide smoothing.

One side of the 12V a.c. input from the mains adaptor is fed via voltage divider resistors R1 and R2 to pin 2 of IC2, a 4518 dual BCD counter i.c. Counter A is wired to divide the 50Hz input at pin 2 of IC2 by 10.

With Clock A input and Reset pins (1 and 7) connected to 0V and the signal input fed to the Enable pin (2), the counter advances on the falling edge of each signal pulse. The output from counter A appears at Q3 (pin 6) and has a frequency of 5Hz.

Counter B is wired to divide by five and has the 5Hz output pulse from counter A connected to its Enable input at pin 10. Series connected NAND gates IC3a and IC3b are used as an AND gate. On the count of five, IC2 counter B outputs Q0 (pin 11) and Q2 (pin 13) both go high causing the AND gate output at pin 4 to also go high, resetting the counter and sending a 1Hz pulse to the collector (c) of transistor TR1, which is used to switch the clock display circuitry on and off.

Gates IC3c and IC3d are used as a "flip-flop", controlled by Start switch S1 connected to IC3d pin 13 and Stop switch S2 connected to IC3c pin 9. Output pin 11 turns TR1 on via base resistor R5, and output pin 10 provides the Reset to the Reset switch S3.

This arrangement is used to prevent the clock from being reset whilst it is running. The Stop button has to be pushed before the Reset button will function.

The 1Hz pulse from *pnp* transistor TR1's emitter (e) is fed to the Clock input of IC7 at pin 1. This is one of four 4026 decade counter/dividers, with 7-segment display outputs. These drive four FND500 common cathode (k) displays to show the clock's Seconds (X4/X3) and Minutes (X2/X1). Each carry out of the counter (pin 5), feeds to the Clock input (pin 1) of the next counter.

Diodes D6 to D8 and transistors TR2 and TR3 form a triple AND gate to reset the seconds display to zero each sixty seconds. The first time the segments E,F and G are turned on together in each count is for the numeral "6".

When this happens, diodes D6 to D8 are turned off and transistor TR3 is turned on, via resistor R10. This turns on TR2 which resets IC6 to zero and advances the minutes by one. Diode D5 is included to prevent the Minutes displays also being reset to zero.

As it stands, the Digital Stop-Clock will time up to one hour. An Hours display could easily be included by duplicating the Minutes display circuit. It is permissible to mount the Start, Stop and Reset switches some distance from the clock.

Barry Freeman,
Morphett Vale, Australia.

Light and Heat Sensor – Biased Solution

An ordinary l.e.d. will generate a small voltage when its *pn* junction is exposed to light or heat. This voltage may amount to a good part of 1V, and the current to a good part of 1μA. This will be appreciably higher where the l.e.d. is exposed to more intense light or heat.

In the circuit of Fig.2, a green l.e.d. (D1) and a red l.e.d. (D2) are wired "back-to-back" to the op.amp's inputs. Since these generate markedly different voltages, we thus deliberately present markedly different potentials to the inverting and non-inverting inputs – assuming of course that the two l.e.d.s are exposed to the same light and heat conditions.

Red l.e.d. D3 on the output is normally illuminated. However, withdraw some light or heat from green l.e.d. D1, and the voltage of red l.e.d. D2 predominates, thus extinguishing l.e.d. D3. This effect may be reversed, simply by reversing both D1 and D2.

To introduce a greater measure of control to the circuit, one could use the input-offset feature provided with many single op.amps. This usually wires pins 1 and 5 to the "extremities" of a 47kΩ preset potentiometer, and the "wiper" (the centre pin) to 0V. One could also add a relay, as shown in IU June '04 (Pressure Pad, Fig.2).

This circuit could have many applications – among them a thermostat, a so-called "cupboard alarm", a broken-beam alarm, or to sense when a car approaches at night. It can hardly be beaten for simplicity and cost.

Almost any op.amp with a high input impedance may be used, with the TL071CN and the OPA177GP also having been tested successfully. Widely varying supply voltages may be used, depending on the limits of the op.amp in question.

Thomas Scarborough,
Cape Town, South Africa

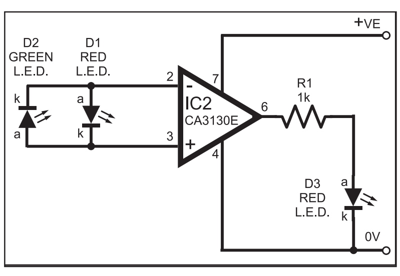


Fig.2. Light and heat sensor

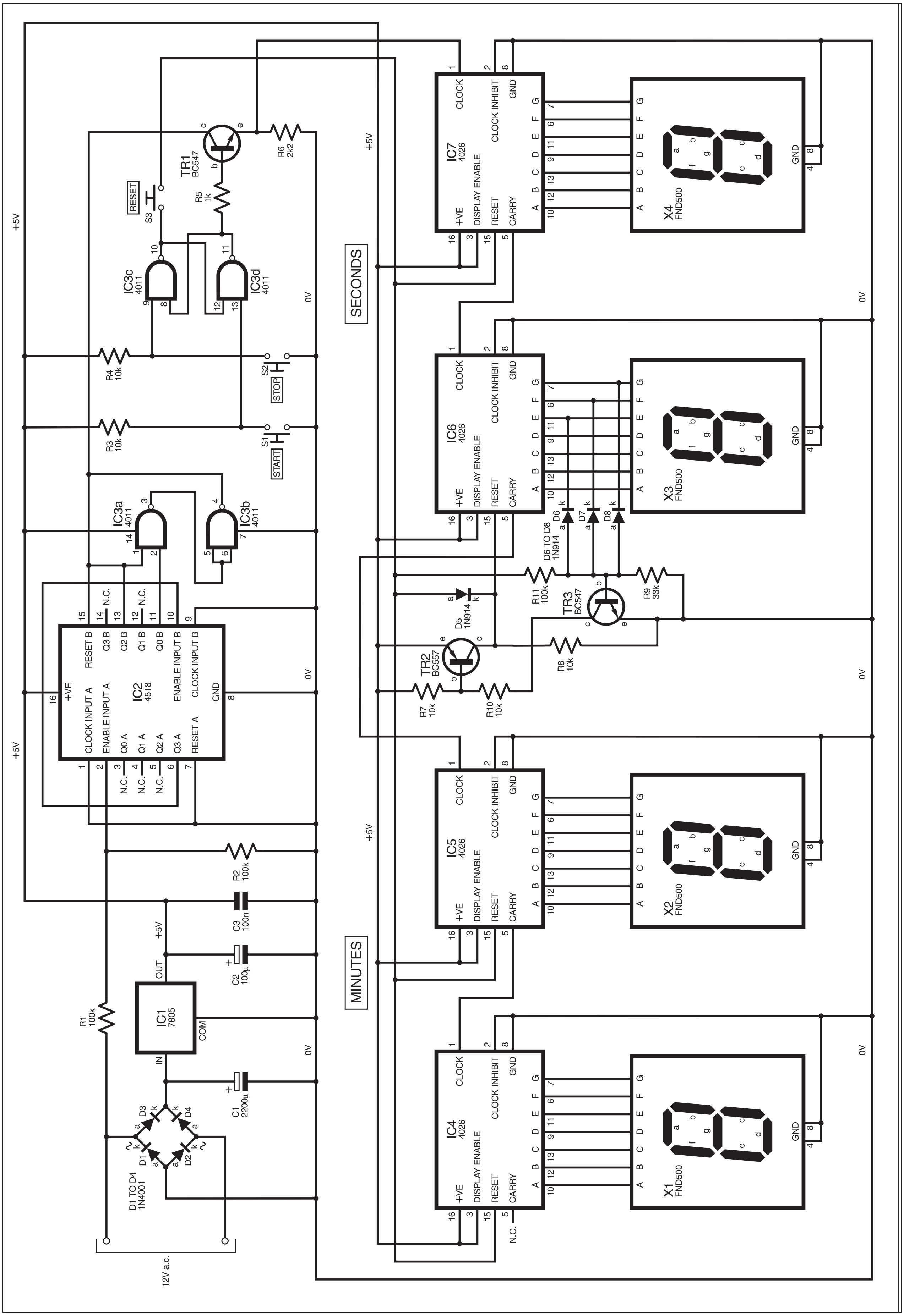


Fig.1. Complete circuit diagram for the Digital Stop Clock.

Special Report

E-Blocks and Flowcode V2.0 Reviews

by Robert Penfold

A system for learning about electronics and PIC programming

E-BLOCKS are electronic modules that are designed to enable users to learn about electronics and programming. They can also be used by experienced users as a means of quickly building and testing prototype designs based on PIC microcontrollers. The basic concept is very simple, and the system is based on a PIC programming module that also acts as the basis of the prototype designs.

Actually, there are two programmers (Fig.1), which are the "Multi" and "Lite" versions. The Multi Programmer has four sockets that accommodate a wide range of PIC processors having from eight to 40 pins. The Lite Programmer unit has a single 18-pin socket and can handle a much more restricted range of devices that includes the PIC16F88 and 18 series PICmicros. The sockets are good quality turned-pin types, but neither unit is equipped with any ZIF sockets, although 40-pin ZIF sockets can be added.

Programmers

Both programmers have a USB socket that connects to the PC. Only a USB 1.1 port is required, but the programmers will work properly with USB 2.0 ports. The Lite Programmer also has two 9-pin female D connectors, and these act as input/output ports when a device has been programmed and the new design is being tested. The Multi Programmer has no less than five of these ports, but some of them will be unused when utilising most PIC processors.

The Lite Programmer is powered from the host PC's USB port, but the Multi Programmer has a mains adapter. The latter is less convenient, but provides more power options. The Multi Programmer has the option of using a crystal or R/C clock oscillator. It is supplied with a 19·6608MHz crystal, but miniature crystals having other operating frequencies can be plugged into the holder instead. The Lite programmer relies on the PICmicro's internal clock oscillator: a feature that is available with newer PICmicros like the PIC16F88. Both units are supplied complete with a PIC16F88 processor.

As described so far the system is of limited use. You can program a PIC microcontroller and then set it working, but without the right hardware on the input/output ports it will not do very much. Obviously it is possible to "do your own thing" and connect whatever you like to the input and output ports. The E-Blocks offer an alternative approach in the form of additional modules that provide a range of input/output functions. The additional modules, a selection of which is shown in Fig.2, vary greatly in complexity.

Starting Blocks

At the most basic level there is a board that has eight l.e.d.s, with one driven from each line of a port. This board has a 9-way male D connector that connects to a programmer board via one of the leads supplied in the kit. There is also a 9-way female D connector that can carry the port's connections through to another module. When using this facility it has to be borne in mind that loading of the output lines by this passive board will reduce the output levels. The simplest input board has eight tiny pushbutton switches that can be used to control the input lines of a port. Again, this board has a port that can carry the connections through to another module.

These boards are primarily aimed at simple experiments when learning about programming, or when first trying out the system. A more sophisticated input board is available, and this has a four by three numeric keypad that includes * and # keys. More refined

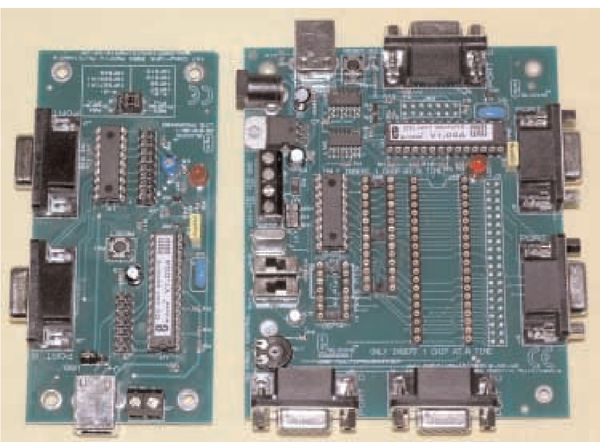


Fig.1. The Multi Programmer can be used with PICs having from eight to 40 pins. The smaller Lite Programmer is only suitable for use with 18-pin PIC processors

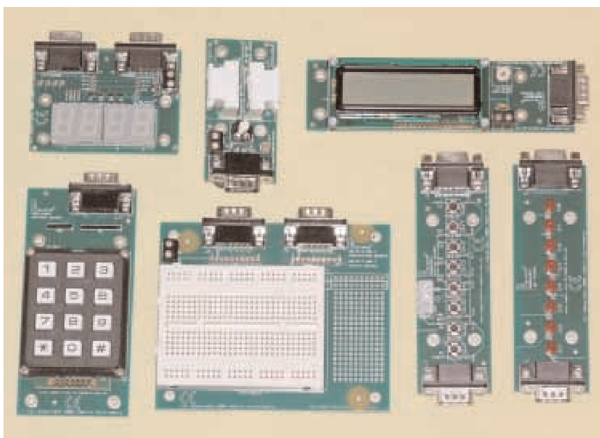


Fig.2. A selection of E-Blocks. Working clockwise from the top left-hand corner they are the four-digit l.e.d. display board, the sensor board, the l.c.d. board, the l.e.d. board, the switch board, the prototyping board, and the keypad board

output boards are available in the form of one having a four-digit 7-segment l.e.d. display and another that has a liquid crystal display. The latter provides two lines of 16 characters, and it uses a single port as it is driven using serial data. It includes a contrast control. Two ports are required to drive the multiplexed 7-segment l.e.d. display module.

Other Modules

Various other modules are available, including a prototyping board that has two ports with each one connecting to a nine-way s.i.l. socket. These sockets permit easy connection to the solderless prototyping board that has a 29 by 10 prototyping area plus four power rails. There is also a small area that has double-sided pads for prototyping of the soldered variety. In a similar vein there is a patch board. This is similar to the prototyping board, but it has a large area containing double-sided pads and no built-in solderless breadboard.

Other boards include one that provides wireless communications via an IrDA (serial infrared) link, an SPI board that provides 64K (8 by 8192) of non-volatile FRAM memory plus digital to analogue conversion, and an RS232C serial board. The serial board enables the system to communicate with another PIC system, a PC, or just about anything that has a standard serial port. There is also a sensor board that has a built-in light sensor, but it can also connect to a range of external analogue and digital sensors. Other boards include: CAN interface, Internet interface, X-10 home automation, CPLD programmer, Atmel AVR programmer, and simple screw terminal board.

All the E-Blocks have rubber feet that enable them to be used freestanding. However, it is definitely better if they are fitted on some form of base-plate, and a heavy steel plate drilled with a matrix of holes is included in the kit. Two side pieces enable the plate to be held at an angle, and this makes it much easier to use the modules. The base-plate assembly weighs a few kilograms, but it gives a firm base to work on and it should last many years. The modules are fixed to the base-plate using the supplied nuts and bolts, and then wired together using the nine-way D connector leads. The base-plate assembly, fitted with the multi-programmer plus the liquid crystal display and keypad modules is shown in Fig.3.

One or two of the modules are passive types, but most of them require power. The nine-way D connectors are only used to carry the ground connection and up to eight data lines. Power is carried via separate leads that connect to simple connector blocks that are included on the relevant modules. There is a +5 volt output on both of the programmers, and the Multi Programmer also has a +14 volt output. The latter is presumably the "raw" output from the mains adapter.

Software

The programmer boards obviously require software in order to perform their intended function, and this is provided in the form of a program called PPP. This requires the usual installation process, and it will run under Windows 98, ME, 2000, or XP. The Programmers are Plug and Play devices that require no installation under modern versions of Windows. After plugging in a programmer for the first time, Windows should report that the new hardware has been installed and is ready for use. A software driver is provided for Windows 98 users. Everything installed easily using a system running Windows XP.

In use the PPP program runs in a small window (Fig.4), and this has the usual menu bar near the top. The first step is to load the data file using the Open button or the Open option from the File menu. Then the Configure PICmicro button is operated so that the required settings for the clock oscillator, timers, etc., can be selected. The options are selected via numerous pop-down menus. A further pop-down menu is used to select the appropriate PIC chip, and radio buttons give the option of using hexadecimal, binary, or decimal source files. The configuration window is shown in Fig.5.

With the programmer set up and ready to go, it is then just a matter of operating the Send to PICmicro button. The program shows how things are progressing during the upload, and after a short while it provides a summary that (hopefully) indicates that the process was completed successfully. Simple test programs are provided with the programmers and the E-Blocks, and these make it easy to check that the various pieces of hardware are functioning correctly. I started with the "moving" lights test program for the Multi Programmer, and this worked first time.

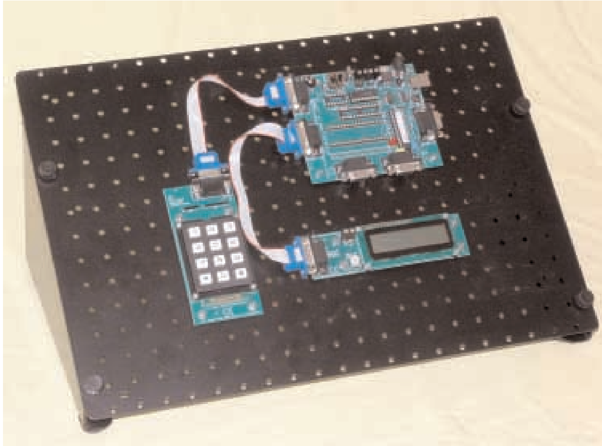


Fig.3. The A3 base-plate assembly is very heavy, tough, and can accommodate several E-Blocks

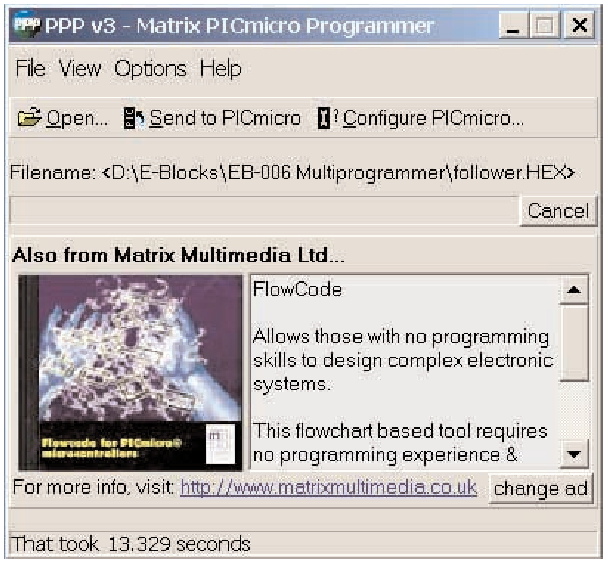


Fig.4. Running the PPP program produces this small window. Operating the Open button enables a program file to be loaded

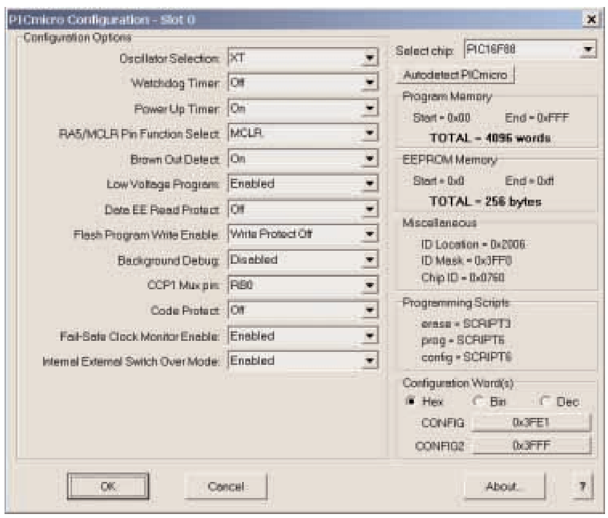


Fig.5. This window enables the PIC processor to be configured. The options vary slightly depending on the type of processor being programmed

Documentation

The documentation is provided in the form of PDF files on a mini CD-ROM that also contains the software and text files that contain last-minute information. Probably most PCs are now equipped with the Adobe Acrobat Reader program that is needed to read the PDF files, but this program is included on the disc. The PDF documents are well produced in full colour, and although quite brief they include all the information needed to use the modules. If necessary, they can be printed from the Acrobat Reader program using any installed printer. One slight problem with the documentation is that it is spread across two or three dozen files in various folders. It would be nice to have everything consolidated into a single document as well.

Also included on the disc are "lite" versions of the company's assembly language, C, and Flowcode programming languages. These are very "lite" versions that only enable the PIC16F84 to be programmed. Additionally, each "lite" language is accompanied by part of a course on programming PIC microcontrollers using that language. The cut-down versions on the disc are really just intended to provide "tasters" of the full languages and training systems. The complete languages and courses are available as optional extras, and they have additional features such as a virtual PIC microcontroller. It is important to realise that you will not become an instant PIC expert simply by buying some E-Blocks. Although the E-Blocks are easy to use, beginners will need some training in order to use them.

Conclusion

Clearly the E-Block system is quite involved, with a wide range of modules on offer. It was not possible to thoroughly test all the modules in the limited time available, but during the testing period everything functioned as expected. The modules themselves are well made and quite tough, as is the base-plate assembly. In fact battleship grey would be a more appropriate colour for the base-plate unit! Given half a chance, the E-Block equipment should provide many years of use. The prices are very reasonable for equipment of this quality.

The kit reviewed here is (more or less) the Deluxe Starter Pack, which includes a comprehensive range of E-Blocks and is supplied in a fitted plastic carrying case. Other packs are available, and buying any of them provides an easy way of getting started with this system. The modules and accessories are available separately as well. You can therefore buy a programmer and one or two simple modules to start learning about PIC programming, and then add more units as you progress.

Experienced PIC users can adopt a similar approach, buying a programmer and one or two of the more advanced modules, with more modules being obtained as required. The system is very flexible, making it easy to mix your own hardware with any of the E-Blocks. Using the E-Blocks clearly has its advantages, but you are not tied to or limited by them.

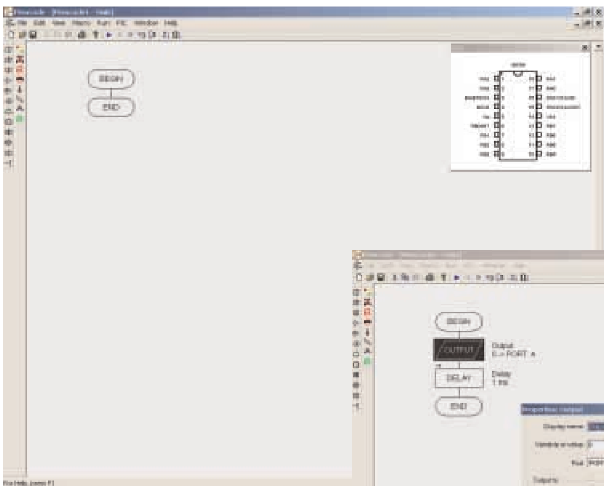
The versatility of the E-Block system makes it suitable for a wide range of users. Together with the languages and training systems, it has obvious appeal in education. The system is suitable for both new and experienced home users. Although the price of a large kit is probably rather high for most hobbyists, a more modest and affordable system is all you need to get started. Professional users will also be attracted to the E-Block system, and it could save a significant amount of development time. The system can be recommended for just about anyone involved with or wishing to get involved with PIC microcontrollers.

Flowcode V2

Flowcode is a high level programming language for PIC microcontrollers. It is well suited to use with the E-Blocks, and it includes some support for E-Blocks such as the l.e.d. and liquid crystal display boards. It should be possible to use Flowcode independently for any PIC based project, but a few features of the program might be of limited use when it is used in this way.

The basic concept of Flowcode is by no means new, and the idea is to program using flowcharts rather than conventional programming code. This provides an easy introduction to programming for beginners, and it can enable more experienced users to produce working programs more quickly than using other methods. With this method you still have to get to grips with some conventional programming concepts, such as loops and variables, but programming using flowcharts is still an easier way of programming.

Several programming languages of this type have failed in the past. The usual problem when it is applied to general programming is that a simple concept becomes very complex in practice. More and more facilities have to be added in order to



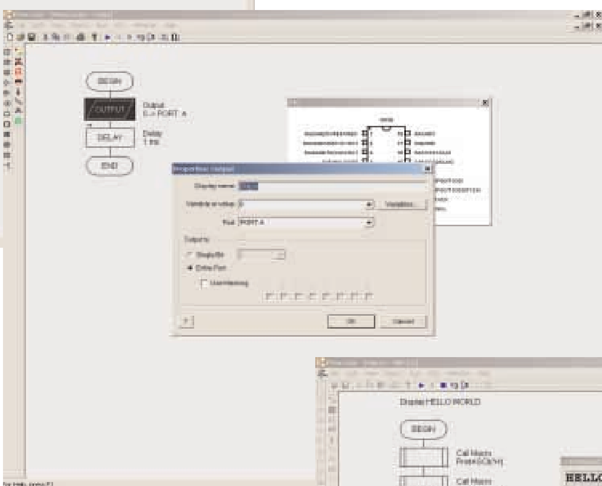


Fig.6 (above). The initial screen of the Flowcode program. Program blocks are dragged and dropped in place between the Begin and End blocks near the top left-hand corner of the screen

Fig.7 (centre). A pop-up window enables the parameters for a programming block to be set. In this case the dialogue box is for an Output instruction

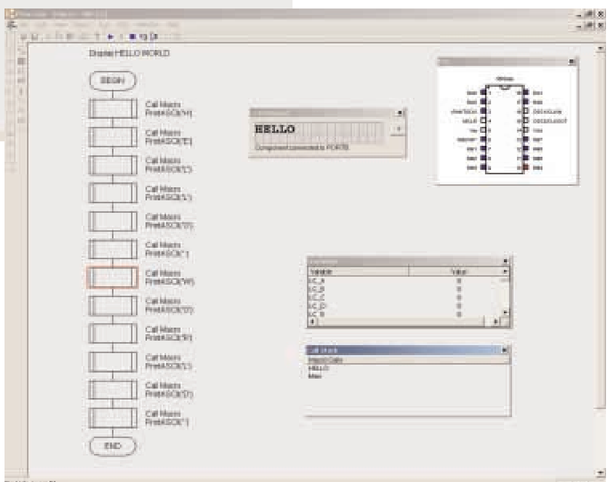


Fig.8 (right). The simulator can run the code in real-time, but it is also possible to go through the program one step at a time, as here accommodate all the requirements of programmers producing software for different applications. This can result in a beginners' programming language becoming more difficult to use than the real thing! The flowchart method works best in situations where relatively simple programs are involved. On the face of it, the reduced instruction set of PIC microcontrollers makes them well suited to this type of programming.

Installing Flowcode is reasonably straightforward, and it will automatically install any required add-ons that are not already present. On running the program you have the choice of opening an existing program or starting a new one. The appropriate PIC processor has to be chosen if a new program is started. This takes things on to the main Flowcode programming screen (Fig.6).

There is the usual menu bar near the top of the screen, with a toolbar just beneath it. The latter provides quick access to the more frequently used menu options. The top right-hand corner of the screen has a pin-out diagram for the selected PIC device. The top left-hand corner is where the program is entered, and initially there are just Begin and End blocks. Two columns of buttons down the left edge of the screen are used to add the programming blocks and external components such as seven-segment displays and the 2 × 16 liquid crystal display. The various screen elements can be switched on and off via the View menu.

Program Until You Drop

Adding the programming blocks is just a matter of dragging them to the appropriate position in the flowchart using the mouse and dropping them in place. The blocks on offer are much as one would expect, with things like loop, delay, decision, input, and output blocks. The usual Windows Cut, Copy, Paste, and Delete functions are available, making it easy to edit charts. With most of the blocks it is necessary to set one or more parameters, such as the delay time or the initial values of variables. This is achieved by double-clicking the appropriate block to produce a dialogue box. The one shown in Fig.7 is for an output operation. It enables a value to be sent to the entire port, a single bit to be set, or masking to be used. A pop-up dialogue box is also used to set the connections to external components.

A section of a chart can be saved as a macro and then used in a program as a single block. This is important because the flowchart method tends to require large amounts of screen space for even quite simple programs. Using macros is likely to be a neater way of programming anyway, but it will often be essential to use them in order to keep programs down to a reasonable size on the screen.

The simulation facility can operate in real-time, and an appropriate clock frequency must be set for this to work properly. Virtual components such as displays will operate much like the real thing, and the simulation will also respond to input signals from virtual switches, etc. It is also possible to run through the program one step at a time, and two pop-up windows then show current state of variables and the Call Stack. This is useful for debugging and is also helpful for those learning about programming as it is possible to see exactly what is going on. Fig.8 shows a version of the classic "Hello World" program in operation.

Problems

Finished programs can be compiled to assembler or transferred to a PIC processor via the PPP software or an alternative program selected by the user. The simulation tests all performed as expected, but some odd results were sometimes produced when programs were run on a real processor. The relevant FAQ section of the Matrix Multimedia web site helps to solve most problems, particularly one that can occur unless loops are programmed in exactly the right way.

Some 28 tutorials are installed with the program, and these cover a wide range of programming techniques. Those with a certain amount of programming experience should have no problem learning from the example programs, and being able to step through the programs is a big help here. The accompanying text for each program is quite brief, and might not be sufficient for complete beginners. A free online course is also available at Matrix Multimedia's website.

Conclusion

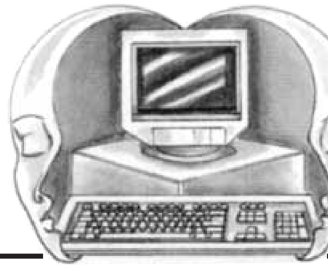
Flowcode provides a relatively easy way to get started in PIC programming and it is logical and straightforward in use. Things are generally done in standard Windows fashion, and this makes it possible to use the program without constantly referring to the online Help system. The simulation part of the program is very good, making it possible to learn a great deal about PIC processors before actually building real PIC projects. As is the modern trend, there is no printed manual. Flowcode fits in well with the E-Blocks system, but it is certainly not limited to operation with E-Blocks.

It is reasonably priced at £99-00 plus VAT for the Pro version, with a ten user version and a site license costing £300-00 plus VAT and £599-00 plus VAT respectively. There is also a Home/Student version that lacks IrDA and RS232C communications, keypad control, and a few other features. This is very competitively priced at £49-00 plus VAT.

Full details of the currently available E-Blocks and accessories, Flowcode, demonstration software, etc., can be obtained from the Matrix Multimedia Limited web site at **www.matrixmultimedia.co.uk** (telephone 0870 700 1831, fax 0870 700 1832). Flowcode is also available from *EPE* – see page the CDROMs pages. □

INTERFACE

Robert Penfold



SIMPLE DIGITAL TO ANALOGUE CONVERSION FOR PCs

THE previous *Interface* article provided details of a simple and inexpensive form of digital to analogue converter. This type of circuit is fine where good precision is not important, but it is of little use where high accuracy is required. Good accuracy and resolution require the use of a proper digital to analogue converter, and various devices offering from 8-to 16-bit resolution are available. For many practical purposes there is no point in going beyond 8-bit resolution, and noise problems can make it difficult to realise the theoretical accuracy of 12- and 16-bit devices.

There are two basic types of converter chip, which are parallel and serial interfacing types. The chips that use serial interfacing are not necessarily designed with an RS232C port in mind. In fact the vast majority of them are designed to interface to the processor via a few ordinary digital lines configured to act as a synchronous serial link. This enables the chip to be interfaced via just a few input and output lines, but the data transfers tend to be relatively slow. Using a synchronous serial link also complicates the control software.

Parallel interfacing requires more lines than the serial variety, but eight output lines and a ground connection are all that is needed for an 8-bit digital to analogue converter. A big advantage of parallel interfacing is that there is normally no need for any handshaking. Driving the chip is just a matter of writing the data to it each time a change in output voltage is required. The output will not respond instantly to changes, and the delay is known as the "settling time". However, the delay is quite small and is typically about one microsecond.

AD557JN

A 12-bit digital-to-analogue converter was covered in previous *Interface* articles, so this time a parallel converter will be described. The old Ferranti converter chips were very good when a simple 8-bit parallel digital to analogue or analogue to digital converter was required. Unfortunately, devices such as the ZN426E (D/A) and ZN427E (A/D) would seem to have disappeared with the company itself.

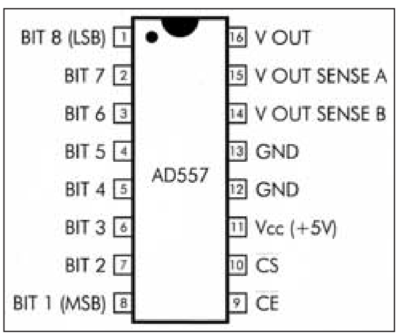


Fig.1. Pinouts for the AD557JN 8-bit D/A converter.

The nearest thing to the ZN426E currently available is probably the AD557JN. This is manufactured by Analogue Devices and in the UK it can be obtained from Rapid Electronics.

The AD557JN has a 16-pin d.i.l. (dual-in-line) encapsulation with the pin configuration shown in Fig.1. Conveniently, the eight data inputs are grouped together on one side of the device (pins 1 to 8), and in the right order.

The manufacturer's labelling for the data inputs and outputs of converter chips can be a bit confusing. Rather than the usual D0 to D7 they are often marked Bit 1 to Bit 8, as in this case. Bit 1 is the most significant bit (D7) and Bit 8 is the least significant bit (D0), which is the opposite of what one would probably expect.

On the other side of the device there are two ground pins and a positive supply input. The chip is designed to operate on an ordinary 5V logic supply, and the supply must be within the range 4·5V to 5·5V. The typical supply current is 15mA, and it will not exceed 25mA. Both ground pins are combined digital and analogue types. The data sheet for the AD557 gives a suggested earthing and decoupling arrangement for use where the lowest possible noise level is important. However, digital noise is not really a major problem with a chip that has 8-bit resolution.

Pins 9 and 10 are respectively *chip select* and *chip enable* inputs. These are only needed in applications where the chip will interface direct to the data bus of a processor. They are not needed in a PC project that has the chip driven from the latching outputs of a parallel port. Both pins are simply connected to ground to make the chip "transparent". The data placed on the data inputs is then fed straight through to the converter section.

The output section of the chip consists of an operational amplifier and three resistors in the arrangement shown in Fig.2. In normal use pins 14 to 16 are simply connected together so that all three resistors are used in the negative feedback loop. This gives an output voltage range of 0V to 2·56V. A maximum output

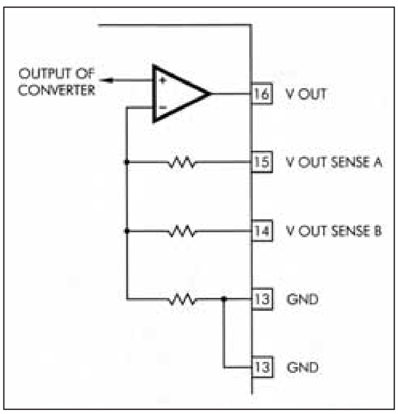


Fig.2. Internal arrangement at the output of the AD557JN.

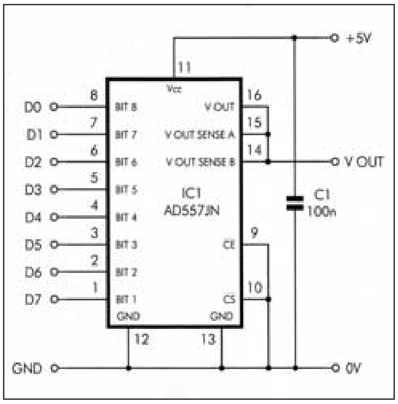


Fig.3. Simplicity of the active AD557JN d/a converter.

potential of 2·55V (10mV bit least significant bit) would have been a more logical choice, and a table in the device's data sheet seems to suggest that this is the correct figure.

Anyway, the exact maximum output voltage is usually of little practical importance. It is possible to trim the output voltage using variable resistors in series with the Sense A and Sense B pins, but in practice the standard output range of 0V to 2·56V is normally used. External amplification and processing is then used to give the required output voltage range.

No external voltage reference is required. The AD557 has a built-in precision band-gap reference source that provides a highly stable 1·2V output. Using a low reference voltage enables the device to operate from a single 5V supply. The full scale accuracy of the chip is plus and minus 2·5 LSB at 25 degrees Celsius, but can be as large as plus and minus 4·5 LSB at extreme temperatures.

Of much greater importance in most practical applications, the relative accuracy is typically plus and minus 0·5 LSB, with a maximum error of plus and minus 1 LSB. This is more than adequate for most applications. The settling time is typically 0·8 microseconds, but can be as much as 1·5 microseconds.

Basic Circuit

Few discrete components are needed in order to produce a basic digital to analogue converter based on the AD557JN. In fact the only discrete component required is a supply decoupling capacitor, as can be seen from the circuit diagram of Fig.3. The data inputs are TTL compatible and can therefore be interfaced direct to any normal PC printer port. The circuit should work equally well with any 9-bit output port that provides latching outputs at TTL levels.

The circuit requires a +5V supply, but this is not available from a PC printer port. Ways of obtaining a +5V supply from a PC have been covered in past issues of *EPE*, and this subject will not be covered again here. The

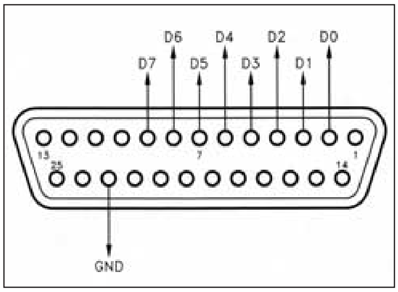


Fig.4. 25-way D connector pinouts for use with the AD557JN circuit in Fig.3.

connections to the PC's printer port are shown in Fig.4. A 25-way male D connector is needed to make the connections to the printer port. One slight drawback of parallel interfacing is that the connecting cable should be no more than about two or three metres long. In this case a somewhat longer cable is acceptable provided high-speed operation is not required.

Digital PSU

In practical applications it will usually be necessary to use some amplification at the output of the converter in order to provide the required output voltage range and output current. The circuit of Fig.5 shows the circuit diagram for a simple computer controlled power supply unit based on the AD557JN. A small monolithic voltage regulator (IC2) is used to produce a 5V supply for the converter from the main supply. The converter has the basic configuration with its nominal 0 to 2·56V output range.

The first requirement in a power supply application is to provide a more useful output voltage range. In this case operational amplifier IC3 is used in the non-inverting mode with a voltage gain of approximately five. This boosts the maximum output voltage to 12·75V with a resolution of 50mV (0·05V). In practice the voltage gain of IC3 must be adjusted to allow for any scaling errors in IC1. With a value of 255 written to the converter, VR1 is adjusted for an output potential of precisely 12·75V.

A buffer stage at the output of IC3 enables currents of up to one amp to be provided. The buffer stage is an emitter-follower type based on Darlington power transistor TR1. The high current gain of this device is needed because of the limited output current available from IC3. An ordinary power transistor is unlikely to give usable results in this circuit.

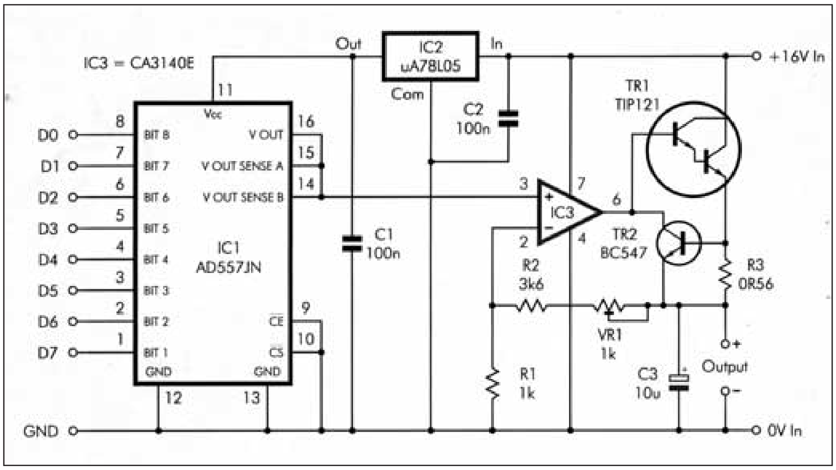


Fig.5. Circuit diagram for the computer-controlled PSU. TR1 requires a large heatsink.

The occasional short-circuit or major overload on the output is inevitable with this type of equipment, so some form of over-current protection is essential. This circuit has a conventional current limiter which has R3 as the current sensing resistor. An output current of more than about 1·1A results in TR2 turning on and pulling the output of IC3 lower in voltage.

The output short-circuit current is typically a little over 1·2A. Other output currents can be accommodated by altering the value of R3. The correct value is obtained by dividing 0·6 by the required output current (in amps). The circuit should work well with output currents of up to about 2A or so.

Points to Note

Due to the voltage drop through the output stage it is essential for the supply voltage to the circuit to be at least 3V more than the output potential. The input supply must not exceed about 30V with no loading on the output. A wide range of supply voltages can therefore be tolerated, and there is no requirement to use a stabilised supply. However, using a regulated supply of about 18V to 20V would probably give a slightly improvement in the stability of the output voltage.

Resistor R3 should have a power rating of at least one watt. IC3 has a PMOS input stage, and the usual anti-static handling precautions should therefore be observed when dealing with this component. The CA3140E used for IC3 is a type that will work in d.c. circuits without using a negative supply rail. Most other operational amplifiers require dual supplies and will not work properly in this circuit.

Transistor TR1 has to dissipate several watts when the unit is used at low output voltages and high currents. Consequently, it must be mounted on a substantial heatsink. Note that the collector terminal connects internally to TR1's heat-tab. Where appropriate, an insulating kit must be used when mounting this device on its heatsink. The TIP121 and TIP122 are both suitable for use in this circuit.

Some refinements to the circuit and the controlling software will be provided in the next *Interface* article.

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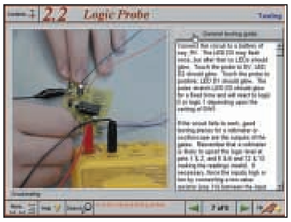
ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

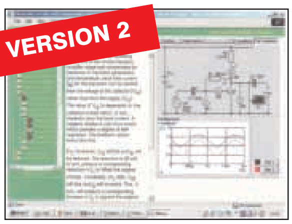


Logic Probe testing

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

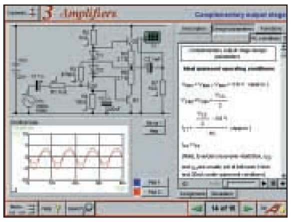
VERSION 2



Circuit simulation screen

Provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits. Active Circuits.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS

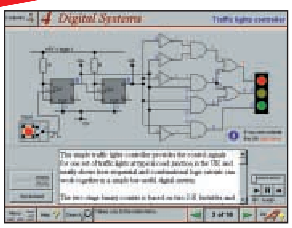


Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

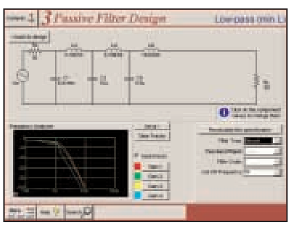
VERSION 2



Virtual laboratory – Traffic Lights

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

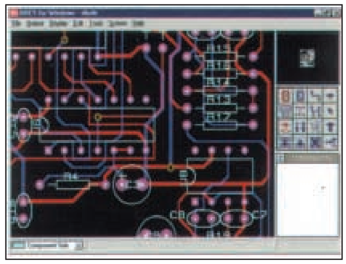
ANALOGUE FILTERS



Filter synthesis

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

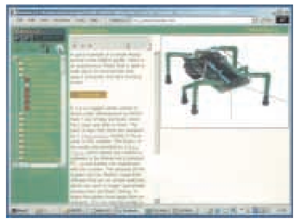
ELECTRONICS CAD PACK



PCB Layout

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

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

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

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

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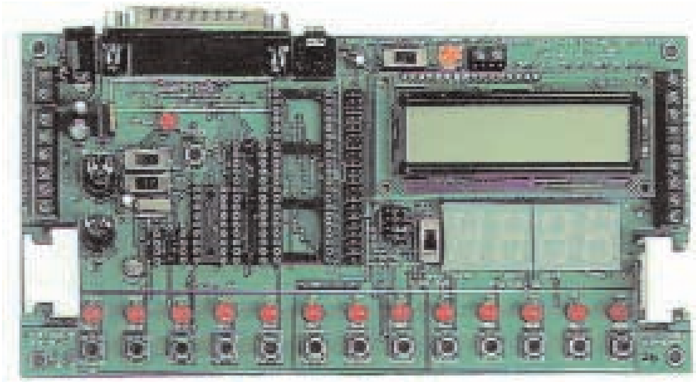

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12V 500mA plug-top PSU (UK plug) £7

25-way 'D' type connecting cable £5

SOFTWARE

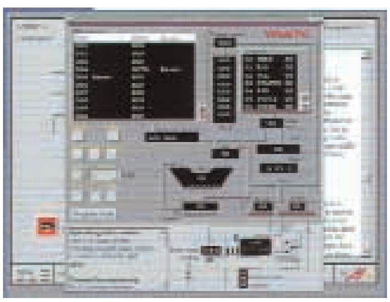
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V2

(Formerly PICtutor)

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

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



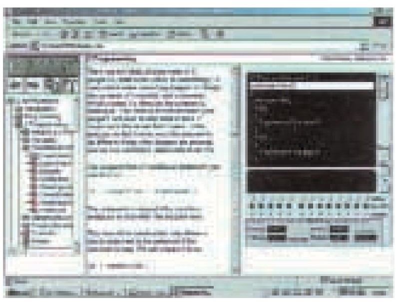
Virtual PICmicro

'C' FOR PICmicro VERSION 2

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

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

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



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

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

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

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

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols (ISO5807) ● Full on-screen simulation allows debugging and speeds up the development process ● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● Professional versions include virtual systems (burglar alarm, buggy and maze, plus RS232, IrDa etc.).

Burglar Alarm Simulation

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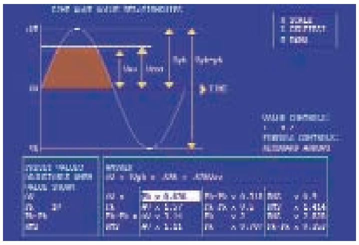

Sine wave relationship values

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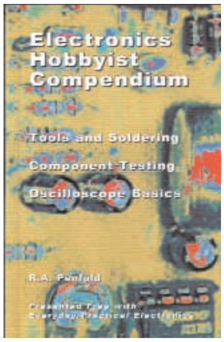

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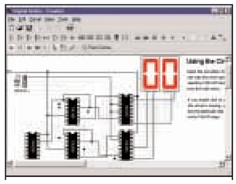

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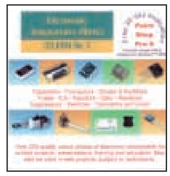

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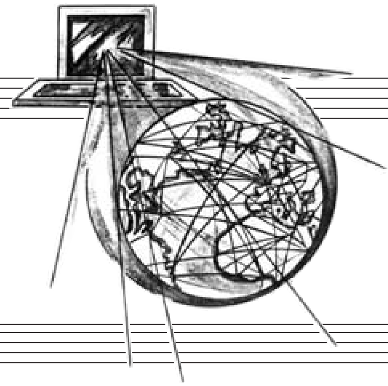


NET WORK

ALAN WINSTANLEY

HAPPY New Year, readers! With 2005 well and truly upon us, attention often turns to starting to clear out our surplus or unwanted items, and for many of us that means mooching over to eBay (**www.ebay.co.uk** and countries). This month's *Net Work* revisits eBay and warns of some of the perils of buying or selling.

It has been said that eBay rates as the world's most recognised brand, even ahead of Mickey Mouse. For many people, eBay is now their first port of call when searching for just about anything. There is no question that eBay, which is probably responsible for the near collapse of traditional Classified advertising in local papers, is a uniquely useful way of putting buyers and sellers in touch with each other.

If you are anything like the author, you hate throwing anything away and you will go to the end of the Earth in order to find an unwanted item a good home. If a few pounds can be made into the bargain, so much the better. Buying on eBay can be equally rewarding, if you know what to look for. A drum of 100 high quality 8-speed DVD-R disks for £19.00 plus p&p proved to be a good bargain, and funnily enough it transpired that the seller lived just a few miles away. Hard to find PVC covers for 8cm mini CDs were also sourced on eBay, as was a rare waterproof rainjacket for a Sony camcorder (and a video lamp). Even British railway operators snap up valuable legacy electrical switchgear on eBay. Once you start, you're hooked! There is plenty for the electronics enthusiast to delve into (but *EPE Chat Zone* users report that tasty-looking second-hand oscilloscopes have a nasty habit of being dead on arrival, so be careful!).

Don't get Burnt on eBay

The principle of *caveat emptor* (let the buyer beware) applies by the shovel-full. The secret of success on eBay is to keep one's feet firmly planted on the ground and not get carried away with bidding. However, for unwary buyers, even the most legitimate-looking bargain carries the potential for fraud, so a very healthy dose of cynicism rarely goes amiss.

In England, a 28 year old woman was prosecuted for selling non-existent concert tickets on eBay. She earned £3,000 ($5,700) for tickets for the Glastonbury Festival pop concert. Judge Richard Bray said "It [eBay] is based entirely on trust, with no checking at all. [Buyers who are] trusting people send money in good faith. I'm not surprised there is fraud. It is truly amazing." In the same way, a 17 year old youth from Wales conned buyers out of nearly £50,000 selling goods that never existed. He blew the money on an exotic lifestyle over in New York before the law caught up with him.

In another case, an English woman paid for a Sony laptop sold by an Italian eBay "user". Payment was required by Western Union before the laptop could be despatched. Anyone can waltz into their nearest Western Union office with some identification and collect the payment, then vanish into the night, and that's exactly what happened; the money was spirited away but no laptop ever arrived. If there is the slightest doubt, never pay by cash transfer for such transactions, especially not by Western Union. The chances are that a deal will work out fine, but bad experiences leave a bitter after-taste with innocent people who have been stung by a transaction facilitated through eBay's online service.

Taken for a Ride

A police acquaintance is a keen golfer who uses eBay to trade in a wide range of golf items. Over a cup of tea he told me about an item he spotted on eBay that aroused his "detective" suspicions. An electric golf cart was up for sale, complete with alloy wheels, special paintwork and heightened suspension, which made this the Acme of all golf carts. The eBay seller's location was clearly stated as "UK" and the selling price was suspiciously low.

A photo showed the cart in all its glory. The trouble was, the houses in the background were definitely not English, neither was the licence plate on the cart. A magnifying glass confirmed that the photo was taken somewhere in Eastern Europe. Some innocent-looking emails sent by my police friend quickly revealed the scam; the seller was actually in the Czech Republic. He was offering to ship the cart across Europe for cash on delivery, provided the freight charges were paid in advance! Digging deeper, the seller's 50+ eBay rating looked suspicious as well – all of the transactions were for very trivial amounts. My police contact emailed all other bidders to warn them of the consequences of paying out. Anyone with any sense would trust their instincts and avoid this item, but the winning buyer (yes, there was one), was in mortal danger of being taken for a ride – on a golf cart that would not have arrived.

There are a number of practical aspects that potential eBayers should remember when trading in the world's largest online emporium. Firstly, it is straightforward enough to build up a positive eBay rating, e.g. by selling a large number of trivial items. Don't be fooled; check into previous transactions by clicking on the "Feedback" rating of the seller. Selling prices can also be inflated by a group of bidders collaborating between themselves to force up the bid, so you pay more.

Protect Yourself

Take nothing for granted. The golden rule is that sellers are not responsible for questions that you do not ask! For example, do not assume that (say) a second-hand inkjet printer comes with ink cartridges or a printer cable if it has not been mentioned in the advert. The cartridges will cost more than the printer! Ask the seller beforehand about all such aspects, and comb the description carefully, thinking about anything that may have deliberately been omitted.

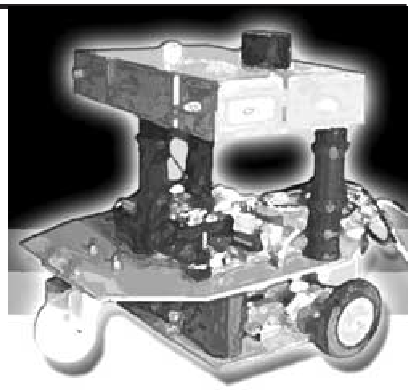
Shipping charges are another way of boosting profits. The writer recently bought a 512MB Mini SD card (for just £39.99) and the p&p was £2.99. Since the memory card is tiny, that's another £2.50 profit on sales. Insurance is another point to consider; it is unsafe to assume that if an item is lost in the post that the seller will send another. The general assumption is that items are posted at the buyer's risk, and if you want extra protection you may need to pay extra costs. For more expensive items (e.g. a laptop), is there a land-line number available to call the seller? One highly seasoned eBay buyer pays to use **192.com** to research the sellers' addresses from their phone number.

Paypal (owned by eBay) offers some limited form of protection but the general feeling appears to be that buyers may have to jump through hoops in order to establish a claim against a defaulting seller. Credit card companies may be able to help with some claims, but if you are brave enough to send cash, Western Union or bank transfers then the risks are extremely high. Revenge is sweet though: take a look at **http://tinyurl.com/685sf** to see how a fraudulent scammer in London was outscammed.

It stands to reason that eBay fraud will rise as more beginners jump on the bandwagon, with fraudsters marvelling at the simplicity of defrauding honest people out of their hard-earned cash. Here's hoping that you don't have to learn a painful lesson. In next month's *Net Work* I'll be looking at the practice of defrauding by "phishing". You can email **alan@epemag.demon.co.uk.**

Constructional Project

Smart Karts



Owen Bishop

Part 5 – SK-3 Goes Pushing and Grabbing

ONE of the stimulating aspects of robotics is that it combines three technologies – electronics, mechanics, and computer programming. The emphasis is on the mechanical side this month, for we give our Smart Kart mobile robot some tools, controlled under another set of PIC program routines, which will be discussed next month. For simplicity we shall call this robot version SK-3.

New Accessories

The grabber (or gripper) is the more useful of the new tools. It picks up objects and then deposits them somewhere else, see below. However, constructing even the simplest gripper requires a certain amount of mechanical skill. We also describe a design for a pusher. This turns SK-3 into a kind of bulldozer, which pushes objects around the tabletop or floor, but does not pick them up.

The robot has to know if there is anything to push or grab, of course. It has a reflected light sensor for this purpose. As usual with mobile robots, we need some way of letting it know where it is. Line following is a sufficiently precise solution to this problem, so we have re-installed the pair of infrared sensors that were used in Part 1 (Oct '04).

A lot of the structures and electronics used in the previous versions are used again in SK-3. As just mentioned, we use the infrared sensors. We also use the complete lower deck with its motors, battery, and power board. We use the middle deck too, with its processor board and battery.

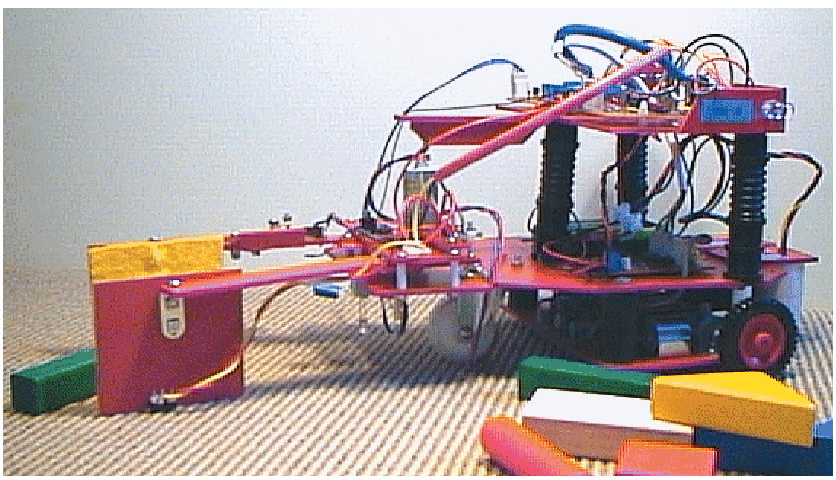
The tools (one or the other, but not both at the same time) are mounted at the rear edge of this deck. But the upper deck is completely new, with a new Distribution board, a Light Sensor board and second copy of the Power Switching board of Part 1 (Oct '04) for driving the motor or motors that operate the new attatchments.

The main theme of SK-3 is *feedback*, mainly that provided by limit switches. These tell the robot what it is doing or, rather, what it has done.

Getting Started

If you are working from SK-2 (Part 3, Dec '04), remove the bumpers and the small bumper board from the middle deck. If you originally built SK-1 (Part 1), you already have its infrared sensors. Mount these at the front edge of the middle deck, as before. They connect to the Processor board (Part 1); the power lines go to the screw terminals and the 2-way socket to pins 6 and 7 of the header plug.

SK-3 uses the same type of microcontroller, a PIC16F84, as used in the earlier versions, so you can simply re-program the one you have or program a new one. (Pre-programmed PICs are available, see *Shoptalk* page.)



Smart Kart SK-3 with its rear-mounted grabber searches for bricks.

Remove the upper deck entirely and replace it with the new deck as described below. Retain the three separators, ready for supporting the new upper deck.

Upper Deck

The upper deck is a single panel with two small panels glued to its edges to support two l.e.d.s, and the two switches used for selecting the programs. It is best to defer wiring and gluing the edge panels until after the winch has been constructed and the circuit boards mounted.

The general layout of the upper deck is shown in Fig.5.1, along with the holes required. As usual, the hole diameters and exact positions depend on factors such as the dimensions of the motor, the winch and the p.c.b. supports. Six holes are needed for these supports. There is a slot for passing the lead through from the Processor board to the boards on this deck.

Winch Assembly

The motor-driven winch is used for raising and lowering the tool (pusher or grabber). Begin construction of the upper deck by building the winch. As shown in the photographs opposite, the motor (which incorporates a reduction gearbox) drives a spindle around which is wound a thin cord. This passes through the hole at the end of the cord support arm, and is tied to the tool (grabber or pusher).

Depending on the material used for the cord support arm and the eventual weight of the gripper (plus load), you may need an arm more rigid than that shown. If using foam PVC, make the arm from two strips 15mm wide and glued together in the form of an L-girder or T-girder (see later).

The various brackets and bearings used in this assembly may be made from strip aluminium drilled and bent to the required shape. Some electronics suppliers list metal angle brackets that are suitable. The prototype used small angle brackets and other Meccano parts, secured with Meccano nuts and bolts.

The motor support panel is held vertical by an angle bracket. It is drilled to accept the front bearing of the motor, which protrudes slightly from the casing. The motor used in the prototype has two M2·5 threaded holes on either side of the bearing and two M2·5 bolts 10mm long were used to bolt the motor to the support.

The shaft of the motor is coupled to the shaft of the winch by a short length of plastic aquarium tubing, 5mm diameter, which is a tight fit on both shafts. The winch shaft is a 4mm diameter steel rod about 50mm long.

Before assembling the motor and coupling it to the winch, check carefully that the shafts of the motor and winch are exactly in line. If the axis of the motor is found to be higher than that of the winch, cut a sliver from the bottom edge of the support before bolting it to the bracket.

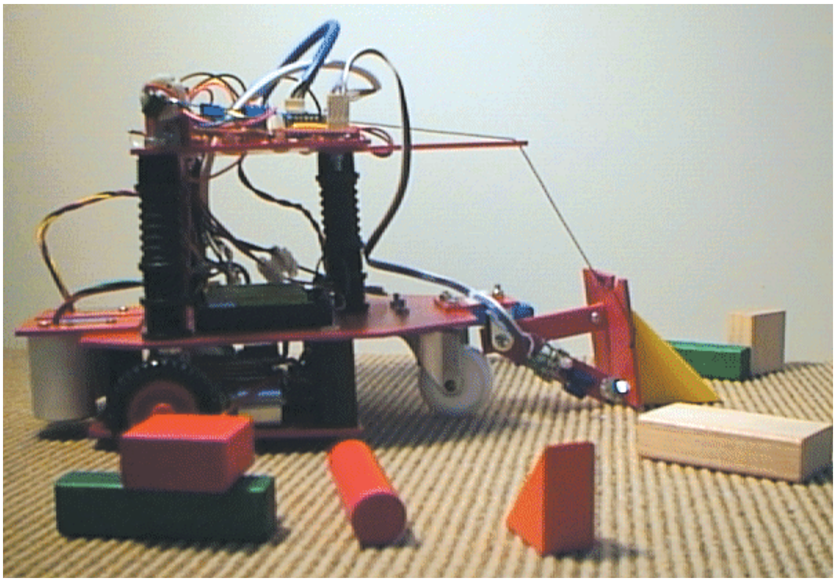
When bolted to the bracket, the bottom edge of the support should rest firmly on the upper deck, to prevent it from turning. Preferably, use a shakeproof nut for securing the bracket to the deck.

The far end of the shaft is prevented from coming free of the bearings by rubber grips. Small rubber grommets or bolt-on feet could be used for this; the prototype used the Meccano equivalent. One of the grips is used to secure the end of the cord to the shaft. Thread the cord a short way from left to right (see photos) through the grip before pushing the grip on to the shaft. Tie a knot in the cord to prevent it from being pulled out of the grip.

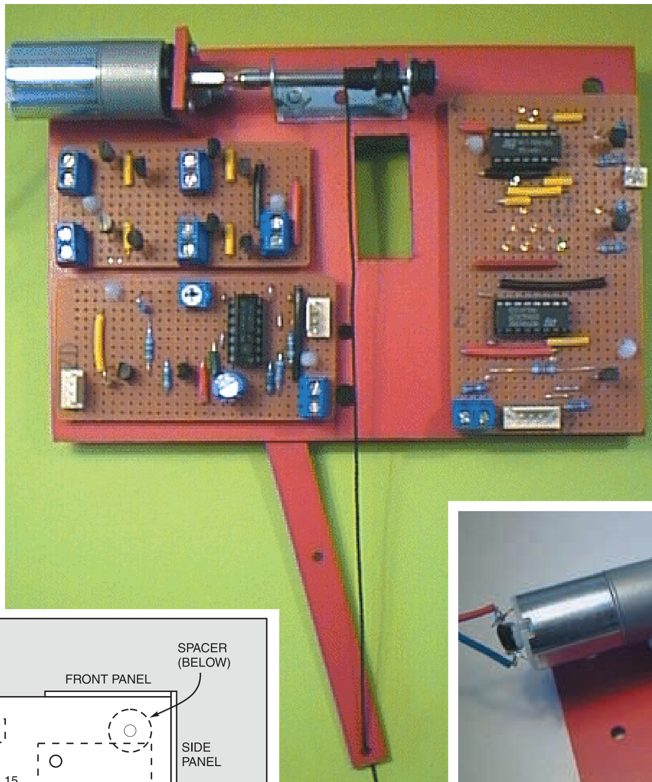
Note the capacitor soldered across the terminals of the motor. Further work on the upper deck is described later, but first the control circuit is described, assembled and tested.

Light Sensor

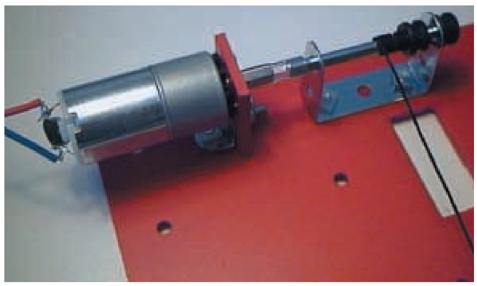
The Light Sensor is designed to detect a small object placed behind the robot (the robot runs in reverse when pushing or grabbing). Its circuit diagram is shown in Fig.5.2.



(Above) In its other version, SK-3 has a rear-mounted pusher attachment for moving objects around the room.



(Left) The upper deck before the inter-board wiring is done. Note the cord support arm.



(Below) The winch is positioned at the front of the Upper Deck and used to raise or lower the pusher or grabber at the rear of the robot.

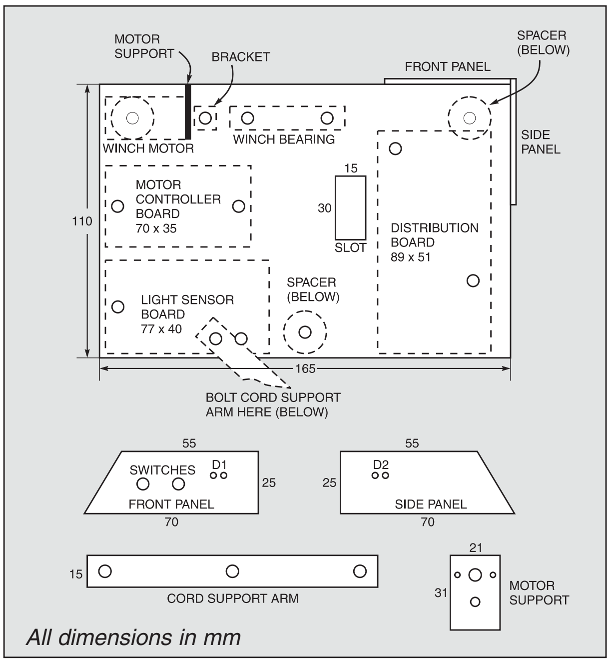


Fig.5.1. The parts and layout of the new Upper deck.

The probe has two high-intensity l.e.d.s, one blue and one red (D1 and D2). The l.e.d.s are switched on alternately by the 1Hz astable built from two CMOS inverter (NOT) gates, IC1a and IC1b, whose outputs are buffered first by IC1c and IC1d, and then by transistors TR1 and TR2, which drive the l.e.d.s. Note that the l.e.d. ballast resistors (R3 and R4) have their values selected to suit the colour intensity of the diodes.

The astable signal is also sent via the Distribution board to the PIC (see Part 1 Fig.5, Oct '04), at pin RB4, so that it knows which l.e.d. is on. Call this the Red-On signal.

The red light is reflected by the object (or not reflected) and is detected by the light dependent resistor (LDR), R8. The voltage across the LDR is inversely proportional to the amount of light falling on it. Therefore, the voltage across resistor R5 and preset potentiometer VR1 is directly proportional to reflected light. Preset VR1 is set so that this voltage is greater than about 2·4V when the object is reflecting (counting as a logic high input to gate IC1e), and less than 2·4V when the object is not reflecting.

The output from IC1e is sent via the Distribution board to PIC pin RB5. Because of the inverting action of the gate, the signal is low for reflecting and high for not reflecting. Call this the LDR signal.

The LDR signal alternates only if there is an object present, and only when the object is near enough (about 8cm away or less) to reflect back sufficient light. If the object is too far away, or if there is no object, the signal output logic depends on the light level in the room. In the dark it is continuously high and in a room with normal or bright illumination, it is low.

What usually happens when the probe is correctly adjusted is that the close-by object shields the LDR from the room illumination, so the LDR signal is low but goes high when the l.e.d. comes on. The PIC monitors the two signals, Red-On and LDR, and from the inputs it receives can determine if there is an object present ready to be pushed or grabbed.

The astable also provides the signals for two 10mm l.e.d.s mounted at the front and rear of the upper deck. The signal goes from the Sensor board, through the Distribution board, to the l.e.d.s.

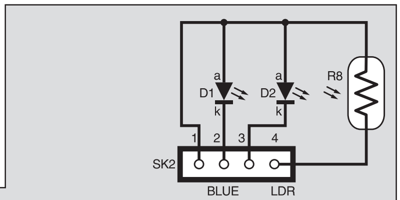
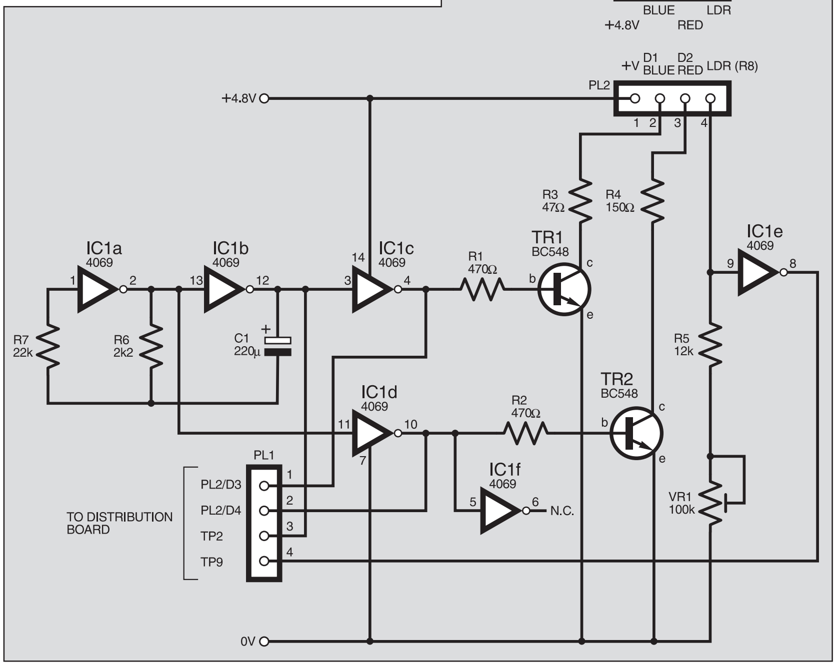



Fig.5.2. Complete circuit diagram for the Light Sensor, including probe head.

Sensor Assembly

The Sensor board's assembly details are shown in Fig.5.3. Assemble in the same manner as you did in Parts 1 and 3, and observing the correct orientation of any polarity-conscious components. Note that the copper tracks beneath IC1 are *not* cut at H9, I9 and K9.

You need another 4-way connecting lead, about 18cm long, to run from PL1 on this board to PL4 on the Distribution board. This has a 4-way header socket on the Sensor board end. At the other end, it has a 2-way header socket for plug PL4 of the Distribution board, and two terminal pin sockets to connect to TP2 and TP9.

Probe Assembly

Assemble the probe on a 4-way screw terminal block as shown in Fig.5.4. The block gives a compact probe that can be mounted at a convenient point on the middle deck, using tape, glue, a double-sided sticky pad or self-adhesive Velcro. This allows you to alter the angle of the probe after a few trials, or for detecting different types of object.

Keep the component wires long enough to allow l.e.d.s D1 and D2 and the LDR to be set at the best angle for reflection. Note that the LDR only responds to the red l.e.d., D1.

Slip short lengths of black or dark-coloured sleeving over l.e.d. D1 and the LDR to improve the directional property of the probe. This also prevents stray light from D1 travelling directly to the LDR.

Solder a 4-way cable to the probe, using thin flexible cable so that it does not interfere with the action of the tool on

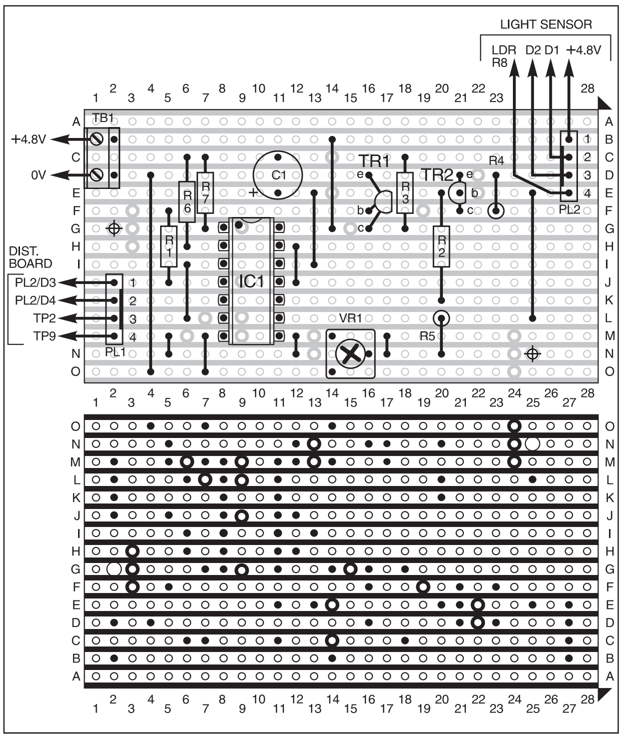
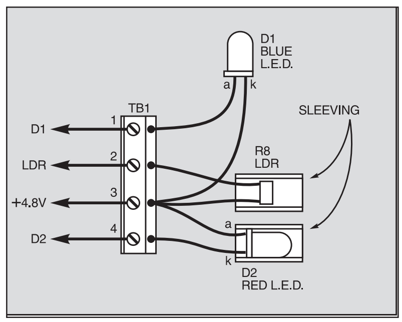
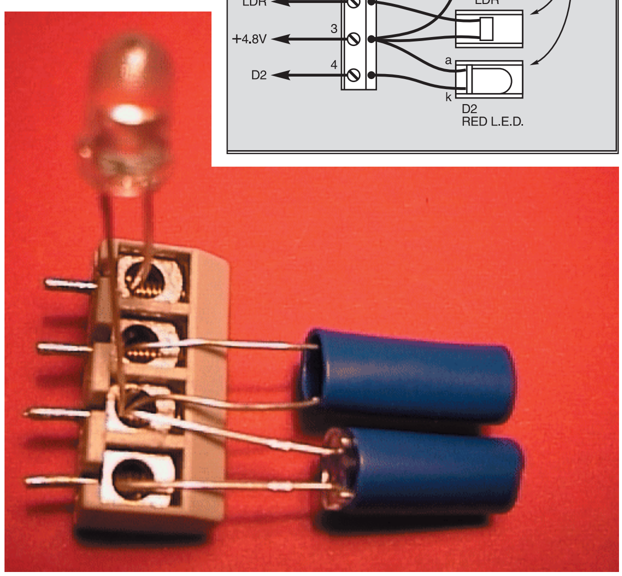


Fig.5.3. Light Sensor stripboard component layout, details of copper strip breaks and lead-off wiring to distribution board and light sensor.

Fig.5.4(right).Showing the connection between the light sensor and distribution boards.





The LDR of the probe is shielded from the red l.e.d. by pushing a piece of sleeving on them. The blue l.e.d. is directed to one side, as it is purely decorative.

which the probe is mounted. The cable should be about 30cm long, or longer if you intend to experiment with using the probe in different locations. Solder the other ends of the wires to a 4-way header socket, noting the polarity of the plug, PL2 in Fig.3.

Testing the Light Sensor

To test the Light Sensor, first connect the power supply. Test the output of IC1 at pins 4 and 12. It should alternate between 0V and +4·8V at about 1Hz. The same signals are found at PL1/1, PL1/2 and PL1/3. Assuming all is well, plug the probe into PL2. The l.e.d.s flash brilliantly, alternately red and blue.

Connect a voltmeter to IC1 output pin 8 or at PL1/4. Test the circuit in low-level room lighting, well away from windows and bright bench lamps. Place a red object close in front of the probe. Cover the end of the sleeving on the LDR, so that it is in darkness. Adjust preset VR1 until the voltage just swings high.

Remove the cover and the voltage swings sharply to just a few millivolts. It stays low if there is no object in view. If the voltage remains low at all times, it may be that the ambient light level is too high, the probe is insufficiently shaded, or the LDR and l.e.d. D1 are not angled to point at the same spot. Also, try readjusting preset VR1.

Distribution Board

The PIC16F84 does not have enough input/output pins to individually control all aspects. Consequently, the technique of multiplexing is used. This allows the PIC to accept data from eight sources via only four input pins. The multiplexing circuit diagram is shown in Fig.5.5.

The circuit is based on a 4019 8-line to 4-line multiplexer, IC2. This has two inputs SA (pin 9) and SB (pin 14) which, when taken high, select Group A inputs (A1 to A4) or Group B inputs (B1 to B4) respectively. Pin SA is fed directly with the signal from PIC pin RA4, pin SB is fed with the RA4 signal inverted by transistor TR3. Thus, one of the two groups is always active. Group A is selected when RA4 is high and Group B when it is low.

The selected group is output via IC2 pins Q1 to Q4. The PIC receives the data via its RB0 to RB3 pins.

IC2 input pins A1 to A3 and B1 to B3

COMPONENTS — *Approx Cost Guidance Only* **£3**

LIGHT SENSOR and PROBE

Resistors

R1, R2	470Ω (2 off)
R3	47Ω
R4	150Ω
R5	12k
R6	2k2
R7	22k
R8	ORP12 LDR, or similar

All 0·25W 5% carbon film or better

Potentiometer

VR1	100k min. preset horiz.

Capacitor

C1	220µ radial elect. 16V

Semiconductors

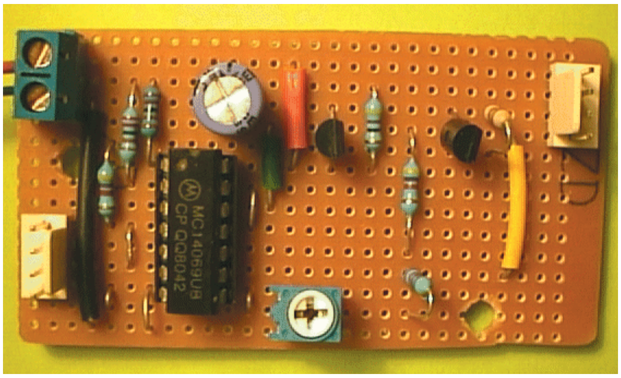
D1	5mm red l.e.d., high intensity (5000 mcd)
D2	5mm blue l.e.d., high intensity (5000 mcd)
IC1	4069 hex inverter
TR1, TR2	BC548 *npn* transistor (2 off)

Miscellaneous

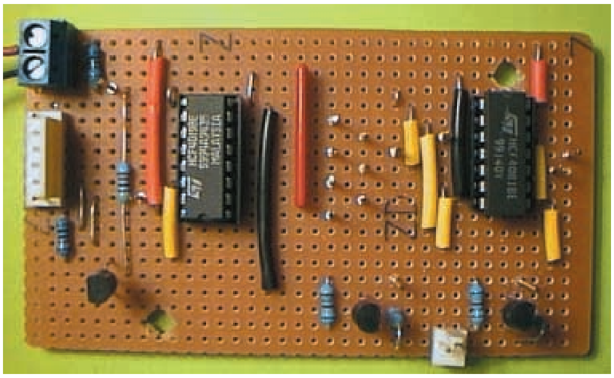
Stripboard 15 strips x 28 holes; 4-way locking and polarising header plug and socket (2 off), 2-way p.c.b. screw terminal, 4-way screw terminal, 14-pin d.i.l. socket, p.c.b. supports (2 off), sleeving, 5mm dia; connecting wire; solder.

Motor Control

See compnent list for the same in Part 1. Only one switching circuit is required if grabber is not to be powered.



Component layout on the prototype Light Sensor board



Prototype Distribution circuit board component layout

COMPONENTS — *Approx Cost Guidance Only* **£12**

DISTRIBUTION BOARD

Resistors

RM1	10k s.i.l. 8-way commoned resistor module
R9, R10	10k (2 off)
R11	4k7
R12, R13	470Ω (2 off)
R14, R15	68Ω (2 off)

All 0·25W 5% or better, unless marked.

Semiconductors

D3, D4	5mm l.e.d., high intensity, any colour (2 off)
IC2	4019 8-line-to-4-line multiplexer
IC3	4081 quad 2-input AND gate
TR3	BC548 *npn* transistor
TR4, TR5	BC337 *npn* transistor (2 off)

Miscellaneous

S1, S2	sub. min. toggle switch (2 off)
S3 to S7	sub. min. microswitch (5 off)

Stripboard 20 strips x 35 holes; 2-way header plug and socket; 6-way header plug and socket; 16-pin d.i.l. socket; 14-pin d.i.l. socket; 2-way screw terminal; pin-header terminal pins and sockets (15 off), p.c.b. supports 6·35mm (2 off), connecting wire, solder.

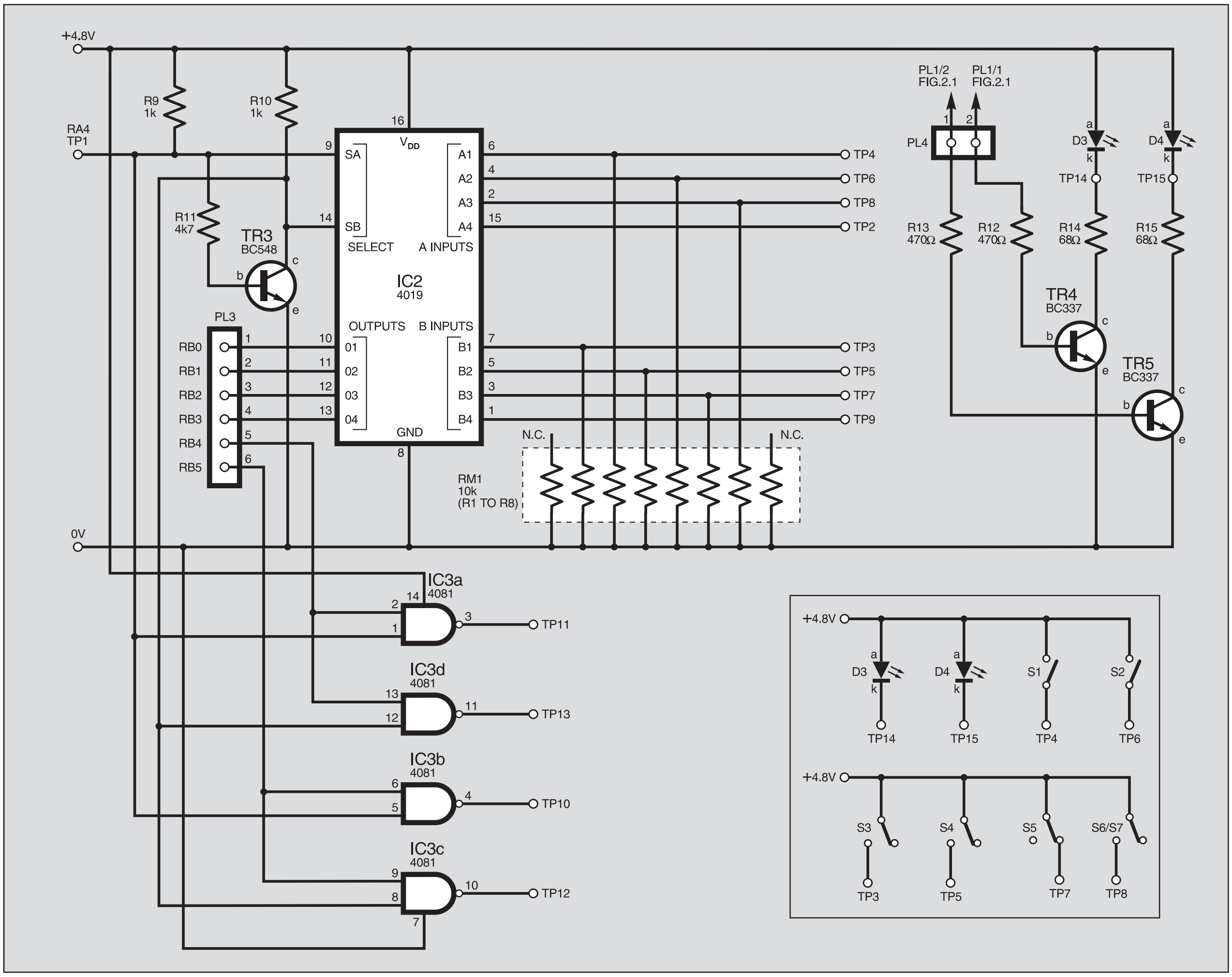


Fig.5.5. Complete circuit diagram for the PIC multiplexing distribution section of Smart Kart SK-3. The Input/Output switching arrangement is shown inset; see also Table 5.1.

are biased low by the resistors in the 8-way commoned resistor module notated as RM1. Two of the resistors are not used since inputs A4 and B4 are fed by logic level signals.

Still referring to Fig.5.5, PIC pins RB4 and RB5 (PL3/5, PL3/6) control the jaw and winch/gripper motors. These control signals are passed to a 2-line to 4-line demultiplexer based on the four AND gates of IC3.

When PIC pin RA4 is high, IC3a and IC3b pass the motor control signals to the jaws motor, via IC3 pin 10 (TP12) and IC3 pin 11 (TP13). When RA4 is low, these gates are disabled, and IC3c and IC3d are enabled instead, passing the signals to the winch motor.

The motor control circuit is the same as that shown in Part 1, Fig.3 and is not repeated here.

Transistors TR4 and TR5 are controlled by the outputs of IC1c and IC1d in Fig.5.2, and in turn control "cosmetic" l.e.d.s D3 and D4.

PIC pins RB6 and RB7 are not connected to either of the above circuits. They stay permanently connected as in Part 1 Fig.5, receiving data from that Part's infra-red sensors.

Multiplexer Data Routing

Table 5.1 sets out the connections for PIC Port B; Port A (RA0 to RA3) is used for controlling the drive motors as in the two previous Smart Kart versions; RA4 selects input groups as described above.

Distribution Board Assembly

The component layout of the Distribution board is shown in Fig.5.6. Prepare and assemble it in the usual way. Note that the copper strips beneath IC3 are *not* cut at F30 and J30.

Resistor module RM1 is an 8-way single-in-line (s.i.l.) package. The common terminal is at C18, on the 0V line. The first two resistors are not used, so their pins (at D18 and E18) are cut off. The other pins are soldered to F18 to K18.

Header plug PL4 is oriented along the strip and requires a break to be made in the strip between T26 and T27. This is easily done using a sharp-pointed craft knife.

The board needs a 6-way cable with 6-way pin-header sockets at both ends. Make the cable about 15cm long. The cable connects PL3 on the Distribution board with six of the pins (0 to 5) on the 8-way plug PL2 of the Processor board (Fig.6 Part 1). The other two pins (6 and 7) on that plug receive the 2-way cable from the infra-red sensors (as in Part 1). Use a sharp knife to pare away one polarising strip on one of the 6-way sockets so that it fits side-by-side with the 2-way socket on the 8-way plug.

Table 5.1: Inputs and Outputs to PIC Port B

PIC Pin	Input/Output	Group A	Group B
RB0	I	Select S1	S3: Jaws wide open
RB1	I	Select S2	S4: Jaws closed and empty
RB2	I	S6 or S7:Pusher or jaws up/down	S5: Jaws closed on object
RB3	I	Red-On signal	LDR signal
RB4	O	Winch motor	Jaws motor
RB5	O		
RB6	I	Infra-red Sensor, right	
RB7	I	Infra-red Sensor, left	S3 to S7 = microswitch

Testing the Distribution Board

Connect the power supply, and connect terminal pin TP1 to 0V, setting IC2 pin 9 of IC1 low and pin 14 high. The levels invert when TP1 is connected to +4·8V.

Monitor the output voltage at PIC pin RB0 on PL3, while TP1 is connected to +4·8V (selecting Group A inputs). The inputs at TP3 and TP4 are held low by their pull-down resistors, so all you need for testing is a flying lead connected to the positive supply.

IC2 output Q1 (PL3/1) follows the logic level at the input at TP4 (the Group A input for RB0). It is unaffected by the input at TP3 (the Group B input for RB0), staying low. Reconnect TP1 to 0V and RB0 will now follow the input at TP3.

Repeat the testing for RB1, RB2 and RB3. With RB3, you need a second flying lead to connect to 0V, as TP2 and TP9 do not have pull-down resistors at the signal source. This completes the test on the multiplexer circuit.

To test the demultiplexer, use flying leads connected to PL3/5 and PL3/6 (RB4 and RB5). With TP1 connected to +4.8V (selecting Group A outputs), the outputs at TP11 and TP10 follow the inputs at PL3/5 and PL3/6 respectively. The outputs at TP12 and TP13 remain low. With TP1 connected to 0V, TP10 and TP11 remain low but TP12 and TP13 follow the inputs at PL3/6 and PL3/5 respectively. It is essential that both PL3/5 and PL3/6 are connected to 0V or +4·8V when testing; floating inputs can give false results.

Finally, connect l.e.d.s D3 and D4 and check that they can be correctly controlled via PL4. Applying a positive voltage turns the l.e.d. on.

Motor Control

The jaws and winch motors are controlled by a copy of the Power Switching board used in Part 1, see its Fig.3 and Fig.4. Motor M1 raises and lowers the winch, motor M2 opens and closes the jaws of the grabber. If you are building only the pusher version of SK-3, you do not need the drive for motor M2 and its associated components can be omitted. Assemble and test the board as described in Part 1.

Installing the Electronics

Mount the three stripboards on their supports, see Fig.5.1. The new motor control board is powered from the same battery on the lower deck that powers the motor board in Part 1. If necessary, remove the middle deck from the lower deck in order to get at the TB1 power supply terminal.

Having made the TB1 connection, thread the wires through the deck holes and secure them to terminal TB1 on the upper motor control board.

When soldering the wires to the tags on the motors, also solder a 100nF capacitor (C1 and C2) across the terminals.

The control leads to the board are screwed directly into the terminals provided. Their other ends require the fitting of terminal pin sockets for pushing on to the terminal pins on the Distribution board. Table 5.2 shows the connections, but there is no need to connect M2 until you install the grabber.

Next, make the cable for connecting the Light Sensor board to the Distribution board.

Table 5.2: Motor connections

Motor	Motor Board 2		Distribution board	
	Terminal	Terminal	Terminal pin	PIC pin
M1, Winch	TB2	ACONT	TP11	RB4(A)
	TB3	BCONT	TP10	RB5(A)
M2, Jaws	TB4	CCONT	TP13	RB4(B)
	TB5	DCONT	TP12	RB5(B)

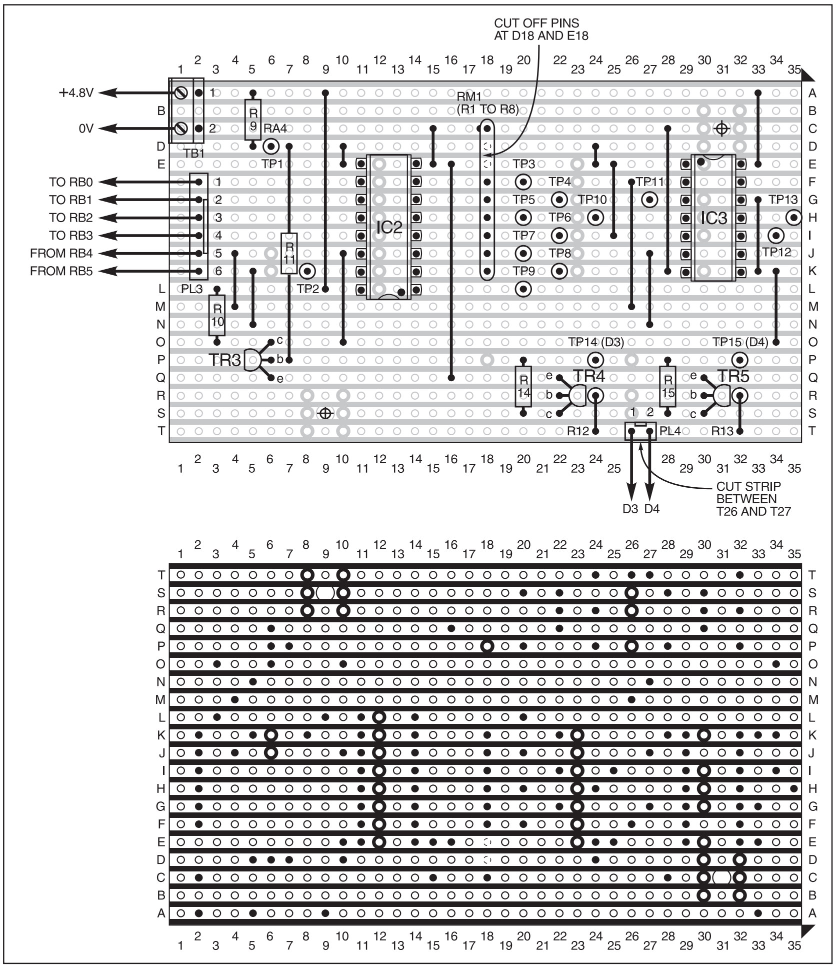


Fig.5.6. Stripboard component layout, wiring details and underside of the board showing required breaks in the copper tracks

Interconnection

The front and side panels are easier to wire as a unit before gluing them to the edges of the Upper Deck (see Fig.5.1). Mount the program select switches S1 and S2 so that their actuators are down when the switch is off.

Cut a wire about 15cm long for the positive supply lead and strip 3cm of insulation from one end. Thread this through the lower terminals of the switches. Bend the anode wire of the l.e.d. D3 on the front panel, to pass through the lower terminal of S1, see photo below.

Solder the wires to the terminals. Slide a short length of sleeving over the anode wire of D4, then wrap the exposed end of the wire around the anode wire of D3; solder them together. Make four leads about 10cm long. Solder one to each switch and each

Wiring the switches and l.e.d.s on the side panels l.e.d. cathode (k) wire (heat-shrink sleeving makes the joint neater), and solder pin sockets to their other ends. Strip the free end of the positive supply lead; this goes to the positive supply terminal of the Distribution board.

Glue the panels to each other by their edges and glue both to the edge of the upper deck.

Complete the power line connections of the upper deck. For the positive supply, join the Distribution board at point A2 to the Light Sensor board at point B2, but *not* to the new motor board. For the 0V supply join all three boards: point D3 to motor board, to point D2 on Light Sensor, to point C2 on Distribution.

Make a 6-way cable about 24cm long and solder 6-way header sockets at both ends. The connections for RB0 to RB5 are at J7 to O7 on the Processor board, connecting to F2 to K2 on the Distribution board. Run the positive supply lead and the 0V lead from the screw terminals on the Processor board to those on the Distribution board.

Cut a wire 15cm long and solder header sockets to both ends. Use this to join the RA4 output on the Processor board to TP1 on the Distribution board.

Mount the infrared sensors (from Part 1) on the front edge of the middle deck. Their leads have a 2-way socket that fits on to pins 6 and 7 of the 8-way plug on the processor board. They also have supply lines that go into the screw terminals on the same board.

Wiring Check

The wiring check procedure is the same as outlined in Part 1. All the l.e.d.s flash as soon as the power is switched on. At the PIC socket (PIC not in it) use a flying lead to make RA4 (pin 3) high or low as required (see Table 5.1). Test the inputs from the switches and microswitches (pins 6 to 8), making pin 3 high to test Group A and low to test Group B. The inputs are normally high but go low when the switch is closed.

With RA4 high, the voltage at multiplexer IC2 pin 9 alternates as the l.e.d.s flash. It goes low when the red l.e.d. of the probe is on. With RA4 low, the LDR signal is monitored. Use flying leads to make IC2 pins 10 and 11 (PL3/1 and PL3/2) high and low, or low and high, to run one of the motors – the winch motor with RA4 low and the grabber jaws motor with RA4 high.

With RA4 high, the winch unwinds when PL3/1 is low and PL3/2 high. Conversely, with RA4 low, the jaws close when PL3/1 is high and PL3/2 low. If a motor runs the wrong way, swap the connections between it and its control board.

IC2 pin 12 (PL3/3) is high when the right infrared sensor points at white; low when it points at black (see Part 1). IC2 pin 13 (P3/4) similarly monitors the output from the left infrared sensor. These inputs are unaffected by the output at RA4.

Pusher

There is plenty of scope for inventing your own Pusher. The essential features are that it must be mounted centrally on the back edge of the Middle Deck. That is, it is mounted so that it can be raised and lowered by the winch, and that it must not prevent the castor from swivelling in all directions. It must have the Down microswitch, S6 (see Table 5.1).

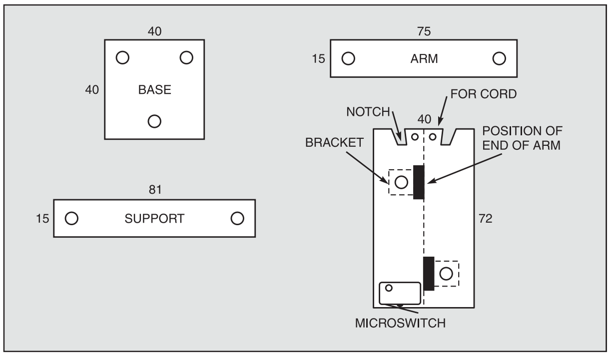
If you are intending to program the PIC yourself you could add up to three more microswitches, using registers RB0 to RB2, in Group B. One point to remember is that the pusher must not be so massive that the robot's drive wheels are lifted off the floor. This may happen with the grabber too, especially when carrying a heavy load.

There is also a loss of traction, particularly on corners and on uneven surfaces. The simplest solution is to ballast the robot by fixing a mass (try 100g to 150g) at the front of the middle deck, just behind the infrared sensors.

Just to get you going, the photos below show the prototype pusher used with SK-3. It can be made from strip and sheet aluminium; the prototype used 3mm p.v.c. boards and Meccano angle brackets. If you want a quick result, make it from stiff cardboard and glue it.

The pusher component parts are shown in Fig.5.7. The exact dimensions depend upon the height of the middle deck above the surface, and the size of the castor. In the prototype the upper surface of the middle deck is exactly 60mm above ground. There is a 2mm clearance between the surface and the lower edge of the plate when the arm is horizontal.

The base is bolted to the middle deck, using two bolts of the type that attach the



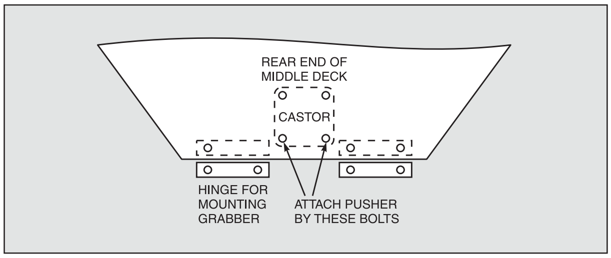
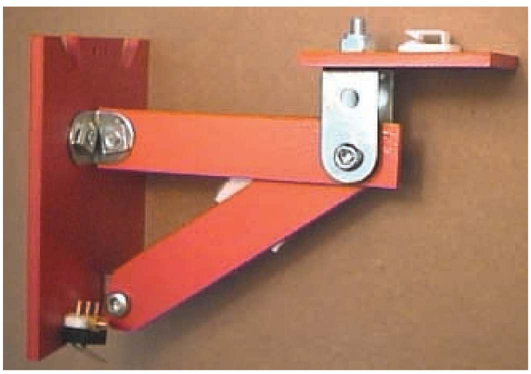
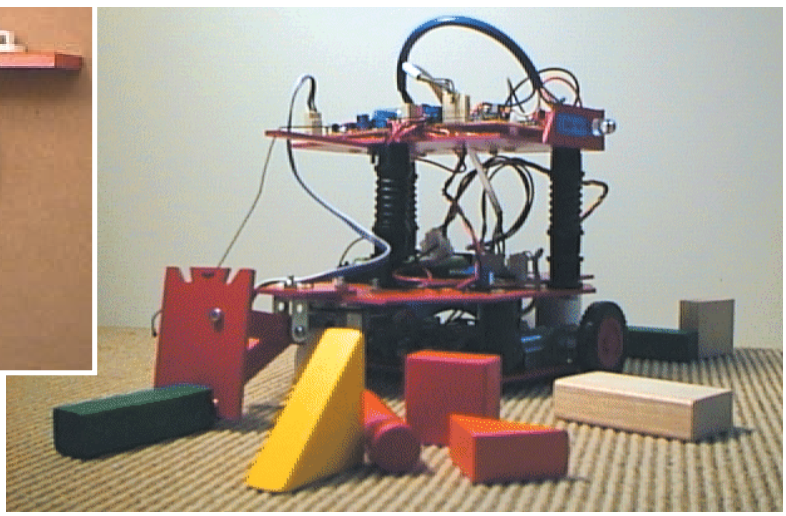


Fig.5.8. Additional holes to be drilled in the middle deck.

Fig.5.7. (left) Cutting and drilling parts for the pusher.



(Above) A rear view of the pusher showing the down microswitch S6. The white tuft behind the support bar is a patch of Velcro used for mounting the light sensor probe.



The pusher in action shunting some "building bricks"

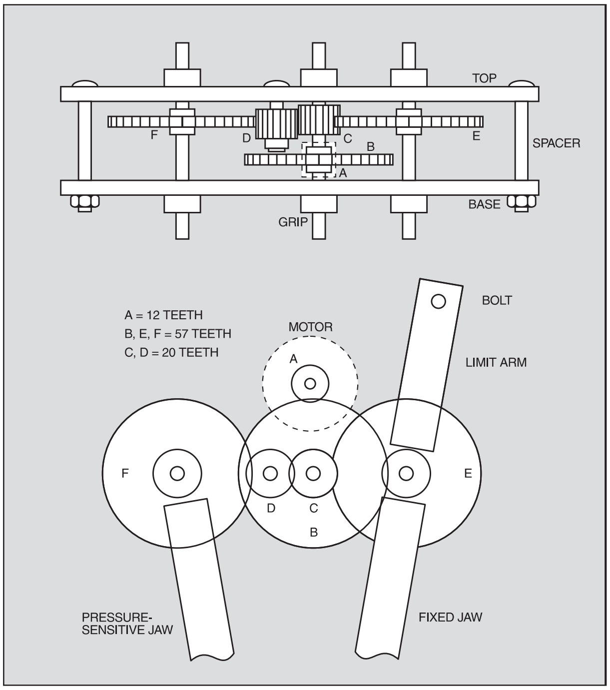
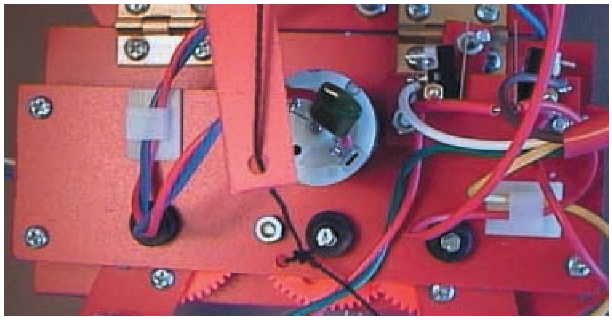
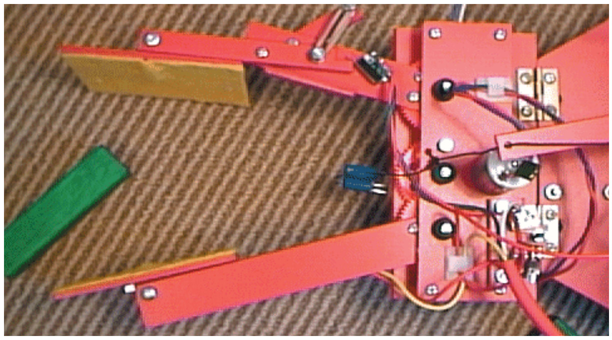


Fig.5.9. The grabber gearbox (spacers on the shafts not shown).



Gearbox as seen from above. Note the cord support arm.



Seen from above, the grabber comprises a motor-driven gearbox and two arms. The upper arm in the photo is the pressure-sensitive arm.

castor. A double angle bracket (a square "U" in section) is bolted to the base, using a shakeproof nut. The arm and support bar pivot on a shaft threaded through this bracket. The ends of the shaft are secured by grommets or slip-on rubber grips. If necessary, washers or short spacers can be threaded on the shaft on either side of the arm and support, to keep them central.

The other ends of the arm and support are fixed to the rear surface of the plate using angle brackets (see outlines in Fig.5.7). Run the cord from the winch, through the hole at the end of the cord support arm, and tie it to the two small holes at the top edge of the plate. Check that it is not caught by components on the circuit boards. Bolt the base to the middle deck, using the two rear bolts that fix the castor (see Fig.5.8).

There are several places for fixing the probe, and you may prefer to experiment. The notches in the top edge of the plate allow the probe to be held in place with a rubber band. For the programs provided in the PIC, we assume that it is mounted on the support bar of the pusher so that, when the pusher is raised, the probe is horizontal and has a clear view of the object. In this position the probe is not confused by reflections from the floor or tabletop.

In our version, the pushing surface is a flat plate, but there is plenty of scope for other forms. You could glue a narrow rim to the vertical edges to prevent objects from sliding off sideways. Alternatively, add prongs made from thin metal (drinks can?) along the bottom edge of the pusher plate. Now you have the equivalent of a forklift truck, with the ability to carry as well as push.

Gripper

Referred to less formally as the Grabber, the Gripper turns the robot into a mobile arm. Compared with most industrial mobile arms, such as those that spray newly made car bodies, this is a very simple arm. But after you have looked into the complexities of designing and building such mechanisms you will probably agree that our grabber is complicated enough!

The grabber has a pair of jaws (see photo above) that detects and closes on an object. That done, the arm lifts the object clear of the surface and the robot dashes away to drop it elsewhere. Thus the arm has one degree of freedom, the ability to rotate in a vertical direction. A pair of hinges (Fig.5.8) join it to the rear edge of the middle deck. The lifting mechanism is the winch that was used for raising and lowering the pusher. Like the pusher, it has a microswitch (S7 in Table 5.1) to detect when the jaws are resting on the surface.

If you make the cord support arm from plastic, such as expanded p.v.c., you may find that it sags when lifting the grabber. This is worse when the grabber is lifting a weighty object. The solution is to make the arm from strip metal (or use a Meccano part).

Bolt one end of the arm to the upper deck where indicated in Fig.5.1, and support the arm halfway along by a vertical strut fixed to the middle deck by one of the castor bolts. In our model the jaws end in flat paddles, 70mm × 80mm. These are covered with stick-on flock paper on their facing surfaces to give a non-slip grip. Thin rubber foam might be better. You could also replace the paddles with curved fingers to improve the grip on certain types of object.

The jaws are opened and closed by a motor-driven gearbox, see Fig.5.9 and photos. The motor used is the same type as used for the winch. This has a built-in gearbox which reduces the motor speed to 70 r.p.m., but this is far too fast to operate the jaws directly.

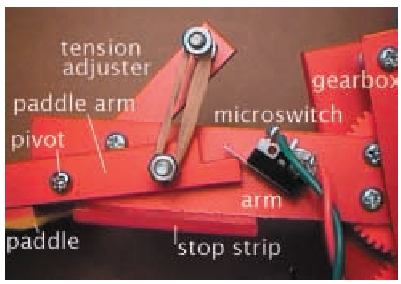
However, it is possible to design a basic winch mechanism coupled to the arms of the jaw. The arms are closed by the winch and there is a spring or rubber band to open them again. We decided to go for gears. There are many plastic gearbox kits available; Meccano gears were used because the shafts are rounded triangular in shape, designed to fit the hubs of the gearwheels.

This means there is no slipping between gears B and C. The overall reduction of this gearbox is 13.5:1, reducing the motor speed to just over 5 r.p.m., or about 0.09 r.p.s., which seems just about right.

The gearbox is built on a base plate (65mm x 130mm) with a top plate (40mm × 130mm) supported on four 15mm spacers. These dimensions are for guidance only, as you may be using gears from another source. The arms of the jaws are bolted on to gears E and F.

The two jaws are referred to as the fixed jaw and the pressure-sensitive jaw (or pressure jaw for short). The fixed jaw is rigid but the pressure jaw is able to "give" slightly when pressed, when there is an object held between the jaws.

The mechanism of the pressure jaw is seen in the photo below. The arm is bolted to the gear F. It is shorter than the arm of the fixed jaw but is extended to the same



The pressure-sensitive mechanism when the jaws are not closing on an object, seen from above.

length by a narrower paddle arm that carries the paddle. The paddle arm is pivoted on the arm by a bolt secured by two nuts locked together. The paddle arm is able to rotate horizontally through a small angle.

In the photo it is shown in its normal position, held tightly against the armature of the microswitch (S5, see Table 5.1) by a rubber band. The tension is set by the angle of the tension adjusting lever. The armature is pressed tightly against the microswitch and, using the two outer contacts, the switch is off.

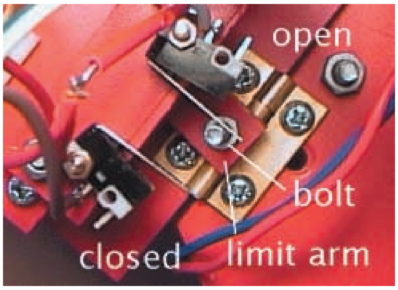
When the jaws have tightened on an object the paddle arm is rotated to a position which releases the armature, and the switch is turned off. A strip glued to the edge of the arm prevents the paddle arm from rotating further, providing a firm grip on the object.

More Limit Switches

The details in Fig.5.9. show a short lever, the limit arm, extending from gear E in the opposite direction to the arm of the fixed jaw. The limit arm extends from beneath the top plate and has a bolt at its end, see photo opposite.

Two microswitches (S3 and S4) are mounted on a small platform that is bolted to the edge of the top plate, so that their armatures engage with the bolt. When the jaws are wide open, the bolt presses on the armature of one of the switches (S3); the switch is closed and a high logic level goes to the PIC at RB0 (if Group B is selected). The PIC then turns off the motor to prevent the jaws opening further and probably damaging the gearbox.

When the jaws are closed without an object between them, the other switch (S4) is closed and the PIC receives a logic high at RB1. As with the other microswitches in this robot, the switches are mounted by a single bolt, so that the angle of their actuators can be set to turn on the switch at the correct moment.



The limit switches on the gearbox seen from above.

Mount the Light Sensor probe centrally on the underside of the gearbox, so that its beam passes out between the open jaws. Connect it to PL2 on the Light Sensor board. Secure the cable with small self-adhesive cable clips.

Complete the wiring by connecting one terminal of all four microswitches to a common positive line and run this back to the screw terminal on the Light Sensor board. Solder a wire to the other terminal of each switch, and terminate their other ends with pin-header sockets. Run these four leads back to the appropriate terminal pins on the Distribution board, as indicated in Fig.5.5.

Resources

Software, including source code files, for the Smart Kart Part 5 is available on 3.5-inch disk from the Editorial office (a small handling charge applies – see the *EPE PCB Service* page). It can also be downloaded *free* from the *EPE* Downloads page, accessible via the home page at **www.epemag.co.uk**. It is held in the PICs folder, under SmartKart. Download all the files within that folder.

Next Month

In Part 6, next month, we discuss the software that controls Smart Kart SK-3.

SHOP TALK

with David Barrington

PIC Electric Mk2

We have found only a single listing for the 24LC256 256 kilobit serial EEPROM memory chip, used in the *PIC Electric Mk2* project, that was **Farnell** ***(☎ 0870 1200 100*** or ***www.farnellinone.co.uk)***, code 300-1696. The Hall effect current transducers were purchased from **RS Components**, code 286-311. They also supplied the optional MAX232 serial interface i.c., code 655-290. Likewise, they stock the rail-to-rail LMC6482 dual op.amp, code 310-919. The RS232 interface i.c. should be stocked by most of our components advertisers. If a local source proves to be elusive, the transducer, op.amp and interface i.c. can be ordered direct (credit card only) from RS on ***(☎ 01536 444079*** or ***rswww.com).***

For those readers unable to program their own PICs, a fully programmed PIC16F876 microcontroller can be purchased from **Magenta Electronics** ***(☎ 02083 565435*** or ***www.magenta2000.co.uk)*** for the inclusive price of £10 each (overseas add £1 for p&p). The software, including source code files, is available on a 3·5in. PC-compatible disk (Disk 8) from the *EPE Editorial Office* for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 141). The software is also available for *Free* download via **www.epemag.co.uk**.

The two printed circuit boards can be obtained from the *EPE PCB Service*, codes 487 (Cont.) and 488 (Sen.) see page 141. Most of our components advertisers should be able to supply a suitable l.c.d. alphanumeric display module.

Sneaky

Some readers may have difficulty finding the RTFQ1 433MHz transmitter and RRFQ1 433MHz receiver modules used in the *Sneaky* "magic" project. These are RF Solutions modules and are currently stocked by **Maplin** ***(☎ 0870 429 6000*** or ***www.maplin.co.uk)*** and sold as a pair, code N47AU. For more details of these devices you can log-on to **RF Solutions** at ***www.rfsolutions.co.uk*** or ***☎ 01273 898000.*** Reference document DS069-7 refers to these units.

The author's suggested 6V trembler motor for this project is the Mabuchi motor from **Total Robots** ***(☎ 0208 823 9220*** or ***www.totalrobots.com).*** These are listed under Beam Robots Components and sold as a two-pack, code RM1. They also list, but has not been tried, a vibrating disk motor. We see from a recent flyer from **WCN Supplies** ***(☎ 023 8066 0700*** or ***www.wcnsupplies.net)*** that they have a special offer on a 3V-6V vibrating motor (code 48-141) which may be worth investigating.

For those readers unable to program their own PICs a preprogrammed PIC16F628 microcontroller (two required) can be purchased from **Magenta Electronics** ***(☎ 01283 565435*** or ***www.magenta2000.co.uk)*** for the inclusive price of £4.90 each (overseas add £1 p&p). The software is available on a 3·5 in. PC-compatible disk (Disk 8) from *EPE Editorial Office* for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 141). The software is also available for *Free* download via **www.epemag.co.uk**.

Smart Karts – 5

The same low voltage d.c. motors, with gearbox, used for the first kart in Part 1 can be used in Smart Kart SK-3, this month's mobile buggy project. They came from Magenta, see below. A good selection of motors can be found listed by **Jaycar** ***(☎ 0800 032 7241*** or ***www.jaycarelectronics.co.uk)*** and **Squires** ***(☎ 01243 842424*** or ***www.squirestools.com)***.

It is not essential to use such a high intensity blue l.e.d., it is only included for "effect" and almost any "high brightness" l.e.d. will surfice.

An updated ready-programmed PIC16F84 microcontroller for Smart Kart SK-3 can be purchased from **Magenta Electronics** ***(☎ 01283 565435*** or ***www.magenta2000.co.uk)*** for the inclusive price of £5.90 each (overseas add £1 p&p). Please quote version SK-3 when ordering. The software is available on a 3·5in. PC-compatible disk (Disk 8) from *EPE Editorial Office* for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 141). The software is also available for *Free* download via **www.epemag.co.uk**.

Sound Card Mixer

We do not expect any buying problems to arise when shopping for components for the *Sound Card Mixer* project. All the semiconductor devices should be off-the-shelf items. The miniature 12mm square, plastic spindle, p.c.b. mounting, conductive plastic potentiometers are stocked by Rapid ***(☎ 01206 751166*** or ***www.rapidelectronics.co.uk)*** codes 68-1292 (log.) and 68-1278 (lin.).

The printed circuit board is available from the *EPE PCB Service*, code 489 (see page 41).

PLEASE TAKE NOTE

Speed Camera Watch *(Jan '05)*

We have been advised by Holux that the GM-21PE GPS modules are not supplied with cables. These are available for an additional £5. They include the connector and about 150mm of bare-ended cable. The Holux phone number to call is 0870 321 5929 (not as quoted in EPE). Note that Holux only accept credit card orders (not American Express), do not send cheques or cash. Fig.3 shows the connections as from the module's base.

High-Efficiency L.E.D. Torch (*I.U. Oct '04*)

The author points out that his intention is for the anode of l.e.d. D7 in Fig.1b to go to the cathode of D2 in Fig.1a, not to +6V, and that the circuit is for white l.e.d.s.

64 L.E.D. Sequencer *(I.U. Jan '05)*

Transistor TR3 is an *npn* device and so should be shown with its collector connected to the collector of TR2, and its emitter connected to R6.

MW Amplitude Modulator *(Nov '04)*

Inductor L1 may be hard to find but the EZ45336 from JAB Components can be used instead, but C4 must be changed to 220pF.

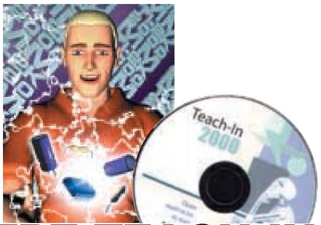
DIRECT BOOK SERVICE

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

FOR A FURTHER SELECTION OF BOOKS SEE THE NEXT TWO ISSUES OF EPE.

All prices include UK postage

FREE *Electronics Hobbyist Compendium* book with Teach-In 2000 CD-ROM



EPE TEACH-IN 2000 CD-ROM

The whole of the 12-part *Teach-In 2000* series by John Becker (published in *EPE* Nov '99 to Oct 2000) is now available on CD-ROM in PDF form. Plus the *Teach-In 2000* interactive software (Win 95, 98, ME and above) covering all aspects of the series and Alan Winstanley's *Basic Soldering Guide* (including illustrations and Desoldering).

Teach-In 2000 covers all the basic principles of electronics from Ohm's Law to Displays, including Op.Amps, Logic Gates etc. Each part has its own section on the interactive software where you can also change component values in the various on-screen demonstration circuits.

The series gives a hands-on approach to electronics with numerous breadboard circuits to try out, plus a simple computer interface (Win 95, 98, ME **ONLY**) which allows a PC to be used as a basic oscilloscope.

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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 **Temporarily out of print**

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 variouus 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.

135 pages **Order code BP392** **£5.49**

TEST EQUIPMENT CONSTRUCTION
R. A. Penfold

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

The following designs are included:-

AF Generator, Capacitance Meter, Test Bench Amplifier, AF Frequency Meter, Audio Mullivoltmeter, Analogue Probe, High Resistance Voltmeter, CMOS Probe, Transistor Tester, TTL Probe. The designs are suitable for both newcomers and more experienced hobbyists.

104 pages **Order code BP248** **£4.49**

COMPUTING

COMPUTING FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s, using plain English and avoiding technical jargon. Large clear type for easy reading.

Among the many practical and useful ideas for using your PC that are covered in this book are: Choosing, setting up and understanding your computer and its main components. Writing letters, leaflets, invitations, etc., and other word processing jobs. Keeping track of your finances using a spreadsheet. Recording details of holidays and other ideas using a database. Using the Internet to find useful information, and email to keep in touch with family and friends. Making 'back-up' copies of your work and checking for viruses. How to use Windows XP to help people with impaired vision, hearing or mobility.

Provides the basic knowledge so you can gain enough confidence to join the local computer class.

308 pages **Order code BP601** **£8.99**

THE INTERNET FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s. Uses only clear and easy-to-understand language. Larger type size for easy reading. Provides basic knowledge to give you confidence to join the local computer class.

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

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

RADIO

SETTING UP AN AMATEUR RADIO STATION
I. D. Poole

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

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

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

EXPERIMENTAL ANTENNA TOPICS
H. C. Wright

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

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

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

72 pages **Order code BP300** **£4.00**

25 SIMPLE INDOOR AND WINDOW AERIALS
E. M. Noll

Many people live in flats and apartments or other types of accommodation where outdoor aerials are prohibited, or a lack of garden space etc. prevents aerials from being erected. This does not mean you have to forgo shortwave-listening, for even a 20-foot length of wire stretched out along the skirting board of a room can produce acceptable results. However, with some additional effort and experimentation one may well be able to improve performance further.

This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers.

50 pages **Order code BP136** **£2.25**

TICKLING THE CRYSTAL Domestic British Crystal Sets of the 1920's
Ian L. Sanders

The first book dedicated to the topic of British crystal sets to be published in the last 25 years. For a very brief period during the early 1920's, these simple receivers played a crucial role in the expansion of domestic wireless throughout the United Kingdom. For many families, rich and poor, the crystal set provided an introduction to the new pastime of listening-in to broadcast programmes. Rapidly made obsolete from homes as suddenly as it had arrived, but not without leaving its mark on the history of wireless.

Written by a long-time authority and enthusiast, *Tickling the Crystal* is the most comprehensive work on the subject ever assembled. Containing almost two hundred excellent quality photographs and a wealth of previously unpublished material, it cannot fail to be an invaluable reference for anyone interested in the history of early wireless receivers.

256 pages hardback **Order code TC1** **£34.00**

THEORY AND REFERENCE

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

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

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

470 pages – large format **Order code BEB1** **£26.95**

BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where “Bebop I” left off, guiding you through the fascinating world of computer design . . . and you’ll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you’re the slightest bit interested in the inner workings of computers, then don’t dare to miss this!

Over 800 pages in Adobe Acrobat format

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ELECTRONICS MADE SIMPLE
Ian Sinclair

Assuming no prior knowledge, *Electronics Made Simple* presents an outline of modern electronics with an emphasis on understanding how systems work rather than on details of circuit diagrams and calculations. It is ideal for students on a range of courses in electronics, including GCSE, C&G and GNVQ, and for students of other subjects who will be using electronic instruments and methods.

Contents: waves and pulses, passive components, active components and ICs, linear circuits, block and circuit diagrams, how radio works, disc and tape recording, elements of TV and radar, digital signals, gating and logic circuits, counting and correcting, microprocessors, calculators and computers, miscellaneous systems.

199 pages **Order code NE23** **£13.99**

SCROGGIE’S FOUNDATIONS OF WIRELESS AND ELECTRONICS – ELEVENTH EDITION
S. W. Amos and Roger Amos

Scroggie’s Foundations is a classic text for anyone working with electronics, who needs to know the art and craft of the subject. It covers both the theory and practical aspects of a huge range of topics from valve and tube technology, and the application of cathode ray tubes to radar, to digital tape systems and optical recording techniques.

Since *Foundations of Wireless* was first published over 60 years ago, it has helped many thousands of readers to become familiar with the principles of radio and electronics. The original author Sowerby was succeeded by Scroggie in the 1940s, whose name became synonymous with this classic primer for practitioners and students alike. Stan Amos, one of the fathers of modern electronics and the author of many well-known books in the area, took over the revision of this book in the 1980s and it is he, with his son, who have produced this latest version.

400 pages **Temporarily out of print**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

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

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Temporarily out of print**

DIGITAL GATES AND FLIP-FLOPS
Ian R. SInclair

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

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£9.95**

MUSIC, AUDIO AND VIDEO

QUICK GUIDE TO ANALOGUE SYNTHESIS
Ian Waugh

Even though music production has moved into the digital domain, modern synthesisers invariably use analogue synthesis techniques. The reason is simple – analogue synthesis is flexible and versatile, and it’s relatively easy for us to understand. The basics are the same for all analogue synths, and you’ll quickly be able to adapt the principles to any instrument, to edit existing sounds and create exciting new ones. This book describes: How analogue synthesis works; The essential modules every synthesiser has; The three steps to synthesis; How to create phat bass sounds; How to generate filter sweeps; Advanced synth modules; How to create simple and complex synth patches; Where to find soft synths on the Web.

If you want to take your synthesiser – of the hardware or software variety – past the presets, and program your own sounds and effects, this practical and well-illustrated book tells you what you need to know.

60 pages **Order code PC118** **£7.45**

QUICK GUIDE TO MP3 AND DIGITAL MUSIC
Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

How to play MP3s on your computer; How to use MP3s with handheld MP3 players; Where to find MP3s on the Web; How MP3s work; How to tune into Internet radio stations; How to create your own MP3s; How to record your own CDs from MP3 files; Other digital audio music formats.

60 pages **Order code PC119** **£7.45**

ELECTRONIC PROJECTS FOR VIDEO ENTHUSIASTS
R. A. Penfold

This book provides a number of practical designs for video accessories that will help you get the best results from your camcorder and VCR. All the projects use inexpensive components that are readily available, and they are easy to construct. Full construction details are provided, including stripboard layouts and wiring diagrams. Where appropriate, simple setting up procedures are described in detail; no test equipment is needed.

The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.

109 pages **Order code BP356** **£5.45**

ELECTRONIC MUSIC AND MIDI PROJECTS
R. A. Penfold

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

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

Projects covered: Simple MIIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit. ~~£10.95~~

124 pages **Order code PC116** **£5.45**

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

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

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

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

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become ‘H25’ – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

420 pages **Order code NE32** **£17.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

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

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

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

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply. ~~£10.95~~

124 pages **Order code PC115** **£5.45**

PC MUSIC – THE EASY GUIDE
Robin Vincent

How do I make music on my PC? Can I record music onto my PC? What’s a sequencer? How can I get my PC to print a music score? What sort of a soundcard do I need? What hardware and software do I need? How do I connect a keyboard to my PC?:

Just a few of the questions you’ve probably asked. Well, you’ll find the answers to all these questions, and many more, in this book. It will show you what can be done, what it all means, and what you will need to start creating your own music on your PC. It’s an easy read, it’s fully illustrated and it will help you understand how a computer can be used as a creative music tool.

It covers soundcards, sequencers, hard disk digital audio recording and editing, plug-ins, printing scores with notation software, using your PC as a synthesiser, getting music onto and off the Internet, using Windows, sample PC music setups, FAQs, a glossary, advice on hardware and software, and a list of industry contacts.

116 pages **Order code PC117** **£11.95**

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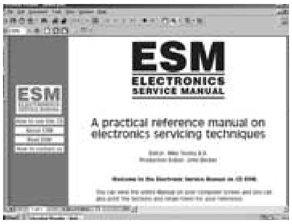

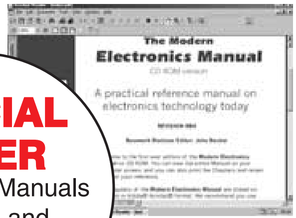

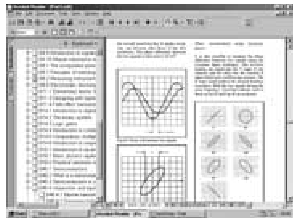

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