THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECT

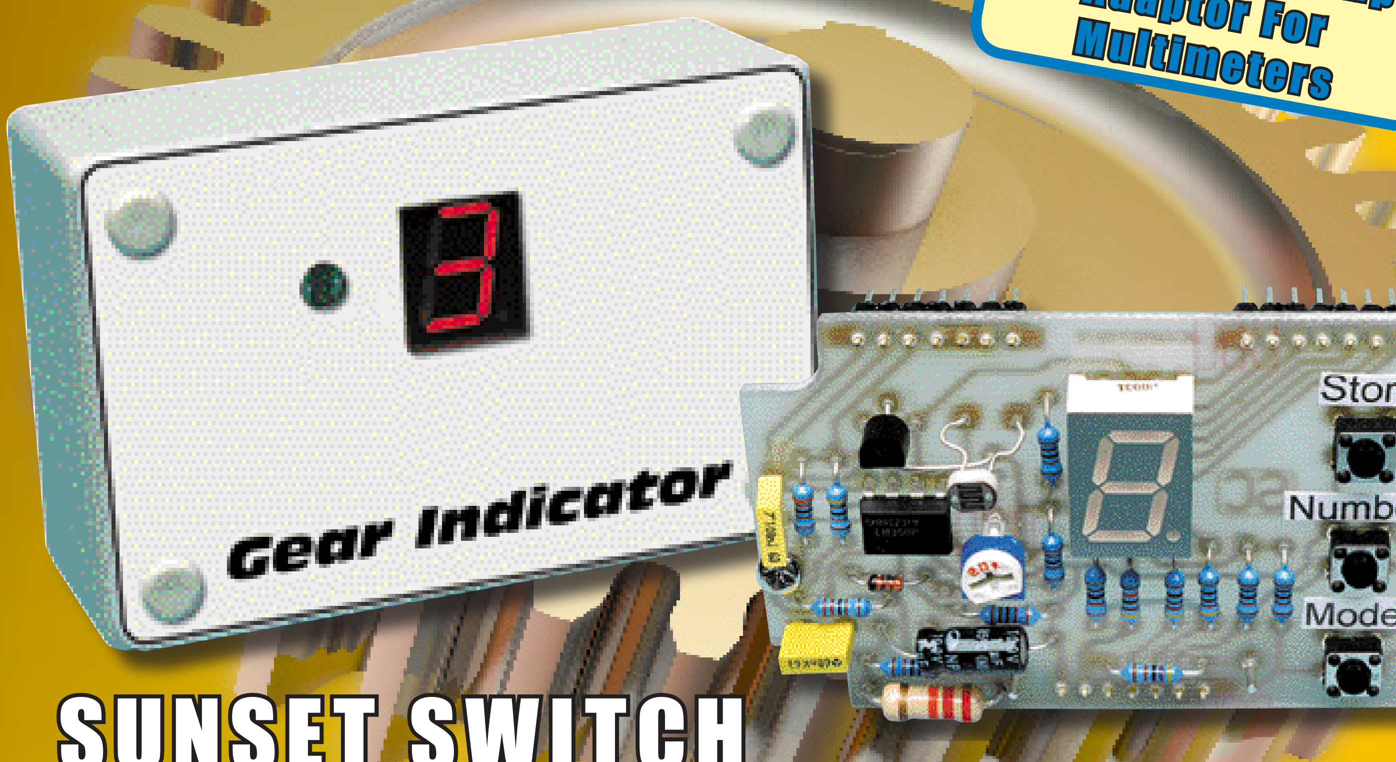
EPE EVERYDAY PRACTICAL ELECTRONICS

www.epemag.co.uk www.epemag.co

"TIPTRONIC" STYLE
GEAR INDICATOR

- ✓ FOR CARS AND MOTORCYCLES
- ✓ INDICATES UP TO 9 GEARS
- ✓ DISPLAY DIMMING
- ✓ EASY TO FIT

PLUS
- PIC Ambilux
- Current Clamp Adaptor For Multimeters



SUNSET SWITCH
For
- ✻ Security
- ✻ Safety

TEACH-IN 2006 – 3

Vol 35 No 1 $5.95 US $7.
PRINTED IN THE UK

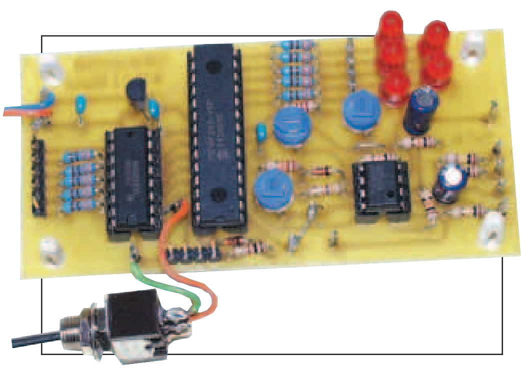
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENTS . . . POPULAR FEATURES . . .

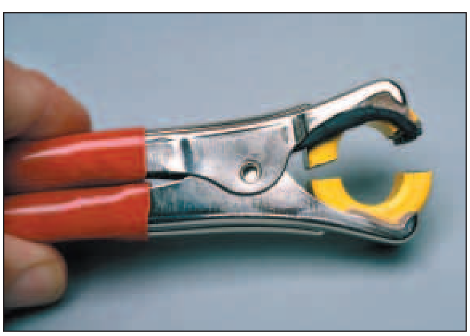
VOL. 35. No. 1 JANUARY 2006

EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

www.epemag.co.uk
EPE Online: www.epemag.com





Projects and Circuits

Series and Features

Regulars and Services

Seasons Greetings
to all our readers

Our February 2006 issue will be published on Thursday, 12 January 2006. See page 3 for details

EPE EVERYDAY PRACTICAL ELECTRONICS

THE UK's No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

VOL. 35 No. 1 JANUARY 2006

Editorial Offices:
EVERYDAY PRACTICAL ELECTRONICS EDITORIAL
Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND
Phone: (01202) 873872. Fax: (01202) 874562.
Email: enquiries@epemag.wimborne.co.uk
Web Site: www.epemag.co.uk
EPE Online (downloadable version of *EPE*)**:** www.epemag.com
EPE Online Shop: www.epemag.wimborne.co.uk/shopdoor.htm
See notes on **Readers' Technical Enquiries** below – we regret technical enquiries cannot be answered over the telephone.
Advertisement Offices:
EVERYDAY PRACTICAL ELECTRONICS ADVERTISEMENTS
408 Wimborne Road East, Ferndown, Dorset BH22 9ND
Phone: 01202 873872 Fax: 01202 874562
Email: stewart.kearn@wimborne.co.uk

Sharp-eyed regular readers will notice some changes to *EPE* this month – besides the obvious ones like the new logo, better quality paper and full colour throughout, which I know you will like. (The reason for these is to push the magazine into the 21st Century and, more importantly, to make sure we appeal to as wide a range of readers as possible. Younger enthusiasts are simply not used to seeing any magazine printed on paper "that changes colour as you read it" – as one contributor put it – or in black and white on most pages.) No, the changes I'm on about are to do with *EPE* staff and projects.

Staff

This issue marks the retirement of David Barrington, Dave has literally worked on *EPE* (or *PE* or *EE*) "man and boy", joining the team before the very first issue back in November 1964. It is Dave who, to a very large extent, has been responsible for the high level of accuracy the magazine has enjoyed, for it is he who checks all the drawings in infinite detail and who lays out much of the magazine. Dave was our Production Editor for many years and for the last seventeen years has been our Deputy Editor. We will, however, not miss him too much as he will keep working for us on a freelance basis. Over 40 years of loyal service to "one" magazine is exceptional and we know that Dave has helped many thousands of readers over the years, he actually joined George Newnes (the original publishers of *PE*) when he left school in 1955, just over 50 years ago.

Also, by the time you read this John Becker will have retired. John has been our Technical Editor for the last eleven years, responsible for the technical accuracy of our material and for his excellent *PIC Tutorials* and PIC-based projects. Again, we will not miss him too much as he will also continue to work for us on a freelance basis. John was a contributor to *PE* back in the seventies, then an advertiser selling kits for projects, followed by a stint as editor of *PE* prior to joining *EPE*.

We wish them both well and hope they find the extra leisure time to their liking. They have both had great influences on the magazine and often kept me on the straight and narrow. We thank them both and look forward to a new on-going way of working with them.

Projects

This month we are delighted to announce our association with another of the world's best electronics magazines, *Silicon Chip*. This will allow us to feature a greater range of constructional projects each month, as well as greatly improved presentation, along with our better paper and four-colour printing. You will see much better circuits and wiring diagrams in colour, along with hi-res colour photos that enable you to see fine constructional detail in projects.

The first of these projects appear in this issue. This association will enable *EPE* to stay at the forefront of the UK hobby electronics market and ensure a greater selection of projects for enthusiasts, with more kits being available as well.

We know you'll enjoy our new look and revised approach. We will continue to publish the regular features and series and we look forward to your positive feedback, to help us keep improving in the future.

Mike Kenward

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see opposite), from all UK newsagents (distributed by COMAG) and from the following electronic component retailers: Omni Electronics and Yebo Electronics (S. Africa). *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased and downloaded for just $15.99US (approx £9.50) per year available from **www.epemag.com**

SUBSCRIPTIONS

Subscriptions for delivery direct to any address in the UK: 6 months £16.50, 12 months £31, two years £57; Overseas: 6 months £19.50 standard air service or £28.50 express airmail, 12 months £37 standard air service or £55 express airmail, 24 months £69 standard air service or £105 express airmail. To subscribe from the **USA** or **Canada** see the last magazine page.

Online subscriptions, for downloading the magazine via the Internet, $15.99US (approx £9.50) for one year available from **www.epemag.com**.

Cheques or bank drafts (in **£ sterling only**) payable to *Everyday Practical Electronics* and sent to EPE Subs. Dept., Wimborne Publishing Ltd. 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872. Fax: 01202 874562. **Email:** subs@epemag.wimborne.co.uk. Also via the **Web** at: **http://www.epemag.wimborne.co.uk**. Subscriptions start with the next available issue. We accept MasterCard, Amex, Diners Club, Maestro or Visa. (For past issues see the *Back Issues* page.)

BINDERS

Binders to hold one volume (12 issues) are available from the above address. These are finished in blue p.v.c., printed with the magazine logo in gold on the spine. Price £7.95 plus £3.50 p&p (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery – more for overseas.*

Payment in £ sterling only please. Visa, Amex, Diners Club, Maestro and MasterCard accepted. Send, fax or phone your card number, card expiry date and card security code (the last 3 digits on or just under the signature strip), with your name, address etc. Or order on our secure server via our UK web site. Overseas customers – your credit card will be charged by the card provider in your local currency at the existing exchange rate.

READERS' TECHNICAL ENQUIRIES

E-mail: techdept@epemag.wimborne.co.uk

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply *must* be accompanied by a **stamped self-addressed envelope or a self-addressed envelope and international reply coupons. We are not able to answer technical queries on the phone.**

PROJECTS AND CIRCUITS

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.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

ADVERTISEMENTS

Although the proprietors and staff of EVERYDAY PRACTICAL ELECTRONICS take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are *bona fide,* the magazine and its Publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or in inserts.

The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before buying any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use or ownership. The laws vary from country to country; readers should check local laws.

News . . .

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

COMPLAINTS ABOUT DAB

Not everyone is convinced that DAB offers better listening as Barry Fox reports

DAB digital radio started out as a hi-fi system. But the broadcasters have cut the data rates so drastically, to get more programmes into each multiplex, that audio quality varies wildly. Poor cover in some parts of the country, and the difficulty of receiving DAB on the move, exacerbates the problem. But the broadcasters have not toned down their advertising claims accordingly. Now they will have to.

Misleading Claims

In early October the Advertising Standards Authority upheld two complaints against advertisements that claimed high audio quality for DAB radio. The broadcast adverts, from London's commercial radio multiplex operator Switchdigital, promised "crystal clear" and "distortion-free" sound which takes "the hiss out of the way you listen to the radio".

This was "misleading" says the ASA in a judgment published on October 5th (**www.asa.org.uk**). A listener complained that the claims "distortion free" and "crystal clear" were misleading because although DAB digital radio may be free from "hiss" or "crackle", a "gurgling noise" can interfere with the sound; and in many cases analogue audio quality is better.

The Radio Advertising Clearance Centre told the ASA that if a DAB digital radio set is correctly set up, it should not suffer from "gurgling" interference noise because "the signal was either on or off, which avoided the fading in and out and background noise that analogue radio is prone to."

Switchdigital argued that the terms "distortion free" and "crystal clear" were used as "an informative public service message" offered "in an entertaining way"; and "distortion free" was used to allegorise the technological benefits of DAB over analogue, like the benefits of CDs over vinyl.

But Switchdigital admitted that there might be digital "artifacts" and "if a listener was receiving a signal that was either too high or too low he/she might hear a "bubbly" noise".

This, decided the ASA, meant that an advert claiming "distortion free" and "crystal clear" sound was misleading.

Beefier Preferred

The RACC also argued that the advert did not refer to analogue radio but merely highlighted the benefits of DAB. Switchdigital said that many analogue radio stations compressed their sound to make it "richer" and "beefier", which some listeners prefer; DAB comes closer to the original audio, and audio quality is a subjective issue anyway.

The ASA was unimpressed and upheld the complaint. "We believe the advert would be understood by listeners to mean that DAB digital radio is superior to analogue in terms of audio quality (and) we received no evidence to show that DAB digital radio is superior to analogue radio in terms of audio quality." Says Nigel Sharman, a PR Director for the classical music industry and Royal Television Society Council member who filed both complaints:

"I just think they are selling DAB on the basis of claims the technology simply can't support. For me, the low-pitched gurgling noise you often get is far more annoying than a bit of hiss and interference; it actually makes you want to tune away from the station because it is so unpleasant".

"We do not wish to make any further comment", says Danny Rose, spokesman for Switchdigital.

Improved Claims

The Digital Radio Development Board, of which Switchdigital is an official partner, is already very careful to claim only "improved sound quality" for DAB, and no "hiss, crackle and fade so familiar on analogue radio." But the DRDB comes to the defence of Switchdigital. Says Ian Dickens, Chief Executive, DRDB: "In a good signal area reception is clean, sharp and clear.

"The Switch ad seems to imply that DAB does some things better than analogue" like "taking the hiss out of the way you listen to the radio", something with which the ASA actually seems to concur when it says, "We noted that DAB digital radio removed the hiss and crackle that could interfere with analogue radio." So, is the ASA penalizing Switch for saying something that the ASA agrees with?

"The fact remains that 1.8 million people have bought a DAB digital radio, and very few are returned on the basis of poor audio or reception." The ASA has rejected another complaint by another listener who thought the claim "distortion free" was misleading.

On this complaint the Radio Advertising Clearance Centre argued that the advert did not claim that DAB duplicates the original sound of a recording. The ASA agreed, saying: "Listeners would understand that the claim 'distortion-free' refers merely to the absence of interference". The ASA still has at least one further complaint on DAB adverts to adjudicate.

Log the Loop

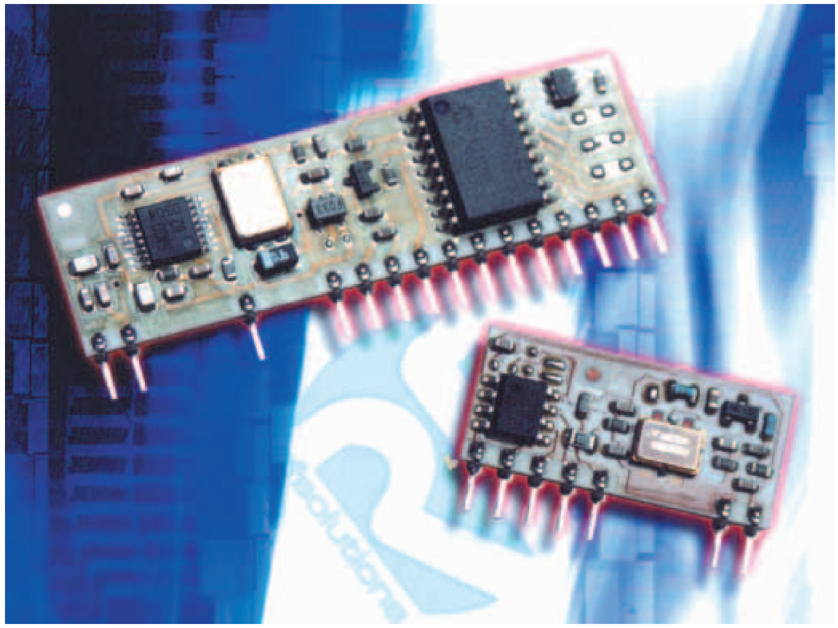
Lascar's EL-USB-4 is the latest data logger to be added to their popular EL-USB range. It is the world's first standalone 4-20mA data logger with direct USB interface and provides a cost effective and easy to use solution for data logging needs.

The unit is supplied with Windows compatible software which is used for configuration of the unit as well as download and graphing of the data. With the logger connected to a USB port, the software enables the user to set the required sampling rate (from one second), custom calibration, high and low alarms, and the logger start time. Once configured, the EL-USB-4 is removed from the computer and the signal to be measured connected to the logger via two screw terminals.

Two l.e.d.s indicate when the unit is logging, when an alarm level has been reached, when the battery needs replacing or when the device has reached full memory capacity (32,000 readings). To download data, the user reconnects the unit to the USB port. The supplied software is then used to download and graph the data from the unit. Data, saved in .TXT format, can be also imported to many industry standard spreadsheet packages for customised analysis.

For more information, contact Lascar Electronics Ltd., Module House, White Parish, Salisbury, Wilts SP5 2SJ. Tel: 01794 884567, Fax: 01794 774 4616. Web: **www.lascarelectronics.com**.

Plug and Play Radio



RF Solutions has added to its range of easy to use "SmartRadio" products with the introduction of the RF620T transmitter and RF620R receiver. The new modules enable the simple implementation of low cost, reliable, "plug and play" wireless data communications in a wide range of applications that includes security systems, EPOS terminals, meter reading and sensor data logging.

The modules provide a serial data communications solution and a remote command and telemetry solution (four remote control lines). A microprocessor is integrated into the design of the modules to automatically perform the necessary encryption and decryption to optimize data for transmission. This functionality helps reduce design and development time and ensures maximum range and reliability of the radio link.

When used in serial comms mode the RF620T and RF620R provide a transparent, wire replacement radio solution. Operated in remote command telemetry mode the modules give a high security four-channel telemetry link where the output on the receiver mirrors the input to the receiver.

The new 433MHz AM modules use advanced hybrid technology. A host interface Baud rate of up to 19200 is specified and operating range is up to 100 metres. Other key features include an on-board buffer and optional host flow control.

Both the transmitter and receiver modules have an operating temperature range of -20°C to +85°C. The RF620T measures 50.8mm × 14.5mm × 3mm and the RF620R measures 63.5mm × 14.5mm × 3mm.

For more information contact R.F. Solutions Ltd, Dept *EPE*, Unit 21, Cliffe Industrial Estate, South Street, Lewes, East Sussex BN8 6JL.
Tel: 01273 898000. Fax: 01273 480661.
Email: sales@rfsolutions.co.uk
Web: **www.rfsolutions.co.uk**

Alternative Toys

If you are looking for alternatives to the usual stocking fillers this year, Teaching Resources Ltd is offering a range of gifts that should keep children and teenagers entertained this Christmas.

Teaching Resources is Middlesex University's award-winning design and technology company and one of the UK's biggest education suppliers. They design, manufacture and distribute educational products for retail sale in the UK's leading museums, visitor attractions and high street shops such as Marks and Spencer and The Natural World.

TR's Bletchley Park kits produce a device with paper and pipes capable of the same level of encoding as the original WW2 Enigma machine. Other kits include the Super Spy Kit, Camera Obscura, Electric Cannon, Station X Rocket, Electric Plane Launcher, and Alien. The latter is a "spitting, talking and moving" design developed for the Science Museum's touring exhibition.

A full range of Teaching Resources products can be found at **www.mutr.co.uk**.

MERG Newsletter

The Model Electronic Railway Group (MERG) have sent us their latest newsletter. It confirms that their range of activities is ever-increasing, as is their membership. If you are interested in such enthralling activities, why not find out more by contacting John Ferguson, Secretary MERG, 5 Butts Lane, Danbury, Essex CM3 4NP. Tel: 01245 223 888. Email: secretary@merg.info. Web: **www.merg.org.uk**. Mention *EPE!*

Art Pad

Selwyn Electronics has announced The Art Pad, a graphics tablet that looks like a small mousemat and comes with a clever artist pen.

The Art Pad connects to a PC or Mac and comes complete with software that provides a full colour pallet on screen with a choice of high quality painting and drawing applications – pen, pencil, crayon, paintbrush, chalk etc.

By using the special pen on the pad, the Art Pad allows you to create superb drawings, paintings and artwork on your PC, either freehand or tracing, with a range of special effects that can recreate a range of finishes – from oil paintings and water colours to cartoons and sketches.

Its features include: a 3-button cordless pen and graphics tablet; adjustable pressure sensitivity; tip pressure changes line width, colour density and opacity; resolution 2540lpi; accuracy: ± 0.01%; customisable pen buttons; can be used as a mouse replacement or alongside a plug & play USB device; compatible with Windows and Macintosh systems; Art Dabbler software included.

The Art Pad has been designed to encourage adults and children alike to develop their creativity and imagination. It costs £35, and is available from Selwyn Electronics at **www.selwyn.co.uk**.

Points Arising

Speed Camera Watch Mk2 (November '05). In Fig.4. Connector 1 pin 1 (not pin 7) should go to PCB JP9 pin 6.

- Indicates up to 9 gears
- Neutral indication
- Reverse indication
- Easy gear calibration
- Adjustable parameters
- Adjustable reverse gear switch level
- Display dimming

A "Tiptronic-style" Gear Indicator

Do you know what gear your car is in at any given time? "Just look at the gear stick", you say. Actually, it's not that easy, especially if you have a 4-speed automatic or a 5 or 6-speed manual gearbox. And what if you ride a motorbike? So you need the Gear Indicator – it will give you the answer on a digital readout.

By JOHN CLARKE

IF YOU'RE DRIVING in traffic, it is quite easy to be in the wrong gear, especially as the noise of the traffic can drown out the engine. And if you have your stereo system blaring as well, then what chance have you got? Yes, you can deliberately look at the gearstick but you're not likely to do that unless you suspect you might be in the wrong gear.

Why would you be in the "wrong gear" in the first place? If your car is stuck in heavy traffic you might easily continue on for some time in 2nd or 3rd after the traffic clears, particularly if your engine is not noisy.

Much the same can happen with an automatic, if you are in the habit of "flicking" back to 3rd or 2nd (eg, when going up a hill or for engine braking downhill). It's all too easy to forget to flick it back into Drive later on. As a result, you could finish up driving quite some distance in a low gear and that's not good for fuel consumption.

The same problem can happen if you ride a motorbike. Wouldn't it be nice to have a digital display to show the gear you're in? In fact, when driving an automatic it can still be useful to know which gear you are in, even if Drive is correctly selected. Modern automatics are so smooth that it can be difficult to "pick" the changes. Now you can "see" what the transmission is doing.

This idea is not new, of course. All cars with Tiptronic transmissions and the latest Honda Jazz with its 7-speed gearbox have a digital gear indicator on the dashboard.

Main features

Basically, the Gear Indicator consists a small box which incorporates a single-digit LED display. This can show gear selections from 1-9, Neutral (which is shown on the display as a dash; ie, "-") and Reverse (which is shown as an "r").

Inside the case are several switches which allow the unit to be calibrated and set up for best gear detection results. Once it's all set up, that's it – there are no user controls on the front panel to fiddle with.

As presented, the unit is designed to be mounted on the dashboard. Alternatively, you could hide the unit under the dashboard and mount the LED display separately, if space is a problem. A 9-strand cable (eg, rainbow cable) would then be required to connect the display back to the main circuit.

The right gear

The Gear Indicator works by monitoring both the speed of the vehicle and the engine RPM. It then decides which gear has been selected by feeding the results into a lookup table that's programmed into an internal microcontroller. And that means that the unit must first be calibrated, so that it knows what the results are for each gear.

Note, however, that neutral (-) is always shown when the unit is first powered up and also if the vehicle is stationary (or almost stationary) while the engine is running. By contrast, reverse (r) is shown when ever the vehicle's reversing lights are activated.

One thing you should note is that the Gear Indicator does not work by detecting gear changes – eg, by fitting switch actuators to the gearstick. This method would not only be unreliable but would also be a mechanical nightmare to set up. What's more, the position of the gear selector in an automatic car doesn't tell you which gear the transmission is in (unless 1st gear is manually selected).

That's because the transmission can still select any one of the lower gears in the remaining positions. For example, if the gear selector is set to 3rd, 2nd and 1st can also be selected.

Of course, it is conceivable that the signals from an electronically controlled automatic transmission could be used to drive a gear display. However, we have not provided for this in the Gear Indicator because these signals would be different on each type of vehicle and may be difficult to utilise effectively.

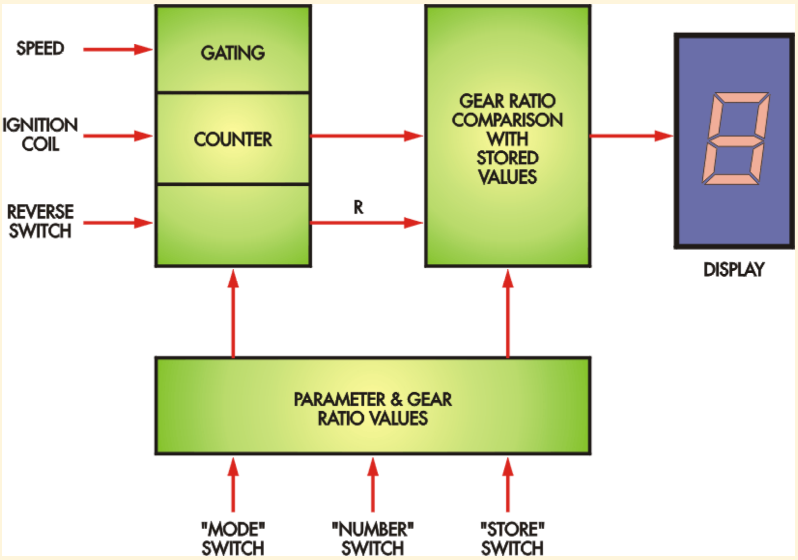


Fig.1: block diagram of the Gear Indicator. It works by counting the number of ignition pulses that occur during a fixed number of pulses from a speed sensor and comparing the result with a "lookup" table that's stored in memory.

Block diagram

Fig.1 shows the basic operation of the Gear Indicator. There are three external inputs: speed sensor pulses, ignition coil pulses and the reversing switch input.

The speed sensor pulses can be obtained from a rotating magnet and coil assembly mounted on the tailshaft. Alternatively, you can use the digital speed signal that comes from the vehicle's engine computer, if this can be identified (and accessed). The ignition pulses can either be obtained from the ignition coil or you can use the low-voltage tachometer signal from the engine management computer if this is available.

The reversing input is obtained, naturally enough, from the reversing switch. When this switch is closed (ie, when reverse gear is selected), the display will show an "r" for reverse as indicated previously. Conversely, when the switch is open, the display will show either neutral (when the unit is first powered up or if there are no pulses) or a gear number.

If the vehicle is moving, the circuit counts the number of ignition coil pulses that occur during a fixed number of speed pulses. If a low gear is selected (eg, 1st gear), it follows that there will be more ignition pulses counted for a given speed compared to those counted at the same speed in a higher gear.

The gear selection number is shown on the 7-segment LED display. This number is obtained by comparing the number of ignition pulses counted with the stored values (in a microcontroller). These stored values are obtained during calibration of the Gear Indicator.

Fig.2 shows how the Gear Indicator compares the ignition pulse counts with the calibration values. These calibration values are different for each gear and are obtained by driving the vehicle in each gear during the initial setup.

This means that comparing the counted pulses with the calibration values should give the correct gear number. However, in practice, the calibration number may differ from the value obtained during driving. That's because the number of ignition pulses counted may vary by up to several counts for the same number of speed pulses, depending on the phase difference between the two.

To counter this effect, a set amount of hysteresis is added to each gear range – see Fig.2. This can be varied to suit the vehicle during calibration and also corrects for any slippage in the transmission – either in the clutch or in the torque converter.

As a further refinement, a slight delay is added between each display update. This delay prevents the display from behaving erratically during

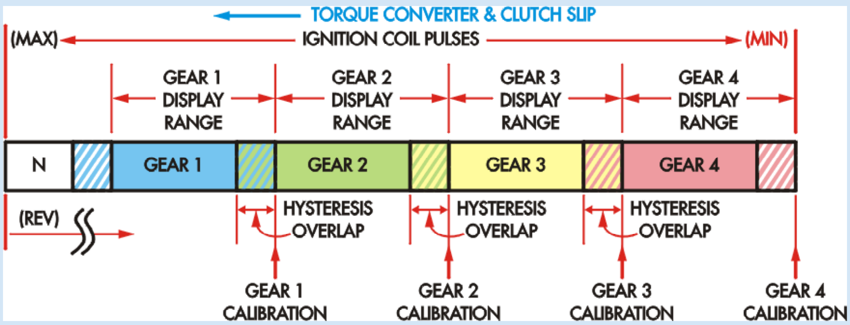


Fig.2: a small amount of hysteresis is added at the end of each gear range to correct for phase errors and transmission slippage. This is set to suit the vehicle and is one of several parameters that are adjusted during the setup procedure.

gear changes, when clutch slippage and changes in engine RPM could otherwise produce an incorrect gear indication.

Circuit details

Refer now to Fig.3 for the circuit details. As indicated above, it's based on a PIC microcontroller (IC1). This device accepts inputs from the various sensors and switches and drives the 7-segment LED display.

OK, let's start with the speed sensor circuit. This consists of a sensing coil which mounts on the chassis, plus four magnets which mount on a drive shaft (or tail shaft). As the magnets spin past, they induce a voltage into the coil and this is detected by comparator stage IC3.

One side of the speed sensing coil connects to a 2.5V supply, derived from a voltage divider consisting of two 2.2k resistors between the +5V rail and ground. This 2.5V rail is decoupled using a 47µF capacitor and biases pin 3 (the non-inverting input) of IC3 via a 22k resistor. It also biases pin 2 of IC3 via the coil and a series 1k resistor. Diodes D1 & D2 clamp the input signal from the coil to 0.6V, while the associated 10nF capacitor filters the pickup signal.

IC3 is wired as an inverting Schmitt trigger comparator. Its hysteresis is set by a 1M positive feedback resistor, which prevents false triggering due to noise.

The output signal from the speed sensor is a 250mV peak-to-peak pulse waveform and this is fed to pin 2 of IC3. Each time the input swings negative, IC3's output (pin 1) goes high (ie, to about 10V).

This output is fed to pin 12 (RB6) of IC1 via a 3.3k current limiting resistor. The internal diodes at RB6 then clamp the signal voltage to about 5.6V. Note that the feedback signal for IC3 is derived from this point to ensure a consistent hysteresis level, regardless of the 12V supply level.

Ignition coil pulses

As shown, signals from the ignition coil are first fed to a voltage divider consisting of 22k and 10k resistors. The associated 68nF capacitor then shunts any signals above 700Hz to ground to eliminate noise.

From there, the signal is AC-coupled via a 1µF capacitor to diode D3 and thence to pin 2 of op amp IC2a. Zener diode ZD2 limits the signal amplitude at D3's anode to 20V, while D3 prevents negative signals from being fed into IC2a. The associated 10k resistor pulls pin 2 low in the absence of a signal input via D3.

A low input (LOW IN) has also been provided at the junction of D3 and ZD2. This input allows the tachometer signal from an engine management computer to be applied instead of using the ignition coil input. The signal level at this input can be anywhere from 2.3V up to a maximum of 20V.

IC2a is wired as an inverting comparator with hysteresis. Its pin 3 input is nominally biased to about 1.6V via a voltage divider connected to the 5V rail, while the 47k feedback resistor provides the hysteresis to set the high and low trigger points (1.7V and 1.5V respectively).

The resulting square-wave signal at IC2a's output is fed to pin 6 of IC1 via a 3.3k resistor. The signal on pin 6 is then clamped by pin 6 (via internal diodes) to 0.6V above IC1's supply rail (5V), as before.

In operation, IC1's pin 6 input is set as an interrupt – ie, the microcontroller's embedded software increments the count each time pin 6 goes low.

Display brightness

Trimpot VR1, light dependent resistor LDR1 and op amp IC2b are used to control the display brightness. As shown, IC2b is connected as a voltage follower and this drives buffer transistor Q1 (which is inside the negative feedback loop) to control the voltage applied to the anode of the 7-segment LED display.

When the ambient light level is high, LDR1 has low resistance and so the voltage on pin 5 is close to the +5V supply rail. As a result, the voltage on Q1's emitter will also be close to +5V and so the display will operate at full brilliance.

As the light level falls, the resistance of the LDR increases and the voltage on pin 5 of IC2b decreases. As a result, Q1's emitter voltage also falls and so the display operates with reduced brightness.

When it's completely dark, the LDR's resistance is very high and the voltage on pin 5 of IC2b is determined solely by VR1. This trimpot is adjusted to give a comfortable display brightness at night.

The 7-segment LED display is driven via the RA1, RB1-RB5 and RB7 outputs of IC1 via 470 resistors. A low output on any one of these output lines lights the corresponding display segment, with the output at RA4 controlling the decimal point.

Switch inputs

Pushbutton switches S1, S2 and S3 are monitored using the RA2 and RA3 inputs. These two inputs are normally tied high via 10k resistors and are only pulled low when the switches are pressed.

When S1 (Mode) is closed, RA2 is pulled low and this is recognised as a closed switch by the software. Similarly, when S2 (Number) is closed, RA3 is pulled low, while pressing S3 (Store) pulls both RA2 & RA3 low to ground (via diodes D4 & D5). As a result, the software can recognise which switch has been pressed and respond accordingly.

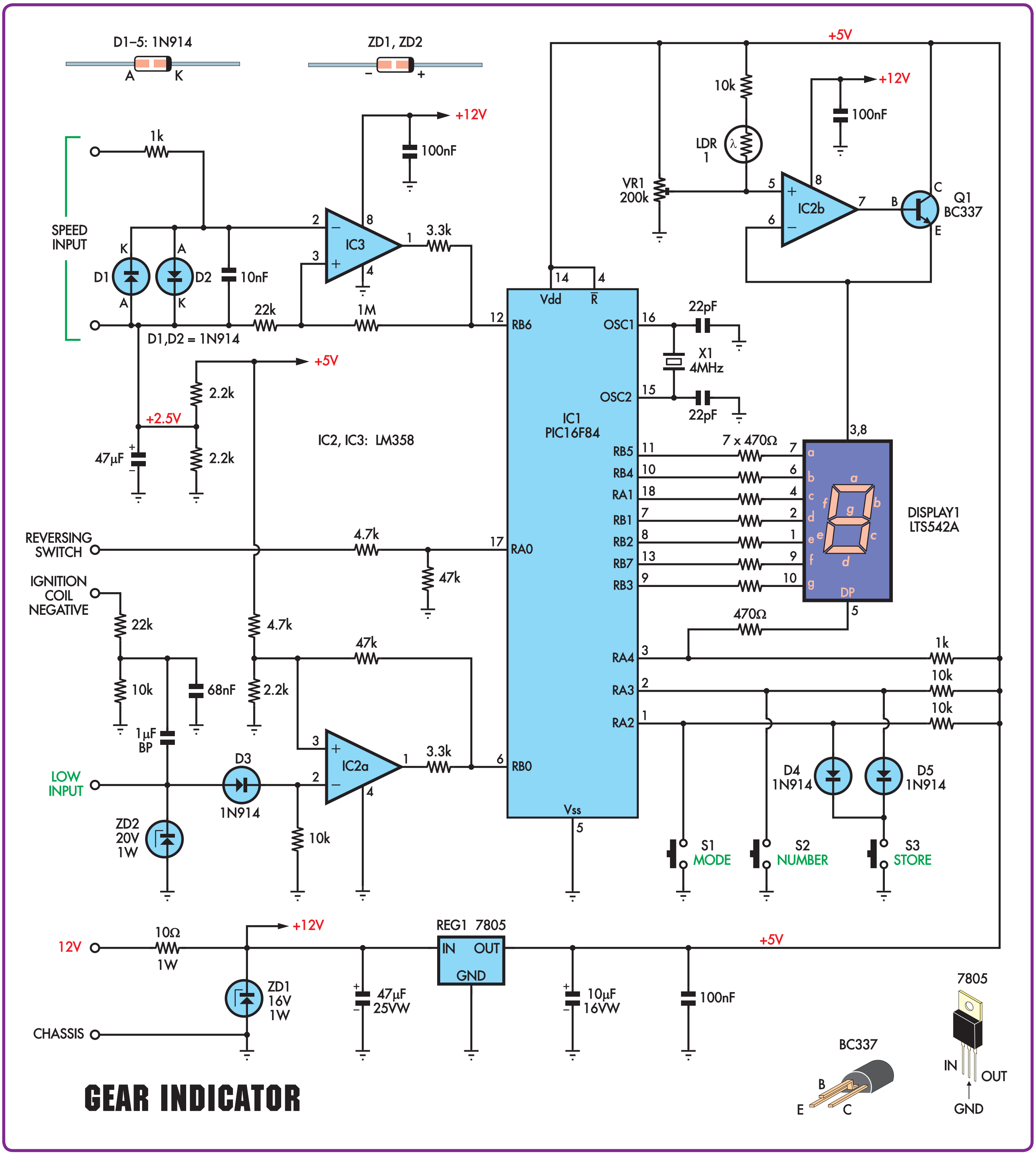


Fig.3: the complete circuit of the Gear Indicator. The PIC microcontroller (IC1) processes the signals from the various inputs and drives a single 7-segment LED display (DISPLAY1) to show the result. IC2b, Q1 & LDR1 automatically dim the display at night, so it is not too bright.

Clock signals

Clock signals for IC1 are provided by an internal oscillator and a 4MHz crystal (X1) connected between pins 15 & 16. The two associated 22pF capacitors are there to provide the correct loading and to ensure that the oscillator starts reliably.

The crystal frequency is divided internally to produce clock signals for the internal circuitry and the various parameters used in the software. It is also used to give a precise time period to count the speed pulses.

Power

Power for the circuit is derived from the vehicle's battery via a fuse and the ignition switch. This supply line is decoupled using a 10 1W resistor and filtered using a 47µF electrolytic capacitor. ZD1 provides transient pro-

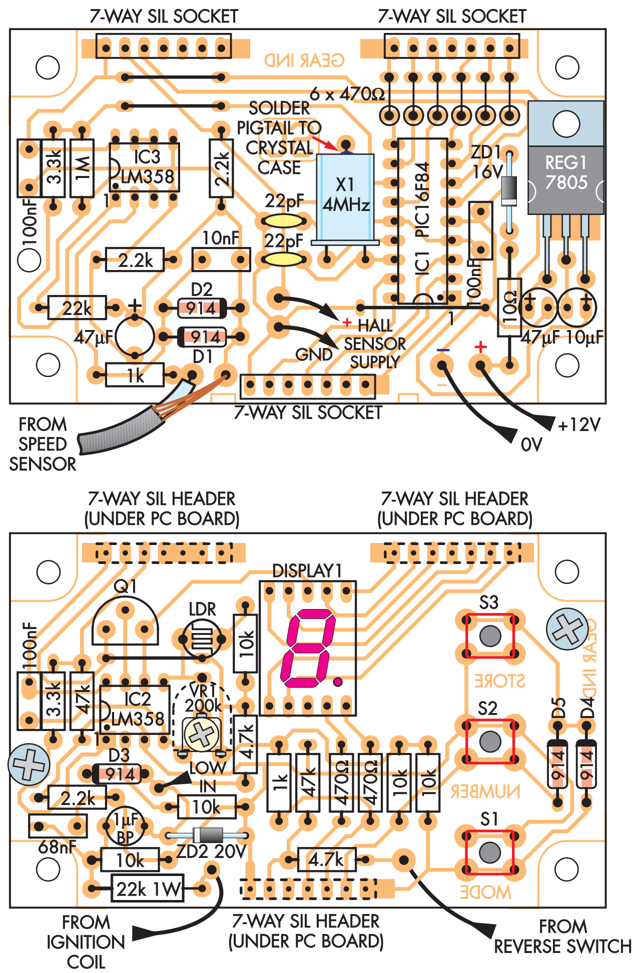


Fig.4: install the parts on the two PC boards as shown here. Note that all the electrolytic capacitors must be mounted so that their bodies lie parallel to the board surfaces (see photos), so that the boards can later be stacked together.

tection by limiting any spike voltages to 16V. It also provides reverse polarity protection – if the supply leads are reversed, ZD1 conducts heavily and "blows" the 10 resistor.

The decoupled supply is fed to 3-terminal regulator REG1 to derive a +5V rail. This rail is then filtered using 10µF and 100nF capacitors and used to power IC1. IC2 and IC3 derive their power directly from the decoupled +12V rail.

Table 2: Capacitor Codes

Value	IEC Code	EIA Code
100nF (0.1µF)	100n	104
68nF (.068µF)	68n	683
10nF (.01µF)	10n	103
22pF (22p)	22p	22

Construction

Fig.4 shows the assembly details. Most of the work involves building two PC boards: a microcontroller board coded 549 and a display board coded 550. These two boards are then stacked together piggyback fashion using pin headers and cut down IC sockets, so that there is very little external wiring.

Begin by carefully checking the PC boards for defects, by comparing them with the published patterns. It's rare to find problems these days but it doesn't hurt to make sure.

The microcontroller board can be assembled first. Install the three wire links first, then follow with the resistors and diodes. Table 1 shows the resistor colour codes but we also recommend that you check each value using a digital multimeter as some colours can be hard to decipher.

Note that the six 470 resistors are mounted end-on to save space. Take care when installing D1 & D2 as they face in opposite directions. Similarly, watch the orientation of ZD1.

REG1 can go in next. It is mounted with its metal tab flat against the PC board. As shown, its leads are bent down at right angles so that they pass through their respective mounting holes. This is best done by slipping an M3 screw through the hole in the

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	1MΩ	brown black green brown	brown black black yellow brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	2	22kΩ	red red orange brown	red red black red brown
❑	5	10kΩ	brown black orange brown	brown black black red brown
❑	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	3	2.2kΩ	red red red brown	red red black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	7	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	10Ω	brown black black brown	N/A

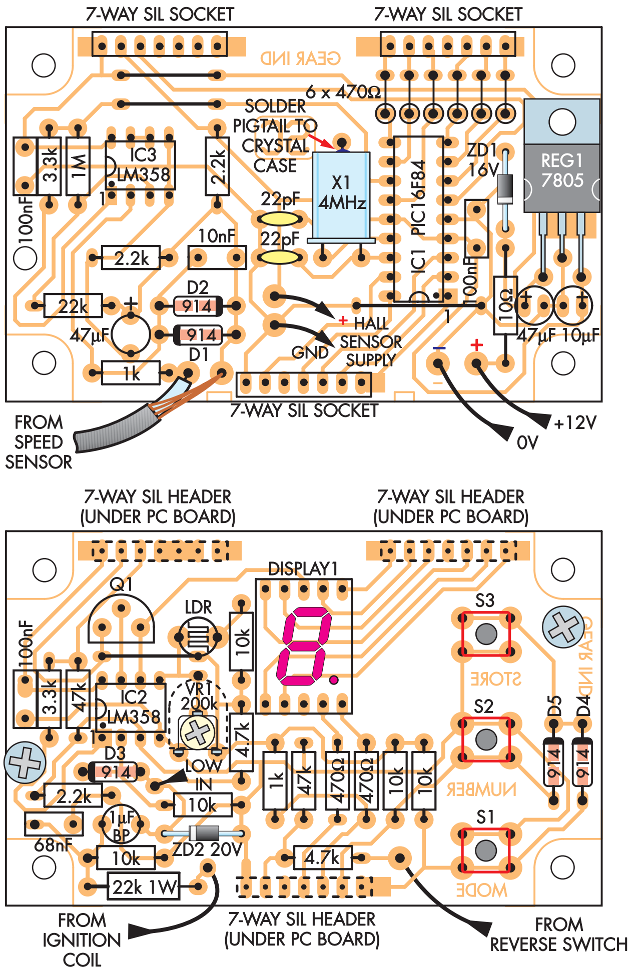


Fig.4: install the parts on the two PC boards as shown here. Note that all the electrolytic capacitors must be mounted so that their bodies lie parallel to the board surfaces (see photos), so that the boards can later be stacked together.

tection by limiting any spike voltages to 16V. It also provides reverse polarity protection – if the supply leads are reversed, ZD1 conducts heavily and “blows” the 10 resistor.

The decoupled supply is fed to 3-terminal regulator REG1 to derive a +5V rail. This rail is then filtered using 10µF and 100nF capacitors and used to power IC1. IC2 and IC3 derive their power directly from the decoupled +12V rail.

Table 2: Capacitor Codes

Value	IEC Code	EIA Code
100nF (0.1µF)	100n	104
68nF (.068µF)	68n	683
10nF (.01µF)	10n	103
22pF (22p)	22p	22

Construction

Fig.4 shows the assembly details. Most of the work involves building two PC boards: a microcontroller board coded 549 and a display board coded 550. These two boards are then stacked together piggyback fashion using pin headers and cut down IC sockets, so that there is very little external wiring.

Begin by carefully checking the PC boards for defects, by comparing them with the published patterns. It’s rare to find problems these days but it doesn’t hurt to make sure.

The microcontroller board can be assembled first. Install the three wire links first, then follow with the resistors and diodes. Table 1 shows the resistor colour codes but we also recommend that you check each value using a digital multimeter as some colours can be hard to decipher.

Note that the six 470 resistors are mounted end-on to save space. Take care when installing D1 & D2 as they face in opposite directions. Similarly, watch the orientation of ZD1.

REG1 can go in next. It is mounted with its metal tab flat against the PC board. As shown, its leads are bent down at right angles so that they pass through their respective mounting holes. This is best done by slipping an M3 screw through the hole in the

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	1MΩ	brown black green brown	brown black black yellow brown
❏	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❏	2	22kΩ	red red orange brown	red red black red brown
❏	5	10kΩ	brown black orange brown	brown black black red brown
❏	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❏	2	3.3kΩ	orange orange red brown	orange orange black brown brown
❏	3	2.2kΩ	red red red brown	red red black brown brown
❏	2	1kΩ	brown black red brown	brown black black brown brown
❏	7	470Ω	yellow violet brown brown	yellow violet black black brown
❏	1	10Ω	brown black black brown	N/A

device tab, positioning it on the PC board and then gripping one of the leads with a pair of needle-nose pliers, just before it reaches the mounting hole. The device is then lifted clear of the PC board and the lead bent down at right angles, after which the procedure is repeated for the next lead.

Next, install a socket for IC1, taking care to ensure that it is the right way around. Don't plug the microcontroller in yet – that step comes later, after you've checked out the power supply. IC3 can then be installed, followed by the capacitors.

Note that the 47μF capacitor near the speed sensor input must be installed so that it lies parallel with the PC board – see photo. Similarly, the adjacent 47μF & 10μF capacitors below REG1 lie over the regulator's leads. In each case, it's simply a matter of bending the capacitor's leads at right angles before installing it on the PC board.

Crystal X1 mounts horizontally on the PC board and can go in either way around. It is secured by soldering a short length of wire between one end of its case and an adjacent PC pad.

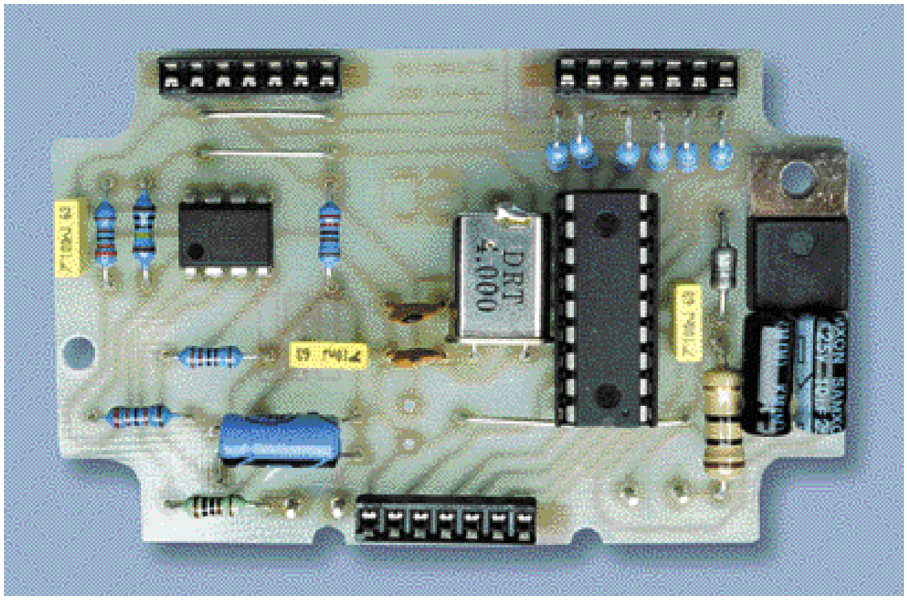
Finally, you can complete the assembly of this board by fitting PC stakes to the external wiring points and fitting the 7-way single in-line (SIL) sockets. The latter are made by cutting down two 14-pin IC sockets into in-line strips using a sharp knife or fine-toothed hacksaw.

Clean up any rough edges with a file before installing them on the PC board.

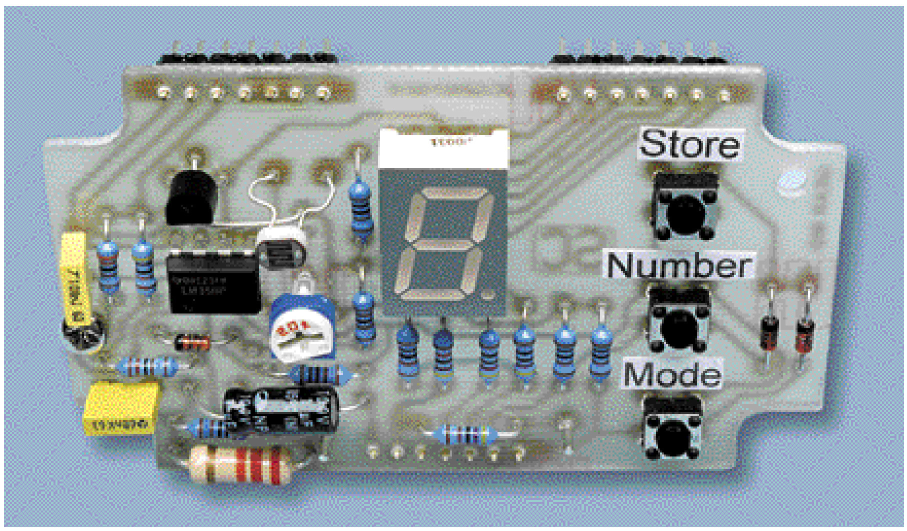
Before plugging in IC1, it's a good idea to check the supply rails (note: you don't need to have the display board connected to do this). All you have to do is connect a 12V supply to the board and check that there is +5V on pins 4 & 14 of the socket (use the metal tab of REG1 for the ground connection). If this is correct, plug IC1 in as shown in Fig.4 – ie, pin 1 towards bottom right.

Display board

Now for the display board. Install the wire link first, followed by the resistors, diodes D3-D5, ZD2 and transistor Q1. The three capacitors can then be installed, along with trimpot VR1 and the 7-segment LED display. Note that the 1μF bipolar capacitor is installed so that it lies across ZD2 – see photo.



This is the fully-assembled microcontroller board. Note particularly how the three electrolytic capacitors are mounted – ie, so that they lie horizontally across other components.



The pin headers on the underside of the display board plug into the in-line sockets on the microcontroller board. Take care to ensure that the 7-segment LED display is correctly oriented.

Watch the orientation of the LED display – its decimal point goes towards bottom right.

LDR1 can go in next. It's mounted so that its top face is about 3mm above the face of the 7-segment display. Once it's in, you can install switches S1-S3 and PC stakes at the external wiring points.

The three 7-way SIL pin headers are installed on the copper side of the PC board with their leads just protruding above the top surface. You will need a fine-tipped soldering iron to install them. Note that you will have to slide the plastic spacers along the pins to allow room for soldering, after which the spacers are pushed back down again.

Final assembly

Work can now begin on the plastic case. First, remove the integral side pillars with a sharp chisel, then slide the microcontroller board into place. That done, mark out the two mounting holes on the base – one aligned with the hole in REG1's metal tab and the other diagonally opposite on the lefthand side.

Now remove the board and drill these two holes to 3mm. Once drilled, they can be slightly countersunk on the outside of the case to suit the mounting screws.

In addition, you will have to drill two holes in the back of the case to ac-

Parts List

1 microcontroller PC board, code 549, 78 x 50mm
1 display PC board, code 550, 78 x 50mm available from the *EPE PCB Service*
1 plastic utility case, 83 x 54 x 30mm
1 dark red transparent Perspex or Acrylic sheet, 14 x 16 x 2·5mm
1 4MHz parallel resonant crystal (X1)
1 LDR
4 or 6 button magnets
1 coil former, 15mm OD, 8mm ID x 7mm
1 20m length of 0·18mm enamelled copper wire
1 6mm x 25mm steel bolt, 2 washers and nut
6 PC stakes
3 7-way pin head launcher
2 DIP-14 low-cost IC socket with wiper contacts (cut for 3 x 7-way single in-line sockets)
3 PC-mount tactile membrane switches (S1-S3)
2 6mm long M3 tapped spacers
1 10mm Nylon spacer or 2 x 6mm spacers with one cut to 4mm
1 9mm long untapped metal spacer
2 M3 x 6mm countersunk screws
2 M3 x 15mm brass screws
1 100mm length of 0.8mm tinned copper wire
1 2m length of single core shielded cable
1 2m length of 7.5A mains rated wire
1 2m length of red automotive wire
1 2m length of black or green automotive wire (ground wire)
1 2m length of white automotive wire
1 200kΩ horizontal trimpot (VR1)

Semiconductors
1 PIC16F84P microprocessor programmed with gear.hex (IC1) (The hex file is available from the downloads section of our website at **www.epemag.co.uk** – preprogrammed microcontrollers are available from Magenta Electronics)
2 LM358 dual op amps (IC2,IC3)
1 7805 or LM340T5 5V 1A 3-terminal regulator (REG1)
1 BC337 NPN transistor (Q1)
1 HDSP5301, LTS542A common anode 7-segment LED display (DISP1)
5 1N914, 1N4148 signal diodes (D1-D5)
1 16V 1W zener diode (ZD1)
1 20V 1W zener diode (ZD2)

Capacitors
2 47µF 25VW PC electrolytic
1 10µF 16VW PC electrolytic
1 1µF bipolar electrolytic
3 100nF MKT polyester
1 68nF MKT polyester
1 10nF MKT polyester
2 22pF ceramic

Resistors (0.25W 1%)

1 1MΩ	2 3·3kΩ
2 47kΩ	3 2·2kΩ
1 22kΩ	2 1kΩ
1 22kΩ 1W	7 470Ω
5 10kΩ	1 10Ω 1W
2 4·7kΩ	

Alternative speed sensor
1 PC board, code 551, 14 x 30mm, available from the *EPE PCB Service.*
1 UGN3503 Hall senosr
1 100nF MKT polyester capacitor
1 2m length of twin-core shielded cable
3 PC stakes

Miscellaneous
Automotive connectors, heatshrink tubing, aluminium bracket, self-tapping screws

cept the power leads, the shielded cable from the speed sensor, the ignition coil and the reversing switch. These holes should be located so that they line up with the relevant PC stakes.

The display PC board can now be plugged into the microcontroller board and the assembly fastened together and installed in the case, as shown in Fig.5. Once it's all together, check that none of the leads on the display board short against any of the parts on the microcontroller board. It may be necessary to trim some of the pigtails on the display board to prevent this.

The panel artwork can now be used as a template for marking out and drilling the front panel. You will need to drill a hole for the LDR plus a series of small holes around the inside perimeter of the display cutout.

Once the holes for the display cutout have been drilled, knock out the centre-piece and clean up the rough edges using a small file. Make the cutout just big enough so that the red Perspex is a tight fit. A few spots of superglue along the inside edges can be used to ensure that the window stays put.

That done, you can affix the front panel label and cut out the holes with a utility knife.

Testing

Now for the smoke test! First, apply power and check that the display shows "-". If it doesn't, switch off immediately and check for wiring errors and solder faults.

Assuming that everything is OK, you can test the dimming feature by holding your finger over the LDR. Adjust VR1 until the display dims to the level you want at night.

Next, connect the leads from the ignition coil (or low level input), the reversing switch and the speed sensor. These leads all connect to the underside of the PC board and the ignition and reversing switch wires pass through to the base of the case via notches cut in the side of the microcontroller PC board. These notches are located on either side of the adjacent 7-way socket and their positions are marked on the PC board using a fine track outline.

Speed sensor

Two different speed sensors can be made up, one based on a coil pickup and the other using a Hall sensor pickup. However, both rely on the use of an adjacent rotating magnet assembly .

The coil pickup is likely to be more rugged and less prone to water damage but the Hall sensor will allow for very low speed operation. That's because its output voltage doesn't depend on the speed at which the magnets rotate past the sensor. It's just a matter of waterproofing it correctly, using heatshrink tubing and silicone sealant.

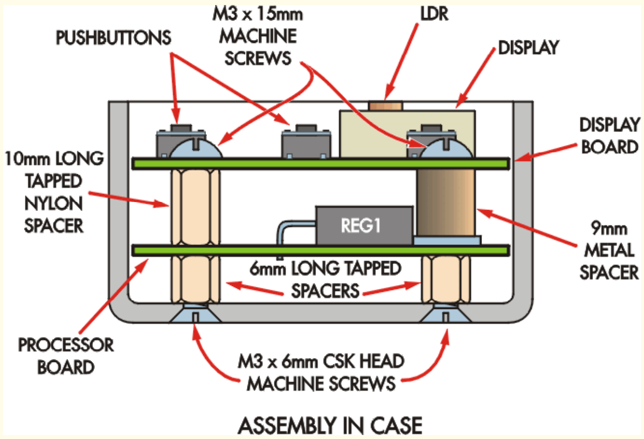


Fig.5: this diagram shows how the two PC boards are stacked together and secured to the bottom of the case using screws, nuts and spacers. Be sure to use nylon spacers where specified.

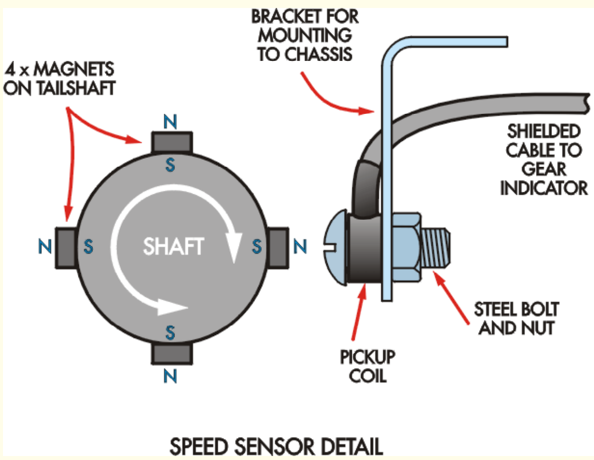


Fig.6: the pickup coil used in the speed sensor is mounted on a L-shaped bracket that's secured to the vehicle's chassis. Position the coil so that it is no more than 10mm away from the magnets as they pass, to ensure sufficient signal pickup. Note that the magnets must all be installed with the same pole facing outwards – either North as shown here or South.

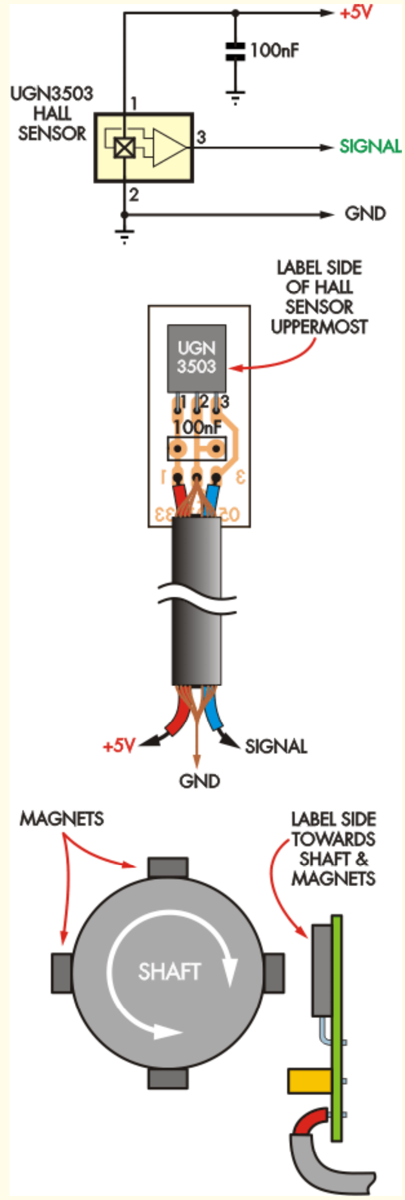
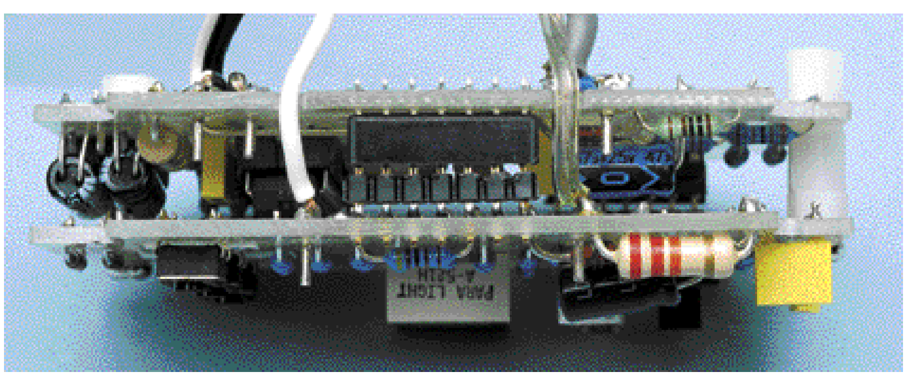


Fig.7: the alternative speed sensor uses a Hall effect device mounted on a small PC board.

The coil sensor version is shown in Fig.6. It is made by winding about 400 turns of 0.18mm enamelled copper wire onto a plastic bobbin measuring 15mm OD x 8mm ID x 5mm. Use electrical tape to secure the turns and leave about 10-20mm of lead length at each end.

Once the coil has been wound, solder its leads to a suitable length of shielded cable – ie, one lead goes to the shield wire and the other goes to the core. Secure this lead to the side of the coil with some tape, then cover the coil with silicone sealant (preferably the non-acid type such as roof and gutter sealant).



This is the completed PC board assembly, ready for mounting in the plastic case. Note that the various external leads are all soldered to PC stakes on the copper side of each board, with the leads from the display board resting in small grooves cut into the microcontroller board.

Adjustable Parameters For The Gear Indicator

Display Value	Speed Pulses (S)	Hysteresis	Delay (d)	Timeout (-)	Reverse (r)	Clear (C)
1	4	2%	0.1s	0.5s	12V = r*	-
2	8	4%	0.2s*	1s	0V = r	-
3	12*	6%	0.3s	1.5s	12V = r*	-
4	16	8%	0.4s	2s	0V = r	-
5	20	10%	0.5s	2.5s*	12V = r*	-
6	24	12%	0.6s	3s	0V = r	-
7	28	14%	0.7s	3.5s	12V = r*	-
8	32	17%	0.8s	4s	0V = r	-
9	36	20%	0.9s	4.5s	12V = r*	-

Table 3: Adjustable Parameters

Note: an asterisk (*) denotes the default value.

Because each vehicle is different, the Gear Indicator requires correct setup to obtain the best results. Consequently, the unit has been designed to cater for up to nine gears and there are various parameters that can be adjusted to control its operation.

Table 3 shows the details of the various parameters. These are as follows:

(1) The first parameter that can be set is the number of speed pulses used to gate the ignition pulses. This is adjustable from 4-36 pulses in increments of 4, using numbers from 1-9. The initial setting is for 12 pulses but this may have to be varied to cater for various speed sensor characteristics.

(2) Next is the amount of hysteresis for each gear comparison. In practice, this value is made just large enough so that the display does not sometimes briefly show the next highest gear number. The default value is 6% of the ignition pulse count and this should be suitable in most cases.

This value will have to be increased if the display shows a tendency to occasionally jump to the next highest gear. Conversely, it should be made lower if this tendency is not apparent and then adjusted back the other way until the effect disappears.

In practice, you can adjust the hysteresis over a range from 2-20%. The lower the value the better, since this gives the greatest range of ignition pulses that are counted for each gear.

The third parameter is the delay between gear changes. Without this delay, the display could show the incorrect number since the engine RPM can vary widely when changing gears.

The initial setting for this is 0.2s which should be suitable for most cars. However, depending on the driver, the 0.1s setting may be better for cars with manual gearboxes. Conversely, a longer delay may be needed for cars with automatic transmissions.

You can set the delay to any value between 0.1s and 0.9s.

The fourth parameter is the timeout

Finally, cover the coil with a short length of heatshrink tubing and shrink it into place using a hot-air gun

The sealant should now be left to dry for about eight hours. A 100mm-long cable tie can be placed around the coil to secure the lead in place.

The alternative Hall sensor is assembled on a small PC board coded 551. Fig.7 shows the assembly details. Apart from the Hall sensor itself, there's just a single 100nF capacitor to be installed.

Note that the UGN3503 Hall sensor is mounted flat against the PC board with the label side up. The connecting lead to the main unit is run using twin-core shielded cable.

Installation

Be sure to use proper automotive cable and connectors when installing the unit into a vehicle. The +12V supply is derived via the ignition switch and the fusebox will provide a suitable connection point. Be sure to choose the fused side of the supply rail, so that the existing fuse is in series.

You should also be able to access the reversing switch connection at the fusebox. The ground connection can be made by connecting the lead to the chassis using a solder eyelet and self-tapping screw.

Fig.6 shows the mounting details for the speed sensor. **Note that the four magnets must all be installed with the same pole facing outwards** – ie, they must all have either their north pole facing outwards or their south pole facing outwards (it doesn't matter which).

This is done by attaching the magnets together in a stack. This will either give an N-S-N-S, etc stack or an S-N-S-N, etc stack. You then mark the outside face of the top magnet and remove it from the stack, then mark the next magnet and remove it and so on until all the magnets are separate. The magnets can then be attached to the driveshaft with the marked faces on the outside.

The magnets should be equally spaced around the driveshaft and can be affixed using builder's adhesive (eg, Liquid Nails, Grip Fill, etc). Covering the magnets with some neutral cure silicone sealant will protect them from damage due to stones and other debris thrown up by the wheels.

The pickup coil can be secured by bolting it to an L-shaped bracket which is then fastened to the chassis. Position it so that there is about a 10mm maximum gap between it and the magnets as they pass.

Alternatively, you can use a Hall sensor instead of the pickup coil, as shown in Fig.7.

The ignition coil input is connected directly to the switched (negative) side period. Normally, the ignition pulses are counted during a set number of speed pulses. However, if the vehicle is moving very slowly or is stopped, the speed pulses may not reach the count setting. Instead, the timeout stops the count and places a neutral (-) reading on the display.

The timeout parameter is initially set at 2.5s but can be set anywhere in the range from 0.5-4.5s, using numbers from 1-9. Its setting is a compromise between showing neutral only when stopped or at a very low speed (long timeout) and getting a fast neutral indication after coming to a stop (short timeout).

The next parameter is the reversing switch sense. Setting an odd number between 1 and 9 (1, 3, 5, 7 or 9) will cause the display to show reverse when the reverse input goes to +12V. Conversely, setting an even number (2, 4, 6 or 8) will cause reverse to show when the reverse input goes to 0V.

This selection is simply made so that the unit shows reverse ("r") when the reversing lights come on.

The final parameter is "clear", which clears all the gear calibration values. The gear ranges will then need to be recalibrated. This "clear" operation should be carried out if the unit is fitted into another vehicle.

of the ignition coil using a 250VAC rated cable.

Using computer signals

As mentioned earlier, instead of making you own speed sensor, you may be able to obtain the speed signal from the engine management computer. This signal is simply fed to the 1k resistor at the speed input.

If the car's speedometer stops operating after connecting the Gear Indicator, increase the 1k resistor on the speed input to 10k and remove the 10nF capacitor.

Similarly, you can use the low-voltage tachometer signal from the computer instead of ignition coil pulses if this is available. In fact, it will be necessary to do this if your car uses several double-ended coils to fire the spark plugs, rather than a single coil.

The low-voltage tachometer signal should be applied to the low input

Setting The Parameters

The various parameters are set by first pressing (and holding down) the Mode switch while the Gear Indicator is powered up. The display decimal point then lights to indicate that the unit is in the "setting mode".

The first parameter shown is an "S" which refers to the speed pulses. If the Mode switch is then released, the display will show the value stored (from 1-9) after 1s. Conversely, if the Mode switch is held down, the other parameter indicators will appear in succession, at a 1s rate.

The parameter values are altered by pressing the Number switch. Each press increments the number by one, while holding the Number button down causes the value to automatically increase at a 1s rate – ie, the numbers cycle from 1-9 and then back to 1 again. When the required value is selected, you simply release the Number switch and press the Store switch to store the value in memory.

Once the "S" (speed) parameter has been set, the other parameters are selected and set in turn. These are "H" (hysteresis; "d" (delay); "-" (timeout) and "r" (reverse). These are all modified and stored exactly as before.

Note that no changes are stored until the Store switch is pressed. This enables you to cycle through the parameters to check their values without making any changes.

The last parameter to be selected simply shows a "C" on the display, without any value. Pressing Store will clear all the gear settings.

Finally, you exit from the Parameter Mode, by switching off and then reapplying power. The display will then show a "-" (ie, the neutral gear indication) and the decimal point will be off.

Gear Calibration

Pressing the Mode switch after the unit has powered up places the unit into the "Calibrate Mode". The decimal point will light to indicate this mode and the number shown initially will be a "1" (ie, 1st gear).

To calibrate the unit, just follow these step-by-step instructions:

(1) Drive the vehicle at light throttle with 1st gear selected (for automatics, you have to select 1st gear rather than Drive). After a few seconds, press the Store button and the calibration for 1st gear is saved.

Note that it may be necessary to drive relatively fast in 1st gear to ensure that the speed pulses are counted within the timeout period. Also, with an automatic, be sure to drive along a flat section of road without accelerating to eliminate torque converter slip.

(2) Next, press the Number button so that the unit shows a "2" (ie, 2nd gear). Now drive at light throttle in 2nd gear for a few seconds and press the Store switch to calibrate the 2nd gear.

Note that it is not necessary to drive at a fast speed in this gear to achieve calibration. If the car is an automatic, be sure to select 2nd gear and drive fast enough to ensure that the car is in this gear (ie, not 1st).

The remaining gears are calibrated in exactly the same manner.

(3) Once you have calibrated all the gears, press the Mode switch again and the decimal point will extinguish. The unit will now revert to the "Gear Indicator" mode.

If you make a mistake during calibration, or if the unit is to be used in a different vehicle, the data should be cleared using the "C" parameter before re-calibrating the unit.

Note too that if you subsequently change the speed pulses parameter after calibration, the gears will need to be recalibrated. Also, if you don't obtain a successful 1st gear calibration, this gear can be recalibrated after extending the timeout delay. In that case, the Store button should be pressed after about 10 seconds to ensure a suitable count for the ignition pulses.

Note that some automatics start in 2nd gear rather than 1st when light throttle settings are used.

Fig.8: this full-size artwork can be used as a drilling template for the front panel. You will need to make cutouts for the LDR and the 7-segment LED display.

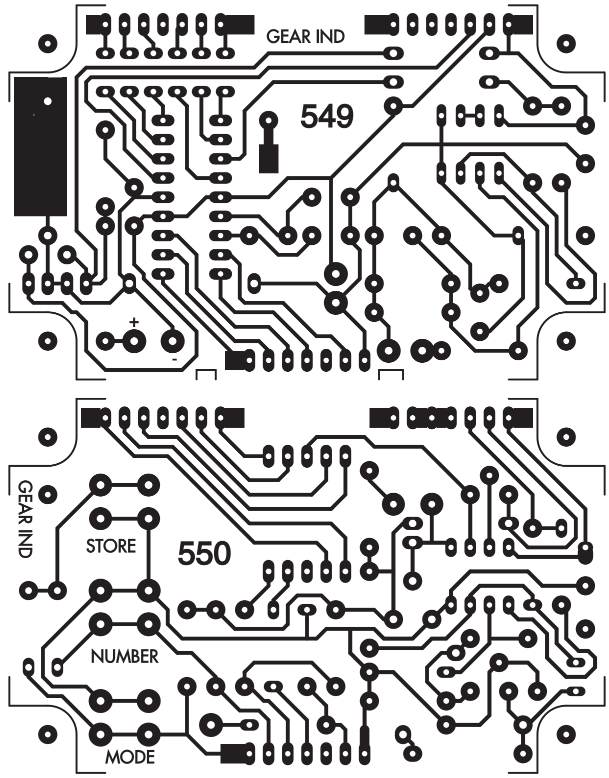
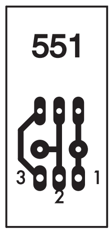
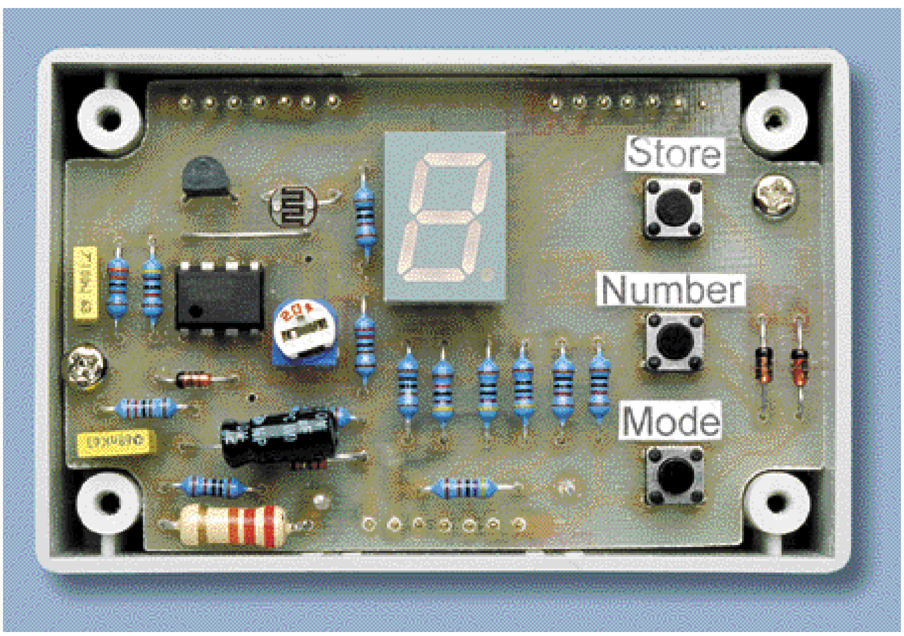


Fig.9 (right): check your etched PC boards against these full-size patterns before installing any of the parts. The smallest board (ie, 551) is for the optional Hall speed sensor.





The corners of the two PC boards must be cut away to clear the mounting pillars inside the case. This should be done before any parts are installed.

terminal on the Gear Indicator (not to the ignition coil terminal).

On-road testing

Once fitted to the vehicle, the various parameters can be set and the unit calibrated as described in the accompanying panels.

The speed pulses setting for the parameters can be made a larger value as described earlier. This will give more ignition pulses to be counted and give a better resolution for the differences in counts for each gear ratio.

The larger value will also provide less tendency to show a lower gear due to clutch or torque converter slippage.

The compromise is that the time required to count the pulses will be longer and the display will have a tendency to show the neutral (-) indication at a higher speed compared to using a smaller speed pulses number. This is because the timeout period will occur before the pulses are counted at slower speeds.

Gear change response will also be slower with a higher speed pulse count number.

In general, use 16 or more speed pulses if you use four magnets on the tailshaft and use 12 or less if you use magnets on the wheel shaft. Use of the speedometer sensor signal should require 28 or more speed pulses but this may need to be smaller if the response at slow speeds is too long, causing neutral indication at not so slow speeds.

Note also that using magnets and a coil pickup will not provide gear indication at very slow speeds since the output from the sensor will be too low to register. The Hall effect pickup will be much better at slow speeds and will provide gear indication down to where the speed pulse count takes longer than the timeout. ***EPE***

AN XMAX TALE

No, not a seasonal misprint but an interesting story of a datacomms technology that appears to defy the laws of science. Sounding as credible as Father Christmas, it's probably just an agreeable myth. But who knows? Mark Nelson assesses the claims.

THE value of investments, and the income from them, can fall as well as rise, and you may not get back the full amount you invest. This familiar and sober government wealth warning will ring true to everyone who remembers the trumped-up claims made for many high-tech investment "opportunities" during the dot-com boom of around five years ago.

Although the hype of that era has evaporated to a large extent since then, every now and then something crops up to astound even seasoned observers (OK, *cynics*) like yours truly. And one of them is xMax.

Let's first look at xMax and the claims made for it, then take a reality check and see how it might make out. The experimental technology – and it certainly is still experimental – is a wireless broadband system, in essence no different from the wireless local area networks (WLANs) that provide localised "hotspots" at airports, stations and motorway service areas. Small hotspots are not what it's designed for, however, since xMax aims to provide wide area service to whole neighbourhoods.

No New Wires

Fundamentally, it's a "no new wires" system. Being wireless, or more accurately, *wire-free* it does not use phone lines nor does it force you to subscribe to cable service. Telephone exchanges don't require upgrading nor does it involve remodelling electric supply mains to carry data signals. It works by radio waves.

That's not new in itself. The UK has seen several wireless broadband systems already, most of which have "risen without trace" and then collapsed with even less attention. Remember Tele2 or Atlantic Telecom? No? I think I've made my point then.

What marks out xMax as something different, however, are the modulation method and the extremely low power of the radio waves used. Press reports describe a "new low power wireless revolution", and speak ecstatically of a technology "a thousand times more efficient than WiMAX" that can deliver a 3·7Mbit/s data stream 18 miles using just 50 milliwatts of radio frequency power at 900MHz.

Even more intriguingly, the system is based on a 50-cent integrated circuit and can operate on several different frequencies simultaneously. The promoters, a startup wireless company called xG Technology in Florida, refuse to release any more information until their patent is granted and have so far allowed observers to see only a black box.

Single Cycle

Quoted in *The Guardian*, the system's inventor, Joe Bobier, declares: "While other modulation schemes take a thousand cycles to send one bit, we can send a bit in a single cycle." How this is achieved is not revealed and the website (**www.xgtechnology.com**) says that xMax is "a novel modulation and encoding technology that boosts the range and power efficiency of all wired and wireless communications. It is not a compression technique, but rather a synergistic mix of two well-established communication approaches that dramatically improves spectrum utilization."

If so, it's doubtful if the system can be patented and if a patent is issued, rival companies will be rushing to examine it for "prior art" that they can exploit to bust the patent. In fact it is well known that publishing a patent is the best way to lose competitive advantage; far better to bring your novelty to market and leave your competitors struggling while they attempt to catch up.

Weasel Words

The company states that xMax can be designed to operate at any frequency and it is suitable for use on licensed and unlicensed spectrum. These weasel words may entice investors but will not fool readers like you. Unlicensed spectrum is of course unlicensable because it "belongs" to other users. There are of course some licence-free parts of the spectrum but these are already "getting mighty crowded".

"By combining elements of traditional narrowband systems with key elements found in wideband systems," the blurb continues, "xMax delivers broadband data rates orders of magnitude farther than other technologies operating at the same frequency and power level. Conversely, xMax achieves equal range with far less power, thereby improving battery life."

This tells us very little but the reports of the demonstration to journalists speak more loudly. The test transmissions were made from the top of an 850ft tower across flat territory using 50mW to a gain antenna at 915MHz across an 18-mile path.

So what? Frankly there's nothing special about that. I used to work Northampton to Malvern (a 90-mile path) on the old 934MHz personal radio band with not much more power than that, using narrowband FM modulation and a 1980s technology radio. The only reason it worked was the line-of-sight path and the same applies to xMax. Try their same experiment in downtown Chicago and I doubt if they would get 18 yards, let alone 18 miles!

Perhaps I'm overstating my case, but there's nothing intrinsically special about that demonstration. In any case, wireless works much better (goes much further) at 900MHz than the microwave bands that xMax would be allowed to use in most parts of the world. It's an accident of history that the USA has the 902-928MHz frequency band allocated as a free-for-all ISM (industrial, scientific and medical) radio band, but this is not the case in most territories.

Flash in the Pan?

So how does it work? The website states that at the heart of the xMax solution is xG's Flash Signal technology, using single-cycle waveforms to transmit information at a minimum effective rate of 1Mbit/s for each megahertz of spectrum utilized in the information-bearing channels. This means even traditionally weak signals are usable, claims the inventor. "Moreover, because the receiver includes a passive wavelet path filter that acknowledges only single-cycle waveforms, all other RF signals are ignored."

There's much more verbiage in this vein, all sounding highly technical but without a scintilla of plain "brass tacks" or block diagrams. Pardon my scepticism but as a pretty good hot air merchant, I can smell the aroma of bull with great acuity.

The company also thinks it can brush aside existing radio regulations too; it says that new entrants can use xMax to break into the wireless broadband market community by re-using existing sub-gigahertz spectrum. Pardon me but existing users will not take kindly to sharing their hard-earned allocations like this, nor will regulatory bodies coalesce willingly. Protagonists of ultra-wideband (UWB) thought they could march in and claim this territory – and have failed.

Season of Goodwill

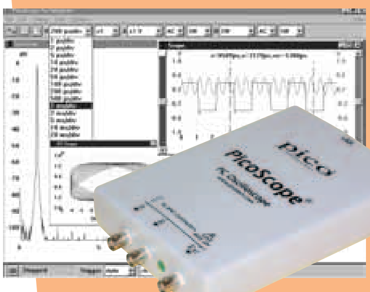
It's possible to go on picking holes in this drivel, but it's just too easy. You doubtless get the message, and in any case this is supposed to be the season of goodwill. Suffice to say that the broadband marketplace is already pretty crowded and with rates starting to tumble in an inevitable price war to come, who on earth would want to get embroiled in a massive investment to upstage some very well-entrenched players?

We can be sure that 2006 will bring some fascinating developments, but if xMax is one of them, look out for a fulsome apology from me in twelve months' time!

Ingenuity Unlimited

WIN A PICO PC BASED OSCILLOSCOPE WORTH £586

- 5GS/s Dual Channel Storage Oscilloscope
- 50MHz Spectrum Analyser
- Multimeter
- Frequency Meter
- USB Interface.



If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC-based oscilloscope could be yours. Every 12 months, Pico Technology will be awarding a PicoScope 3205 digital storage oscilloscope for the best IU submission. In addition a DrDAQ Data Logger/Scope worth £59 will be presented to the runner up.

Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas *must be the reader's own work* and **must not have been published or submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and include a full circuit diagram showing all component values. **Please draw all circuit schematics as clearly as possible.** Send your circuit ideas to: *Ingenuity Unlimited,* Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. (We **do not** accept submissions for IU via email). Your ideas could earn you some cash **and a prize!**

Simple FM Radio – *Euro Set*

WHILE innumerable circuits for simple medium or shortwave radios have been published over the years, the author has never come across anything similar for the f.m. band. So this is an attempt to fill the apparent gap. It was developed as part of a school project.

The full circuit diagram for the Simple FM Radio is shown in Fig.1. It consists of a regenerative r.f. stage, TR1, followed by a two or three-stage audio amplifier, TR2 to TR4. In some areas three stages of a.f. amplification may not be necessary, in which case transistor TR3 and its associated components can be omitted and the free end of capacitor C5 connected to the collector (c) of transistor TR2.

The critical part of the circuit is the first stage, TR1/VC1, where the wiring must be kept as short as possible. Coil L1 is formed by winding 8 turns of 1mm (20s.w.g.) enamelled copper wire on a 6mm diameter former, which is then removed. After that coil L1 should be stretched carefully and evenly to a length of about 13mm, which is a good starting point for later adjustment.

The tuning capacitor VC1 is one of the two f.m. sections of a miniature "transistor radio" type, with built-in trimmers (VC2). The "earthy" end (moving vanes and spindle) is connected to the 22p capacitor C1. The value of the r.f. choke L2 is not critical, anything from 1μH to 10μH being suitable.

The output is suitable for ordinary Walkman-type earphones connected in series, i.e. using the tip and ring connections on the plug to provide an impedance of 64 ohms. Several equivalents of transistor TR1 worked equally well in this circuit.

Tuning-In

To operate the receiver, potentiometer VR1 must first be advanced slowly (towards the end of the track connected to battery positive – see Fig.1) until, at about the half-way point, a sudden slight increase in background noise will be heard, indicating the onset of oscillation. It should then be backed off, very slowly, until oscillation just stops; it should then be possible to tune in some stations. The correct frequency range of 87MHz to 108MHz can be obtained by adjusting trimmer VC2 at the high frequency (h.f.) end of the band (108MHz) and slightly stretching or squeezing together the turns of coil L1 at the other end (87MHz).

The radio has been "field" tested at various locations in three different countries including England and has always brought in several stations at good volume.

Francis Hall, Meinerzhagen, Germany

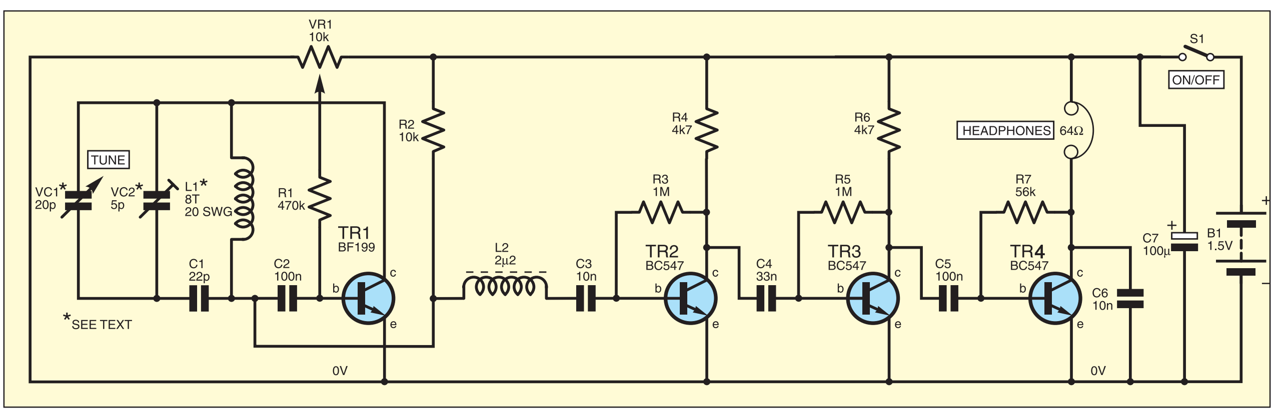
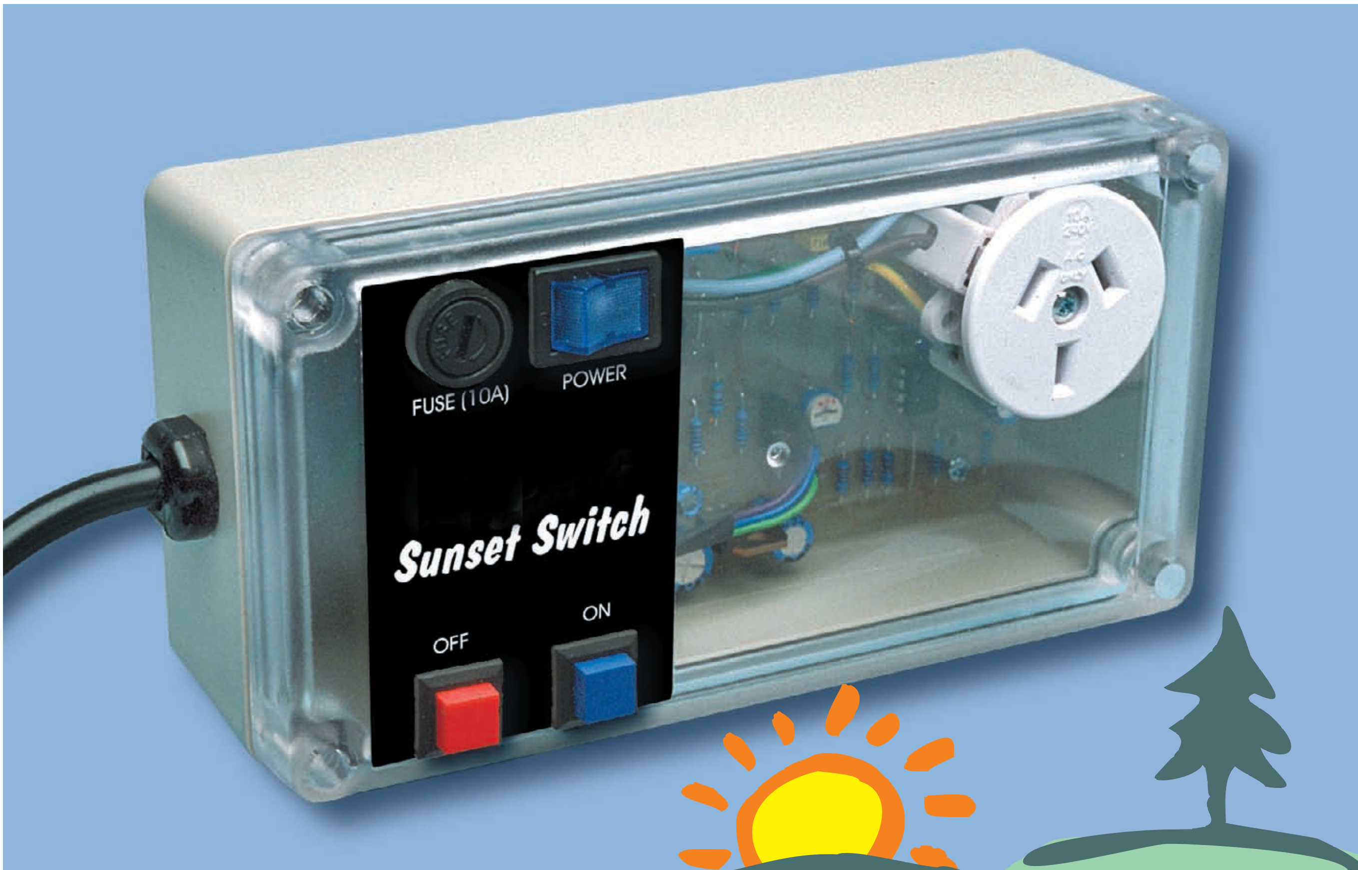


Fig.1. Complete circuit diagram for the simple FM Radio



Sunset Switch

Want to switch on an appliance at dusk and off again after a few hours or at dawn? This sunset switch can do this automatically for you. It is ideal for security and garden lighting.

By JOHN CLARKE

Main Features

- Switches on mains power at preset darkness level
- Optional timeout
- Four timeout selections
- Manual on and off switching
- 6A mains switching

PATHWAY LIGHTS, entrance foyer lighting, house numbers and outside security lights all need to be lit at the onset of darkness; ie, sunset. Of course you can switch these lights on manually each day when darkness falls and switch them off in the morning but it is too easy to forget. The result is that lights are often left on all day and that can waste a lot of electricity.

What you need is a sunset switch – a fully automatic switch which turns on at dusk and off at sunrise. You probably also want a timer that switches the power off after a few hours (selectable). And we'll throw in manual ON and OFF switching so that you can override the system.

So that's what we've done. The Sunset Switch has all of the above features and can switch up to 6A at 240VAC. This gives a total load of 1440W of lights or whatever. The unit is housed in a rugged plastic case with a clear lid which allows the ambient light to be detected by the internal light dependent resistor. There is also an LED inside the box to indicate whenever power is applied.

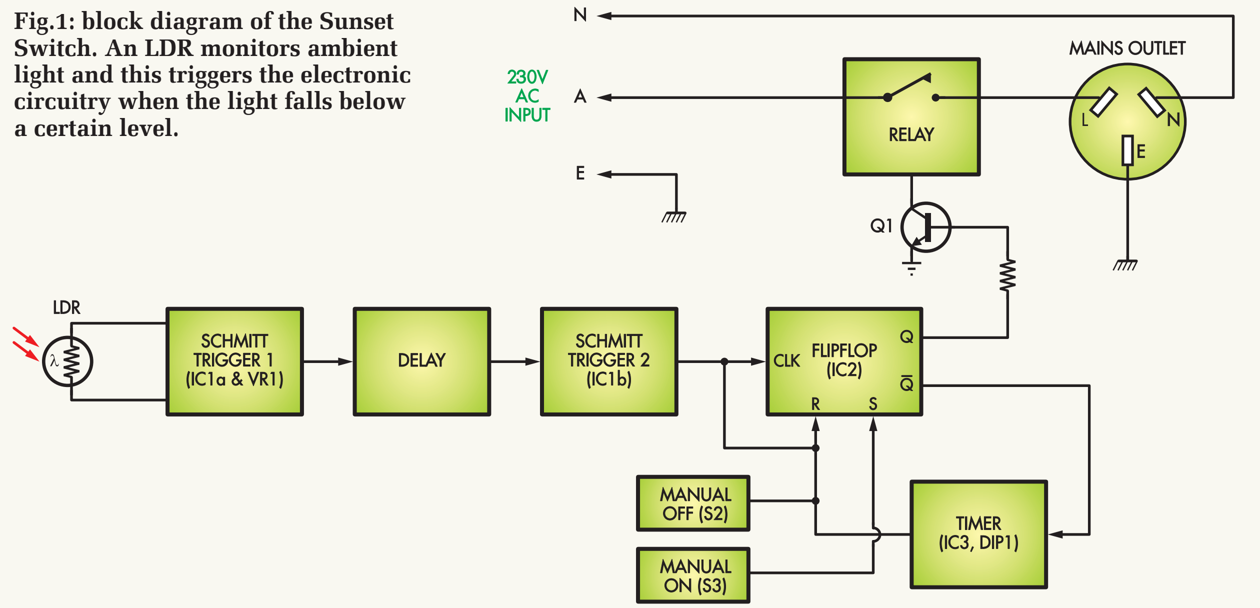


Fig.1: block diagram of the Sunset Switch. An LDR monitors ambient light and this triggers the electronic circuitry when the light falls below a certain level.

Fig.1 is a block diagram showing the operation of the Sunset Switch. An LDR monitors ambient light and when the light drops below a certain threshold, the following Schmitt trigger changes its output level and this is sent through a delay. It takes a few seconds before the second Schmitt trigger changes its output level. This delay prevents momentary changes in light level from causing the circuit to trigger.

The second Schmitt trigger clocks a flipflop and its output drives a transistor (Q1) and the relay. The relay switches power to the mains outlet. At the same time, the flipflop starts the timer and after the selected time (set via the DIP1 switches) it resets the flipflop and the relay is switched off. If the switches are left open, the flipflop will be reset when the LDR receives sufficient light to trip the Schmitt trigger outputs again and reset the flipflop.

Under manual control, the flipflop is set (ON) with switch S3 to turn on the relay and reset (OFF) with switch S2.

Circuit details

Fig.2 shows the full circuit of the Sunset Switch. There are just three ICs and a 3-terminal regulator.

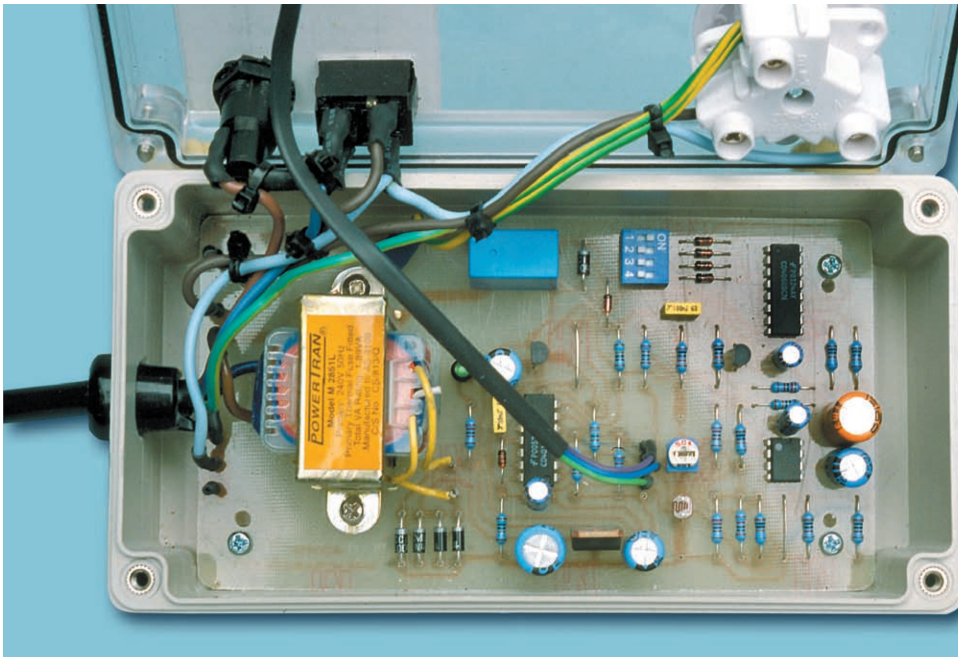
IC1 is an LM393 dual comparator and both comparators are connected as Schmitt triggers IC1a monitors the LDR voltage at its inverting input, pin 2. The resistance of the LDR when exposed to daylight is around 10kΩ, so the voltage at pin 2 of IC1a in daylight is normally below 1V. This is lower than the voltage at pin 3 so the output of IC1a will be high.

In darkness, the resistance of the LDR rises and so the voltage at pin 2 rises above that at pin 3 and the output of IC1a goes low. The 100kΩ resistor between pins 1 & 3 of IC1a provides about 200mV hysteresis which prevents the output from erratically switching low and high as the light level changes.

Trimpot VR1 sets the light threshold for the Sunset Switch. You can set it from twilight to quite dark.

The output from IC1a is fed via an RC delay network consisting of a 100kΩ resistor and 100µF capacitor. This delays the triggering of the following Schmitt trigger, IC1b, by a few seconds. This prevents false triggering due to sudden changes in light level.

Low light levels result in IC1b's output going high and this triggers the clock input of the D-type flipflop IC2 at pin 3. This causes the Q output at pin



This is the view inside the completed unit. Be sure to use mains-rated cable for all 240V AC wiring to the fuse, power switch & mains socket.

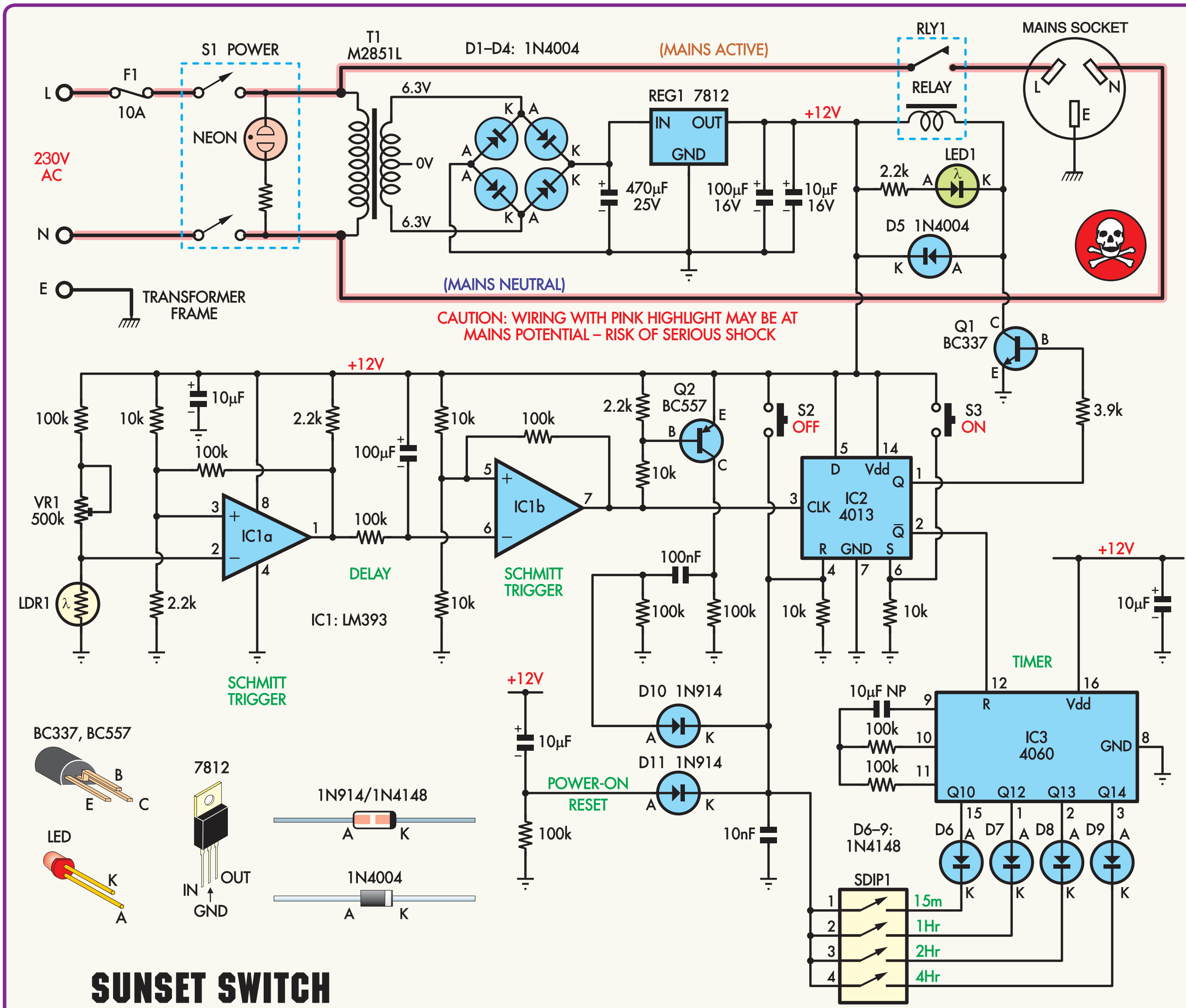


Fig.2: the complete circuit of the Sunset Switch. IC1a & IC1b function as Schmitt triggers, while flipflop IC2 drives the relay (via Q1) and resets timer IC3 (a 4060 counter). VR1 sets the light threshold at which triggering occurs.

1 to go high. This turns on transistor Q1 which powers relay RLY1. LED1 lights to indicate whenever the relay is switched on.

At the same time as pin 1 of IC2 goes high, the complementary output at pin 2 goes low and this releases the reset on counter IC3. IC3 includes a free-running oscillator at 1.2Hz, as set by the components at pins 9, 10 and 11. As a result, the outputs at Q10, Q12, Q13 and Q14 go high after 15 minutes, 1 hour, 2 hours and 4 hours, respectively. If one of the DIP switches is closed, the selected output will reset flipflop IC2. This causes the relay to switch off.

Should all the DIP switches be open, flipflop IC2 will not be reset by the timer; ie, the timer has no control. In this case, the only way the flipflop can be reset is if the Off switch, S2, is pressed or the ambient light on the LDR increases and causes IC1a and IC1b to respond accordingly; ie, IC1b's output goes low and transistor Q2 turns on. This resets the flipflop via the 100nF capacitor and diode D10.

Manual switch-on is via switch S3 which sets the flipflop so that pin 1 is high and pin 2 is low.

Power for the circuit comes from a mains transformer with a centre-tapped 12.6V winding. This feeds a bridge rectifier consisting of diodes D1-D4 and the rectified output is filtered with a 470μF capacitor. The 3-terminal regulator, REG1, provides the required 12V for the relay and ICs.

IC2 is reset at switch-on via D11 and the associated 10μF capacitor.

Construction

The Sunset Switch is built on a PC board coded 547 (138 × 76mm). This is housed in a ***plastic case*** measuring 165 × 85 × 55mm which has the control switches and mains socket mounted on the transparent lid. **Note that, to ensure safety, you should use the specified plastic case for this project. Note also that everything must be contained inside the case – there must be no metal screws or other metal parts passing through from inside the case to the outside (or vice versa).**

The wiring layout and component overlay for the PC board is shown

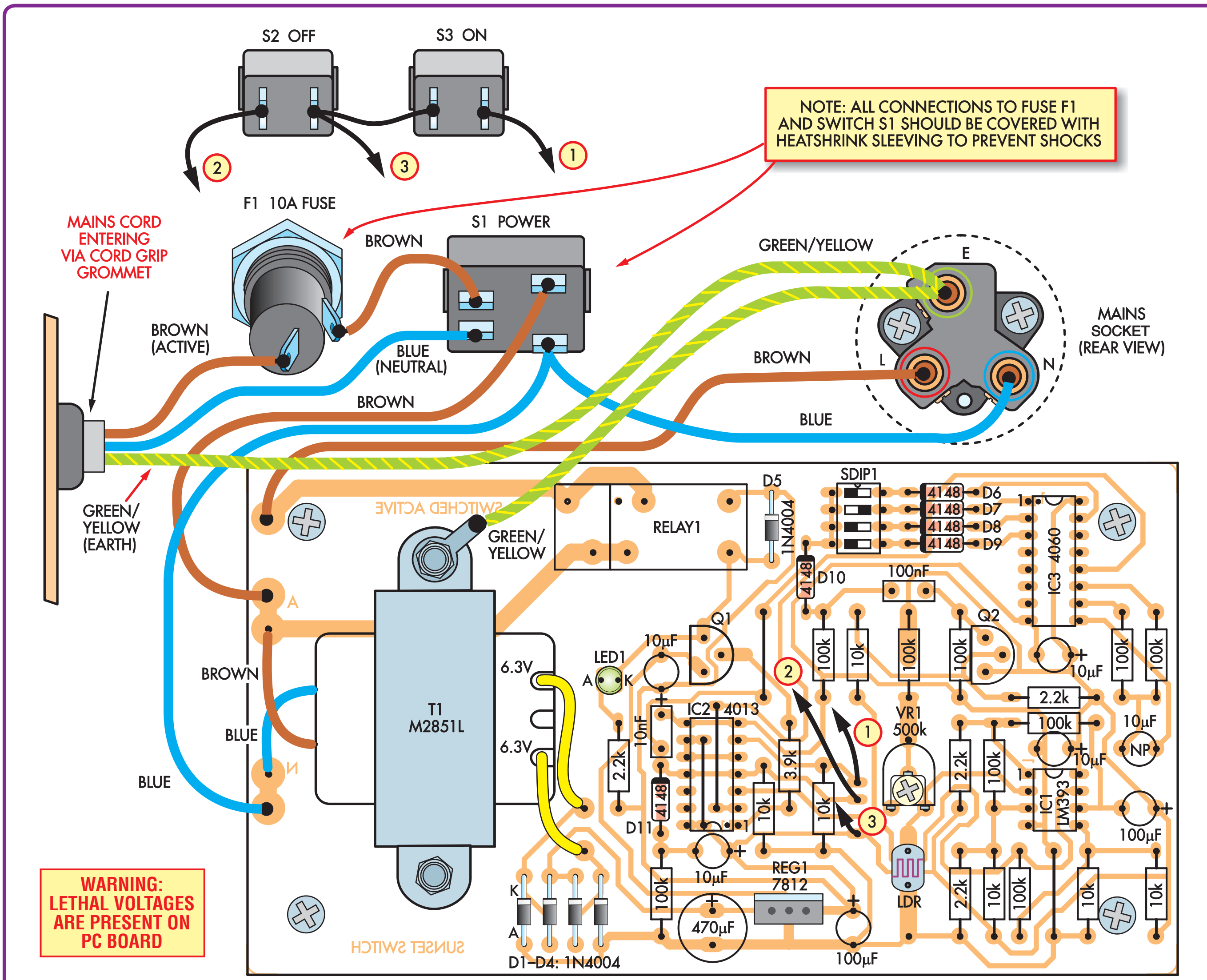


Fig.3: install the parts on the PC board and complete the wiring as shown here. Exercise extreme care when installing the mains wiring and make sure that all exposed mains terminals are sleeved with heatshrink tubing to avoid accidental contact with the mains voltages.

in Fig.3. You can begin construction by checking the PC board against the published pattern (see Fig.6). Check for any shorts or breaks in the tracks and fix any faults as necessary.

Start assembly by inserting PC stakes at all the external wiring points on the PC board (8 required), then insert the links and the resistors.

Next, you can install the ICs, taking care with their orientation. The DIP switch and trimpot VR1 can also now be inserted and soldered in place.

When installing the diodes, transistors and 3-terminal regulator, take care with their orientation and be sure that the correct transistor is in each position. The electrolytic capacitors must be oriented with the polarity as shown with the exception of the 10µF bipolar (NP or BP) type which can be mounted either way around.

Table 2: Capacitor

Value	IEC Code	EIA Code
100nF (0.1µF)	104	100n
10nF (.01µF)	103	10n

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	9	100kΩ	brown black yellow brown	brown black black orange brown
❏	6	10kΩ	brown black orange brown	brown black black red brown
❏	1	3.9kΩ	orange white red brown	orange white black brown brown
❏	4	2.2kΩ	red red red brown	red red black brown brown

Parts List

1 PC board, code 547, 138 x 76mm, available from the *EPE PCB Service*
1 sealed enclosure with clear lid, 165 x 85 x 55mm
1 mounting foot pack (4)
1 12V relay with 10A 250VAC contacts (RLY1)
1 chassis-mount mains socket
1 12.6V 150mA mains transformer with thermal fuse (T1)
1 M205 mains safety panel-mount fuseholder
1 M205 10A fast-blow fuse (F1)
1 DPDT 6A mains rocker switch with neon (S1)
1 LDR dark resistance 1MΩ light resistance 5kΩ
1 4-way DIP switch (SDIP1)
6 100mm long cable ties
1 500kΩ horizontal trimpot (VR1)
1 3mm crimp eyelets
1 red momentary 250VAC pushbutton switch; (S2)
1 black or blue momentary 250VAC pushbutton switch (S3)
1 7.5A mains cord and moulded plug
1 cordgrip grommet to suit mains cord
1 150mm length of 4.8mm heatshrink tubing
1 250mm length of 3.2mm heatshrink tubing
1 150mm length of blue 7.5A mains wire
1 150mm length of brown 7.5A mains wire
1 150mm length of green/yellow 7.5A mains wire
1 200mm length of 3-way rainbow cable
1 100mm length of 0.8mm tinned copper wire
1 M3 x 6mm screw
1 M3 x 15mm screw
3 M3 nuts
2 M3 star washer
10 PC stakes

Semiconductors
1 LM393 dual comparator (IC1)
1 4013 dual D flipflop (IC2)
1 4060 counter (IC3)
1 BC337 NPN transistor (Q1)
1 BC557 PNP transistor (Q2)
1 7812 1A 12V regulator (REG1)
5 1N4004 1A diodes (D1-D5)
6 1N4148, 1N914 diodes (D6-D11)
1 3mm green LED (LED1)

Capacitors
1 470µF 25V PC electrolytic
2 100µF 16V PC electrolytic
4 10µF 16V PC electrolytic
1 10µF bipolar electrolytic
1 100nF MKT polyester
1 10nF MKT polyester

Resistors (0.25W, 1%)

9 100kΩ	1 3.9kΩ
6 10kΩ	4 2.2kΩ

The LDR can be mounted with its body about 5mm above the PC board. The LED and relay is mounted next.

Drilling the case

Drill out and shape the hole in the end of the case for the cordgrip grommet. When fitted, the cordgrip grommet must be such a fit that it will continue to hold the mains cord in place even if the cord is pulled with considerable force.

Mark out and drill the front panel for the mains outlet, switches and fuseholder. Then mount the mains socket, switches and fuseholder.

The incoming earth lead (green/yellow) goes direct to the mains socket as shown in Fig.3. A second (mains-rated) earth lead is then run from the mains socket and is either soldered or crimped to a solder lug attached to one of the transformer mounting screws.

Fig.4 shows the mounting details for this solder lug. It is secured using an M3 x 15mm metal screw, two nuts and a star washer. Make sure the transformer case is indeed earthed; ie, check for a short circuit between earth and the transformer mounting.

In some cases, it may be necessary to scrape away the lacquer coating on the transformer mounting foot to allow a good contact. Secure the other side of the transformer to the PC board using an M3 × 10mm screw and nut.

Next, secure the PC board to the integral spacers inside the case using the small self-tapping screws supplied. That done, run the remaining connections to the fuseholder, mains switch and mains socket as shown and use heatshrink tubing over the terminals. Tie the wires with cable ties to prevent them breaking and coming loose from their terminations. **Note that the fuseholder must be a mains safety type.**

If your plastic case doesn't have matching integral standoffs, then you can secure the PC board USING NYLON SPACERS AND NYLON SCREWS. Do not, under any circumstances, use metal spacers and screws to secure the board – we repeat, there must be no exposed metal screws on the outside of the case.

Switches S2 and S3 are wired using 3-way rainbow cable **which is sheathed in heatshrink tubing. This prevents the wires from accidentally making contact with any mains terminals.**

WARNING

This circuit is connected to the 230VAC mains supply and LETHAL VOLTAGES are present on the PC board.

Do not operate the unit unless it is fully enclosed in a plastic case and DO NOT TOUCH ANY PART OF THE CIRCUIT when it is plugged into a mains outlet. Always remove the plug from the mains before working on the circuit or making any adjustments.

Finally, do not build this project unless you are completely familiar with mains wiring practices and techniques.

Setting up

Before going any further, refer to the warning panel at the left. Set all DIP switches off, plug a test lamp into the mains socket and apply power. Cover

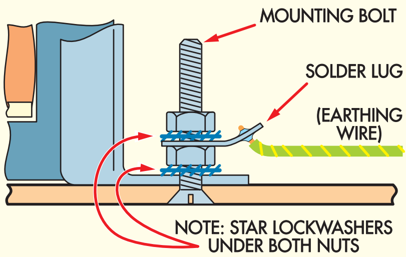
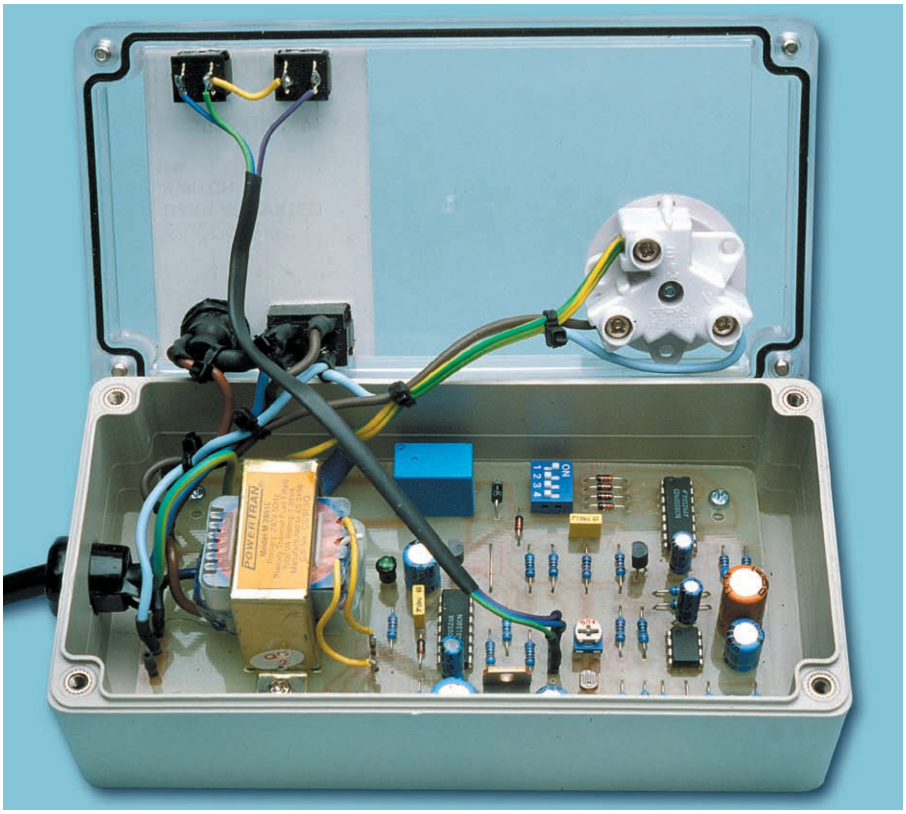


Fig.4: the mounting details for the earth solder lug attached to the transformer.

MAINS SOCKET

Please note that the photos in this article show an Australian style mains socket. This should be replaced with an approved panel mounting socket suitably rated for the country of use; ie in the UK a 13A panel mounting mains socket or an IEC chassis socket.

Reproduced by arrangement with SILICON CHIP magazine 2006.
www.siliconchip.com.au



A length of heatshrink tubing should be used to sleeve the wiring to switches S2 & S3 (see text). Secure all mains wiring using cable ties.

the unit and the light should come on immediately. Uncovering the unit should turn the light off.

Trimpot VR1 is best adjusted by trial and error. **Switch off power and remove the mains plug.** To set the unit to trigger at a darker light level, turn VR1 anticlockwise. To have it switch on at a brighter level, turn VR1 clockwise.

Also test the operation of the Off and On switches. Then check DIP switch S1. Set it to on, plug in the test lamp, apply power and cover the unit. The test lamp should stay on for about 15 minutes. If this is the case, then you can expect S2 to switch the lamp on for one hour, S3 for two hours and S4 for four hours.

By the way, if you have more than one DIP switch on, say, S2 and S3, it will give the low setting (15 minutes), not the sum of the two. If you want longer times, swap the two 100kΩ resistors at pins 10 and 11 of IC3 for larger values. Two 220kΩ resistors should about double these times.

Installation

The Sunset Switch should be installed where it receives outside light but must not be exposed to the weather. It should also be shielded from the lights that it controls, otherwise it may get into a "race" condition whereby it switches on and off continuously.

Do not drill inside the case to mount it on a wall. Instead, use mounting feet and self-tapping screws into the special screw holes provided on the underside of the case. ***EPE***

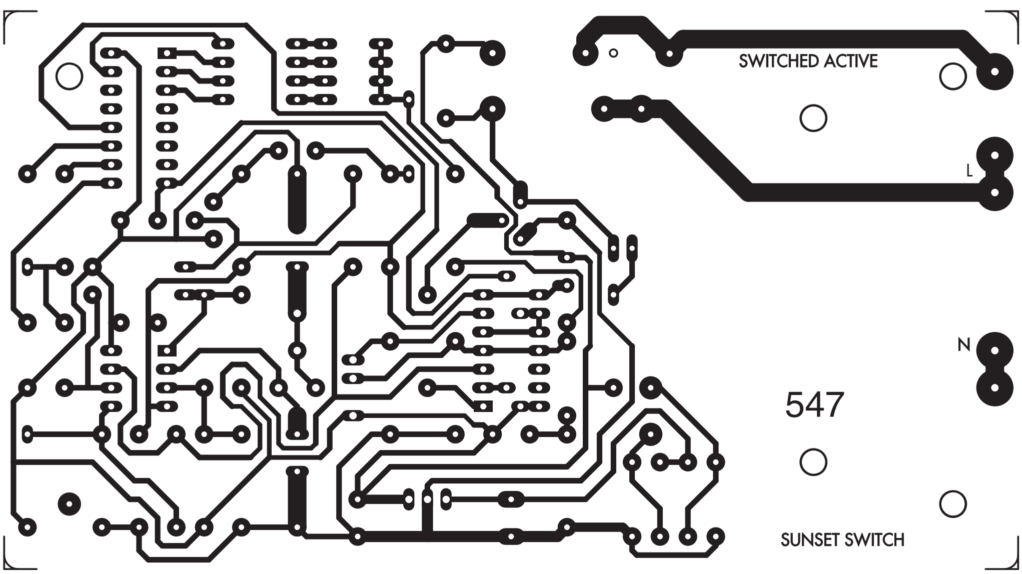


Fig.6: this is the full-size etching pattern for the PC board. Check your board carefully against this pattern before installing any of the parts.

PIC N' MIX

MIKE HIBBETT

Our periodic column for your PIC programming enlightenment

Using SPI Bus Devices

MICROCONTROLLERS, especially PICs, come pre-equipped with many useful peripherals such as serial ports, analogue-to-digital converters, non-volatile memory and more. When specifying a project, however, one often needs to add more, for example, larger non-volatile memory, or an interface to other sensors or controllers.

Interface Standards

Decades ago microcontroller manufacturers recognised this fact and came up with a number of simple interfaces in an attempt to standardise the way in which microcontrollers communicate with other complex integrated circuits. Three interfaces came to dominate the market; the Inter Integrated Circuit (I^{2}C) bus from Philips, the Serial Peripheral Interface (SPI) from Motorola and (to a much lesser extent) Microwire from National Semiconductor.

While other standards such as CAN bus exist today for linking circuits together, these three standards have dominated the market for connecting individual components together.

Philips and Motorola have aggressively marketed their standards over the years to the extent that either or sometimes even both interfaces are the *de facto* method for connecting a peripheral device to a microcontroller. Microcontroller manufacturers, from Microchip up to Motorola, provide direct support for both standards through highly configurable on-chip peripheral interfaces.

Devices such as low density EEPROM are supplied by many manufacturers to both standards; The 24 series of devices are I^{2}C, and the 25 series are SPI. However, at around 256K bit densities and above, SPI parts are hard to find. Then when you look at large density serial flash memory, SPI is the dominant standard. Clearly, if you are going to interface external ICs to your microcontroller projects then you are going to want to have both SPI and I^{2}C in your design toolbox.

There are also some very interesting devices that come equipped with an SPI interface. Microchip, for example, are coming out with a 28-pin Ethernet controller, with just an SPI interface to the micro. Maybe now is the time to get interested in this simple protocol.

Twin Standards

So why do two standards still prevail? It's because they actually support two different system design approaches. I^{2}C bus uses an addressing scheme embedded in the data transmission to select the device it wants to talk to. SPI relies on a unique chip select signal per device, so there is only one device active at any one time.

I^{2}C is also a much more complex protocol and provides support for multiple masters driving the bus. This means that I^{2}C is more complex to implement on-chip, but requires fewer connections when large numbers of devices are being accessed.

In an embedded system where you have only a few external devices to talk to, SPI can be a better solution because the protocol is simpler, and in most cases the transfer speeds are much higher.

There have been many articles published by *EPE* that used I^{2}C interfaces over the years, and few using SPI. So for this article we will concentrate on the SPI bus, and look in particular at interfacing to two memory devices; the 25C256 32K byte EEPROM, and the 25P32 4M byte flash device. Both devices use the SPI bus but operate differently.

SPI Benefits

So why would you want to move over to SPI? What are the benefits?

Let's take an example. *EPE* recently published the author's *Speed Camera Watch Mk2* (Nov '05), where we described how this was ten times faster than the original design (Jan '05). Half of this performance increase was attributed to improvements in the processor, but the other half was directly as a result of changing from I^{2}C to SPI based serial EEPROM for the memory.

The SPI bus is just so much quicker than I^{2}C. Although the write cycle times of the devices used were the same, the main limiting factor in the design was how quickly the processor could read from memory. In an I^{2}C device the data transfer rate is 100kHz, while in an SPI it is 10MHz. Clearly SPI based memory was the right technology for this design.

SPI Signals

Physically, the SPI interface consists of three main signals:

- SI Serial Data (into the device)
- SO Serial Data (out of the device)
- SCK Clock Signal (latches data into or out of the device)

As you may have guessed, data bytes are transferred serially, that is bit by bit with the most significant bit being sent or received first.

All SPI enabled devices have an additional chip select input, called CS, that is used to enable the device (low level) or disable it (high level). Don't forget that there is no device addressing within the SPI protocol itself, you must explicitly enable one and only one device at a time prior to communicating with it.

SPI enabled memory devices typically include two additional inputs:

- WP Write Protect – writes to the device will be ignored
- HOLD Pause data transmission

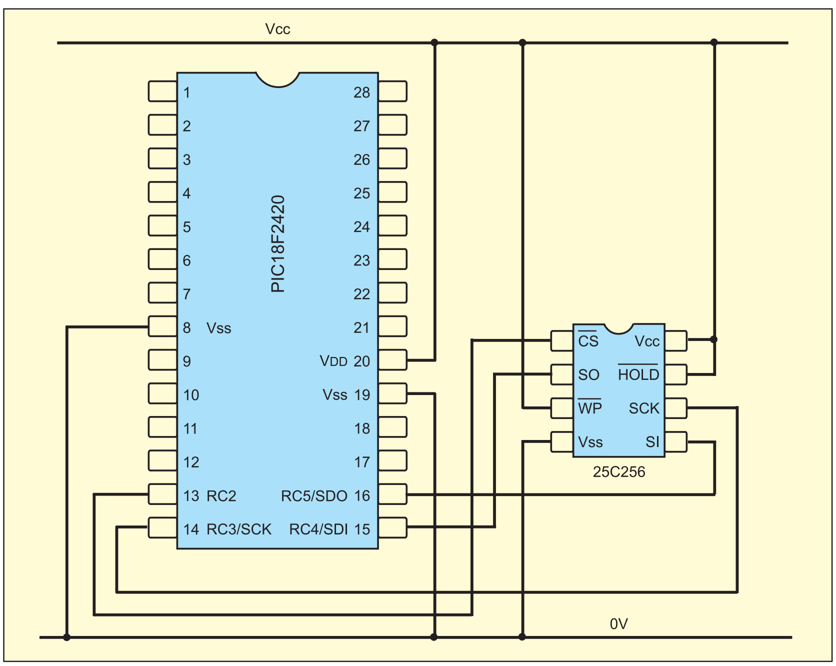


Fig.1. Interfacing a PIC 18F2420 to a 25C256 SPI Device

HOLD may be hard wired high to disable the feature. The author has yet to discover a use for it! WP can also be hard wired high to disabled it too, since most designs will want the device to be programmable. WP is sometimes used to reduce the likelihood of accidental data changes, especially during power up and power down situations. In most hobby (and many commercial) applications such use is an over-kill and is normally handled by careful software design.

Example Connections

Typical connection requirements to a PIC microcontroller are shown in Fig.2. As you can see, it's even simpler than for the I²C interface as there are no pull-up resistors required. We show the connections to the PIC18F2420's SPI port, plus an output port to drive the chip select signal. For bit-bashed software any four I/O pins will suffice. A 100nF decoupling capacitor across the supply rails close to the chip is probably a good idea, though not essential.

The distance between the processor and the device should be kept reasonably short, say less than 20cm, especially if you intend to run the interface at high speed. The signals will pass through PCB connectors without trouble.

Software Requirements

So that's the hardware requirements covered – now to the software.

Data is transferred bit by bit in a synchronous fashion. This simply means that the data signals are only tested for a "1" or "0" level when the clock signal changes its level. This makes talking to a device very easy in software since, unlike the asynchronous RS232 protocol, accurate data bit timings are not required. This means that SPI lends itself very well to "bit-bashing" software implementations, allowing the use of very simple microcontrollers not equipped with integrated SPI peripheral modules.

If you can use an integrated SPI module it will always be better to do so as it will require less code, and much less processor time – you do not need to clock each data bit in.

To allow for maximum flexibility for device manufacturers, Motorola have allowed for four different operational modes to be implemented:

- Mode 0 – The inactive state of the clock signal is 0. Data is read in on the rising edge of the clock. Data is written on the falling edge.
- Mode 1 – The inactive state of the clock signal is 0. Data is read in on the falling edge of the clock. Data is written on the rising edge.
- Mode 2 – The inactive state of the clock signal is 1. Data is read in on the rising edge of the clock. Data is written on the falling edge.
- Mode 4 – The inactive state of the clock signal is 1. Data is read in on the falling edge of the clock. Data is written on the rising edge.

Creating some confusion, these modes are often referred to by the two configuration bits used by Motorola microcontrollers, CPOL and CPHA:

Mode	CPOL	CPHA
0	0	0
1	0	1
2	1	0
3	1	1

You will need to refer back to this information if you are using the microcontrollers built in SPI peripheral module since you have to tell it in which mode to operate. Individual devices will support different modes of operation, sometimes several. This flexibility is confusing, but thankfully that is as confusing as it gets!

Next Month

Next month we describe communication with a SPI device.

Net Work

Alan Winstanley

Protect and Survive

Welcome to *Net Work* – last month I highlighted an anti-virus package from the Czech Republic that is proving itself to be a very credible alternative to better-known Western software. ALWIL Software's Avast! Anti Virus claims a 100% detection record and you can download a free version from **www.avast.com**. Registration is free for home users and lasts twelve months – then simply renew it again. There is now no reason why home users should not be shielded against incoming viruses – and protecting other users against any outgoing ones.

Some ISPs will filter out viruses or spam (or both) before they reach a subscriber's mailbox. In 2003 Demon Internet, for example, introduced filtering based on Brightmail's anti-spam filtering, but after nearly 11 years there is still no virus protection included on the writer's "epemag" account, which still costs £141 per year.

A number of commercial third party filtering services are available that screen out viruses and spam before they can reach their destination. These include MessageLabs and EmailFiltering, the latter being a service that I reviewed several years ago when it was first introduced. This type of service avoids the need to download viruses or spams to begin with, though using local AV software is still a wise precaution.

Emailfiltering (**www.emailfiltering.com**) offered home-based users an anti-virus and anti-spam service for just a few pounds per month, and this proved to be an extremely effective and invaluable service to protect the author's main mailbox: installing EMF's filtering service came as a breath of fresh air.

The need for the past tense is because EMF has discontinued its services for home users as from this month. Depressingly, it has been necessary for EMF's home users to revert to fetching their mail in its raw, unfiltered mode. Renewing the old and, hopefully, long-forgotten battle against spam and viruses has proved to be as welcome as having to stem the flow in a leaking sewage pipe. EMF still offers highly effective filtering systems, but with the more profitable enterprise user firmly in mind.

Spam Out

Spam is a lot more problematic: Demon Internet's Brightmail-powered filters seem to do a reasonable job: however, filtered-out mails are irrecoverable by users, so whether genuine mails (false positives) are also being filtered in error is unknown, but the probabilities are hopefully remote.

Other software-based anti-spam systems include the popular Mailwasher program, free from **www.mailwasher.net** and SpamButcher from **www.spambutcher.com.** There are many more virus, spyware and spam products available at the software portal sites of **www.downloads.com** and **www.snapfiles.com** for you to try.

A Google Convert!

Google is the omnipresent search engine that strives to provide directly relevant results based on over 100 different criteria. One must-have free utility is Google's toolbar (**www.toolbar.google.com**), which is available for MSIE and Firefox, and should be part of every serious surfer's armoury.

Did you know that Google is also a fine one-line calculator and conversion tool? It has a remarkable ability to answers queries made in plain English. Type the expression "37 + 587" into the Google toolbar (or search page) and the answer 624 is calculated. For division, try typing 132/11 and the result 12 is shown. Raising to a power: 9^2 gives 81 and 9^4 gives 6,561. For multiplication, use an asterisk as usual: 2*8 is 16. (Use the PC keyboard's numpad.) Percentages too: "50% of 125" = 62·5, Google assures us.

Square roots: use "sqrt 64" and the answer 8 is given. Google Calculator understands some constants as well: type "pi^2" to obtain the square of pi, 9·8696044. Logarithms and the value of "e" are understood as well.

Google can convert units queried in ordinary English. Type "185 pounds in kilos" and it shows an answer of 83·9145885. Enter "13 stones 8 ounces in pounds" and Google responds with 182·5 pounds. "37 miles in kilometres" is no problem: 59·545728. Try your car's fuel consumption: "35 miles per gallon in kilometres per litre" produces 14·8800297.

Google helps you convert confusing capacitance values

A query of "180 degrees Celsius in Fahrenheit" displays the answer of 356 Fahrenheit. Ask Google "227 degrees Kelvin in Celsius" and the result is minus 46·15 degrees Celsius. "50 million light years in kilometres" shows 4·7302642 × 10^{20} kilometres. 17 knots is 19·5632506 miles per hour.

Cap That

Let's try capacitance, then: type "1,000 nanofarads in picofarads" and the answer is 1,000,000pF, and "1 nanofarad in microfarads" is 0·001 microfarads. Inductance: "1 microhenry in henries" is 1 × 10^{-6} Henries. Google struggled with resistance values though.

Cooks everywhere can learn that "half a cup in teaspoons" is 24 US teaspoons and "three tablespoons in ounces" is actually 1·5 US fluid ounces. Furthermore, "one imperial tablespoon in imperial ounces" is 0·625 Imperial fluid ounces.

Our American readers may be unaware that US gallons differ from British (Imperial) ones: "imperial gallons in a US gallon" is 1 US gallon = 0·832673844 Imperial gallons.

How about Roman numerals: "MCXXV in English" shows one thousand one hundred twenty-five and "1958 in Roman" shows MCMLVIII. Binary and hexadecimal: "137 to binary" produces 0b10001001 ("b" for binary). To convert the hex value 'df283784' to decimal, try "0xdf283784 in decimal" noting the 0x prefix. (The answer is 3,743,954,820.) Binary to decimal conversion: "0b100110101011 to decimal" returns 2,475 as the answer.

Google will be the ideal online conversion tool for many, and more details of Google's features can be found at **www.google.co.uk/help/cheatsheet.html**

Wishing all readers Compliments of the Season and a happy and safe 2006. You can email comments to **alan@epemag.demon.co.uk.**

Circuit Surgery

Ian Bell

Continuing his response to a reader's question, our "consultant surgeon" amplifies gain and impedance calculations in respect of FETs.

LAST month we started to address a question on transistor amplifier circuits posted on the *EPE Chat Zone* by ***Alan Jones***:

For a simple, single transistor amplifier, gain equals value of collector resistor divided by value of emitter resistor. If the emitter resistor is bypassed by an electrolytic capacitor, gain is increased as the emitter resistance is reduced to something like 25 ohms. This is a rough approximation but close enough for most purposes.

My question: does a similar calculation apply to a simple FET circuit (or a valve circuit for that matter) and what is the impedance value equivalent to "emitter resistance" when a bypass capacitor is used?

In fact last month we only got at far as looking at the bipolar transistor circuit. We looked at the fact that the emitter resistor provided negative feedback which stabilized the transistor's bias and made the circuit's gain dependent on the resistor values rather than the transistor gain.

We also saw how by replacing the transistor with a simple equivalent circuit we could use some basic circuit theory to come up with a formula for the gain. By making some assumptions about the relative size of different bits of this formula, we were able to remove some parts that had a minor effect and so simplify the formula to the well known R_C/R_E (collector over emitter resistor as mentioned in the question).

Next we considered what happens if the emitter resistor is bypassed by a largish capacitor. For DC, the bias of R_E's affect remains and we still get our bias stability. For AC the effective emitter resistor value is very low. The simplifications we made earlier to the formula no longer work. We have to go back to the full formula and apply the new situation. This gives us the $R_C/25$ value for gain at room temperature at around 1mA of bias current in the collector path.

The simple answer to Alan's question is: yes you can do the same thing for FET circuits, but there are some differences. Alan does not say if he is specifically interested in JFETs or MOSFETs, so we have chosen to look at JFET circuits. Before we get to the circuits it is useful to consider the fundamental differences between the bipolar transistor and the JFET.

The input to a JFET is basically a reverse biased diode junction so the gate current is effectively zero. Compare this with the bipolar transistor, which has a forward biased diode junction as its input, causing significant currents to flow into the base.

High Impedance

The very high input impedance of FETs is a key advantage, but voltage gains of FET amplifiers are typically smaller than similar bipolar transistor amplifiers. However, if source loading is taken into account the effective gain of a FET circuit connected to a high impedance source may be greater than that obtained using a bipolar transistor. This accounts for the use of FET input stages followed by bipolar transistor gain stages in some amplifier designs.

We usually think of the bipolar transistor as being a current amplifier, that is, we have an input current (the base current) which controls the output current (the collector current). The bipolar transistor therefore has a current gain of collector current divided by base current. As we are dividing two currents the gain is a pure number and is not measured in any physical units.

However, for a FET the input is voltage – the gate source-voltage – which controls the drain (and source) current. The gain is therefore given by drain current over gate-source voltage.

If we think of Ohm's law (R = V/I) we see that the ratio of current over voltage corresponds to 1 over resistance, or conductance, (G = 1/R = I/V). So the gain of the FET is not a pure number, like bipolar transistor gain it is a conductance; however it is not a simple conductance but one relating the transfer of a signal from input to output, so it is called *transconductance*.

Transconductance

The usual symbol for transconductance is g_m. The $_m$ in the symbol means "mutual" – another name for transconductance is *mutual conductance*. Conductance (and transconductance) is measured in Siemens, symbol S, although it is often written in the form A/V (Amps per Volt), or more commonly mA/V for FET gains.

Transconductance is sometimes also called *forward transfer conductance* (g_{fs}). Units of mhos were once used to measure conductance, the name is simply Ohm backwards! Mhos and Siemens have the same value, they are just different names for the same thing, but Siemens are part of the SI standard for measurements.

Typical values of g_m for discrete JFETs aimed at amplifier applications range from 2mS to 10mS, but higher and lower values occur too.

Clarification

Actually, the definition of transconductance given above is not quite correct. The gain varies with the operating point, so it is defined in terms of the change of output caused by an (very small) input change. So more strictly, the transconductance of a FET is the change in the drain current divided by the change in the gate-source voltage at a constant drain to source voltage.

Transconductance is not exclusive to FETs, and in fact it is possible to describe bipolar transistor gain in terms of transconductance as the variation of a bipolar transistor's base-emitter voltage controls the collector current. So for a bipolar transistor, transconductance is the change in the collector voltage divided by the change in the base-emitter voltage. It is equal to current gain over base-emitter resistance ($g_m = \beta/r_{be}$ or h_{fe}/h_{ie} in h-parameter terms). The collector current is given by $I_c = g_m v_{be}$.

As an aside, note that as well as transconductance amplifiers (voltage in, current out) there are also *transresistance* amplifiers (current in, voltage out). The gain of a transresistance amplifier is measured in Ohms.

In Fig.1 is shown the basic bias circuit for an *n*-channel JFET. The transistor needs a negative gate-source voltage to bias it to a suitable operating point and this could be supplied by a battery as shown. As the gate current is effectively zero, the

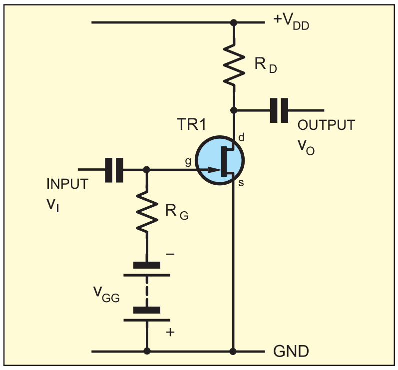


Fig.1. Basic JFET bias circuit

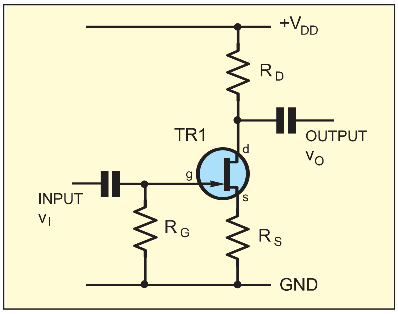


Fig.2. Self-biased JFET amplifier

current in R_G is also zero and no voltage is dropped across it.

The gate source bias voltage is therefore equal to the V_{GG} battery voltage. Note that R_G is needed because if the battery was connected directly to the gate the gate-source voltage would be fixed and unable to respond to the input signal.

The circuit in Fig.1 is not very convenient to implement, so we turn to the circuit in Fig.2, which is referred to as the *self-biased configuration*. Here the gate is connected to ground via R_G, so to get the required negative gate-source voltage we use R_S. This drops a voltage of R_SI_D, where I_D is the drain bias current, making the source positive with respect to the gate, so $V_{GS} = –R_SI_D$.

As with the bipolar transistor circuit we looked at last month, we have a negative feedback situation. An increase in I_D increases R_SI_D making the gate-source voltage more negative and hence tending to reduce I_D.

Calculations

We can work out an expression for the voltage gain for the circuit in Fig.2 using the same approach that we used for the bipolar transistor circuit last month. We start with the equivalent circuit for the FET, which is shown in Fig.3.

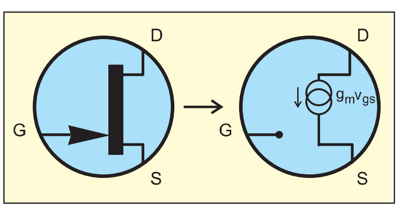


Fig.3. Simple equivalent circuit model of a JFET

Note that the FET equivalent circuit has nothing connected to the gate. This reflects the very high impedance of the gate, which we approximate to being infinity. The open gate node also means no current will flow into the gate when we use this model of the transistor. For a more detailed analysis, particularly if we are looking at frequency response, we would have to include the gate-source capacitance and possibly other capacitances within the FET.

For our purposes here, though, we can make do with a very simple transistor equivalent. Recall that to perform this analysis we assume that our signal is so small that it does not change conditions in the circuit, thus we refer to the procedure as *small signal analysis*. Under this assumption we can ignore the bias voltages and currents and still get the right answer, so before analyzing the circuit we set all the DC voltages to zero, which means that power supplies appear as short circuits in the equivalent circuit used for the analysis.

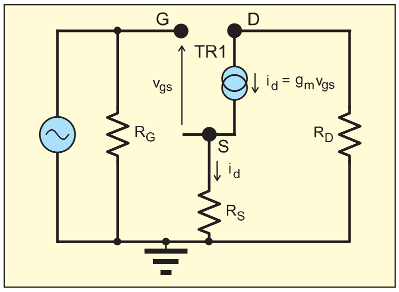


Fig.4. Small signal equivalent circuit of Fig.2. using the transistor equivalent circuit of Fig.3

Equivalent Circuit

If we do not want to analyse frequency response, we can replace the coupling capacitors with short circuits too. Fig.4 shows the small signal equivalent circuit for Fig.2, in which the JFET has been replaced by the circuit from Fig.3,

Note that v_{gs} is labelled on the diagram. We have also included R_G in the circuit for clarity, although we will not use it in the calculation. If the input signal source impedance was comparable with R_G it would have an impact, but we are assuming zero source resistance for simplicity. As mentioned above the capacitors have been removed so the input signal source connects directly to the gate.

The input voltage, v_i, is equal to the voltage across R_S (i_dR_S by Ohm's law) plus the gate-source voltage v_{gs}. So:

$$v_i = v_{gs} + i_dR_S.$$

We can rearrange this to:

$$v_{gs} = v_i – i_dR_S.$$

Now from the transistor model, $i_d = g_mv_{gs}$, or $v_{gs} = i_d/g_m$, which we can substitute into the previous equation to give:

$$i_d = g_m(v_i – i_dR_S).$$

Rearranging we get:

$$i_d = \frac{g_mv_i}{1+g_mR_s}$$

The output voltage, v_o, is equal to i_dR_D (Ohm's law), so substituting $i_d = v_o/R_D$ into the previous equation and rearranging to give the circuit's voltage gain (v_o/v_i) we get:

$$A_v = \frac{g_mR_D}{1+g_mR_S}$$

At this point it would be tempting to try to simplify the above formula to R_D/R_S thus making it very similar to the R_C/R_E formula mentioned above for the bipolar transistor. Unfortunately the relatively low value of the FET g_m and hence the fact that g_mR_S is not much larger than one, means we cannot do this. Typical values might be g_m = 2mS, R_D = 4kΩ, R_S = 1kΩ, which would give a voltage gain of 2.

As with the bipolar transistor, it is possible to bypass the source resistance to increase the AC gain, whilst retaining its role in providing bias. The circuit is shown in Fig.5.

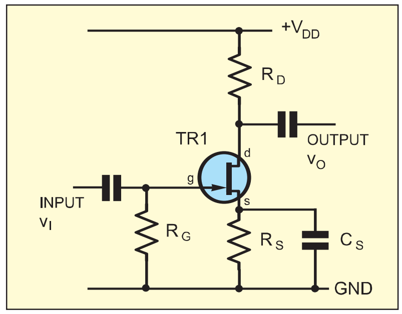


Fig.5. JFET circuit with source capacitor bypassed

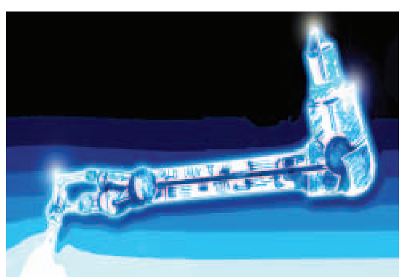
If we put R_S = 0 in the above formula we get:

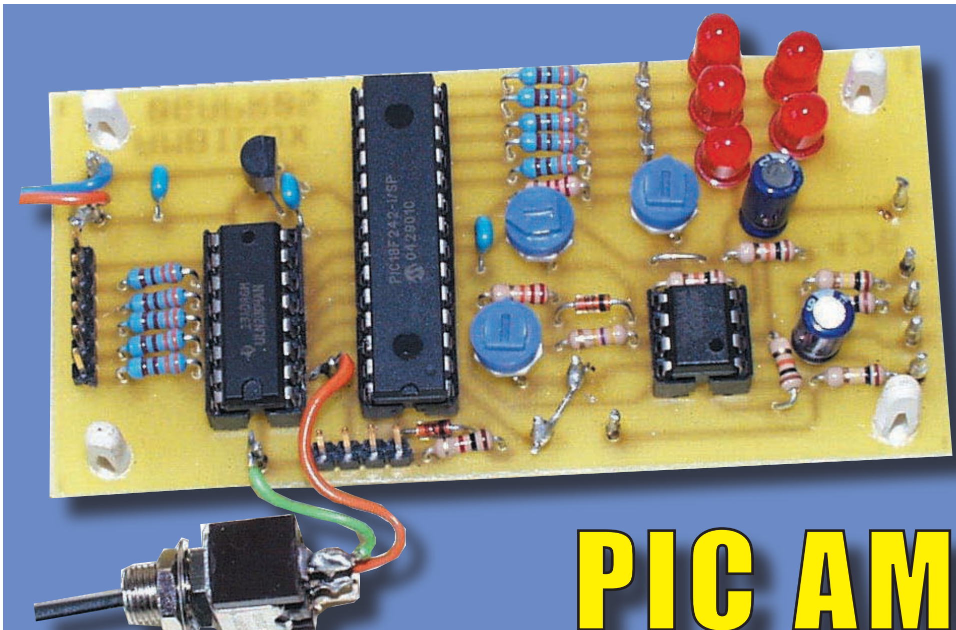
$$A_V = g_mR_D$$

which is indeed the voltage gain of the bypassed circuit.

The gain formulae for both the bypassed and non-bypassed versions of the circuit are correct if the output or drain-source resistance of the JFET is much larger (10 times or more) than the value of R_D. If this does not apply, a more detailed analysis producing a more complex formula is required. A typical value of JFET output resistance might be 50kΩ, in which case it would be satisfactory to use R_D = 4kΩ as in the above example.

Note that the output resistance of FETs is often expressed as conductance rather than a resistance so instead of 50kΩ the value would be written as 20μS.





- PIC-based
- Easy to build
- Changes colour with temperature
- Can interface to other sensors

PIC AMBILUX

Got the moody blues? Add some ambient sensing colour to your life with this PIC based design!

By JOHN BECKER

IN *Techno Talk* of May '05, reference was made to an ambient-sensing light display known as the "Stock Orb". It was quoted as being an ornament that glows in various colours depending on a number of external factors. These factors ranged from sensing the surrounding temperature, to the ever-changing ups and downs of values on the Stock Market. The concept caused the author to slip on his thinking cap, yet again!

The design described here is a much simplified version of what the Stock Orb can probably do, using just a handful of components on a small printed circuit board. As presented, it simply interfaces to a rudimentary temperature sensor and controls five coloured l.e.d.s. Its ultimate use and interface to other sensors is up to the ingenuity of the reader, although some ideas are given later.

Colourful world

The heart of the Ambilux coloured light controller is shown in the circuit of Fig.1. Naturally, it is based around a PIC microcontroller, IC1, in this instance a PIC18F242 (or PIC18F252) device – one of the newer PIC family beginning to show itself in our pages. In point of fact, a PIC16F876 could just have readily been used instead, although the author chose the 18F device to show how easy it is to use. Note, however, that the software cannot be used with a 16F device without suitable code translation.

The PIC is operated in RC mode, with its clock rate set by resistor R12, preset VR3 and capacitor C3. With VR3 set for minimum resistance, the clock rate is about 4MHz or so. The rate is far from critical (also see later).

Via its analogue-to-digital converter (ADC), the PIC inputs the signal voltage produced by a particular source, such as the temperature sensor, though it could equally well be just from a manually controlled potentiometer. In response to that voltage, a bank of five l.e.d.s having different colours is triggered accordingly so that a particular colour hue is set to glow.

The choice of colours and their order of activation is up to the user, but the basic range of l.e.d. colours available is typically red, orange, yellow, green and blue, although other colours are available, including white.

Basic principle

The maximum voltage range that can be processed by the PIC's ADC, which is accessed in this instance via pin RA0, is from 0V to +5V d.c., a range which must not be exceeded.

Suppose the input voltage is 0V, the software has been written so that l.e.d. D1 is at full intensity and the other l.e.d.s., D2 to D5, are turned off. As the input voltage increases, the intensity of D1 begins to fall, and that of D2 starts to rise. When the input is at about 0·625V, both D1 and D2 have the same brilliance, and the other l.e.d.s still remain off.

When the voltage has risen to about 1·25V, D1 is fully turned off and D2 fully turned on. As the voltage rises above 1·25V, so D2 now starts to dim as D3 starts to glow, until at 1·875V, both are equally bright. As the voltage continues to rise, so the intensity of the respective l.e.d.s fades up and then down. This continues until the voltage has risen to 5V, at which point only l.e.d. D5 will be fully on, and all other l.e.d.s will be turned off.

Depending on the order in which the colours have been arranged in the sequence, so the effective colour hue perceived inside a translucent enclosure (a "frosted" glass globe for instance) will change. If the colour sequence is as above, and the voltage change is progressively from 0V to 5V, the displayed colour will appear to change from red to orangy-red, orange, yellowy-orange, yellow, greeny-yellow, green, bluey-green, blue, and around 128 shades between these groups.

As the input voltage falls again, so the colour-changing sequence is reversed. If the voltage remains static at any point in the sequence, so does the colour at that level.

Software technique

The software technique that causes the colour response is quite straightforward, but deserves a bit of explanation. The PIC's ADC is sampled on a continuous basis and each conversion value can range from 0 to 1023 for an input voltage range of 0V to 5V.

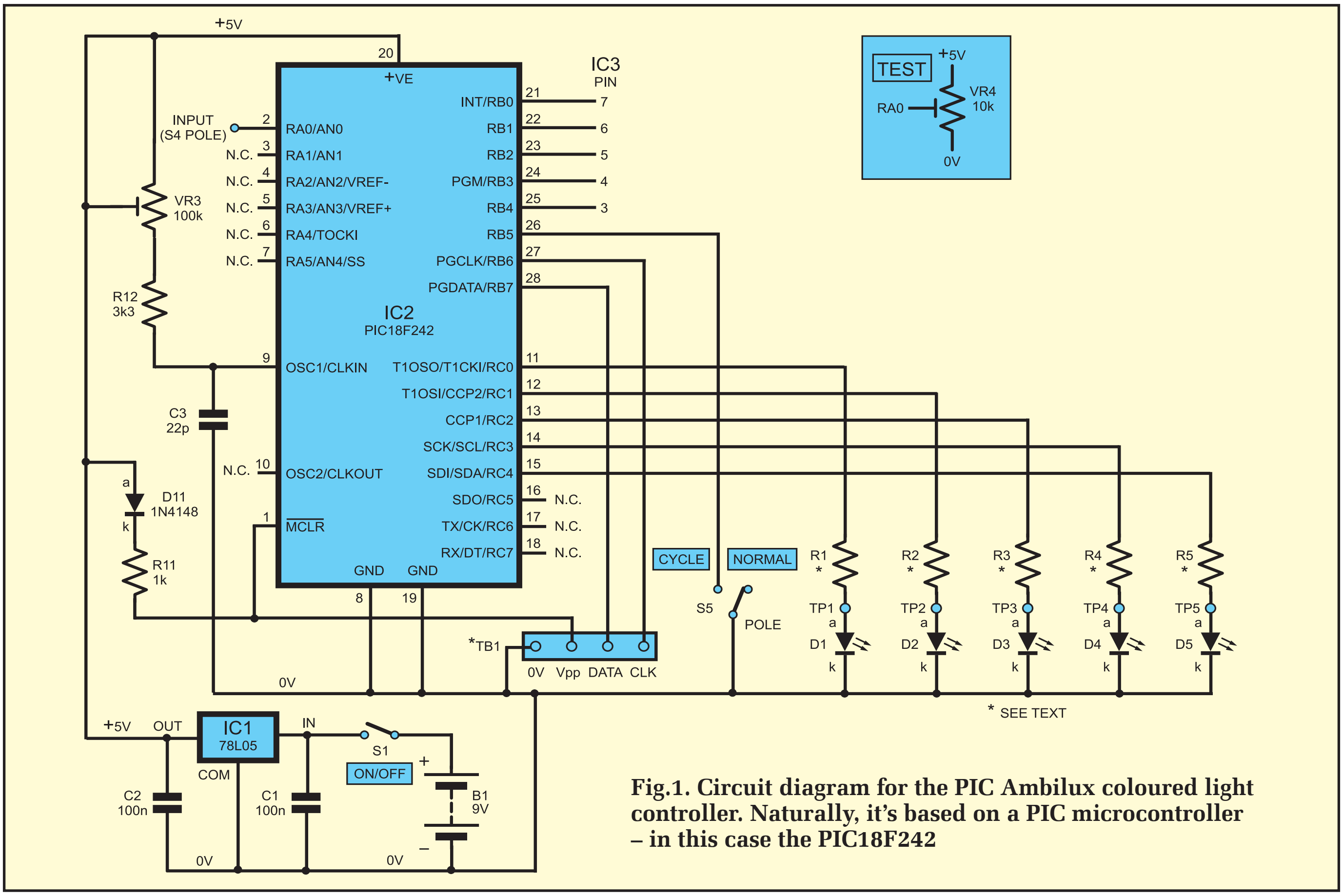


Fig.1. Circuit diagram for the PIC Ambilux coloured light controller. Naturally, it's based on a PIC microcontroller – in this case the PIC18F242

This value is 10 bits long, with the MSB (most significant byte) holding the upper two bits, and the LSB (least significant byte) holding the low eight bits.

The value of the MSB when considered separately can range from 0 to 3. This value determines which of the first four l.e.d.s (D1 to D4) is to be the one primarily controlled. The LSB value, which can lie between 0 and 255, determines the duration for which that l.e.d. is turned on or off.

The control is performed using pulse width modulation (PWM). The LSB value is inverted and placed into a counter specific to the primary l.e.d. (e.g. D1), call it counter 1. It is also placed "as is" into another counter specific to the l.e.d. that follows the first (e.g. D2), call it counter 2.

Both counters are then decremented until zero is reached. While a counter value is greater than zero, so its associated l.e.d. is turned on. If the counter value is zero, the l.e.d. is turned off.

Because one counter starts off at an inverted value compared to the other, the total duration of the loops is always 255 cycles, resulting in an overall consistent timing pattern.

Suppose, for example, that D1's counter is initially set to 255, D2's counter is the inverse of 255, i.e. zero. In the 255-cycle

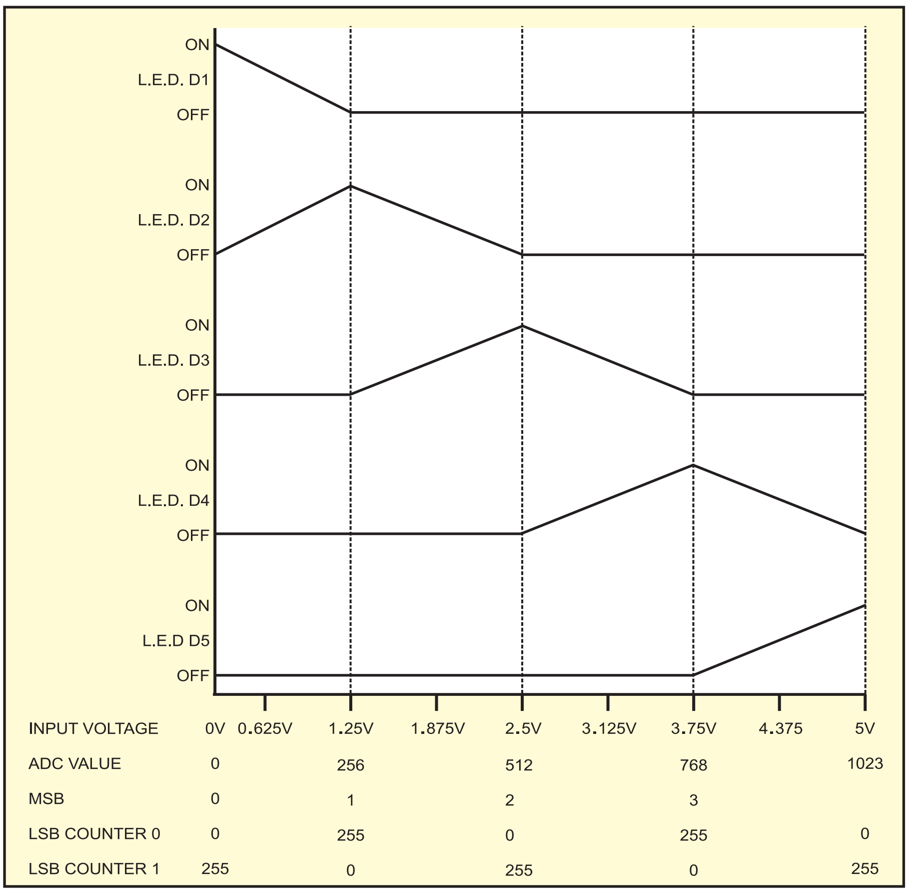


Fig.2. Full l.e.d. sequence progressing from an input of 0V up to +5V

loop, D1 will be turned on for all 255 steps, while D2 is never turned on at all. Suppose, though, D1's value is 127, D2's inverse value is thus 128 (255 – 127). Consequently, both l.e.d.s will be turned on for effectively the same duration (within one cycle), so an equal mix of the two l.e.d. colours will be seen. As a third instance, if D1's value is 63, then D2's value will be 192 (255 – 63), and so D2 will appear to be brighter than D1.

The same principle applies to all the l.e.d.s in the sequence, the primary one depending on the value in the MSB. The MSB has only four possible values, though, so what about l.e.d. D5? The principle is still the same – with D4 selected as the primary, it is D5 which becomes the secondary and gradually fades up to full intensity as D4 fades down to minimum intensity.

A waveform diagram of the full sequence progressing from an input of 0V to one of 5V is shown in Fig.2.

It is worth appreciating that due to the persistence of vision in the human eye, the l.e.d. brightness will not appear to change in such a linear fashion as the triangular waveform would suggest. The effect is that if, for example, the unit is fed with a slow but visibly changing sinusoidal or triangular waveform, an l.e.d. may appear to be on longer than it appears to be off.

Brightly normal

The l.e.d.s catered for in the circuit of Fig.1 are those which fall into the "normal" to "high brightness" categories, i.e. those normally used in a basic design powered at 5V. It is also possible to use two l.e.d.s in sequence in any of the five control paths from PIC pins RC0 to RC4.

In both cases the ballast resistor value (R1 to R5) needs to be that which provides the required current. The formula for calculating ballast resistor values in respect of l.e.d.s and control voltages is given by the formula:

$$R = (V_s - V_f) / I_f$$

where:

R = resistor value in ohms
V_s = supply voltage
V_f = forward voltage drop across l.e.d.
I_f = forward current through l.e.d.

Example:

V_f = 2·5V
I_f = 20mA
V_s = 5V

therefore:

$$R = (5 - 2{\cdot}5)/0{\cdot}02 = 125\Omega \text{ (say } 120\Omega)$$

and with V_s = 9V

$$R = (9 - 2{\cdot}5)/0{\cdot}02 = 325\Omega \text{ (say } 330\Omega)$$

Be aware that the ballast resistor value needed may be different for different colour l.e.d.s, even though they may appear to be the same type. The values for Vf and If for any given l.e.d. are shown in the catalogues of major electronic component retailers.

Note that the PIC can only provide a maximum current of 25mA from each of its output pins. Furthermore, the total current output by the PIC must not exceed the maximum limit of 200mA.

Super-bright

The ability to control even the brightest of l.e.d.s available has been provided, but not directly from the PIC's outputs. As you are probably aware, there are some really super-bright l.e.d.s around now, including such visual wonders as the Luxeon V type. As component advertiser's catalogues will confirm, even these super-brights are available in several colours.

Beware that some of these super-bright l.e.d.s can be damaging to the eyes if viewed directly.

The current required by many ultra-high intensity l.e.d.s far exceeds the 25mA that a PIC can supply, some types even consume up to 800mA! The Ambilux, though, has had an interface provided which can cope with these high currents, and with an l.e.d. supply voltage greater than the PIC's 5V limit.

These devices are still controlled by the PIC, this time via Port B (RB0 to RB4). Moreover, they can be controlled at the same time as those l.e.d.s on Port C, the same control code being written simultaneously to both ports.

Interface

The circuit diagram for the Interface is shown in Fig.3. The interfacing chip is the now-familiar device ULN2004A. This is a 7-way Darlington driver, of which only five ways are used. It is an inverting device which sets its outputs low in response to high (e.g. 5V) voltage levels at its inputs.

Each input has its own internal buffer resistor and does not need external resistors between it and its driving source. It also has internal back-e.m.f diodes which are beneficial when the device drives inductive loads (but of no importance in this design).

The device can be powered at 9V (from 6V to 15V), allowing it and the l.e.d.s it controls to be powered from the same battery source that supplies the +5V voltage regulator (IC1) on the main circuit. It and the l.e.d.s it controls can also be powered from a separate battery, say 12V.

Parts List

1 mono jack socket, size to suit
2 s.p.s.t. min. toggle switch
3 s.p.d.t. min. toggle switch
1 printed curcuit board, available from the *EPE PCB Service*, code 546;
1 8-pin d.i.l. socket;
1 16-pin d.i.l. socket;
1 28-pin d.i.l. socket;
1 9V battery and clip (see text);
1 enclosure(s) to suit (see text); connecting wire; solder, etc.

Resistors (0·25W 5%)
10 select values to suit l.e.d.s (see text)
1 1k
1 3k3
1 22k
1 470k (see text)
4 10k
2 100k

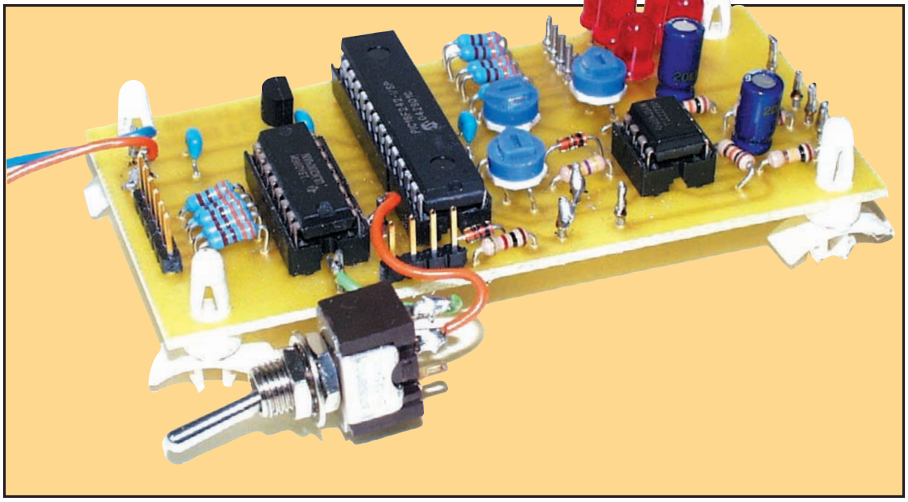
Potentiometers
1 100k min. preset, round
1 47K min. preset, round
1 500k (or 470k) min. preset, round (see text)
1 10k rotary or preset (test purposes only)

Capacitors
2 100n ceramic disc, 5mm pitch
1 22p ceramic disc, 5mm pitch
2 22µ radial elect.16V

Semiconductors
5 standard or high-brightness l.e.d.s. colours of choice (see text)
5 ultra-high intensity l.e.d.s., colours of choice (see text)
2 1N4148 signal diode
1 78L05 +5V 100mA voltage regulator
1 PIC18F242 or PIC18F252 microcontroller, pre-programmed (see text)
1 ULN2004A 7-way Darlington array (see text)
1 TLC2272IP dual rail-to-rail op.amp (see text)

Note that the device can control up to 500mA of current. Those l.e.d.s which can accept more than this must be limited accordingly.

It is also possible to use the interface with chains of standard l.e.d.s connected between it and the positive supply line. Whatever the l.e.d. types with which the interface is used, though, the ballast resistor values (R6 to R10) must be chosen to suit the particular type and its power voltage. Again refer to the formula given earlier.



Temperature sensor

For the sake of demonstrating how the Ambilux can be used to provide a colourful indication of ambient conditions, a simple temperature sensing circuit has been included, although its use is optional. Its circuit diagram is shown at the left of Fig.4.

Silicon diodes such as the 1N4148 can be used as temperature detecting devices.

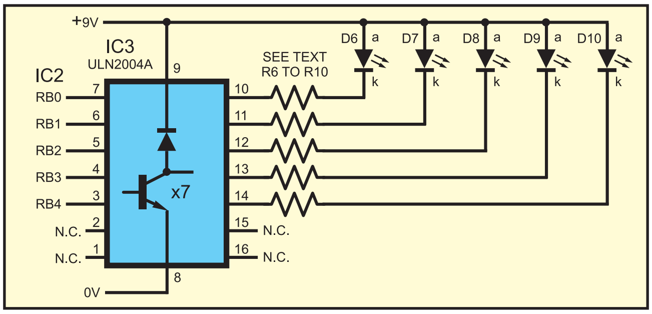


Fig.3. Bolt-on PIC Ambilux Interface circuit diagram

When a small current flows through a silicon diode, such as the 1N4148, it yields a nearly linear relationship between the voltage and temperature with a typical sensitivity of about 430°C per volt (2·3mV per °C). The equation for computing junction temperature from the measured diode voltage is the straight line equation:

$$T_j = m \times V_f + T_o$$

where T_j is the junction temperature, m is the temperature sensitivity expressed in terms of °C per volt, V_f is the diode forward voltage and T_o is the offset temperature.

The current through the diode must be sufficiently large to establish conduction in the body of the junction rather than just a superficial leakage conduction. It must, though, not be so large as to artificially raise the internal temperature of the diode. Generally 0·1mA is taken as the required current.

In Fig.4 the temperature sensing diode is notated as D12. On the anode (a) side it is biased from the +5V line via resistor R13. On the cathode (k) side, it is connected to the 0V line via preset VR1. The cathode is also connected to the non-inverting input (pin 5) of op.amp IC4a.

The basic bias voltage level seen at IC4a pin 5 can be set by the adjustment of VR1 – increased resistance raising the bias, decreased resistance lowering it. In this way a mid-way bias representing, say, a temperature of 15°C can be set.

In practical terms, if we take the temperature range we want as being 0°C to 30°C, the change in current between the extremes is 30 × 2·3mV = 69mV. The PIC's ADC input range is 0V to 5V. The gain required by IC4a is thus 5000mV / 69mV = 72.

Preset VR2 in the feedback path between the op.amp's output (pin 7) and inverting input (pin 6) can be used to adjust the op.amp's gain, to between about ×47 and ×100 (the ratio of R17 to the total of R14 plus VR2, plus 1). With VR2's wiper set midway, an approximation of the required gain can be set, and subsequently adjusted if desired. The resulting output voltage can then be fed via switch S4 (Thermo) to the PIC's RA0 ADC pin.

Adjustment of VR2 should be made (in the light of experience) so that the temperature typically experienced in a house can produce a reasonable range of display colour bands. It is suggested that blue indicates the lowest temperature, and red the highest – but the choice is yours.

If you wanted a narrower range, say a 10°C swing between 15°C to 25°C, the calculation is then 10 × 2·3mV = 23mV. The gain then needed is 5000mV/23mV = 217, thus requiring a feedback resistance of 2170kΩ, say 2M2Ω. In this case amend R14 to 1M5Ω, but leave VR2 at 500kΩ (a 470kΩ preset may be used in either instance).

Amplifier stage

It is perfectly feasible to apply a voltage of between 0V and 5V d.c. directly to PIC pin RA0. However, it is envisaged that lower range voltage levels might be supplied by

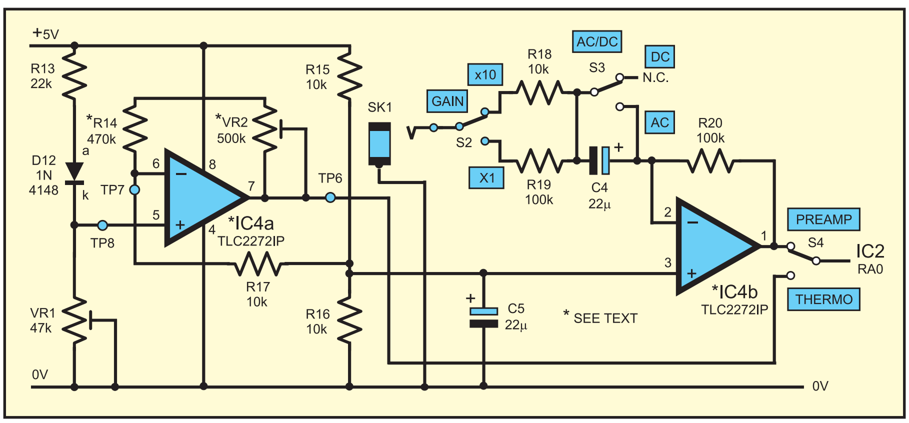


Fig.4. Circuit diagram for an optional "colourful" ambient temperature sensor

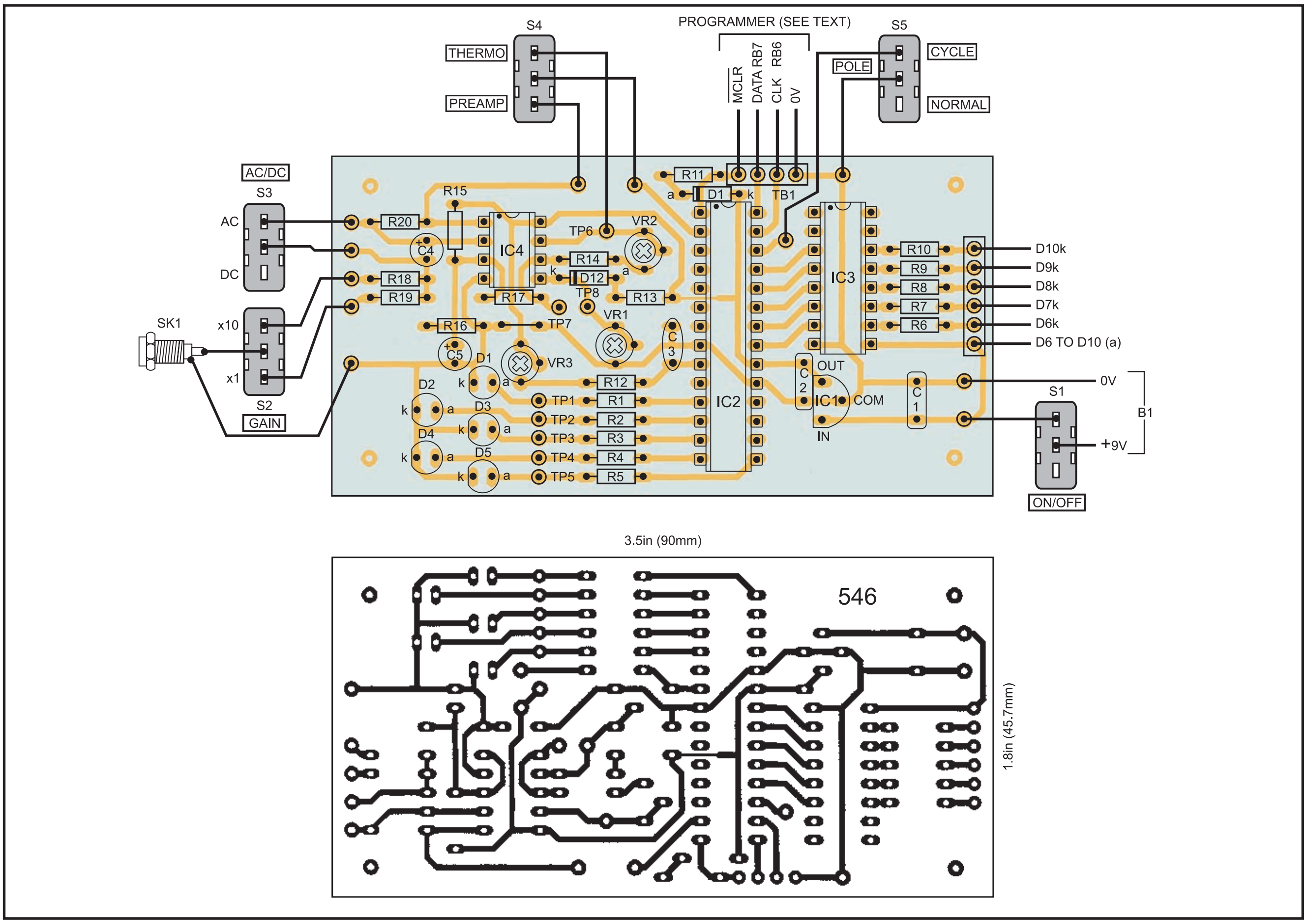


Fig.5. Printed circuit board component layout, wiring details and full-size master for PIC Ambilux. Take care with component orientation

other sensing device sources. To this end, an a.c./d.c. amplifying stage has been provided, via IC4b in Fig.4. This not only provides for a gain choice of ×1 or ×10, as selected by switch S2, but also a choice of a.c. or d.c. input, as selected by S3.

Via the selected path, the input signal from socket SK1 is routed to the inverting input (pin 2) of IC4a. The non-inverting input (pin 3) is biased to a mid-level voltage (2·5V) by resistors R15 and R16. Capacitor C5 enhances the stability of this input. (The same bias level is also used by IC4a.)

The output from IC4b pin 1 can be routed to the PIC's ADC pin RA0 via switch S4.

The op.amp type shown in Fig.4 is a TLC2272IP rail-to-rail device, providing an output that can fully swing between 0V and 5V on a 5V supply. Other rail-to-rail dual op.amps may be used instead.

If you know precisely how you wish to use the interface in Fig.4, you may prefer to omit switches S2 to S4, hard-wiring only those connections that you want. Furthermore, any then-unused components in Fig.4 could be omitted as well.

Construction

The printed circuit board component and track layout details for the Ambilux are shown in Fig.5. This board is available from the *EPE PCB Service*, code 546.

Note that only l.e.d.s D1 to D5 can be mounted on the board. If other l.e.d.s are to be driven via the Interface circuit (Fig.3), they must be mounted off-board in a suitable manner. This will depend on the type of display you wish to create, and could even be on an insulated vertical pillar. In this type of instance, the l.e.d.s could be mounted some distance away from the control board via insulated and stranded connecting wires.

The wires must be suitable for carrying the maximum current to be drawn. In this context, though, it is worth noting that only two l.e.d.s can appear to be on at the same time. But, in reality, only one l.e.d. is ever actually turned on as the software multiplexes the individual outputs from both Port B and Port C.

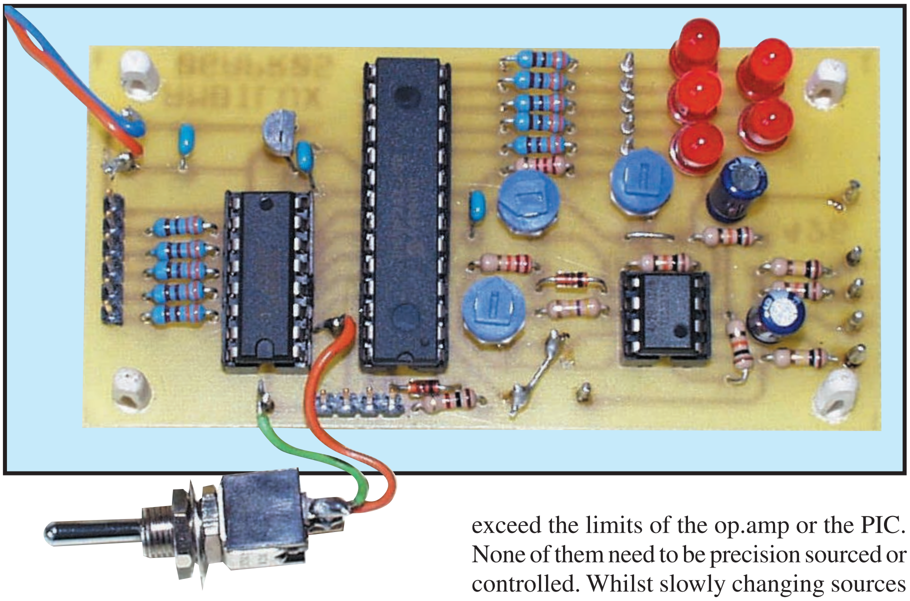
Consequently, you can consider the maximum current required by a single l.e.d. as being the total maximum l.e.d. current ever required. This must be the most current-hungry l.e.d. of course. Thus if Luxeon V devices are used for control at 500mA, your connecting wires each need to be rated at a little over this, say 1A.

Assemble the board in the usual order of ascending component size, and use sockets for IC2 to IC4. The latter should not be inserted until the output from regulator IC1 has been confirmed to be 5V.

No specific housing is recommended for the Ambilux. Choose whatever enclosure(s) for the controller and its l.e.d.s as you wish. Even one of those paper globes used with low-cost domestic ceiling lights might be used. More elegant globes can probably be purchased from a decent lighting shop. Bathroom ceiling light globes come to mind.

Testing

Having thoroughly checked the assembled board for accuracy of assembly and component positioning, and with the d.i.l. i.c.s omitted, connect a meter between the cathode (k) of D12 (TP8) and the 0V line. With power on, adjust preset VR1 until the voltage reads 2.5V (half line voltage).



Switch off power and measure the resistance between IC4a output pin 7 (TP6) and input pin 6 (TP7). Adjust VR2 until a resistance of about 720kΩ is set. This sets the op.amp gain to approximately the suggested ×72. Now adjust VR1 again (carefully), until the output voltage at TP6 is about 2·5V.

If you warm diode D12 with your finger, the output at TP6 should be seen to change by several millivolts. Both VR1 and VR2 can be slightly readjusted later if desired, in the light of experience, so that you get the desired colour change in response to changing temperature.

Other sensor interfaces

If you wish to test the PIC without the Interfaces in Fig.4, ADC input RA0 can be fed with a voltage between 0V and 5V by the test potentiometer, VR4, shown inset in Fig.1.

Any changing voltage level can be applied to the Ambilux, provided its extremes do not exceed the limits of the op.amp or the PIC. None of them need to be precision sourced or controlled. Whilst slowly changing sources might be more generally pleasing to the eye, there's no reason why a sound source could not be used, using the Ambilux to behave as a simple sound-to-light converter, responding to sound amplitudes.

Steve Challinor showed a few examples of possible sensor sources in his *Versatile PIC Flasher Mk2* article (Dec '04). They may need a bit of modifying to suit the Ambilux, but they seem reasonable starting points. His suggestions included a Sound Sensor using an electret microphone, a thermistor-based Temperature Sensor, an LDR-based Light Sensor, and a Movement Detector (which could be modified to cause different colours depending on a person's proximity to the sensor – lots of fun for kids here!).

Those of you with PIC program writing and programming skills could also write various control routines for embedding into the PIC's software (lots of code space still available). Indeed if you connect and switch on S5 (Fig.1) you will find that the author has already provided you with a simple sequencer. It cycles through D1 to D5 as described, then at D5, both D5 and D1 become the controlled l.e.d. pair, and the sequence repeats.

If you want to externally set the rate at which the sequence changes, use a linear rotary potentiometer in place of preset VR3. A value of 50k rather than 100k might be better to avoid low PIC clock rates that cause the l.e.d.s. to flash.

We're sure you'll find plenty of uses for this unusual display novelty once you've built its basic framework! ***EPE***

Resources

Software, including source code files, for the PIC Ambilux can be downloaded free from the EPE Downloads site, accessible via the home page at **www.epemag.co.uk**. *It is held in the PICs folder, under Ambilux. Download all the files within that folder.*

As usual with the author's designs, the PIC can be programmed in situ via the TB1 terminal pins allocated on the board. Ready-to-go programmed PIC18F242 Ambilux microcontrollers are available from Magenta Electronics.

The PIC program source code (ASM) was written using EPE Toolkit TK3 *software (also available via the Downloads site) and a variant of the TASM dialect. It may be translated to MPASM via TK3 if preferred. The run-time assembly is supplied as an MPASM HEX file, which has PIC18F configurations embedded in it. If you wish to program the PIC yourself, simply load this HEX file into the PIC using your own PIC programming software and hardware.*

EPE SUBSCRIPTION PRICES

Subscriptions for delivery direct to any address in the UK: 6 months £17.50, 12 months £33, two years £61; Overseas: 6 months £20.50 standard air service or £29.50 express airmail, 12 months £39 standard air service or £57 express airmail, 24 months £73 standard air service or £109 express airmail. Cheques or bank drafts (in **£ sterling only**) payable to *Everyday Practical Electronics* and sent to *EPE* Subs. Dept., Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872. Fax: 01202 874562. **Email**: subs@epemag.wimborne.co.uk. Also via the **Web** at **http://www.epemag.co.uk**. Subscriptions start with the next available issue. We accept MasterCard, Amex, Diners Club, Maestro or Visa. (For past issues see the *Back Issues* page.)

ONLINE SUBSCRIPTIONS

Online subscriptions, for downloading the magazine via the Internet, $15.99US (approx. £9.50) for one year available from **www.epemag.com**.

USA/CANADA SUBSCRIPTIONS

To subscribe to *EPE* from the USA or Canada please telephone Express Mag toll free on 1877 363-1310 and have your credit card details ready. Or fax (514) 355 3332 or write to Express Mag, PO Box 2769, Plattsburgh, NY 12901-0239 or Express Mag, 8155 Larrey Street, Anjou, Quebec, H1J 2L5.
Email address: expsmag@expressmag.com.
Web site: **www.expressmag.com**.
USA price $60(US) per annum, Canada price $97(Can) per annum – 12 issues per year.

Everyday Practical Electronics, periodicals pending, ISSN 0262 3617 is published twelve times a year by Wimborne Publishing Ltd., USA agent USACAN at 1320 Route 9, Champlain, NY 12919. Subscription price in US $60(US) per annum. Periodicals postage paid at Champlain NY and at additional mailing offices. POSTMASTER: Send USA and Canada address changes to Everyday Practical Electronics, c/o Express Mag., PO Box 2769, Plattsburgh, NY, USA 12901-0239.

EVERYDAY PRACTICAL ELECTRONICS

UK readers you can

SAVE 55p

on every issue of *EPE*

SUBSCRIPTION ORDER FORM

☐ **6 Months: UK £17.50, Overseas £20.50 (standard air service), £29.50 (express airmail)**
☐ **1 Year: UK £33.00, Overseas £39.00 (standard air service) £57 (express airmail)**
☐ **2 Years: UK £61.00, Overseas £73.00 (standard air service) £109 (express airmail)**

To: Everyday Practical Electronics,
Wimborne Publishing Ltd., 408 Wimborne Road East,
Ferndown, Dorset BH22 9ND
Tel: 01202 873872 Fax: 01202 874562
E-mail: subs@epemag.wimborne.co.uk

I enclose payment of £ .... (cheque/PO in £ sterling only), payable to *Everyday Practical Electronics*

My card number is: ....
Please print clearly, and check that you have the number correct

Signature ....

Card Security Code .... (The last 3 digits on or just under the signature strip)

Card Ex. Date .... Maestro Issue No. ....

Name ....

Address ....

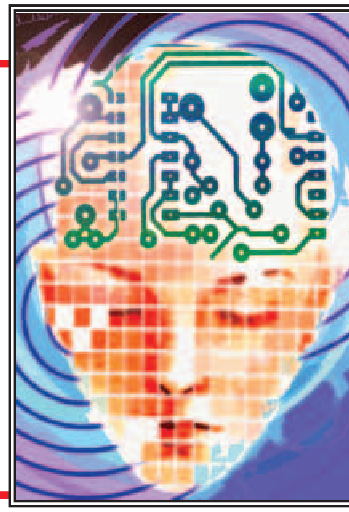
Post code .... Tel. ....

Subscriptions can only start with the next available issue.

EPE Tutorial Series

TEACH-IN 2006

Part Three – Capacitance. Introducing Capacitors.



MIKE TOOLEY BA

Our Teach-In 2006 series provides a broad-based introduction to electronics for the complete newcomer. The series also provides the more experienced reader with an opportunity to "brush up" on topics with which he or she may be less familiar. This month we investigate the theory that underpins capacitors.

Capacitance

The two charged plates in Fig.3.1 form a device for concentrating and storing an electric charge. We refer to this device as a *capacitor* and its ability to store a charge is called *capacitance*. Put simply, capacitance is a measure of the ability of a capacitor to store an electric charge when a potential difference is applied. Thus a large capacitance will store a larger charge for a given applied voltage.

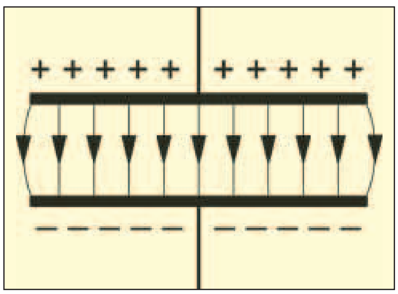


Fig.3.1. Electric field between two charged parallel metal plates

A simple *parallel plate capacitor* is shown in Fig.3.2 In practice and although air-spaced capacitors are used in some radio frequency (RF) applications, the space between the plates of most capacitors is filled with an insulating material, known as a *dielectric*. Typical dielectric materials are polyester, mica, or ceramic. Note that a dielectric material must be a good insulator (it must not conduct electric current) and also that it must be able to retain its insulating properties when a high voltage is applied to it.

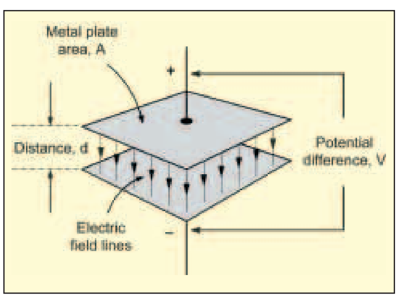


Fig.3.2. A simple parallel-plate capacitor

If we plot charge, Q, against potential difference, V, for a capacitor we arrive at a *straight line law*. The slope of this graph is an indication of the capacitance, C, of the capacitor, as shown in Fig.3.3.

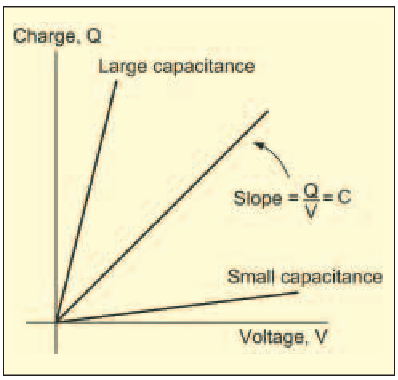


Fig.3.3. Charge, Q, plotted against potential difference, V, for three different values of capacitance

From Fig.3.3, the capacitance is directly proportional to the slope of the graph, as follows:

$$\text{Capacitance} = \frac{\text{amount of charge on the capacitor's plates}}{\text{potential difference between the plates}}$$

In symbols this relationship is simply

$$C = \frac{Q}{V}$$

from which we can obtain the further relationships:

$$Q = CV \quad \text{and} \quad V = \frac{Q}{C}$$

where the charge, Q, is measured in coulombs (C) and the potential difference, V, is measured in volts (V).

The unit of capacitance is the *Farad* (F) where one Farad of capacitance produces a charge of one Coulomb when a potential difference of one volt is applied. Note that, in practice, the Farad is a very large unit and we therefore often deal with sub-multiples of the basic unit such as μF (1×10^{-6}F), nF (1×10^{-9}F), and pF (1×10^{-12}F).

Example 3.1

Determine the capacitance of a capacitor if a potential of 200V is required to create a charge of 400μC.

The capacitance of the capacitor (expressed in Farads) is given by:

$$C = \frac{Q}{V} = \frac{400\times10^{-6}\text{C}}{200\text{V}}\ 2\times10^{-6}\text{F} = 2\mu\text{F}$$

Example 3.2

What potential difference must be applied to the plates of a 10μF capacitor in order to produce a charge of 2·5mC.

The potential difference can be calculated by re-arranging the expression to make V the subject, as follows:

$$V = \frac{Q}{C} = \frac{2{\cdot}5\times10^{-3}\text{C}}{10\times10^{-6}} = 0{\cdot}25\times10^{3} = 250\text{V}$$

Charge and Discharge

We have already said that a capacitor is a device for storing electric charge. In effect, it is a *reservoir* for charge. Typical applications for capacitors include reservoir and smoothing capacitors for use in power supplies, coupling AC signals between the stages of amplifiers, and decoupling supply rails (i.e. effectively grounding the supply rails to residual AC signals and noise). You will learn more about these applications in future parts of *Teach-In* but, for now, we

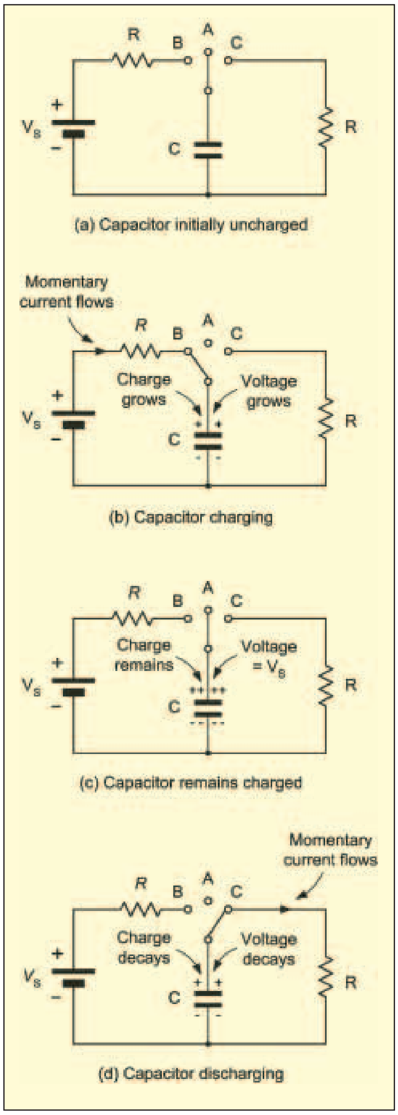


Fig.3.4. Charging and discharging a capacitor

will concentrate our efforts on explaining how a capacitor works and what it does!

Consider the arrangement shown in Fig.3.4. If the switch is left open (position A – see Fig3.4a), no charge will appear on the plates and in this condition there will be no electric field in the space between the plates nor will there be any charge stored in the capacitor.

When the switch is moved to position B (Fig.3.4b), electrons will be attracted from the positive plate to the positive terminal of the battery. At the same time, a similar number of electrons will move from the negative terminal of the battery to the negative plate. This sudden movement of electrons will manifest itself in a momentary surge of current (conventional current will flow from the positive terminal of the battery towards the positive terminal of the capacitor).

Eventually, enough electrons will have moved to make the e.m.f. between the plates the same as that of the battery. In this state, the capacitor is said to be *charged* and an electric field will be present in the space between the two plates.

If, at some later time the switch is moved back to position A (Fig.3.4c), the positive plate will be left with a deficiency of electrons whilst the negative plate will be left with a surplus of electrons. Furthermore, since there is no path for current to flow between the two plates the capacitor will remain charged and a potential difference will be maintained between the plates.

Discharge

Now assume that the switch is moved to position C (Fig.3.4d). The excess electrons on the negative plate will flow through the resistor to the positive plate until a neutral state once again exists (i.e. until there is no excess charge on either plate). In this state the capacitor is said to be *discharged* and the electric field between the plates will rapidly collapse. The movement of electrons during the discharging of the capacitor will again result in a momentary surge of current (current will flow from the positive terminal of the capacitor into the resistor).

Figs. 3.5a and 3.5b respectively show the direction of current flow when the capacitor is being charged (switch in position B) and discharged (switch in position C). It should be noted that, even though the circuit is apparently broken by the gap between the capacitor plates, current flows momentarily when the capacitor is charged and discharged.

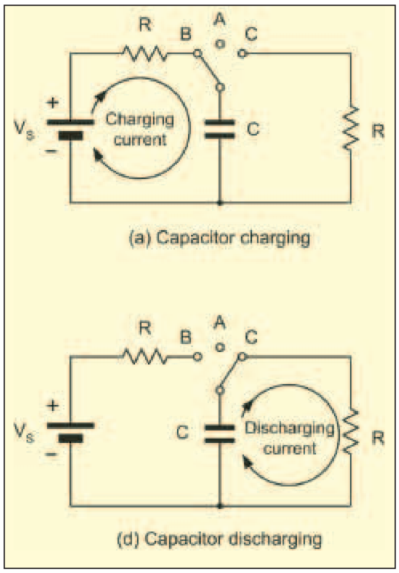


Fig.3.5. Current flow during charging and discharging

When a capacitor is being charged (as shown in Fig.3.5a) the voltage across the capacitor, V_C, will rise exponentially as shown in Fig.3.6. Eventually the voltage will become almost equal to (but never quite the same as) the supply voltage, V_S. At the same time, the current flowing in the circuit, i, will fall, as shown in Fig.3.7. Note that the initial value of current (at t = 0) will be given by V_S/R.

The rate of growth of voltage with time and decay of current with time is dependent upon the product of capacitance, C, and resistance, R. This value is known as the *time constant* of the circuit. Hence:

Time constant, $t = C \times R$

where C is the value of capacitance (in F), R is the resistance (in Ω), and t is the time constant (in s).

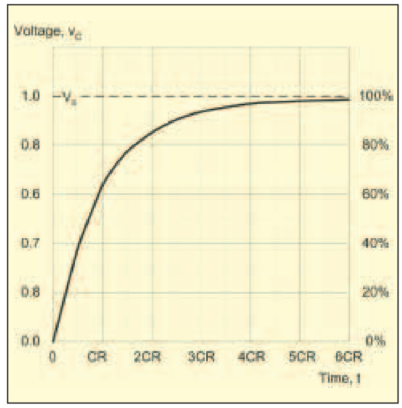


Fig.3.6. Growth of voltage when a capacitor is being charged

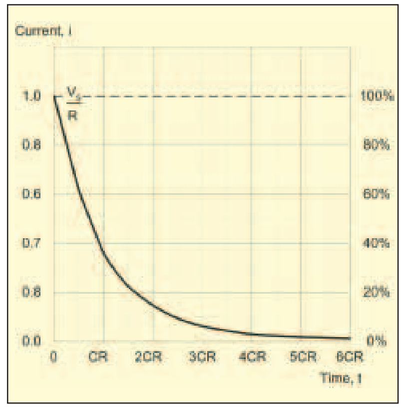


Fig.3.7. Decay of current when capacitor is being charged

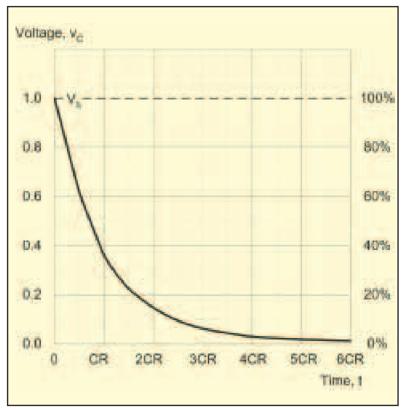


Fig.3.8. Decay of voltage when a capacitor is being discharged

When the capacitor is charging, the capacitor voltage will rise to approximately 63% of the supply voltage in a time interval equal to the time constant (CR). At the end of the next interval of time equal to the time constant (i.e. after an elapsed time equal to 2CR) the voltage will have risen by 63% of the remainder, and so on. In theory, the capacitor will never quite become fully charged. However, after a period of time equal to 5CR, the capacitor voltage will to all intents and purposes be equal to the supply voltage. At this point the capacitor voltage will have risen to 99.3% of its final value and we can consider it to be fully charged.

When a capacitor is being discharged (as shown in Fig.3.5b) the voltage across the capacitor, V_C, will fall exponentially

Table 3.1. Determining Voltage and Current in a CR Circuit

$\frac{t}{CR}$	k (fraction of final value) Exponential growth	Exponential decay
0·0	0·0000	1·0000
0·1	0·0951	0·9048
0·2	0·1812	0·8187 (see example)
0·3	0·2591	0·7408
0·4	0·3296	0·6703
0·5	0·3935	0·6065
0·6	0·4511	0·5488
0·7	0·5034	0·4965
0·8	0·5506	0·4493
0·9	0·5934	0·4065
1·0	0·6321	0·3679
1·5	0·7769	0·2231
2·0	0·8647	0·1353
2·5	0·9179	0·0821
3·0	0·9502	0·0498
3·5	0·9698	0·0302
4·0	0·9817	0·0183
4·5	0·9889	0·0111
5·0	0·9933	0·0067

as shown in Fig.3.8. At the same time, the current flowing in the circuit, i, will fall, as shown previously in Fig.3.7. Note that the initial value of current is once again Vs/R.

The current will fall to approximately 37% of the initial current in a time equal to the time constant. At the end of the next interval of time equal to the time constant (i.e. after a total time of 2CR has elapsed) the current will have fallen by a further 37% of the remainder, and so on.

In order to avoid the some of the more difficult mathematics concerned with exponential growth and decay, Table 3.1 provides a simple method that may be used to determine the voltage and current in a C-R circuit. The use of this table is illustrated in Example 3.3.

Example 3.3

A 100μF capacitor is charged to a potential of 50V. The capacitor is then removed from the charging source and connected to a 1MΩ resistor. Determine the capacitor voltage 20 seconds later.

First we need to find the time constant:

$C \times R = 100\mu F \times 1M\Omega = 100s$

(note that the time constant will be in seconds whenever we work in units of μF and MΩ)

Next we find the ratio of t to CR. After 20 seconds the ratio of t to CR is:

$$\frac{t}{CR} = \frac{20}{100} = 0{\cdot}2$$

Referring to Table 3.1 we find that when t/CR = 0·2, the value of k for decay is 0·8187.

Thus:

$$\frac{Vc}{Vs} = 0{\cdot}8187$$

or

$Vc = 0{\cdot}8187 \times 50 = 40{\cdot}935V$

Check Point 3.1

The time constant of a C-R circuit is the product of the capacitance, C, and resistance, R.

Check Point 3.2

The voltage across the plates of a charging capacitor grows exponentially at a rate determined by the time constant of the circuit. Conversely, the voltage across the plates of a discharging capacitor decays exponentially at a rate determined by the time constant of the circuit.

Factors Determining Capacitance

The capacitance of a capacitor depends upon the physical dimensions of the capacitor (i.e., the size of the plates and the separation between them) and the dielectric material between the plates. The capacitance of a conventional parallel plate capacitor is given by:

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

where C is the capacitance (in Farads), ε_0 is the permittivity of free space, ε_r is the relative permittivity (or dielectric constant) of the dielectric medium between the plates), A is the area of the plates (in square metres), and d is the separation between the plates (in metres). The permittivity of free space, ε_0, is $8{\cdot}854 \times 10^{-12}$ F/m.

Some typical capacitor dielectric materials and relative permittivity are given in Table 3.2.

Example 3.5

Two parallel metal plates, each of area 0·2m^2 are separated by an air gap of 1mm. Determine the capacitance of this arrangement.

Here we must use the formula:

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

where $A = 0{\cdot}2m^2$, $d = 1 \times 10^{-3}$m, $\varepsilon_r = 1$, and $\varepsilon_0 = 8{\cdot}854 \times 10^{-12}$ F/m.

Hence:

$$C = \frac{8{\cdot}854\times10^{-12}\times1\times0.2}{1\times10^{-3}} = \frac{1{\cdot}7708\times10^{-12}}{1\times10^{-3}}$$

$= 1{\cdot}7708\times10^{-9}F = 1{\cdot}7708nF$

Example 6

A capacitor of 100pF is required. If a dielectric material of thickness 0·5mm and relative permittivity 5 is available, determine the required plate area.

Solution

Re-arranging the formula

$$C = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

to make A the subject gives:

$$A = \frac{Cd}{\varepsilon_0 \varepsilon_r} = \frac{100\times10^{-12}\times0.5\times10^{-3}}{8{\cdot}854\times10^{-12}\times5} =$$

$$\frac{50\times10^{-15}}{44{\cdot}27\times10^{-12}} = 1/129\times10^{-3}m^2$$

thus $A = 1{\cdot}129\times10^{-3}$ m^2
or $11{\cdot}29\times10^{-4}$ m^2 = 11·29 cm^2

In order to increase the capacitance of a capacitor, many practical components employ interleaved multiple plates (see Fig. 3.9a) in which case the capacitance is then given by:

$$C = \frac{\varepsilon_0 \varepsilon_r (n\text{-}l) A}{d}$$

where C is the capacitance (in Farads), ε_0 is the permittivity of free space, ε_r is the relative permittivity of the dielectric medium between the plates), n is the number of plates, A is the area of the plates (in square metres), and d is the separation between the plates (in metres).

Table 3.2. Relative Permittivity of Typical Dielectric Materials

Dielectric material	Relative permittivity (Free space = 1)
Vacuum	1
Air	1.0006 (i.e. 1!)
Polythene	2.2
Paper	2 to 2.5
Epoxy resin	4.0
Mica	3 to 7
Glass	5 to 10
Porcelain	6 to 7
Aluminium oxide	7
Ceramic materials	15 to 500

Here are a few questions for you to try:

Questions 3.1

Q3.1. An initially uncharged 10μF capacitor is charged through a 2MΩ resistor from a 15V supply. What voltage will appear across the capacitor 10 seconds after the supply is connected?

Q3.2. In Question Q3.1, what will the initial value of current be when the supply is first connected?

Q3.3. In Question Q3.1, what current will be flowing 40 seconds after the supply is first connected?

Q3.4. Two parallel metal plates, each of area 0·1m^2 are separated by a dielectric material having a relative permittivity of 200 and a thickness of 0·5mm. Determine the capacitance of this arrangement.

Introducing Capacitors

The specifications for a capacitor usually include the value of capacitance (expressed in μF, nF, or pF), the voltage rating (i.e. the maximum voltage which can be continuously applied to the capacitor under a given set of conditions), and the accuracy or tolerance (quoted as the maximum permissible percentage deviation from the marked value).

Other practical considerations when selecting capacitors for use in a particular application include temperature coefficient, leakage current, stability and ambient temperature range. Electrolytic capacitors require the application of a DC polarising voltage in order to work properly. This voltage must be applied with the correct polarity (invariably this is clearly marked on the case of the capacitor) with a positive (+) sign or negative (–) sign or a coloured stripe or other marking. Failure to observe the correct polarity can result in over-heating, leakage, and even a risk of explosion!

The typical specifications for some common types of capacitor are shown in Table 3.3.

Working voltages are related to operating temperatures and capacitors must be de-rated at high temperatures. Where reliability is important capacitors should be operated at well below their nominal maximum working voltages.

Where the voltage rating is expressed in terms of a direct voltage (e.g. 250V DC) unless otherwise stated, this is related to the maximum working temperature. It is, however, always wise to operate capacitors with a considerable margin for safety which also helps to ensure long term reliability. The author's own rule of thumb is that the working DC voltage of a capacitor should be no more than about 50% to 60% of its rated DC voltage.

Where an AC voltage rating is specified this is normally for sinusoidal operation. Performance will not be significantly affected at low frequencies (up to 100kHz, or so) but, above this, or when non-sinusoidal (e.g. pulse) waveforms are involved the capacitor must be de-rated in order to minimise dielectric losses that can produce internal heating and lack of stability.

Special care must be exercised when dealing with high-voltage circuits as large value electrolytic and metalised film capacitors can retain an appreciable charge for some considerable time. In the case of components operating at high voltages, a carbon film *bleed resistor* (of typically 1MΩ 0·5W) is often connected in parallel with the capacitor to provide a discharge path.

Some typical small capacitors are shown in Photos 3.1 to 3.3.

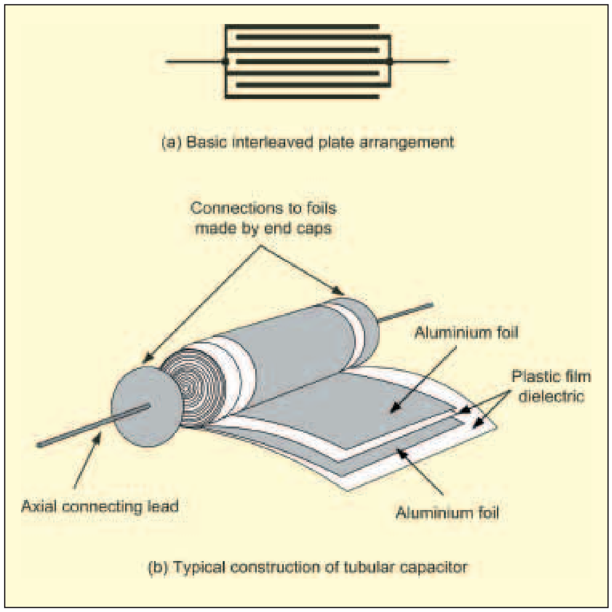


Fig.3.9. Capacitor construction

Check Point 3.3

The specifications for a capacitor usually include the value of capacitance (expressed in μF, nF or pF), the accuracy or tolerance of the marked value (quoted as the maximum permissible percentage deviation from the marked value), the voltage rating (which must be equal to, or greater than, the maximum expected voltage applied to the capacitor). The temperature coefficient and stability are also important considerations when a capacitor is used in some applications.

Capacitor Markings and Colour Codes

The vast majority of capacitors employ written markings which indicate their values, working voltages, and tolerance. The most usual method of marking resin dipped polyester (and other) types of capacitor

Table 3.3. Typical Capacitor Specifications

Capacitor type	**Ceramic dielectric**	**Electrolytic**	**Metalised film**	**Mica dielectric**	**Polyester dielectric**
Capacitance range	2.2pF to 100nF	100nF to 68mF	1µF to 16µF	2.2pF to 10nF	10nF to 2.2µF
Typical tolerance	±10% and ±20%	-10% to +50%	±20%	±1%	±20%
Voltage rating	50V to 250V	6.3V to 400V	250V to 600V	350V	250V
Temperature coefficent	+100 to -4700 ppm/°C	+1000 ppm/°C	+100 to +200 ppm/°C	+50 ppm/°C	+250 ppm/°C
Stability	Fair	Poor	Fair	Excellent	Good
Temperature range	-85°C to +85°C	-40°C to +85°C	-25°C to +85°C	-40°C to +85°C	-40°C to +100°C
Typical applications	General purpose	Power supplies	High-voltage power supplies	Oscillators, tuned circuits	General purpose

Photo 3.1. Various non-electrolytic capacitors with values ranging from 15pF to 470nF and voltage ratings from 50V to 250V

Photo 3.3. An airspaced variable capacitor used for tuning a radio receiver. This component is a dual-gang type that has two separate sections, each of which is variable over the range 5pF to 365pF

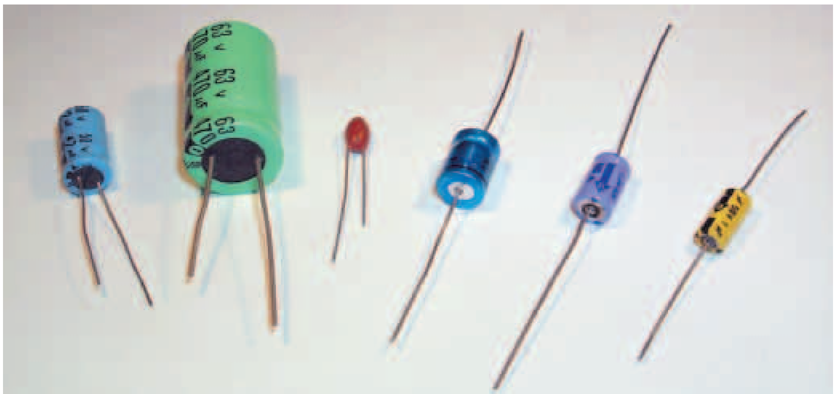


Photo 3.2. Various electrolytic capacitors with values ranging from 1µF to 470µF and voltages ratings from 10V to 63V

involves quoting the value (in µF, nF or pF), the tolerance (often either 10% or 20%), and the working voltage (using _ and ~ to indicate DC and AC respectively). Several manufacturers use two separate lines for their capacitor markings and these have the following meanings:

First line: capacitance (in pF or µF) and tolerance (K=10%, M=20%)

Second line: rated DC voltage and code for the dielectric material.

A three-digit code is sometimes used to mark monolithic ceramic capacitors. The first two digits correspond to the first two digits of the value whilst the third digit is a multiplier that gives the number of zeroes to be added to give the value in pF. Some typical capacitor markings, with their corresponding values, are shown in Fig.3.10.

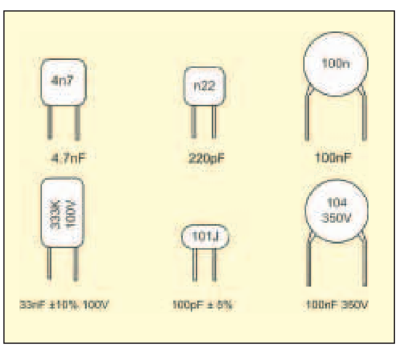


Fig.3.10. Some typical capacitor markings

The colour code shown in Fig.3.11 is used for some small ceramic and polyester types of capacitor. Note, however, that this colour code is not as universal as that used for resistors and that the values are marked in pF (not F).

Capacitors in Series and Parallel

In order to obtain a particular value of capacitance, fixed capacitors may be arranged in either series (Fig.3.12) or parallel (Fig.3.13).

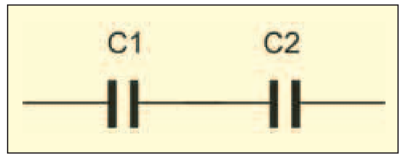


Fig.3.12. Two capacitors in series

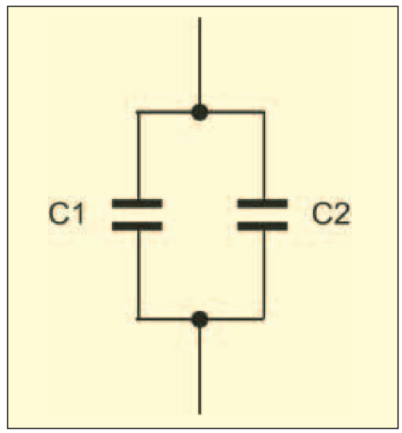


Fig.3.13. Two capacitors in parallel

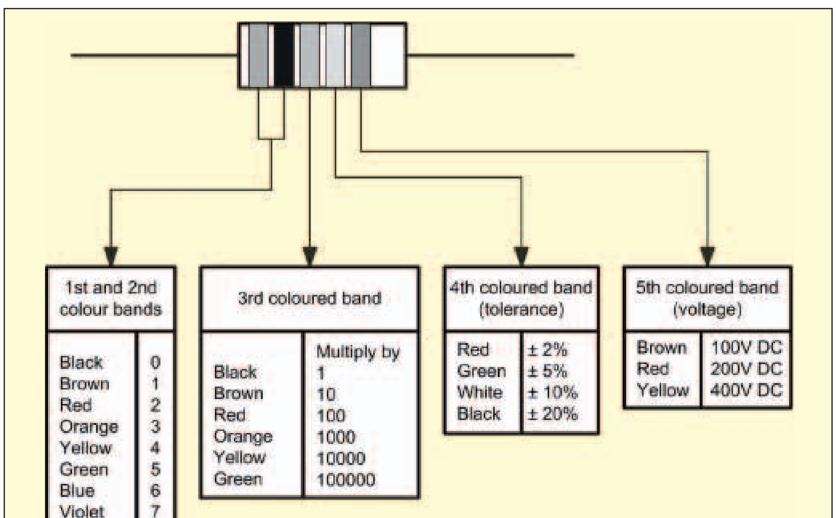


Fig.3.11. Capacitor colour code chart

When two capacitors are connected in series (Fig.3.12) the capacitance of the series circuit is given by:

$$\frac{1}{C} = \frac{1}{C1} + \frac{1}{C2}$$

This can be arranged to give the slightly more convenient expression:

$$C = \frac{C1 \times C2}{C1 + C2}$$

Note that this particular expression is *only correct for two capacitors*. It cannot be extended for three or more!

Check Point 3.4

The *reciprocal* of the equivalent capacitance of a number of capacitors connected in series can be found by simply adding together the *reciprocals* of the individual values of capacitance. When *only two* capacitors are connected in series it can be found by taking the *product* of the two capacitance values and *dividing* it by the *sum* of the two capacitance values (in other words, *product over sum*).

When two capacitors are connected in parallel (Fig.3.13) the capacitance of the parallel circuit is given by:

$$C = C1 + C2$$

Check Point 3.5

The equivalent capacitance of a number of capacitors connected in parallel can be found by simply adding together the individual values of capacitance.

Example 7

Capacitors of $2{\cdot}2\mu F$ and $6{\cdot}8\mu F$ are connected (a) in series and (b) in parallel. Determine the equivalent value of capacitance in each case.

Solution

(a) Here we can use the simplified equation for just two capacitors connected in series:

$$C = \frac{C1 \times C2}{C1 + C2} = \frac{2{\cdot}2 \times 6{\cdot}8}{2{\cdot}2 + 6{\cdot}8} = \frac{14{\cdot}96}{9} = 1{\cdot}66\mu F$$

(b) Here we use the formula for two capacitors connected in parallel:

$$C = C1 + C2 = 2{\cdot}2 + 6{\cdot}8 = 9\mu F$$

Questions 3.2

Q3.5. Determine the equivalent capacitance of each of the circuits shown in Fig.3.14.

Q3.6. Three $10\mu F$ capacitors are available. What values can be produced by connecting these components in different series/parallel arrangements?

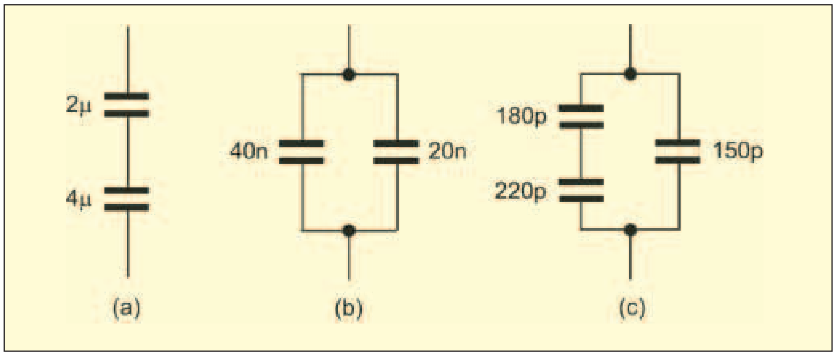


Fig.3.14. See question Q3.5

Practical Investigation 3.1

Objective: To investigate the charge and discharge of a capacitor.

Components and materials: Breadboard, 9V DC power source (either a PP9 9V battery or an AC mains adapter with a 9V 400mA DC output), digital multimeter with test leads, resistors of 100kΩ, 220kΩ and 47kΩ, capacitor of $470\mu F$, insulated wire links (various lengths), assorted crocodile leads, short lengths of black, red, and green insulated solid wire. A watch or clock with a seconds display will also be required for timing.

Circuit diagram: See Fig.3.15

Wiring diagram: See Fig.3.16

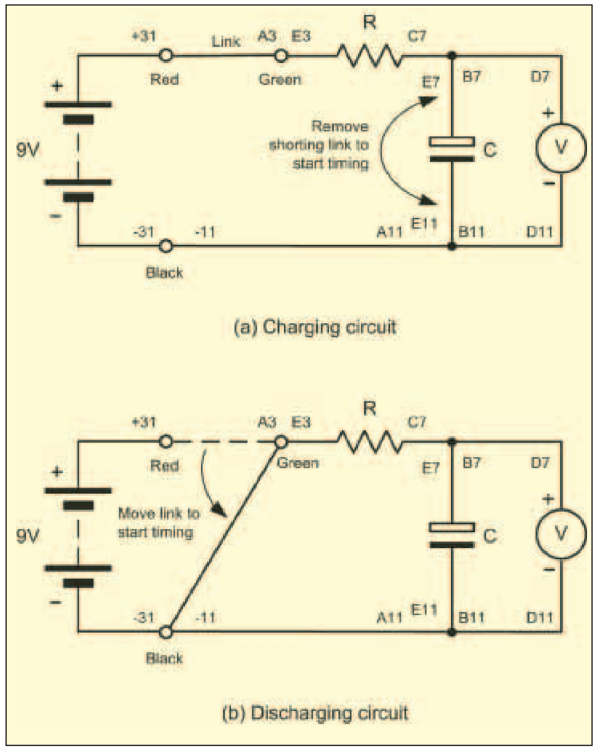


Fig.3.15. Circuit diagrams for the Practical Investigation 3.1

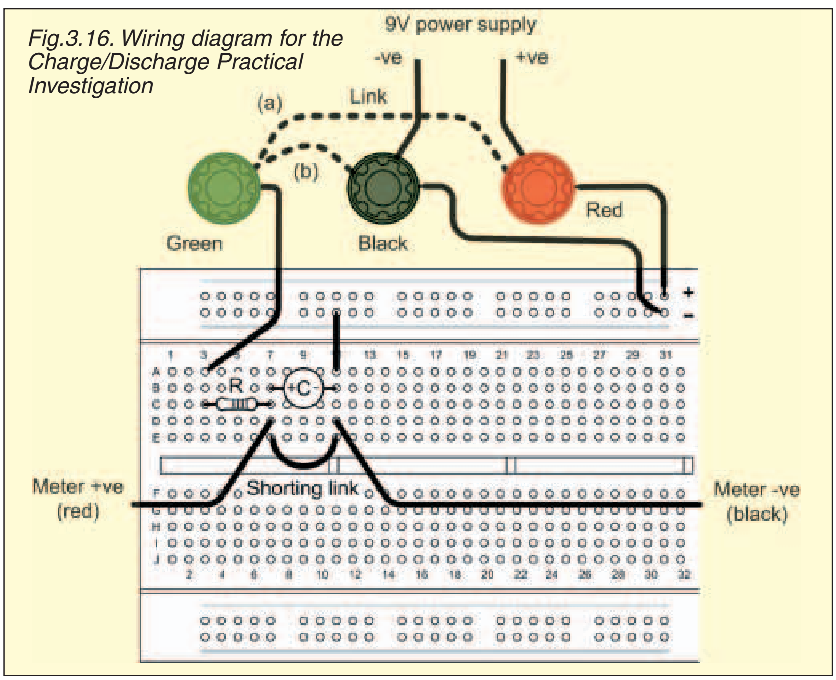


Fig.3.16. Wiring diagram for the Charge/Discharge Practical Investigation

Table 3.4

Step	Connection, link or component	From	To
1	-9V supply	-9V	Black terminal
2	+9V supply	+9V	Red terminal
3	Black wire	Black terminal	-31
4	Red wire	Red terminal	+31
5	Green wire	Green terminal	A3
6	100kΩ	C3	C7
7	470μF	B7	B11
8	Yellow link	A11	-11
9	Meter positive	V (Red)	D7
10	Meter negative	COM (Black)	D11

Table 3.5

Step	Connection, link or component	From	To
11	Wire link	Red terminal	Green terminal
12	Shorting link (remove to start timing)	E7	E11

Table 3.6

Step	Connection, link or component	From	To
13	Wire link (connect to start timing)	Black terminal	Green terminal

Procedure: The required breadboard wiring is shown in Table 3.4.

To carry out the charging investigation (Fig.3.15a) see Table 3.5.

To carry out the discharging investigation (Fig.3.15b) see Table 3.6.

Connect the circuit as shown in Fig.3.16 and the links as described in Steps 11 and 12. Before switching on the DC supply or connecting the battery, check that the meter is set to the 200V DC voltage range. Switch on (or connect the battery) then switch the multimeter on and read the capacitor voltage. This should be zero with the shorting link in place. Now remove the shorting link, start timing and record the charging capacitor voltage at the time intervals shown in Table 3.7.

Switch off (or disconnect the battery) and disconnect the circuit as described in Step 13. Start timing as soon as the link is reconnected (you will need to do this fairly quickly so as not to lose any charge). Record the discharging capacitor voltage at the time intervals shown in Table 3.7.

If time permits, repeat the investigation with R = 220kΩ and R = 47kΩ.

Table 3.7

Time (s)	Capacitor voltage (V)	
	Charging	Discharging
0		
10		
20		
30		
40		
50		
60		
70		
80		
90		
120		
150		
180		
210		
240		

Measurements:

Plot graphs of voltage (on the vertical axis) against time (on the horizontal axis) using the graph sheet shown in Fig.3.17.

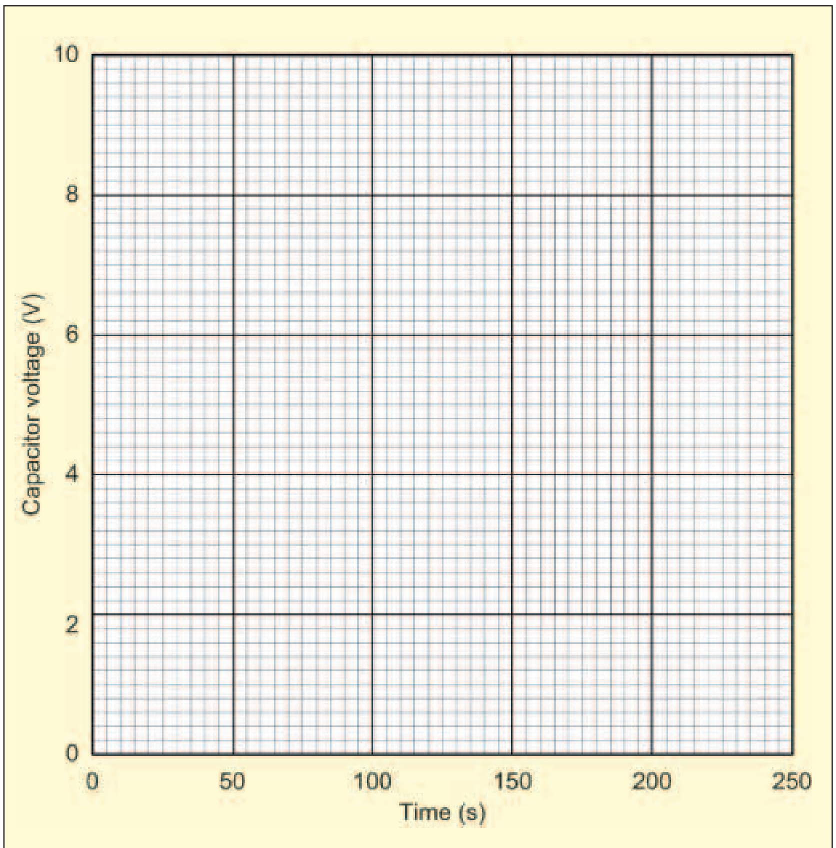


Fig.3.17. Graph sheet for plotting the results of the Charge/Discharge Practical Investigation

Conclusion:

Comment on the shape of the two graphs. Is this what you would expect? Calculate the time constant and mark this on your graph. Compare your results with the graphs shown in Figs.3.6 and 3.8.

Answers

Q.3.1. 5.9V
Q.3.2. 7.5μA
Q.3.3. 1.01μA
Q.3.4. 354nF
Q.3.5. 1.33μF, (b) 80n, (c) 249pF
Q.3.6. 3·33μF, 5μF, 6.67μF, 10μF, 15μF, 20μF, 30μF

Next Month

In Part 4, next month, we shall be introducing inductors, transformers and diodes and investigating power supply circuits. In the meantime you might like to see how you get on with our on-line quiz for Part 3. You will find this at: **www.mike-tooley.info/teach-in/quiz3.htm**

Correction Part 2 Dec '05

In Example 2.2, the formula used to solve this problem should be as follows:

–0·5 –I = 0 thus I = –0·5

The negative answer tells us that I is flowing in the opposite direction to that which we assumed in Fig.2.7.

In other words, the unknown current, I, is 0·5A flowing towards the junction.

PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

THE subject of producing front panel overlays and labels using a computer and a printer is a subject that has been covered in *EPE* in the past, and it usually produces a fair amount of interest from readers. This is not really surprising. Many of the more traditional methods of labelling panels have become obsolete or are difficult to use due to the limited availability of the materials required. The way things are going there will soon be no real alternative to using a hi-tech method such as a computer based system or an electronic label maker.

Professional Touch

Of course, even if all the traditional methods were still going strong, there would still be big advantages in using a computer. Perhaps the most important advantage is that it is much easier to produce professional looking results using a computer based system. In a similar vein, because the tasks are generally much easier using a computer, you can go that much further and produce dials, symbols, etc., that you could not tackle using traditional methods.

Comparing the costs of the old and new methods is difficult, but there seems to be no major difference. Both methods can be very cheap or quite expensive depending on the type and quality of the end result. However, this assumes that you have access to a suitable computer and printer. Even with the relatively low cost of modern computer hardware, producing panels using a computer is unlikely to be a practical proposition if you do not already own suitable equipment.

Past experience suggests that it is not the printing and fitting of computer labels and panels that causes the main problem for newcomers to this method of panel production. This aspect of things is fairly low-tech, and a little bit of ingenuity will usually crack any problems that arise. The main problem is in finding suitable design software that is free or reasonably cheap. Unfortunately, a drawing program of an appropriate type is not the type of thing that is likely to come as standard with a typical PC.

Graphic Illustration

These days many PC users have graphics programs that are primarily intended for enhancing digital photographs. While most software of this type can be used for producing labels and panels, it is less than ideal for the present application. Image editing and "paint" programs work with bitmaps, but vector graphics programs are better suited to the production of things like panel designs, technical drawings, and diagrams. Vector graphics programs are usually in the guise of CAD (computer aided design) and illustration programs.

CAD programs are intended for producing technical drawings such as circuit diagrams, machine parts, and architectural plans. Any reasonably modern CAD program that runs under Windows should be able to handle the full range of installed fonts (lettering styles) and produce printouts that are scaled accurately. This makes them well suited to the production of labels and front panel overlays.

In general though, illustration software is the better choice. Programs of this type are specifically designed for use by graphic designers, and often have features that enable text to be manipulated in clever and unusual ways.

An illustration program is therefore better if you wish to be artistic and "do your own thing". Try not to get carried away though. It is very easy to produce a design that uses a range of clever effects, but is confusing rather than helpful to those using the finished piece of equipment. Although more limited in scope, a simple CAD program is probably a more practical choice if you are only interested in producing simple and straightforward panel designs.

It is not necessary to use a drawing problem at all if you will only undertake the production of simple labels rather than complete panel overlays. Even the most basic of word processors can handle a wide range of text sizes using all the installed fonts. The simple word processor built into Windows (WordPad) is perfectly adequate for this type of thing. It is launched by going to the Start menu and selecting Accessories and the WordPad from the sub-menu that appears.

Cheap or Free

Illustration and CAD software tends to be aimed at professional users, which means that much of it is quite expensive. AutoCAD is the industry standard CAD program, and even in its cut down "LT" version it costs hundreds of pounds. Corel Draw is probably the most widely used illustration program, and as part of a graphics suite it is a comparative snip at a few hundred pounds.

Probably the most realistic "big name" option is Corel Draw Essentials 2 at about £50 plus VAT. According to the Corel UK web site **www.corel.co.uk** this now includes Corel Draw 11, which is only one version down from the latest version, and is the one that the author sometimes uses. This is definitely a bargain, but it can be difficult to track down a source that actually has it in stock.

Any recent version of Corel Draw has a fairly straightforward user interface (see Fig.1) and does not look very intimidating. The same is true of other high-end illustration programs such as Adobe Illustrator, but make no mistake, these are powerful programs that have a huge number of features.

It requires a bit of effort to master the basics of these programs, and a fair amount of time and effort to really get to grips with the more advanced features. It pays to bear in mind that these programs have sophisticated undo facilities so that you can go back a number of steps if things go badly awry!

Cost Conscious

Even £50 or so is a fair amount of money for software that will only be used to design and print front panels for projects. However, there are very low cost and free alternatives.

While these will not give the full range of features available from expensive illustration software, they should still enable perfectly good front panel designs to be produced.

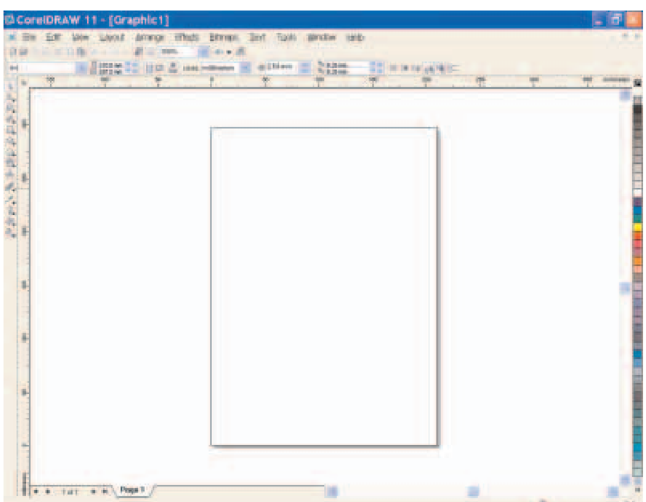


Fig.1. Programs such as Corel Draw are deliberately designed to have an uncomplicated user-interface. Do not be fooled though, as the range of facilities available is truly vast

The large computer stores usually have displays of cheap software that is often something less than fully up-to-date but still perfectly usable. There should be at least one CAD program or some other type of drawing software on offer.

Freebies

A few years ago there were plenty of free drawing programs available, including free versions of some powerful CAD programs. Unfortunately, the free versions of programs such as TurboCAD and IntelliCAD seem to have been withdrawn. Although there are still many free drawings programs available on the Internet, most of these seem to be very basic with minimal facilities for handling text. However, there is still a free version of DrawPlus, which is a CorelDraw style program from the British company Serif. This download is available from **www.freeserifsoftware.com** and not the main Serif site (www.serif.com).

QuickTours shows you how to add objects onto a drawing and edit them, how to manipulate text, and so on.

There is obviously no printed manual with a program that is a free download, and there is no PDF version either. Consequently, the QuickTours are more than a little useful. DrawPlus 4.0 also has a comprehensive Help system that is fully functional.

When the program is used in earnest for the first time you must select a page size. This will usually be the default paper size of the printer. You are then taken into the program, which has the usual menus, buttons, etc. (see Fig.3). The normal first step is to draw the outline of the front panel, and various drawing tools are available via the buttons on the left. The rulers above and to the left of the drawing area are useful, but in order to get everything placed accurately it is essential to use the snap-grid feature. This is a grid of dots on the screen, and it is only possible draw

restricted to simple solid fills. A graduated fill can be used, as in the example panel design in Fig.3.

Transparently Obvious

When two objects overlap, one of them will be on top and fully visible while the other will be to the rear and at least partially obscured by the other. In Fig.3 the text and "holes" are on top, and the panel is behind. Options in the Arrange menu enable the order of objects to be controlled. Using the facilities of the Transparency tab near the top right-hand corner of the window it is possible to "fade" objects so that anything behind them tends to show through. Probably not the type of thing you would use on every panel design, but it could be useful.

Text is added via the text tool button on the left of the window. The Text tab in the right-hand section of the screen then gives the usual range of Windows fonts, text sizes, alignment options, and

Fig.2. Before using the DrawPlus 4.0 in earnest it is a good idea to view the QuickTours. The program has a good built-in Help system

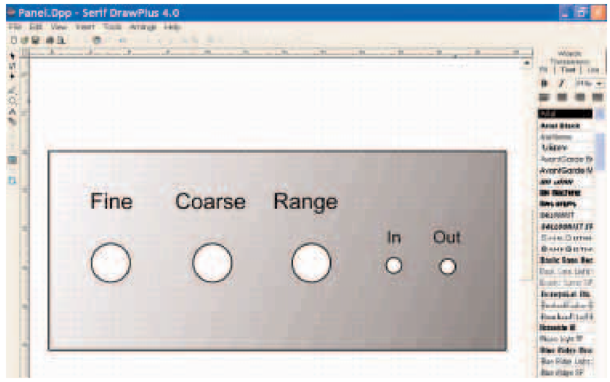


Fig.3. DrawPlus 4.0 has the usual menu bar and control buttons. The drawing facilities are mainly accessed via the buttons on the left. Note the dot grid pattern

The free download is version 4.0, while the current commercial version is 7.0, so the free version is a few years old. It still has a good range of features though, and it does not require an advanced PC in order to run well. Version 5.0 is sometimes given away on the "free" cover-mounted discs of computer magazines, and it might be worthwhile keeping an eye out for it. Should you decide to move up to the latest version it will only cost about £50.

You have to go through a simple registration process in order to obtain a validation code for any free version of the program. This requires the submission of a proper email address, but it is not essential to use your normal email address. If you do not already have a "dummy" account for this type of thing you can quickly set up a new account with one of the many free email services.

On Tour

The initial screen of Fig.2 is obtained when the program is first run. Normally the "Create a Drawing" option is used here, but initially it is a good idea to use the "View a QuickTour" option. The

lines to and from these dots, place objects on them, and so on. The grid spacing can be adjusted via the Snapping section of the Options dialogue box (Fig.4). This is obtained by selecting Options from the Tools menu.

With this type of program all non-text objects have an outline and a fill. There are two tabs near the top right-hand corner of the window that provide access to the Fill and Line settings. The Line settings control both simple lines and the outlines of shapes. It is possible to effectively get rid of outlines by setting a width of zero, and fills can be removed by using white as the fill colour or using the "None" option.

Like most programs of this type, you are not

so on. For the final positioning of text it can be useful to switch off the snap grid. The best position for each piece of text is the one that looks the best and not necessarily the one that is mathematically correct.

Although the full range of installed fonts will be available, most will be of little use in the current context. For many panels something simple and straight-

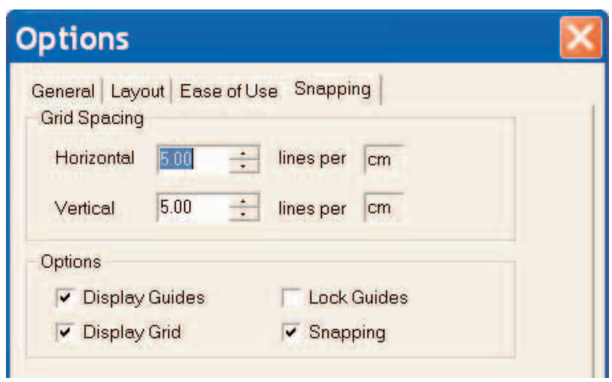


Fig.4. This section of the options screen enables the size of the snap grid to be adjusted. The grid is essential when drawing with precision, but it can be switched off when you need to do things "by eye"

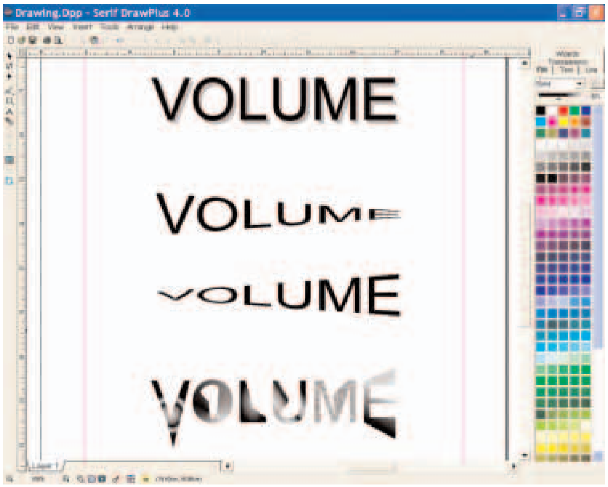


Fig.5. The range of effects that can be applied to text is impressive but try not to get carried away

forward will be the best choice. Many fonts tend to look rather "heavy" when used for front panels. The Arial font supplied with Windows usually looks neat when used on control panels.

It is possible to apply a huge range of effects to text using a program such as DrawPlus 4.0. The drop-shadow effect at the top in Fig.5 was produced by copying the word, fading it using the Transparency feature, and offsetting it slightly from the original. The two pieces of text near the middle of the window have been distorted using the Envelope feature.

In the example near the bottom of the window the text has been converted to curves. In other words, it has been turned into ordinary fills and outlines so that the normal editing facilities can be used. This makes it possible to adjust the nodes that control the shape of each letter so that elaborate distortions can be applied. It also makes it possible to have a different colour and fill style for each letter.

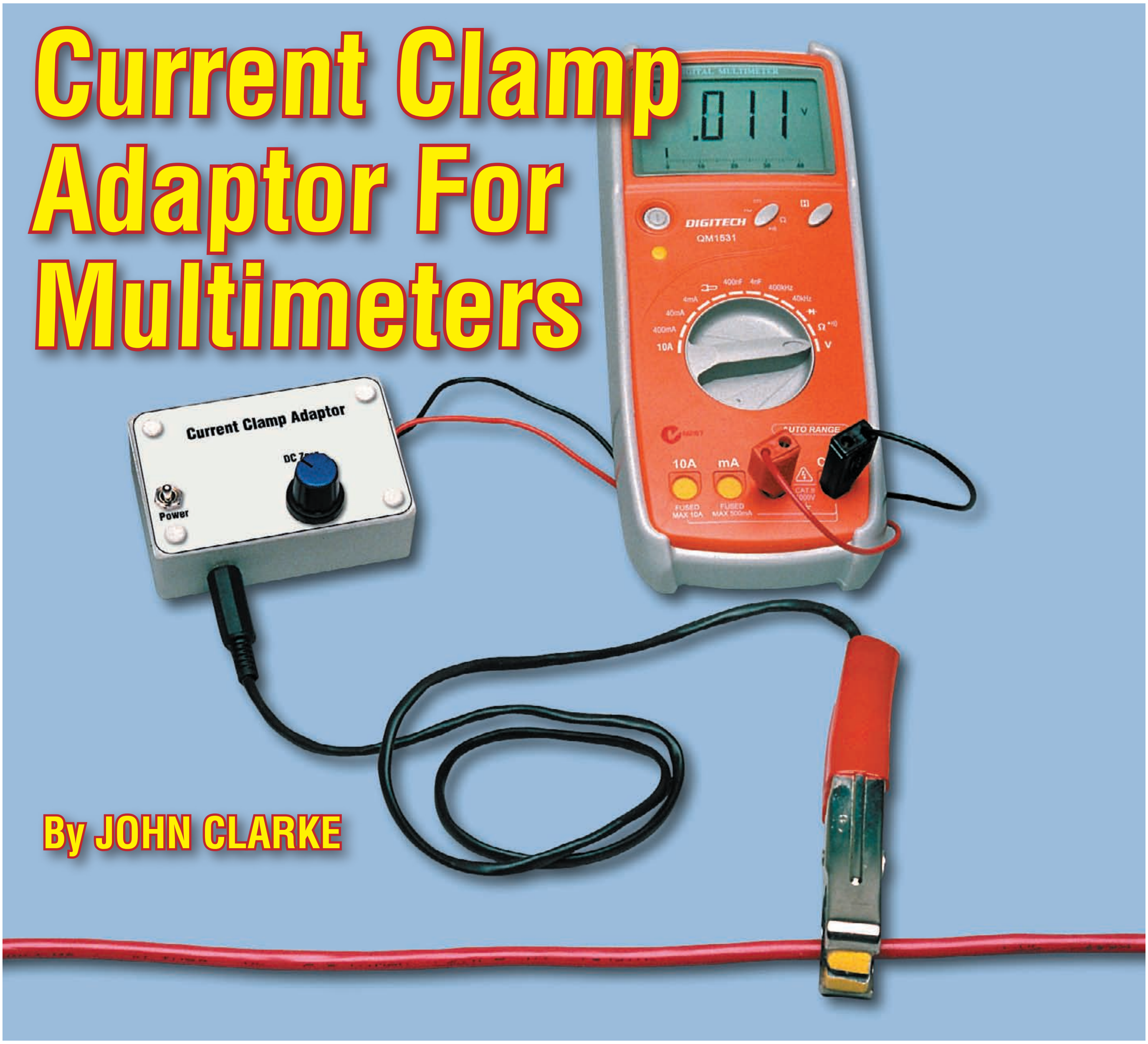
Finally

When designing a panel using a computer do not overlook the practicalities. Make careful measurements to ensure that the layout leaves sufficient room for the actual controls, sockets, lights, or whatever. Make sure that the legends will not be partially obscured by the control knobs, and try to avoid the classic mistake of missing out a control or socket! If you include drilling marks, the finished design can be printed on ordinary paper, temporarily fixed to the actual panel, and then used as a drilling guide.

Try not to get carried away with clever but inappropriate effects. A psychedelic front panel could be well suited to some projects, but is likely to look decidedly out of place on something like a piece of test gear. Be prepared to take some time to learn the range of facilities available from whatever drawing program you use.

Current Clamp Adaptor For Multimeters

By JOHN CLARKE



Looking for a current clamp meter that won't break the bank? Here's a simple clamp meter adaptor that you can build for about £15. It plugs into a standard DMM and can measure both AC and DC currents.

CLAMP METERS are very convenient when it comes to measuring current, since they do not require breaking the current path. Instead, they simply clip over the wire or lead that's carrying the current and the reading is then displayed on the meter.

This is not only much easier than "in-circuit" current measurements but is often a lot safer as well; eg, where high voltages and currents are involved. However, clamp meters are not particularly useful for making low-current measurements (ie, below 1A) due to their inaccuracy and lack of resolution.

Unlike this unit, many commercial current clamp meters can only measure AC. That's because they are basically current transformers, comprising turns of wire around a magnetic core. This magnetic core is clipped around the wire to be measured, which effectively behaves as a half-turn primary winding. The winding on the core itself acts as the secondary and connects to the multimeter's current terminals.

The measured current is a divided down value of the true current flowing in the wire. Usually, the division ratio is 1000:1 so that 1mA shown on the meter equates to 1A through the wire that's being measured.

Clamp meters capable of measuring DC as well as AC do not use a current transformer but a Hall effect sensor instead. This sensor is placed inside

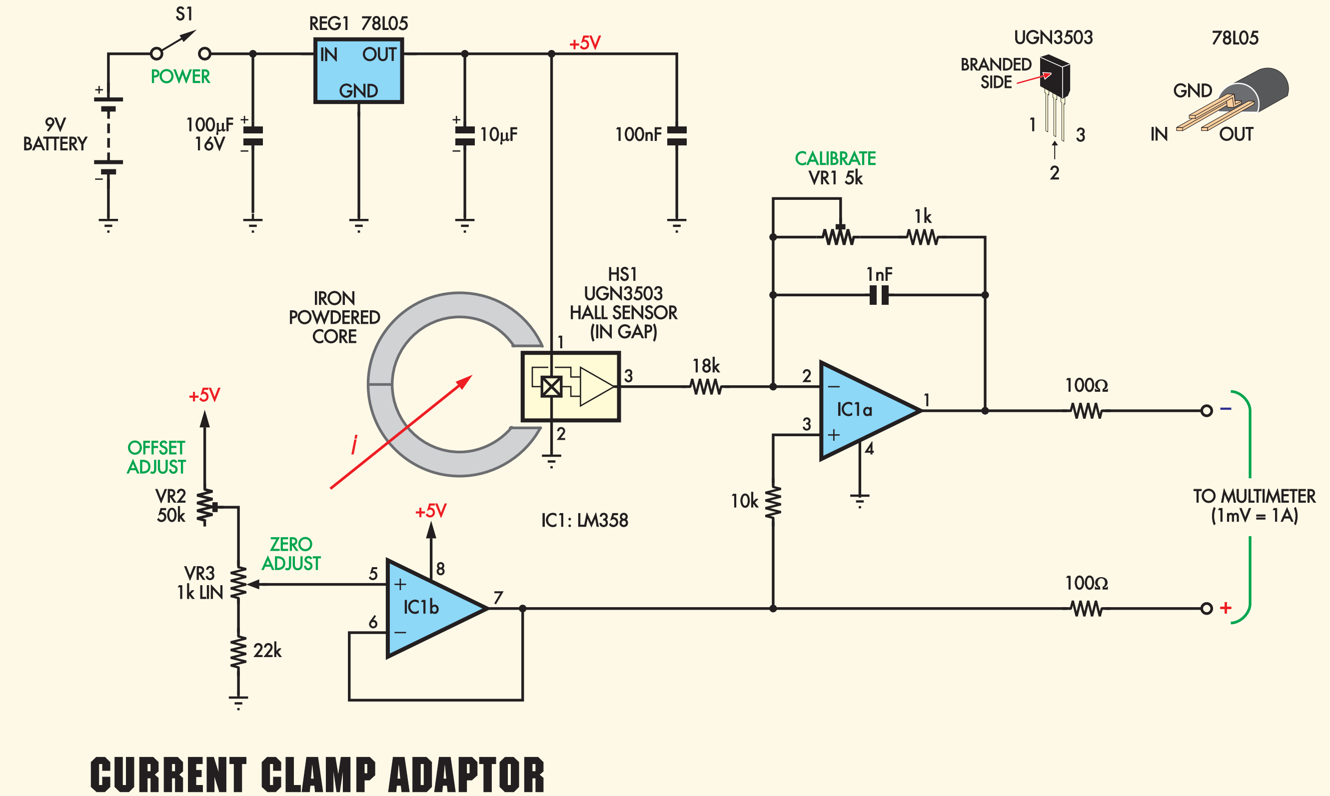


Fig.1: the circuit uses Hall effect sensor HS1 which produces a voltage at its pin 3 output that depends on the magnetic field induced into an iron-powdered toroid core. This voltage is fed to op amp IC1a which then drives the negative terminal of the multimeter. IC1b drives the meter's positive terminal and provides null adjustment.

a gap in an iron-powdered toroid core. It measures the magnetic flux produced as a result of the current flowing through the wire and produces a proportional output voltage.

How it works

To make it as versatile as possible, the Clamp Meter Adaptor also uses a Hall effect sensor so that it can measure both DC and AC currents. The output of this sensor is then processed using a couple of low-cost op amps which then provide a signal for a standard DMM or analog multimeter.

When measuring DC current, the multimeter is set to its DC mV range and 1A through the wire in the core equates to a reading of 1mV on the meter. A potentiometer allows the output to be nulled (ie, adjusted to 0mV) when there is no current flow.

Similarly, for AC current measurements using the clamp meter, the multimeter is simply set to its AC mV range. In this case, the DC offset potentiometer is not needed, since the multimeter automatically ignores any DC levels.

The high-frequency response of the adaptor for AC measurements is 3dB down at 20kHz (ie, 0.7071 of the real value). However, the actual measurement displayed will also depend on the high-frequency response of the multimeter itself. Some multimeters give useful readings up to 20kHz, while others begin to roll off the signal above 1kHz (ie, frequencies above this will not be accurately measured).

If necessary, the output from the Clamp Meter Adaptor can be monitored using an oscilloscope if AC measurements have to be made at high frequencies. However, AC current measurements at 50Hz (ie, the mains frequency) will be accurate using virtually any multimeter.

Note that most multimeters are calibrated to display the RMS values of AC current measurements, although they are only accurate for sinusoidal waveforms. This unit will not affect meter calibration, since it does not change the shape of the waveform for signals below 20kHz and only converts the current waveform to a voltage waveform. However, for non-sinusoidal waveforms, the multimeter will display an erroneous result unless it is a true RMS type.

Specifications

Output: 1A = 1mV for AC and DC ranges

Resolution: multimeter dependent (100mA with 0.1mV resolution on multimeter)

Maximum DC current: 150A recommended (up to 900A if core is demagnetised afterwards)

Maximum AC current: 630A recommended

Linearity: typically better than 4% over range at 25°C

AC frequency response: -3dB at 20kHz (meter reading depends on multimeter AC response)

Current consumption: 15mA

Demagnetising the core

One problem with clamp meters is that the core can remain magnetised after making high DC current measurements; ie, even when the current flow has been reduced to zero. In fact, this effect becomes apparent when measuring DC currents above about 150A. It is easily detected because the output from the sensor remains at several millivolts after the current ceases flowing.

Fortunately, there's an easy solution to this. If the core does become magnetised, it can be demagnetised again by momentarily reversing the current flow in the core.

In practice, this is done by unclipping the core from the wire, replacing it over the wire upside down and applying the current again for a brief period of time.

Modified battery clamp

To keep costs down, the Clamp Meter Adaptor uses a modified car battery clip as the current clamp. This is fitted with an iron-powdered toroid core which is cut in half so that the clip can be opened and slipped over the current-carrying wire. The Hall effect sensor sits in a gap in the toroid, near the front of the clip – see Fig.2.

The output from this sensor is fed to a processing circuit which is built on a small PC board and housed in a plastic case, along with the battery. This circuit in turn connects to the meter via two leads.

By the way, commercial clamp meters using Hall effect sensors usually place the sensor at the hinge end of the core. This can be done when the clamp material is non-magnetic. However, when the clamp is magnetic, as in this design, the magnetic flux is conducted through it instead and bypasses the air gap where the sensor sits – see Fig.2 (top drawing).

This problem is solved by simply placing the sensor in an air gap at the front of the clamp, so that it cannot be bypassed.

Circuit details

Refer now to Fig.1 for the circuit details. It's relatively simple and comprises a dual op amp (IC1a & IC1b), a 3-terminal regulator (REG1), the Hall effect sensor (HS1) and a few resistors and capacitors.

Power for the circuit is derived from a 9V battery and is fed to REG1 which provides a regulated +5V rail. This then powers the Hall effect sensor and op amps IC1a & IC1b. Note that a regulated supply is necessary, since the Hall sensor output will vary with supply rail variations.

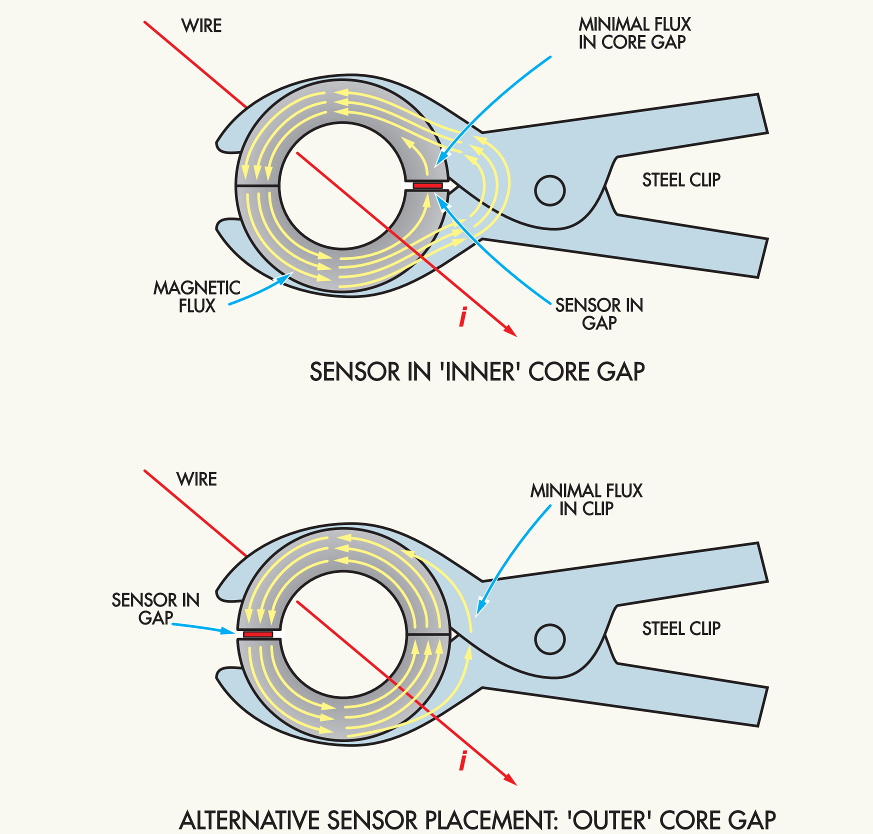


Fig.2: if a steel (ie, magnetic) clamp is used, the Hall sensor must be placed in an air gap in the toroidal core as shown in the bottom diagram. This is necessary to ensure that it is not bypassed by magnetic flux flowing through the clamp instead.

In operation, the Hall effect sensor produces a voltage at its pin 3 output that depends on the magnetic field in the core. If the marked face of the sensor faces a south magnetic field, its output voltage will rise. Conversely, if it faces a north field, the output voltage will fall.

The sensor's output with no magnetic field applied to it will sit between 2.25V and 2.75V, depending on the sensor. This voltage remains stable, providing the supply voltage remains stable.

The output of the Hall effect sensor is fed to op amp IC1a. This stage is wired as an inverting amplifier and it attenuates the signal by an amount that depends on the setting of trimpot VR1 (calibrate). Note that the gain of IC1a is set by the resistance between pins 1 & 2 divided by the 18kΩ input resistor.

This means that if VR1 is set to half-way, IC1a has a gain of (2.5kΩ + 1kΩ)/18kΩ = 0.19.

In practice, VR1 is adjusted so that it produces an output of 1mV per amp flowing through the current-carrying wire.

Op amp IC1b and its associated circuitry compensate for the initial DC voltage at the output of the Hall effect sensor (ie, with no magnetic field applied). As shown, IC1b is connected as a unity gain buffer with its output connected to its pin 6 inverting input. The non-inverting input at pin 5 connects to a resistive divider network consisting of VR2, VR3 and a 22kΩ resistor.

The output from IC1b (pin 7) goes to the positive meter terminal and is also used to bias pin 3 of IC1a via a 10kΩ resistor. This bias voltage is nominally about 2.5V (ie, 0.5Vcc) and allows the output of IC1a to swing up or down about this voltage, depending on the sensor input. It also effectively allows the quiescent voltage from the Hall sensor to be nulled so that we get a 0V reading on the meter when no current is being measured.

VR2 is initially adjusted with VR3

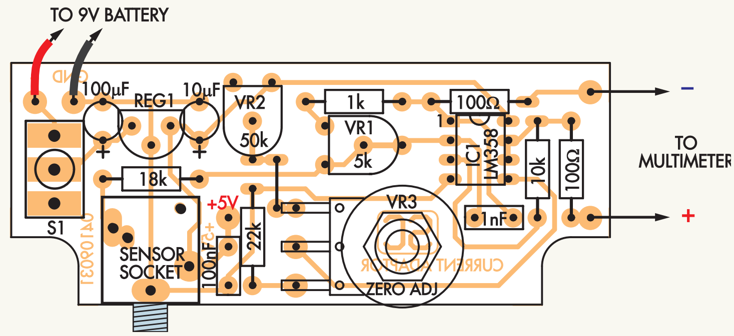


Fig.3: install the parts on the PC board as shown here. The Zero Adjust pot (VR3) is installed by soldering its terminals to three PC stakes.

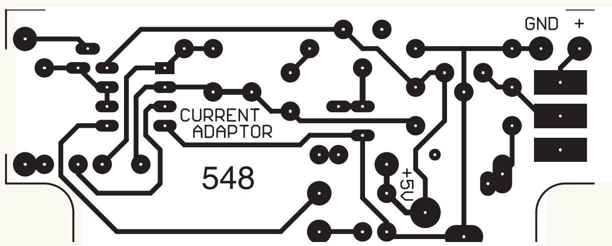


Fig.4: the full-size etching pattern for the PC board.

set to mid-range, so that the multimeter reads 0V with no magnetic field applied to the Hall sensor. VR3 is then adjusted during subsequent use of the clamp meter – it can vary IC1b's output by about 25mV to null out any small voltage readings.

In effect, trimpot VR2 acts as a coarse offset adjustment, while VR3 allows fine adjustment to precisely zero the reading.

Looked at another way, VR2 & VR3 are simply adjusted so that the voltage on pin 7 of IC1b is the same as the voltage on pin 1 of IC1a when there is no magnetic field applied to the Hall effect sensor – ie, the voltage between pins 1 & 7 is 0V.

The outputs from both op amps are fed to the multimeter via 100Ω resistors. These provide short-circuit protection for the op amp outputs and also decouple the outputs from the cable capacitance.

Construction

Building the circuit is easy since all the parts are mounted on a small PC board coded 548 and measuring 75 × 30mm. Begin construction by checking the PC board for any shorts between tracks and for any breaks in the copper pattern. Also check that the hole sizes are all correct for the various components, particularly those for the PC-mount stereo socket and the on/off switch (S1).

Note that two of the corners on the PC board need to removed, so that the board later clears the corner pillars inside the case. If your board is supplied with these corners intact, they can be cut away using a small hacksaw and carefully finished off using a rat-tail file.

Fig.3 shows the assembly details. Install the resistors and wire link first, using Table 1 to guide you on the resistor colour codes. It's also a good idea to check the resistor values with a DMM, just to make sure.

IC1 can go in next, taking care to ensure that it is oriented correctly. That done, install the trimpots and the capacitors, noting that the electrolytics must be oriented with the polarity shown. The trimpots are usually labelled with a code value, with 502 equivalent to 5kΩ (VR1) and 503 equivalent to 50kΩ (VR2).

Next, install PC stakes at the two power supply inputs, the +5V terminal, the three VR3 terminal positions and the two multimeter outputs. These can be followed with the switch and the PC-mount stereo socket.

Finally, complete the board assembly by installing potentiometer VR3 – it is mounted with its terminals soldered to the top of its PC stakes. Position it so that the top of its mounting thread is at the same height as the top of the switch thread.

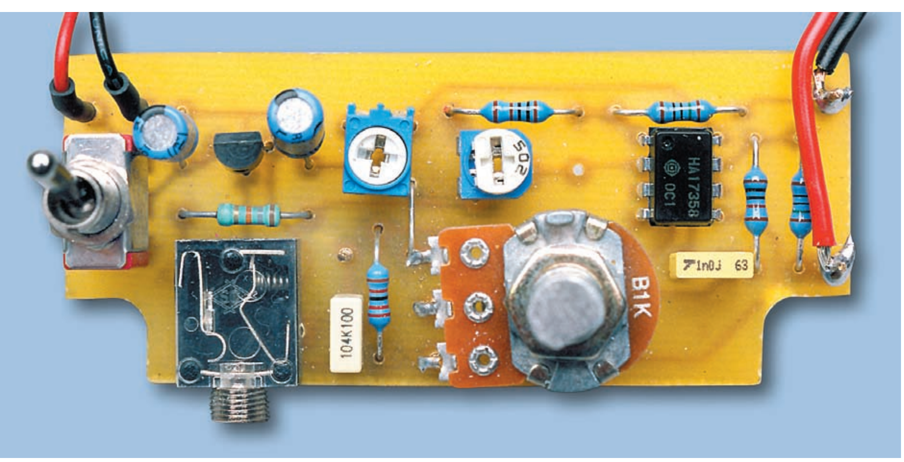
Drilling the case

The front panel artwork (Fig.8) can now be used as a template to mark out and drill the lid of the small plastic utility case that's used to house the board. You will need to drill two holes – one for the switch and the other for the potentiometer.

In addition, you will have to drill a 4mm hole in one end of the case for the multimeter leads, plus a 7mm hole in one side to accept the stereo socket. The latter should be positioned 14mm down from the top of the case and 21mm in from the outside edge.

Note that it's always best to drill small pilot holes first and then carefully enlarge them to size using a tapered reamer.

Next, the integral side clips inside the box need to be removed using a



Check your completed PC board assembly carefully to ensure that all polarised components have been correctly installed. These parts include IC1, REG1 and the two electrolytic capacitors.

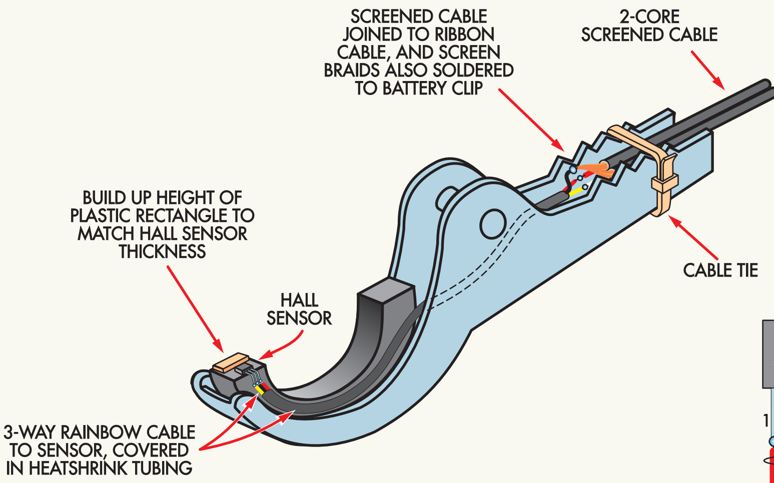
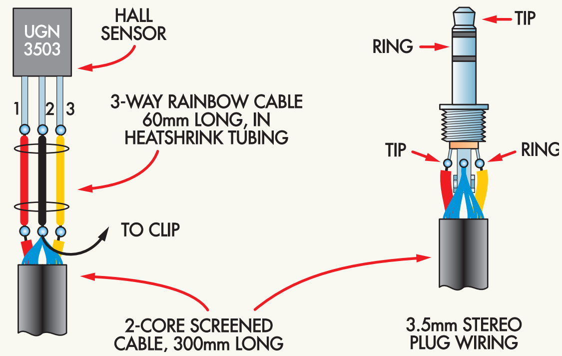


Fig.5 (above): this exploded diagram shows how the toroid core and Hall sensor are fitted to the clamp. Each core half is secured in position using builders' adhesive, as are the Hall sensor and the adjacent plastic rectangle. Note the earth connection to the metalwork of the clamp.

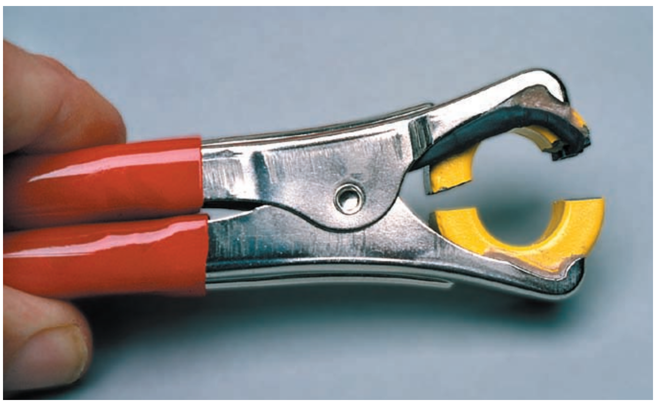
Fig.6 (below): a 60mm-length of 3-way rainbow cable is used to make the connections to the Hall sensor. This cable is then joined to a 300mm length of 2-core shielded cable which is then terminated in 3.5mm stereo plug.



chisel. Be sure to protect your eyes when doing this, as the plastic tends to splinter and fly out. You can then attach the front panel label and cut the holes out with a sharp knife.

The next step is to solder the battery clip leads to the supply terminals (red to positive, black to negative). That done, connect the multimeter leads to the output terminals, then feed these wires through the hole in the box and attach banana plugs to each free end.

Don't fit the board to the case lid at this stage. That step comes later, after calibration has been completed.



This view of the completed current clamp clearly shows the general arrangement. If the toroid core becomes magnetised during use, it can be demagnetised by momentarily reversing the current flow in the core.

Clamp assembly

The clamp assembly comprises a car battery clip, the toroidal core and the Hall effect sensor. Figs.5 & 6 show the assembly details for this unit.

The first step is to cut the core in half using a fine-toothed hacksaw blade. That done, the Hall sensor should be wired using a 60mm length of 3-way rainbow cable which should be sheathed in heatshrink tubing (see Fig.5). The other end of this cable is then connected to a 300mm length of 2-core shielded cable which in turn is terminated with a 3.5mm stereo plug.

As shown in Fig.6, the cable shields are joined together and connected to the earth lead of the rainbow cable. They are also connected to the metalwork of the clip using a short length of hookup wire. Small pieces of insulating tape should be used to prevent shorts between the wires where the cables join, after which the join should be covered using heatshrink tubing.

Table 2: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
100nF	0.1µF	104	100n
1nF	0.001µF	102	1n0

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	22kΩ	red red orange brown	red red black red brown
❏	1	18kΩ	brown grey orange brown	brown grey black red brown
❏	1	10kΩ	brown black orange brown	brown black black red brown
❏	1	1kΩ	brown black red brown	brown black black brown brown
❏	2	100Ω	brown black brown brown	brown black black black brown

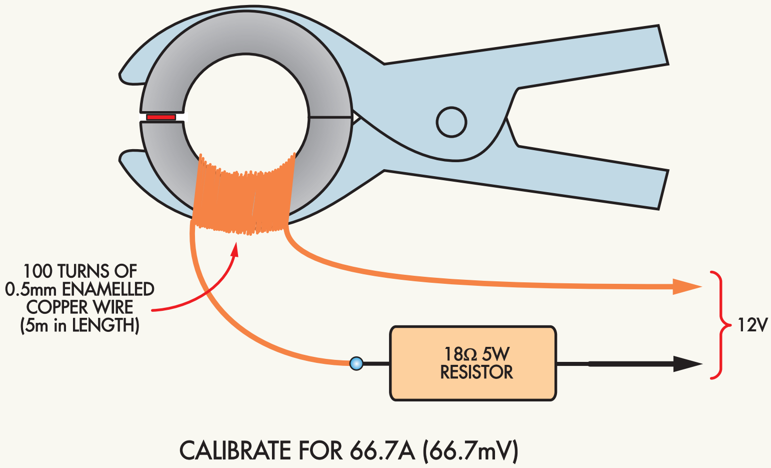


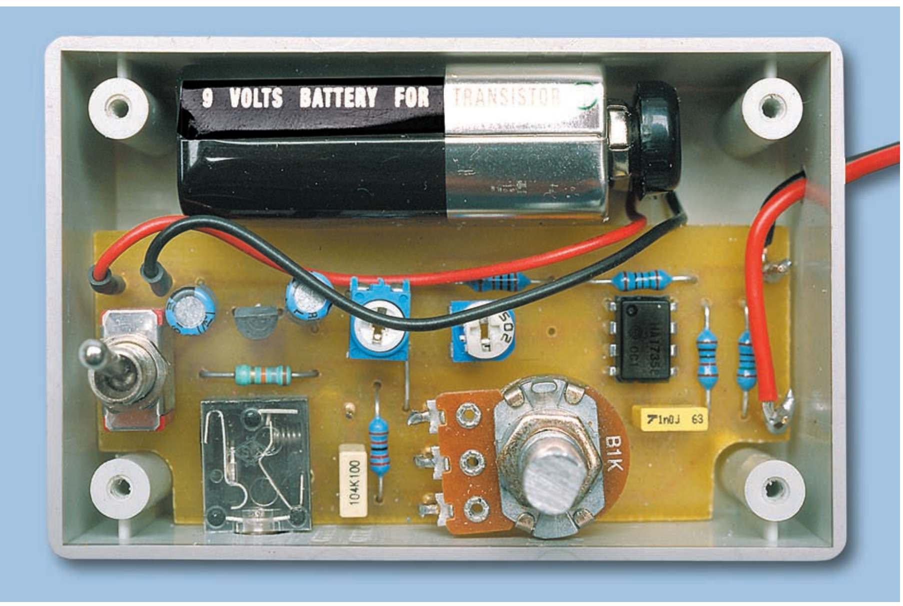
Fig.7: this simple setup can be used to calibrate the Clamp Meter Adapter. Null the reading first using potentiometer VR3, then switch on the 12V supply and adjust trimpot VR1 for a reading of 66.7mV.

The next step is to glue the Hall sensor to one of the core pieces using some builders' adhesive (it can go in either way up). That done, glue a small piece of plastic to the remaining part of the core gap to protect the Hall sensor from damage when the clamp closes. Naturally, this piece of plastic needs to be slightly thicker than the Hall sensor to provide this protection.

The two core pieces can now be glued in position on the jaws of the battery clip, again using builders' adhesive. Make sure that the two halves are correctly aligned before the glue sets.

Once the core pieces are secure, the wiring for the Hall sensor can be glued in position and secured at the end of the clip with a cable tie. In addition, the metal tabs on the clip should be bent over to hold the wire in place. This must also be done on the other handle, so that the jaws of the clamp can be opened as wide as possible.

The 3.5mm stereo plug is wired as shown, with the tip and ring terminals connecting to the red and black wires respectively. If your twin shielded wire has different colours, take care to ensure that pin 1 on the Hall sensor goes to the tip connection. Pin 3 must go to the ring terminal and pin 2 is the ground and shield.



There's plenty of room inside the case for the PC board and a 9V battery. The board is held in position by slipping the case lid over the switch and pot shafts and doing up the nuts.

As it stands, the clamp can be slipped over leads up to 7mm in diameter. A larger clamp with jaws that open wider than the specified unit will be necessary if you intend measuring currents flowing in leads that are thicker than 7mm.

Note that the clamp adapter is not suitable for use with 240VAC mains when the wiring is uninsulated.

Testing

The unit is now ready for testing. First, connect the battery and check that there is +5V at the test point on the PC board (ie, 5V between this test point and ground). There should also be +5V on pin 8 of IC1.

If these measurements check OK, plug the clamp assembly into the socket on the PC board and check the voltages again. If they are no longer correct, check component placement and the wiring to the Hall sensor.

Next, connect the output leads from the unit to the voltage inputs on your multimeter and set the range to mV DC. That done, set VR3 to its mid-position and adjust VR2 for a reading of 0mV.

Calibration

The Current Clamp Adaptor is calibrated using a 12V power supply, a 5m length of 0.5mm enamelled copper wire and an 18Ω 5W resistor.

First, wind 100 turns of the ECW around the core and connect it to the 12V supply via the 18Ω resistor as shown in Fig.7. The current through the wire will be 12/18 = 0.667A and, as far as the clamp meter is concerned, this is effectively multiplied by 100 due to the number of turns on the core.

All you have to do now is adjust VR1 for a reading of 66.7mV. And that's it – the calibration is complete!

Note that if the power supply is not exactly 12V, you can compensate for this by calibrating to a different reading. Just measure the supply voltage, divide the value by 18 (to get the current) and multiply by 100 to obtain the calibration number.

For example, if you are using a 13.8V supply, you will have to set VR1 for a reading of 76.7mV on the meter (ie, 13.8/18 × 100 = 76.7).

Once the calibration has been completed, the PC board can be attached to the case lid. It's held in place simply by slipping the lid over the switch and pot shafts and doing up the nuts.

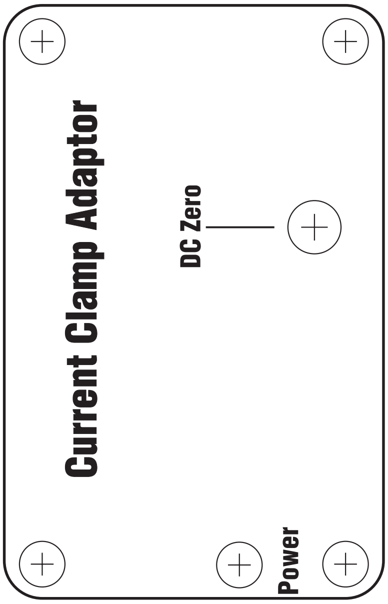


Fig.8: this full-size artwork for the front panel.

Using the clamp meter

Note that before making a measurement, the DC Zero potentiometer must first be adjusted so the multimeter reads 0mV when there is no current flow. Note also that the core may need to be demagnetised after measuring high DC currents, as described previously. This will be necessary when the DC Zero control no longer has sufficient range to null the reading.

When measuring relatively low currents (eg, between 100mA and 10A), increasing the number of turns of the current-carrying wire through the core will improve the resolution. However, this will only be possible if the wire diameter allows the extra turns to be fed through the core.

Note that the readout on the multimeter must be divided by the number of turns through the core to obtain the correct current reading. Note also that the accuracy of the unit will vary according to the temperature of the Hall sensor, particularly when making high current measurements.

By the way, it's a good idea to mark the top of the clamp with an arrow to indicate the direction of positive current flow once you have the unit working correctly. This can easily be determined by trial and error.

Finally, do not forget to switch the unit off when it is not in use. There's no power indicator LED to warn you that the unit is on, so take care here! *EPE*

Parts List

1 PC board, code 548, 75 x 30mm, available from the *EPE PCB Service*
1 plastic box, 82 x 54 x 30mm
1 iron powdered toroidal core, 28 x 14 x 11mm
1 50A car battery clip
1 3.5mm stereo PC board mount socket
1 3.5mm stereo jack plug
1 SPDT toggle switch (S1)
1 5kΩ (code 502) horizontal trimpot (VR1)
1 50kΩ (code 503) horizontal trimpot (VR2)
1 1kΩ 16mm linear potentiometer (VR3)
1 red banana line plug
1 black banana line plug
1 9V battery clip
1 9V battery
1 potentiometer knob
1 4 x 4 x 2mm piece of soft plastic
1 300mm length of twin core shielded cable
1 60mm length of 3-way rainbow cable
1 200mm length of red heavy duty hookup wire
1 200mm length of black heavy duty hookup wire
1 50mm length of green heavy duty hookup wire
1 50mm length of 4.8mm diameter heatshrink tubing
1 100mm cable tie
8 PC stakes

Semiconductors
1 LM358 dual op amp (IC1)
1 UGN3503 Hall effect sensor
1 78L05 5V regulator (REG1)

Capacitors
1 100μF 16V PC electrolytic
1 10μF 16V PC electrolytic
1 100nF MKT polyester
1 1nF MKT polyester

Resistors (1% 0.25W)

1 22kΩ	1 1kΩ
1 18kΩ	2 100Ω
1 10kΩ	

Calibration parts
1 5m length of 0.5mm enamelled copper wire
1 18Ω 5W resistor

There's no power LED on the front panel to warn you when the power is on, so be sure to switch the unit off when it is not in use to save battery life. Also, be sure to null the reading on the multimeter (ie, when there is no current flow through the core) before taking a measurement.

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%.

Don't Patronise Us

Dear EPE,

I am one of the silent majority. I have read your magazine since issue one, and (somewhere) I have kept all my copies. I should say therefore that I am a pretty loyal customer and I daresay you will be interested in my continuing to be so.

I was motivated to write today by concern at two things in the November 2005 issue, "Face Lift" in your *Editorial* and "Will the Bulldog C to Oz" in *Readout*.

I used to take all of the electronics magazines when I was a student, and I've seen most of them come and go, and in my business, Greenbank Electronics (established 1970), I advertised in most of them too.

Look at the magazines that failed, and look at what they did just before the end (you should know, you bought most of them when they finally collapsed) – they revamped the magazine, alienated their old customers, and, oh dear, picked up hardly any new customers. Increased expense, acceleration of circulation loss, insufficient new customers, liquidation, bankruptcy.

You've lasted (?) thirty five years, don't lose your way now. Keep doing what you do so well, and there will always be a hard core base you can rely on; if you damage your foundations and betray the existing readership, there won't be another generation to rely on.

Which brings me to my second point: listen to your readers – they pay your wages. They will tell you exactly what they want; it may not be what you want to give, but they are the customers, you'd better be aware that the customer is always right.

But what an awful patronising reply to your Australian reader, John O'Hagan, in *Readout*. All he did was write and compliment your magazine, and ask for some support for the "C" language he uses, and some break from the monotony of the wall to wall PICs in your magazine, for such as say the Atmel microprocessors.

Your reply, although politely phrased was too patronising for me: basically you admit that "C" is what the readers want, but you don't care about that, you think PIC assembler is better, so tough on you. All he did was write in and tell you what he wanted, there's no need to put him in his place; he might even have a better idea than you do about what interests people nowadays.

I have been a reader for thirty-odd years, and have never built one of your circuits. Nevertheless I read the magazine with great interest, interest which would be considerably greater if you varied the menu a little. I too program in assembler (I'm that old) which is probably why I would welcome a bit of "C" for a change.

You want to keep your existing readers and attract new ones. Engineers and potential engineers are always interested in alternative and new ways of doing things, and they love a magazine that tells them about them.

So why do I stay, if I'm so critical and unappreciative of your efforts? Simple: your diagrams draw resistors properly (with wiggly lines that look like resistors, and transistors that look like transistors), and your writing style is clear and pleasantly enthusiastic.

David Parkins, via email

Editor Mike received David's much longer email and replied:

Wow! We do seem to have upset you! First of all thanks for your loyalty and comments. Sorry that you feel we have been patronising to our readers – certainly not our intention.

We don't want to alienate our existing customers with the revamp – we hope you will like it and that some new readers will be attracted too. The magazine has looked very old fashioned to younger readers and we need them as well as our old friends. We will continue to publish the same type of articles, just the presentation will change and rest assured that due to changes in the way we work it will not cost us more money to produce the magazine.

We have taken your comments on board regarding "C" and Atmel and we will see what others have to say on this. We do try to get an idea of what readers are interested in from the *Chat Zone*, and from the books, CDs, p.c.b.s etc they buy, from comments we get on the phone, from emails like yours and from notes with subscription renewals etc. Part of the reason for publishing such letters is to see reader response and we often ask for it on the *Readout* page, it is not often as worrying as your email!

I hope what we have planned will be of interest to you, we are aiming for more variety and hope to cover high level languages, other chips etc.

Mike Kenward, Editor

★ LETTER OF THE MONTH ★

Rockin' Howler!

Dear EPE,

Thanks to you and Mike Hibbett for the *Halloween Howler* (Oct '05). I am using the device to add snoring to a rocking chair skeleton, and it works very well! Next year I will probably use several in different parts of the yard.

Attached are a few photos that show the implementation. On display the skeleton will have a blanket covering from the lap on down. This will hide the mechanism. Nothing there except a car windshield wiper motor and the howler.

You can see the Fairchild QRB1134 Reflective Object Sensor on the L-bracket near the motor. This synchronizes the snoring with the motion of the chair. Not shown are the dual fog generators with automatic changeover and the small controller that detects Trick Or Treaters and starts the fog and rocker.

Readers might also care to browse a website that sells skeletons! **www.scary-terry.com/rockchair/rockchair.htm**

Richard T. Stofer, via email

Richard's rocking skeleton seemingly taking a nap, while waiting to howl at any intrepid onlooker who comes too close!

How splendid Richard. I told Mike, he was highly amused (as am I)!

All at C - As Quickly As Possible!

Dear EPE,

John O'Hagan is absolutely right (*Readout*, Nov '05, Will the Bulldog C to Oz?). *EPE* should definitely abandon PIC assembler as quickly as possible and switch to C. PIC assembler should only be used in those cases in which the small reduction in program size is actually necessary. John Becker's argument for PIC assembler that, "it achieves more compact code and consequent reduction in PIC program space" is, for most *EPE* PIC projects, entirely spurious. PIC program space is there to be used, not conserved. Program space that is unused is, quite literally, a waste of space, and there is no virtue at all in conserving it.

I've been a professional computer programmer on PCs for over 15 years, and, in the early days of PC computing when memory space was scarce, there was an argument for assembler. Nowadays, memory is simply not a problem on the PC, and no one uses assembler any more. We have all made the transition to higher level languages. The consequence of this has been a massive increase in productivity and in the level of program complexity that we are able to deal with. However, this was not an easy transition, and many programmers who had hard-won assembler skills argued for the use of assembly language long after it was rendered obsolete by high level languages.

This history is being recapitulated with microcontrollers. In the early days, program memory was scarce, and assembler was the only viable option. Nowadays, for many, if not most PIC projects, program space is simply not an issue and we can avail ourselves of the capabilities of high level languages. I confidently predict that in only a few years time, PIC program memory will be so large, and high level languages so readily available (in fact they already are) that no electronics magazine will be publishing PIC programs in assembler any more. I have always looked to *EPE* for innovation and new ideas, and I encourage your magazine to lead the way to this high level future in the UK.

Dr Jim Arlow, Harrow, via email

Thank you Jim, but there are other factors to be considered too, such as readers who don't know C but do know PIC assembler; code size can affect which PIC is chosen; more "library" routines for PICs are available in assembler than for C; Microchip's examples in their books/datasheets are in assembler; what code readers use for the projects they send. We've no problem if readers send us C for them but very few do.

Jim then came back to me following my reply:

All true. Of course it's quite feasible to mix C and assembler. In fact, in the early PC days, that's exactly what we did. Most of the code was written in C for reasons of clarity, comprehensibility, portability and productivity whilst key routines (that were not yet available as C subroutines) were in assembler and called from C just like C subroutines.

Perhaps one of the reasons we in England seem to be somewhat behind the rest of the world in terms of using high level languages with microcontrollers is that there have been few (in fact I don't personally know of any) tutorials in magazines about using languages such as Basic or C. In fact, even those tutorials that I have come across elsewhere are often pretty poor. This is because they really need to be written by a computer programmer (someone who really knows how to build good software) rather than by an electronics enthusiast.

I often see things in programs on the Web, in magazines etc. that make me cringe as a professional programmer. This isn't just purism – it's about the understandability, quality and maintainability of software. Program style is also about significantly raising the level of complexity that the average electronics enthusiast/programmer is capable of dealing with. These things become increasingly important as electronics as a hobby incorporates more and more software. Poorly written software is exactly analogous to the rats nest wiring method of creating an electronic project. Well designed and written software is like having a p.c.b.

The fundamental problem with assembler is that it doesn't scale. This is perhaps the primary reason the software engineering community has largely abandoned it. Even simple things are quite difficult to do, and difficult things become prohibitively difficult. High level languages such as C and BASIC scale much better – simple things tend to be very simple and difficult things tend to be tractable. Yes – anything that you can write in C or BASIC, you can write in assembler, but the question is, with these languages available and enough computing resources cheaply available, why would you bother?

The whole history of computing has been characterized by a continual increase in the level of abstraction. In the early days we programmed in hardware (wires and switches etc.), then we programmed in binary, then we had assembler, then we had procedural languages such as FORTRAN, BASIC, C, then object oriented languages such as Smalltalk, Java, Python. Nowadays some of us are even "programming" in abstract modeling languages such as the Unified Modeling Language (UML) and getting the computer to generate the code.

The relationship of UML to Java has become that of C to assembler! Others of us are even "programming" in metalanguages that allow us to create our own languages specialized to a particular problem domain. And this is all good. After experiencing a high-level language, *properly taught*, there's just no going back to stuff like assembler.

Dr Jim Arlow, by email

Thanks again Jim. Readers – your opinions please!

Ghost Busters 2

Dear EPE,

I was interested to read the letter from Suheil Bukhzam ("Ghost Buster?") in the Nov '05 issue regarding the problem of ghosting on l.e.d. displays.

This reminds me of a similar situation I faced back in the eighties (back when computers were *real* machines and you could still buy a house for less than the GDP of a small country). In my case it was a home-brew Z80 circuit writing to a tiny 9-digit, 7-segment l.e.d. display from a pocket calculator.

As you quite rightly say, by far the biggest improvement is obtained by switching off all segments before selecting the next digit (or in Suheil's case, column). In my design that did in fact cure the ghosting problem, but left me with another in the form of display flicker. I eventually solved that with the aid of two techniques which just might be of help here – after all, it's all about persistence of vision:

1. The display refresh routine should scan right to left, not the more intuitive left to right. I've no idea why this should make a difference, unless it's something to do with the way the eye moves when we read?

2. Non-sequential refresh. In other words, instead of writing to column 0, then to column 1 etc in strict sequence, try writing all the odd columns first then all the even ones (somewhat akin to interlacing on TV screens).

Rob Banks (and yes, that is my real name), via email

Thanks Rob, the suggestions sound useful. You are the only person to respond to the letter and it's appreciated that you have. I wonder if others might come in on it when your reply has been published, I may quote them too if they do.

Surprise Edition

Dear EPE,

Imagine my surprise when I discovered the *EPE* August '05 issue (as I write it is the first of November here) at the local media store. What is so surprising is that I live in a sparsely inhabited county in Southern Colorado. And my greater surprise was to open the cover and find the magazine that I was wishing someone would publish. I'm an electronics hobbyist as well as an avid R/C flying modeller. I especially like your great coverage of PIC projects and thus I will be ordering your online subscription.

My latest PIC project is a PIC controlled CDI ignition for use on converted weed trimmer two cycle gasoline (I think you chaps call it petrol?) powered engines for model use. It gives great performance at both idle and full throttle. With the PIC/CDI I'm able to eliminate the magneto and save one pound of weight. My next project is to develop a harmless noisemaker (maybe propane fuelled blaster) to scare off birds from my wife's fruit orchard.

Congratulations for your great mag and keep up the good work.

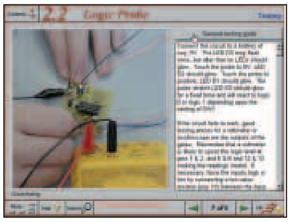
Marlowe Cassetti, Penrose, Colorado, USA, via email

Thanks Marlowe, so glad you are impressed by us, long may you remain so! PICs are my favourite too, they are a lot of fun and as you are finding there are many things you can do with them.

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

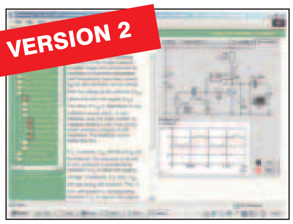


Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture**, **circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

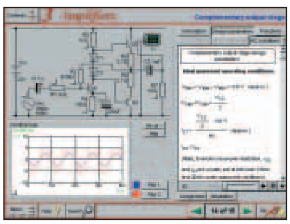
VERSION 2



Circuit simulation screen

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

ANALOGUE ELECTRONICS

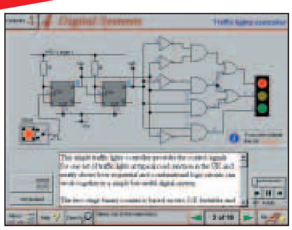


Complimentary output stage

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

DIGITAL ELECTRONICS V2.0

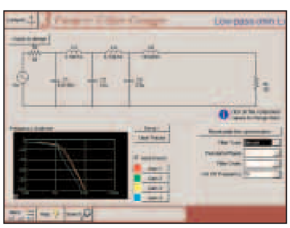
VERSION 2



Virtual laboratory – Traffic Lights

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

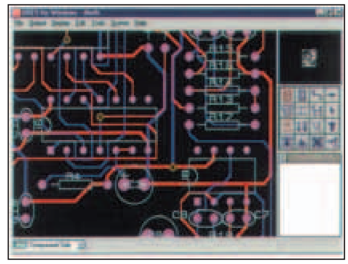
ANALOGUE FILTERS



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

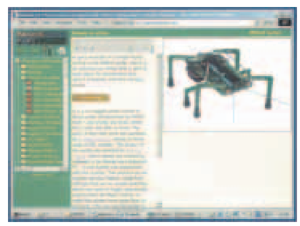
ELECTRONICS CAD PACK



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

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student ....£45 inc VAT
Institutional (Schools/HE/FE/Industry)..............£99 *plus* VAT
Institutional 10 user (Network Licence) ....£249 *plus* VAT
Site Licence...£499 *plus* VAT

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

PICmicro TUTORIALS AND PROGRAMMING

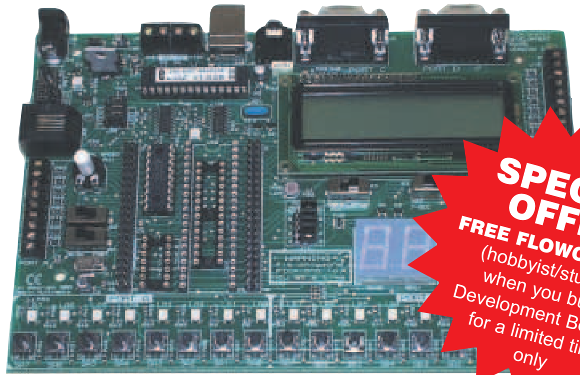
HARDWARE

VERSION 3 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices from the 12, 16 and 18 series PICmicro ranges. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 16 individual l.e.d.s, quad 7-segment display and alphanumeric l.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- USB programmable
- Can be powered by USB (no power supply required)



SPECIAL OFFER

FREE FLOWCODE V2 (hobbyist/student) when you buy a Development Board – for a limited time only

£158 including VAT and postage

supplied with USB cable and programming software

SOFTWARE

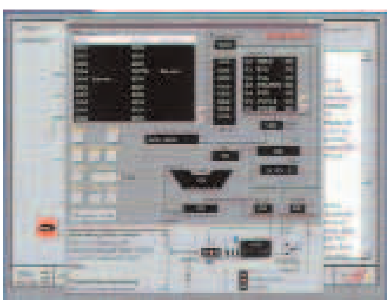
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

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

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



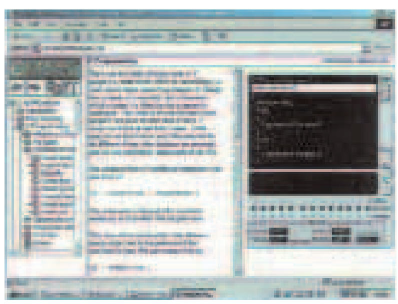
Virtual PICmicro

'C' FOR PICmicro VERSION 2

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

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

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



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

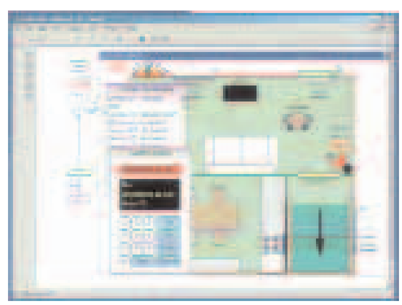
FLOWCODE FOR PICmicro V2

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

PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

Hobbyist/Student	£45 inc VAT
Flowcode V2 Hobbyist/Student	£57 inc VAT
Institutional (Schools/HE/FE/Industry)	£99 *plus* VAT
Flowcode Professional	£99 *plus* VAT
Institutional/Professional 10 user (Network Licence)	£300 *plus* VAT
Site Licence	£599 *plus* VAT

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

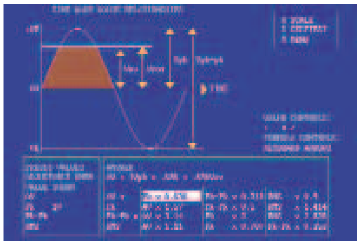
TEACH-IN 2000 – LEARN ELECTRONICS WITH EPE

EPE's own *Teach-In* CD-ROM, contains the full 12-part *Teach-In* series by John Becker in PDF form plus the *Teach-In* interactive software (Win 95, 98, ME and above) covering all aspects of the series. We have also added Alan Winstanley's highly acclaimed *Basic Soldering Guide* which is fully illustrated and which also includes *Desoldering*. The *Teach-In* series covers: Colour Codes and Resistors, Capacitors, Potentiometers, Sensor Resistors, Ohm's Law, Diodes and L.E.D.s, Waveforms, Frequency and Time, Logic Gates, Binary and Hex Logic, Op.amps, Comparators, Mixers, Audio and Sensor Amplifiers, Transistors, Transformers and Rectifiers, Voltage Regulation, Integration, Differentiation, 7-segment Displays, L.C.D.s, Digital-to-Analogue.
Each part has an associated practical section and the series includes a simple PC interface (Win 95, 98, ME **ONLY**) so you can use your PC as a basic oscilloscope with the various circuits.

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

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

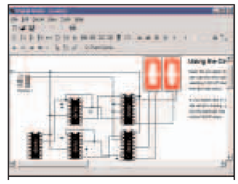
FREE WITH EACH TEACH-IN CD-ROM – *Electronics Hobbyist Compendium* 80-page book by Robert Penfold. Covers Tools For The Job; Component Testing; Oscilloscope Basics.



Sine wave relationship values

FREE BOOK WITH TEACH-IN 2000 CD-ROM

DIGITAL WORKS 3.0



Counter project

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

Hobbyist/Student £45 inc. VAT.
Institutional £99 *plus* VAT.
Institutional 10 user £249 *plus* VAT.
Site Licence £599 *plus* VAT.

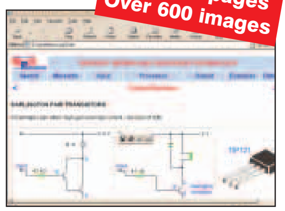
NEW

PROJECT DESIGN WITH CROCODILE TECHNOLOGY

An Interactive Guide to Circuit Design

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

Over 150 pages Over 600 images



WHAT'S INCLUDED

Light Modules, Temperature Modules, Sound Modules, Moisture Modules, Switch Modules, Astables including 555, Remote Control (IR & Radio), Transistor Amplifiers, Thyristor, Relay, Op-Amp Modules, Logic Modules, 555 Timer, PIC/PICAXE, Output Devices, Transistor Drivers, Relay Motor Direction & Speed Control, 7 Segment Displays. Data sections with pinouts etc., Example Projects, Full Search Facility, Further Background Information and Animated Diagrams.

Runs in Microsoft Internet Explorer

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

Single User £39.00 inc. VAT.
Multiple Educational Users (under 500 students) £59.00 plus VAT. Over 500 students £79.00 plus VAT.
(UK and EU customers add VAT at 17·5% to "plus VAT" prices)

ELECTRONIC COMPONENTS PHOTOS

A high quality selection of over 200 JPG images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details).
Also contains a **FREE** 30-day evaluation of Paint Shop Pro 6 – Paint Shop Pro image editing tips and on-line help included!

Price £19.95 inc. VAT

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

CD-ROM ORDER FORM

Please send me:

- ☐ **Electronic Projects**
- ☐ **Electronic Circuits & Components V2.0**
- ☐ **Analogue Electronics**
- ☐ **Digital Electronics V2.0**
- ☐ **Analogue Filters**
- ☐ **Electronics CAD Pack**
- ☐ **Robotics & Mechatronics**
- ☐ **Assembly for PICmicro V3**
- ☐ **'C' for PICmicro V2**
- ☐ **Flowcode V2 for PICmicro**
- ☐ **Digital Works 3.0**

Version required:

- ☐ **Hobbyist/Student**
- ☐ **Institutional**
- ☐ **Institutional/Professional 10 user**
- ☐ **Site licence**

- ☐ **PICmicro Development Board V3 (hardware)**

- ☐ **Teach-In 2000 + FREE BOOK**
- ☐ **Electronic Components Photos**
- ☐ **Project Design – Single User**
- ☐ **Project Design – Multiple User (under 500 students)**
- ☐ **Project Design – Multiple User (over 500 students)**

Note: The software on each version is the same, only the licence for use varies.

Full name: . . . .

Address: . . . .

. . . . .Post code: . . . . .Tel. No: . . . .

Signature: . . . .

☐ I enclose cheque/PO in £ sterling payable to WIMBORNE PUBLISHING LTD for £

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch: £

Valid From: . . . . .Card expiry date: . . . .

Card No: . . . . Switch Issue No. . . . .

Card Security Code . . . . (The last 3 digits on or just under the signature strip)

ORDERING

ALL PRICES INCLUDE UK POSTAGE

Student/Single User/Standard Version price includes postage to most countries in the world
EU residents outside the UK add £5 for airmail postage per order

Institutional, Multiple User and Deluxe Versions – overseas readers add £5 to the basic price of each order for airmail postage (**do not add VAT** unless you live in an EU (European Union) country, then add 17½% VAT or provide your official VAT registration number).

Send your order to:
Direct Book Service
Wimborne Publishing Ltd
408 Wimborne Road East
Ferndown, Dorset BH22 9ND

To order by phone ring
01202 873872. Fax: 01202 874562

Goods are normally sent within seven days

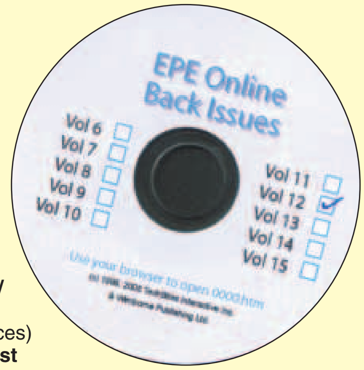
E-mail: orders@wimborne.co.uk

Online shop:
www.epemag.wimborne.co.uk/shopdoor.htm

STORE YOUR BACK ISSUES ON CD-ROMS

VOL 13
NOW AVAILABLE

ONLY
£14.45 each
including VAT
and p&p



A great way to buy *EPE* Back Issues – our 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.

VOL 1: BACK ISSUES – January 1999 to June 1999
Plus some bonus material from Nov and Dec 1998

VOL 2: BACK ISSUES – July 1999 to December 1999

VOL 3: BACK ISSUES – January 2000 to June 2000

VOL 4: BACK ISSUES – July 2000 to December 2000

VOL 5: BACK ISSUES – January 2001 to June 2001

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

VOL 12: BACK ISSUES – July 2004 to December 2004

VOL 13: BACK ISSUES – January 2005 to June 2005

NOTE: These mini CD-ROMs are suitable for use on any PC with a CD-ROM drive. They require Adobe Acrobat Reader (available free from the Internet – **www.adobe.com/acrobat**)

WHAT IS INCLUDED

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.

EXTRA ARTICLES – ON ALL VOLUMES

BASIC SOLDERING GUIDE – Alan Winstanley's internationally acclaimed fully illustrated guide. **UNDERSTANDING PASSIVE COMPONENTS** – Introduction to the basic principles of passive components. **HOW TO USE INTELLIGENT L.C.Ds**, by Julyan Ilett – An utterly practical guide to interfacing and programming intelligent liquid crystal display modules. **PhyzzyB COMPUTERS BONUS ARTICLE 1** – Signed and Unsigned Binary Numbers. By Clive "Max" Maxfield and Alvin Brown. **PhyzzyB COMPUTERS BONUS ARTICLE 2** – Creating an Event Counter. By Clive "Max" Maxfield and Alvin Brown. **INTERGRAPH COMPUTER SYSTEMS 3D GRAPHICS** – A chapter from Intergraph's book that explains computer graphics technology. **FROM RUSSIA WITH LOVE,** by Barry Fox – Russian rockets launching American Satellites. **PC ENGINES,** by Ernest Flint – The evolution of Intel's microprocessors. **THE END TO ALL DISEASE,** by Aubrey Scoon – The original work of Rife. **COLLECTING AND RESTORING VINTAGE RADIOS,** by Paul Stenning. **THE LIFE & WORKS OF KONRAD ZUSE** – a brilliant pioneer in the evolution of computers. A bonus article on his life and work written by his eldest son, including many previously unpublished photographs.

Note: Some of the **EXTRA ARTICLES** require WinZip to unzip them.

Order on-line from
www.epemag.wimborne.co.uk/shopdoor.htm
or www.epemag.com (USA $ prices)
or by phone, Fax, E-mail or Post

BACK ISSUES CD-ROM ORDER FORM

Please send me the following Back Issue CD-ROMs. Volume Numbers:. . . . .

. . . .

. . . .

Price £14.45 each – includes postage to anywhere in the world.

Name . . . .

Address . . . .

. . . .

. . . . Post Code . . . .

☐ I enclose cheque/P.O./bank draft to the value of £ . . . .

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Maestro

£ . . . .

Card No. . . . .

Card Security Code . . . . (The last 3 digits on or just under the signature strip)

Valid From . . . . .Expiry Date . . . .

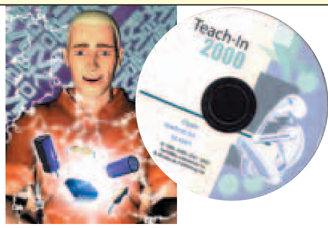
Maestro Issue No. . . . .

SEND TO: **Everyday Practical Electronics,**
Wimborne Publishing Ltd.,
408 Wimborne Road East, Ferndown, Dorset BH22 9ND.

Tel: 01202 873872. Fax: 01202 874562.
E-mail: orders@epemag.wimborne.co.uk

Payments must be by card or in £ Sterling – cheque or bank draft drawn on a UK bank.
Normally supplied within seven days of receipt of order.

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. 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.

ONLY **£12.45** including VAT and p&p

Order code Teach-In CD-ROM

Robotics

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

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

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

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

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision Command System

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

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

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

ANDROIDS, ROBOTS AND ANIMATRONS – Second Edition – John Iovine

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

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

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

DIRECT BOOK SERVICE

NOTE: ALL PRICES INCLUDE UK POSTAGE

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

For a further selection of books see the next two issues of *EPE*.

Radio

BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages **Order code NE30** **£18.99**

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.

92 pages **Order code BP304** **£4.45**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages **Order code BP257** **£5.49**

Computers and Computing

THE INTERNET FOR THE OLDER GENERATION
Jim Gatenby

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

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

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

HOW TO BUILD YOUR OWN PC – Third Edition
Morris Rosenthal

More and more people are building their own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a state-of-the-art computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. For non-specialists, there's even a graphical glossary that clearly illustrates technical terms. The author goes "under the hood" and shows step-by-step how to create a socket 7 (Pentium and non-intel chipsets) and a Slot 1 (Pentium II) computer, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows 98. The few existing books on this subject, although badly outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

224 pages – large format **Order code MGH2** **£20.99**

PIC YOUR PERSONAL INTRODUCTORY COURSE SECOND EDITION John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PIC's capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised second edition covers the popular reprogrammable EEPROM PICs: P16C84/16F84 as well as the P54 and P71 families.

270 pages **Order code NE36** **£15.99**

eBAY FOR BEGINNERS
Cherry Nixon

There are two kinds of people, those who are trading on eBay and the rest who are missing out. Though eBay has been embraced by entrepreneurs all over the world, it remains the peoples' site and offers the largest market for the smallest fee.

eBay presents an opportunity for everyone, the trick is to master it. This book shows you how to start trading on eBay UK. It also offers advice on getting organised and tips to put you ahead.

The book has been developed from Cherry's popular hands-on course "Buying and Selling on eBay for Technological Simpletons". In addition to fully explaining eBay and how to trade on it there are sections on Paypal, producing pictures of your sale items, fees and accounts, safety and security including what to do when things go wrong and what protection is provided.

178 pages **Order code BP551** **£8.99**

NEWNES PC TROUBLESHOOTING POCKET BOOK – THIRD EDITION
Howard Anderson, Mike Tooley

All the essential data for PC fault-finding and upgrading. This book provides a concise and compact reference that describes, in a clear and straightforward manner, the principles and practice of fault-finding and upgrading PCs and peripherals. The book is aimed at anyone who is involved with the installation, configuration, maintenance, upgrading, repair or support of PC systems. It also provides non-technical users with sufficient background information, charts and checklists to enable the diagnosis of faults and help to carry out simple modifications and repairs. In order to reflect rapid changes in computer technology (both hardware and software) this new edition has been completely revised and rewritten.

256 pages **Order code NE41** **£19.99**

Theory and Reference

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

BOOK PLUS CD-ROM

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. Comes with a free CD-ROM which contains an eBook version with full text search plus bonus chapter – An Illustrated History of Electronics and Computing.

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

500 pages | **Order code BEB1** | **£27.50**

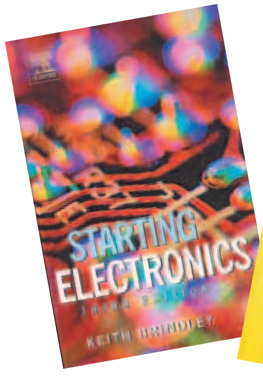
BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

CD-ROM

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

Over 800 pages in Adobe Acrobat format

CD-ROM | **Order code BEB2 CD-ROM** | **£21.95**



GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

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

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

96 pages | **Order code BP239** | **£5.49**

STARTING ELECTRONICS, THIRD EDITION
KEITH BRINDLEY

NEW

A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.

A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.

Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages | **Order code NE42** | **£10.99**

THE AMATEUR SCIENTIST CD-ROM

CD-ROM

The complete collection of The Amateur Scientist articles from *Scientific American* magazine. Over 1,000 classic science projects from a renowned source of winning projects. All projects are rated for cost, difficulty and possible hazards.

Plus over 1,000 pages of helpful science techniques that never appeared in *Scientific American*.

Exciting science projects in: Astronomy; Earth Science; Biology; Physics; Chemistry; Weather . . . and much more! The most complete resource ever assembled for hobbyists, and professionals looking for novel solutions to research problems.

Includes extensive Science Software Library with even more science tools.

Suitable for Mac, Windows, Linux or UNIX. 32MB RAM minimum, Netscape 4.0 or higher or Internet Explorer 4.0 or higher.

Over 1,000 projects

CD-ROM | **Order code AS1 CD-ROM** | **£19.95**

Music, Audio and Video

MAKING MUSIC WITH YOUR COMPUTER
Stephen Bennett

NEW

Nearly everyone with musical aspirations also has a computer. This same computer can double as a high quality recording studio capable of producing professional recordings. This book tells you what software and hardware you will need to get the best results.

You'll learn about recording techniques, software and effects, mixing, mastering and CD production.

Suitable for PC and Mac users, the book is full of tips, "how to do" topics and illustrations. It's the perfect answer to the question "How do I use my computer to produce my own CD?"

92 pages | **Order code PC120** | **£10.95**

QUICK GUIDE TO 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.

Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

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

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.

124 pages | **Order code PC116** | ~~£10.95~~ **£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 'H2S' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

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.

124 pages | **Order code PC115** | ~~£10.95~~ **£5.45**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold

Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages **Temporarily out of print**

Data and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop

This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

88 pages **Order code BP299** **£5.49**

DIGITAL LOGIC GATES AND FLIP-FLOPS
Ian R. Sinclair

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

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

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

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

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages **Order code BP332** **£5.45**

MICROCONTROLLER COOKBOOK
Mike James

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

240 pages **Order code NE26** **£23.99**

RADIO BYGONES

We also carry a selection of books aimed at readers of *EPE*'s sister magazine on vintage radio *Radio Bygones.* These books include the *Comprehensive Radio Valve Guides.* Also Jonathan Hill's excellent *Radio Radio,* a comprehensive book with hundreds of photos depicting the development of the British wireless set up to the late 1960s.

The four volumes of our own *Wireless For the Warrior* by Louis Meulstee are also available. These are a technical history of radio communication equipment in the British Army and clandestine equipment from pre-war through to the 1960s.

For details see the shop on our UK web site at **www.epemag.co.uk** or contact us for a list of *Radio Bygones* books.

Project Building & Testing

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages **Order code BP371** **£5.45**

FAULT-FINDING ELECTRONIC PROJECTS
R. A. Penfold

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

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

136 pages **Temporarily out of print**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

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

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

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

132 pages **Order code BP374** **£5.45**

DISCOVERING PICS
W.D.Phillips

BOOK PLUS CDROM PLUS HARDWARE

A good introduction to PIC programming, covering everything you need to know to get you started. No previous knowledge of microcontrollers is required, but some previous experience with electronic circuits is assumed. Covers the basic concept of a microcontroller, fundamentals of a PIC-based circuit and using the MPLAB program. Further chapters introduce binary, PIC architecture, the instruction set, the PIC memory map and special registers plus real world programming. Four simple projects are also fully described; a Wavy Wand, an Electronic Dice, a Games Timer and a Pulse Monitor.

The associated CDROM contains the book in PDF format, MPLAB (plus instruction manuals in PDF format) and all the programs covered in the book as assembler (ASM) files.

In addition a p.c.b. based hardware kit is also available that makes up into the Wavy Wand which will spell out a short message via a line of l.e.d.s when waved through the air.

190 pages, A4 spiral bound

Book + CDROM Order code DOC1 **£22.00**

Book + CDROM + Hardware Order code DOC2 **£28.50**

For a further selection of books see the next two issues of *EPE*

BOOK ORDERING DETAILS

All prices include UK postage. For postage to Europe (air) and the rest of the world (surface) please add £2 per book. For the rest of the world airmail add £3 per book. CD-ROM prices include VAT and/or postage to anywhere in the world. Send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or card details, Visa, Mastercard, Amex, Diners Club or Maestro to:

DIRECT BOOK SERVICE, WIMBORNE PUBLISHING LTD.,
408 WIMBORNE ROAD EAST, FERNDOWN, DORSET BH22 9ND.

Orders are normally sent out within seven days of receipt, but please allow 28 days for delivery – more for overseas orders. *Please check price and availability (see latest issue of* Everyday Practical Electronics*) before ordering from old lists.*

For a further selection of books and CD-ROMs see the next two issues of *EPE*.

Tel 01202 873872 Fax 01202 874562. Email: dbs@epemag.wimborne.co.uk

Order from our online shop at: www.epemag.co.uk/shopdoor.htm

BOOK/CD-ROM ORDER FORM

Full name: ....

Address: ....

....

....

.... Post code: .... Telephone No: ....

Signature: ....

☐ I enclose cheque/PO payable to DIRECT BOOK SERVICE for £ ....

☐ Please charge my card £ .... Card expiry date...................

Card Number .... Maestro Issue No.................

Card Security Code .... (The last 3 digits on or just below the signature strip)

Please send book/CD-ROM order codes: ....

....

Please continue on separate sheet of paper if necessary
If you do not wish to cut your magazine, send a letter or copy of this form

PCB SERVICE

Printed circuit boards for most recent *EPE* constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for *airmail* outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872; Fax 01202 874562; Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag.wimborne.co.uk/shopdoor.htm.** Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**
NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.
Back numbers or photocopies of articles are available if required – see the *Back Issues* page for details. We do not supply kits or components for our projects.

Please check price and availability in the latest issue.
A large number of older boards are listed on our website.
Boards can only be supplied on a payment with order basis.

PROJECT TITLE		Order Code	Cost
★Bongo Box	JULY '04	451	£6.02
Portable Mini Alarm – Sensor		452	£5.23
– Counter		453	£5.07
★EPE Magnetometry Logger		455	£5.71
Keyring L.E.D. Torch	AUG '04	456	£4.12
★Teach-In '04 Part 10 – PIC Curtain or Blind Winder		457	£5.39
Simple F.M. Radio – F.M. Tuner		458	£5.07
– Tone Control		459	£4.75
– Audio Power Amp (TDA2003)		347	£4.60
– Power Supply		460	£5.39
★EPE Scorer – Control Board		461	£6.66
– Display Board		462	£7.93
– Slave Board		463	£5.55
★PIC to Mouse/Keyboard – **Software only**		–	–
EPE Wart Zapper	SEPT '04	464	£4.60
★Radio Control Failsafe		465	£4.76
★AlphaMouse Game		466	£4.60
★Rainbow Lighting Controller – **Software only**		–	–
★Moon and Tide Clock Calendar	OCT '04	467	£5.55
Volts Checker		468	£4.20
★Smart Karts – **Software only**		–	
Logic Probe	NOV '04	469	£4.76
Thunderstorm Monitor		470	£5.39
MW Amplitude Modulator			
– V.F.O./Buffer		471	£4.76
– Modulator/PA		472	£5.07
– Power Supply		473	£4.76
Super Vibration Switch	DEC '04	474	£4.75
Wind Direction Indicator		475	£6.18
★PIC Flasher Mk2 – Control Board		476	£4.75
– Transmitter		477	£4.44
– Multipurpose Board		478	£4.75
– Simple Cycler		479	£4.44
– Luxeon V Controller		480	£4.44
– Power Supply		473	£4.76
Light Detector	JAN '05	481	£4.44
★Camera Watch		482	£6.03
Gate Alarm – Oscillator		483	£4.92
– Delay/Timer		484	£4.92
★Sneaky – Transmitter	FEB '05	485	£4.60
– Receiver		486	£4.91
★PIC Electric Mk2 – Control		487	£5.87
– Sensor		488	£5.71
Sound Card Mixer		489	£7.29
Headphone Monitor	MAR '05	490	£5.71
EPE Cat Flap		491	£6.02
★Bingo Box – Main		492	£9.04
– Big Digit Display		493	£10.31
Spontaflex Radio– Tuner	APR '05	494	£5.55
– Coil Pack		495	£5.71
– Audio Amplifier		496	£5.55
– Tuning Capacitor Board		406	£4.28
★Safety Interface		497	£6.18
Back-To-Basics 1– Fridge/Freezer Door Alarm		498	£5.39
★Crossword Solver	MAY '05	499	£6.66
20W Amplifier Module		500	£5.14
Back-To-Basics 2 – Water Level Alarm		501	£5.39
– Burglar Alarm		502	£5.87
★PIC Ultrasonic Scanner	JUN '05	503	£6.66
★Radio Control Model Switcher		504	£5.87
Back-To-Basics 3 – Scarecrow		505	£5.55
– Digital Lock		506	£6.66
CompactFlash Interface Board		507	£6.66
LF/VLF Converter	JUL '05		
– Fixed Capacitor Board		508	£5.71
– Mixer/Oscillator Board		509	£5.86
– Buffer Amplifier		510	£5.23
– Q-Multiplier		511	£5.23
– Tuning Capacitor Board		406	£4.28
Back-To-Basics 4 – Doorchime		512	£6.34
– Electronic Dice		513	£6.02
★Cybervox		514	£6.82
Multi-Clap Switch		515	£6.66

PROJECT TITLE		Order Code	Cost
Audio System	AUG '05		
– Preamplifier		516	£6.02
– Mic. Supply Board		517	£5.23
– Power Amp		518	£6.02
★Pain Monitor		519	£7.14
MotorAmp		520	£7.45
Back-To-Basics 5 – Kitchen Timer		521	£5.87
– Room Thermometer		522	£6.02
All-Band Radio – Full Version	SEPT '05	523	£5.71
– Mini Version		524	£5.23
★Multicore Cable Tester – Main		525	£6.19
– Active		526	£5.55
Back-To-Basics 6 – Daily Reminder		527	£6.19
– Whistle Switch		528	£5.87
★Model Railway Signal Control		529	£6.19
★Snooker/Darts Scoreboard		530	£8.72
Photic Phone – Transmitter	OCT '05	531 } pair	£6.98
– Receiver		532 }	
Back-To-Basics 7 – Parking Radar		533	£5.71
– Telephone Switch		534	£5.55
★Haloween Howler		535	£6.02
★PIC-Based USB Interface		536	£6.19
★PIC Chromatone	NOV '05	537	£6.82
Back-To-Basics 8 – Noughts and Crosses Enigma		538	£6.66
– Weather Vane Repeater		539	£6.18
★Multi-Function R/C Switch		540	£5.87
★Speed Camera Watch Mk2		541	£6.35
Solid-State Valve Power Supply	DEC '05	542	£6.35
★Vehicle Frost Box Mk2		543	£5.71
★Propeller Monitor		544	£6.02
Solid-State Hammond		545	£6.18
★PIC Ambilux	JAN '06	546	£5.71
Sunset Switch		547	£6.98
Current Clamp Adaptor for Multimeters		548	£5.39
★Tiptronic-Style Gear Indicator			
– Micro Board		549 } per	
– Display Board		550 } set	£7.61
– Hall Speed Board		551 }	

EPE SOFTWARE

★ All software programs for *EPE* Projects marked with an asterisk, and others previously published, can be downloaded *free* from our Downloads site, accessible via our home page at: **www.epemag.co.uk.**

EPE PRINTED CIRCUIT BOARD SERVICE

Order Code Project Quantity Price

....

Name ....

Address ....

....

Tel. No. ....

I enclose payment of £................ (cheque/PO in **£ sterling only**) to:

Everyday Practical Electronics

MasterCard, Amex, Diners Club, Visa or Switch/Maestro

Card No. ....

Valid From .... Expiry Date ....

Card Security Code .... Switch/Maestro Issue No ....
(The last 3 digits on or just under the signature strip)

Signature ....

NOTE: You can also order p.c.b.s by phone, Fax, Email or via our Web site on a secure server:
http://www.epemag.wimborne.co.uk/shopdoor.htm