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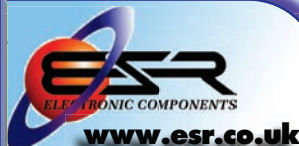
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VM163	Panel Clock Module	25.17
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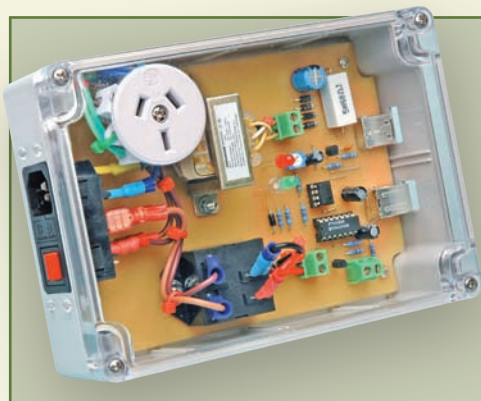
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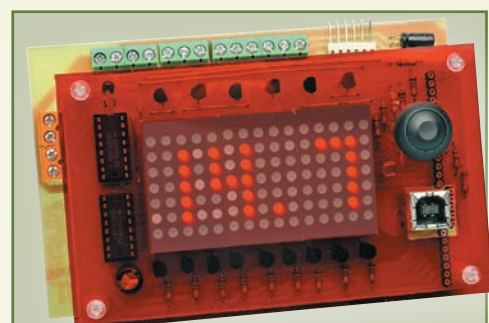
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Ideal for wireless remote control of practically anything in a range of 200m.
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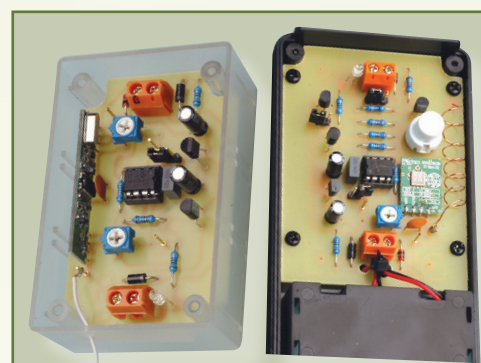
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Our February 2011 issue will be published on Thursday 13 January 2011, see page 80 for details.

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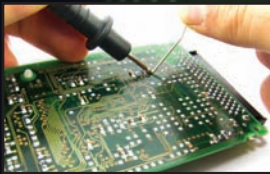
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KA-1811 £11.00 plus postage & packing

Turn your computer into an oscilloscope, audio monitor or spectrum analyser! Plug the kit into your computer's soundcard and by using software available over the Internet, measure or monitor just about any audio signal. Most PC sound card inputs have a limited dynamic range, relatively low input impedance and poor overload protection - this kit will eliminate these limitations and allow tiny signals, like those from op-amps, to be measured without degradation. Power is derived from the soundcard's D15 Joystick output socket.

- Kit includes case, silk-screened front panel, PCB, and all electronic components
- Optional CRO probe to suit - use our QC-1902 £14.00
- Or use it for amplifying a high quality microphone for sampling



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KC-5489 £32.75 plus postage & packing

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- PCB Dimensions: 123 x 74mm



BEST SELLER

USB POWER INJECTOR

KC-5399 £12.00 plus postage & packing

A power boost for your USB port! If you have a lot of peripheral devices running from your computer, they may be trying to draw more current than your USB port can provide. This project will allow full current draw no matter how many peripheral devices you are running. It uses an external power supply to tap into the existing line, effectively boosting the available current. Kit supplied with PCB, case with silk screened and punched panels, and all electronic components.



FULL FUNCTION SMART CARD READER / PROGRAMMER KIT

KC-5361 £20.00 plus postage & packing

Program both the microcontroller and EEPROM in the popular gold, silver and emerald wafer cards. Card used needs to conform to ISO-7816 standards. Powered by 9-12 VDC wall adaptor or a 9V battery. Instructions outline software requirements that are freely available on the internet. Kit supplied with PCB, wafer card socket and all electronic components.

- PCB measures: 141 x 101mm



Jaycar Electronics will not accept responsibility for the operation of this device, its related software, or its potential to be used for unlawful purposes.

PC INFRARED TRANSCEIVER KIT

KC-5323 £8.50 plus postage & packing

This quick and easy kit plugs into your motherboard to provide IR support for external devices such as notebook computers, PDAs, digital cameras, data samplers - and the list goes on!

- Kit includes PCB and all specified electronic components



WIND AND SOLAR POWERED RC CARS

KJ-8838 & KJ-8839 £17.50 each plus postage & packing

These mini remote controlled cars will surely entertain and educate curious minds about the concept of wind and solar power. The kits are very simple to build and come with a manual that provides construction details and explains how alternative energy can generate electricity.

Car size: 60(L) x 30(W)mm

- KJ-8838 - Wind Powered
- KJ-8839 - Solar Powered



**Happy New Year From
the JAYCAR Team**

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Note: Products are despatched from Australia, so local customs duty & taxes may apply.

- All pricing in Pounds Sterling
- Minimum order £10

Prices valid until 31/1/2011

HOW TO ORDER

WEB: www.jaycarelectronics.co.uk
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FAX: +61 2 8832 3118*
EMAIL: techstore@jaycarelectronics.co.uk
POST: P.O. Box 107, Rydalmere NSW 2116 Australia

*Australian Eastern Standard Time
 (Monday - Friday 09.00 to 17.30 GMT + 10 hours)
 Expect 10-14 days for air parcel delivery

NEW YEAR... NEW KITS

Remote Control Digital Timer Kit

KC-5496 £14.00 plus postage & packing

Remote-controlled digital timer with a bright 20mm-high 7-segment red LED display. It can count up or down from one second to 100 hours in 1-second increments. Its timing period can either be set and controlled using the remote control or it can be automatically controlled via external trigger/reset inputs. An internal relay and buzzer activate when the unit times out. The relay contacts can be used to switch devices rated up to 30VDC or 24VAC and the project can be powered from a plugpack or a battery. Short form kit only - you'll need to add your own universal remote, power supply and enclosure.

- 9-12VDC @300mA
- PCB and components



new

High Power Ultrasonic Cleaner Kit

KC-5499 £69.50 plus postage & packing

Most people would know that you can get small ultrasonic cleaners for jewellery and similar small items, so why not a much larger version? It would be ideal for cleaning automotive and other mechanical parts, fabrics which can't be machine washed, ornate bric-a-brac and a host of other hard-to-clean items. You can use a variety of receptacles for a tank, such as an old cistern or laundry tub. It can also be used with solvents such as kerosene or just water and detergent. The kit includes the transducer, case, cable and electronics and can be powered from a 2.5A 12VDC plugpack. Everything is included in the kit except for a housing for the transducer and sealant. For sealant you can use any neutral cure silicone suitable for wet areas. You'll also need epoxy resin such as Araldite or JB Weld, and for a housing, a short piece of 65mm PVC plumbing pipe and a drain, waste and vent end cap available from any plumbing supplier will do the job.

- Power requirements: 12V, 2.5A
- Transducer voltage: 250VAC square wave
- Frequency range: Main mode 19kHz to 42kHz
- Timeout adjustment: 30s to 10m
- PCB and components
- 12VDC



new

KIT OF THE MONTH

DAB+/FM Digital Radio Kit

KC-5491 £144.50 plus postage & packing

There are very few digital radios available as hi-fi components and the few that are cost north of £300. Many hi-fi enthusiasts want to add a digital tuner to their system and want function and sound quality over bells and whistles. It is designed to complement an existing home hi-fi system by adding DAB+ tuning, and just sits neatly atop your existing hi-fi receiver in the a 430mm wide hi-fi component case as if it were a brand name model. It covers DAB+ and FM, has analogue and optical audio outputs, IR remote (optional extra), an external antenna connector and is powered by a low-cost mains plugpack. The kit is complete with everything, including the case. See website for full specs.



- Digital station info display
- RCA and optical audio output
- External antenna connection
- Station memory presets
- Requires mains plugpack

Order online: www.jaycarelectronics.co.uk

Jaycar
Electronics

4000 Series		74HC157	£0.22	74LS368	£0.21	OP495GP	£8.69	Diodes		Thyristors	BC225	£0.15	BU208A	£1.53	 High Quality Collet Fixing Control Knobs www.esr.co.uk
4000B	£0.27	74HC158	£0.23	74LS373	£0.43	RC4136	£1.00	2N5060	£0.19	BC237B	£0.11	BU326A	£1.40		
4001B	£0.16	74HC161	£0.27	74LS374	£0.38	SG3524AN	£0.82	2N5061	£0.19	BC238B	£0.11	BU500	£1.54		
4002B	£0.19	74HC162	£0.45	74LS378	£0.62	SG3543	£0.88	BT151-500R	£0.65	BC250A	£0.15	BU508A	£1.40		
4006B	£0.65	74HC163	£0.26	74LS390	£0.26	SSM2141P	£3.21	PO102AA	£0.30	BC261B	£0.30	BU508D	£0.98		
4009UB	£0.23	74HC164	£0.20	74LS393	£0.33	SSM2142P	£6.16	TIC106D	£0.60	BC262B	£0.24	BU806	£1.06		
4010B	£0.23	74HC165	£0.26	74LS395	£0.26	SSM2143P	£3.78	TIC116D	£0.66	BC267B	£0.36	BU111AF	£1.14		
4011B	£0.16	74HC173	£0.38	74 Series				TIC126D	£0.77	BC319C	£0.13	BUX84	£0.78		
4012B	£0.16	74HC174	£0.27	7407	£0.40	TBA800	£0.75	BT136-500	£0.58	BC327	£0.08	BUZ900	£7.68		
4013B	£0.24	74HC175	£0.35	Linear ICs				BT136-600	£0.50	BC328	£0.09	BUZ905	£7.68		
4014B	£0.30	74HC193	£0.39	AD524AD	£23.04	DA2000A	£4.20	BT137-600	£0.58	BC337-16	£0.10	BUZ905P	£5.55		
4015B	£0.27	74HC195	£0.32	AD548JN	£2.48	DA2003V	£1.25	BT139-600	£0.50	BC337-25	£0.08	IRF530	£0.75		
4016B	£0.20	74HC240	£0.32	AD595AQ	£13.92	DA2050V	£2.51	BT139-600	£0.50	BC348B	£0.14	IRF540	£0.80		
4017B	£0.26	74HC241	£0.37	AD620AN	£9.88	DA2611A	£1.88	BT139-600	£0.50	BC357	£0.25	IRF630	£0.42		
4018B	£0.25	74HC244	£0.40	AD625JN	£16.20	DA2822A	£0.79	BT139-600	£0.50	BC393	£0.73	IRF640	£0.81		
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4021B	£0.22	74HC253	£0.25	AD648JN	£5.31	ED3718DP	£5.03	BT139-600	£0.50	BC477	£0.32	IRF830	£0.68		
4022B	£0.38	74HC257	£0.25	AD648JN	£5.31	ED3718DP	£5.03	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4023B	£0.23	74HC259	£0.29	AD648JN	£5.31	ED3718DP	£5.03	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4024B	£0.22	74HC273	£0.32	AD648JN	£5.31	ED3718DP	£5.03	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4025B	£0.20	74HC299	£0.61	AD648JN	£5.31	ED3718DP	£5.03	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4026B	£0.67	74HC365	£0.28	AD736JN	£5.28	LO62CP	£0.21	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4027B	£0.21	74HC367	£0.38	AD736JN	£5.28	LO62CP	£0.21	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4028B	£0.21	74HC368	£0.38	AD8112N	£6.00	LO71CN	£0.20	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4029B	£0.38	74HC373	£0.35	AD8122AN	£6.32	LO72CN	£0.20	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4030B	£0.17	74HC374	£0.34	AD820AN	£3.41	LO74CN	£0.25	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4035B	£0.31	74HC390	£0.37	AD822AN	£4.27	LO81CN	£0.17	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4040B	£0.34	74HC393	£0.36	AD829JN	£6.41	LO82CN	£0.32	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
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4042B	£0.19	74HC573	£0.27	AD847JN	£5.75	LT7055ACP	£0.82	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4043B	£0.35	74HC574	£0.27	AD9696JN	£7.73	TLC271	£0.63	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
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4049UB	£0.17	74HC4017	£0.24	ADM666AN	£2.72	UA741CN	£0.18	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
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4052B	£0.32	74HC4049	£0.31	ADM695AN	£6.48	ULN2004A	£0.44	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
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4060B	£0.17	74HC4060	£0.23	CA3140E	£0.63	24LC08BP	£0.73	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4063B	£0.41	74HC4075	£0.27	CA3240E	£0.91	27256-200	£3.99	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4066B	£0.22	74HC4078	£0.37	DG2211CJ	£1.25	27256-15F	£3.98	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4068B	£0.19	74HC4511	£0.64	DG411DJ	£2.20	27256-15F	£3.98	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4069UB	£0.18	74HC4514	£0.84	ICL7106CPL	£2.21	27C1001-15	£3.98	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
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4075B	£0.15	74LS03	£0.21	ICM7555	£0.40	Data Acquisition	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4077B	£0.28	74LS04	£0.12	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4078B	£0.30	74LS05	£0.14	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4081B	£0.13	74LS08	£0.19	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4082B	£0.26	74LS09	£0.15	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4085B	£0.21	74LS10	£0.17	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4086B	£0.33	74LS10	£0.27	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4093B	£0.21	74LS11	£0.17	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4094B	£0.29	74LS12	£0.25	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4098B	£0.40	74LS14	£0.36	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4099B	£0.35	74LS15	£0.24	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4502B	£0.32	74LS20	£0.27	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
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4508B	£1.40	74LS26	£0.17	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
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4511B	£0.30	74LS30	£0.20	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4512B	£0.27	74LS32	£0.23	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4515B	£0.99	74LS37	£0.11	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4516B	£0.44	74LS38	£0.11	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
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4520B	£0.34	74LS43	£0.38	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4526B	£0.68	74LS48	£0.38	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4526B	£0.68	74LS48	£0.38	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4527B	£0.40	74LS48	£0.25	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4529B	£0.44	74LS92	£0.45	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4532B	£0.24	74LS93	£0.44	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4536B	£1.00	74LS107	£0.30	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4538B	£0.26	74LS109	£0.21	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
4541B	£0.33	74LS112	£0.24	ICM7555	£0.40	ICM7555	£0.40	BT139-600	£0.50	BC477	£0.32	IRF840	£0.78		
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Where does the time go?

I know it's a cliché, but I can hardly believe I'm already writing the editorial for January. Another year and another 12 issues of EPE have been dispatched to readers near and far.

It was an exciting year to be involved with electronics. A new word, 'iPad', entered our language, as powerful portable computing with no moving parts, even a keyboard, started to spread. 3D TV seems to be making real headway and Panasonic have launched a consumer-level 3D camcorder, although at \$21,000 I'm pretty sure it won't be in my Christmas stocking. Realistic prices for more down-to-earth items continue to fall each year. I remember paying £300 for a 100Mb hard disk for one of my early computers, but this year I bought a 2Tb back-up drive for under £200 – a fall in price from £3 per megabyte to 10p per gigabyte!

In 2010, EPE produced 12 fantastic issues, bursting at the seams with fascinating features, projects and news. We have planned a fair chunk of 2011, and I can guarantee that the same range and quality we saw this year is planned for the next 12 issues. For beginners, our Teach-In series is going very well and there is plenty more to come. Please keep sending us your letters, ideas, praise and the occasional piece of constructive criticism! EPE is your magazine and we never tire of hearing what you want to see in it.

I'll sign off now with best wishes for Christmas and the new year from myself, our publisher Mike Kenward and the hard-working publishing team and regular contributors at Wimborne.

Happy Christmas!

Mike

AVAILABILITY

Copies of EPE are available on subscription anywhere in the world (see opposite) and from all UK newsagents (distributed by SEYMOUR). EPE can also be purchased from retail magazine outlets around the world. An Internet online version can be purchased and downloaded for just \$19.99US (approx £13) per year, available from www.epemag.com

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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 that 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.

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NEWS

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



Audiovisual innovation by Barry Fox

Truly innovative audio and video equipment is hard for the maker to describe, so it can be difficult to get across to the 'gadget mag' press, which is mostly interested in the colour of the box, how many gigabytes it hides and the price.

British high-end hifi company Arcam's rCube is a good example. It's an iPod dock with built-in Kleer – the Canadian system for sending 16-bit CD quality audio over the same frequencies as Bluetooth, but without the compression delay and lip-sync-destroying 'latency' introduced by the standard Bluetooth stereo system called A2DP (Advanced Audio Distribution Profile with Sub Band Coding)

rCube is a black box, smaller than a football, but with four built-in speakers driven by a 90Wrms digital amplifier. Although mains-powered, rCube can run for eight hours on a lithium-ion battery.

In addition to the standard iPod 30-pin physical connector, the built-in Kleer transceiver with diversity antennae can receive streamed audio from a PC or Mac, or MP3 player, iPod, iPhone or iPad when fitted with a Kleer dongle. Kleer claims one tenth the power drain of Bluetooth, so longer battery life for portables.

Kleer works in the same ISM (Industrial, Scientific and Medical) band as

Bluetooth – 2.4GHz – but carries an overall data stream of 2Mbps, which is sufficient for the 1.4Mbps needed for uncompressed CD-quality stereo plus the data that has to be re-sent because of interference; for example, from microwave ovens, which also work in the 2.4GHz band. Kleer slots a 2.37Mbps data stream in a 3MHz channel, continually scanning the ISM band for clear spaces and hopping in. The scanning is so fast that latency is less than 20ms.)



Arcam rWave – Amplified USB Kleer wireless dongle for Mac / PC / Laptop. Transmits high-power lossless Kleer signal to rCube and rDac, approx 100m range

The rCube can also stream lossless audio from one rCube to a mesh of up to seven others round a house or garden; or rCube can stream to headphones from TDK, Sennheiser or Opera that have a built-in Kleer receiver.

Because it is the Kleer dongles that pair, rather than the audio devices, party-goers

can swap dongles to play their own music from their own players through a common shared rCube, or mesh of rCubes. The rCube costs around £500.

The new family of 3D video devices from Viewsonic are also hard to describe simply. Three basic components are sold separately, but work hand-in-hand; the V3D241 3D 24-inch 3D monitor costing around £330, the 3DV5-E 3D DV Camcorder costing around £150, and the similarly priced 3DPF8-E 8-inch autostereoscopic no-glasses 3D digital photo frame with a built-in battery.

The camcorder captures HD movies in 2D or 3D at 720p, or 5 megapixel stills, on an SD card. A built-in 2.4-inch autostereoscopic no-glasses viewfinder previews and plays in 2D or 3D, albeit with fairly coarse resolution.

The captured footage can then be shown in high resolution 2D or 3D on the 24-inch LED-lit, full HD monitor. 3D display is one of either two modes: as red/blue anaglyph or NVidia frame sequential images at 120Hz for viewing with shutter glasses. The set comes with one pair of shutter glasses. The monitor can also display 3D video or games.

The captured footage can also be shown in medium resolution 2D or 3D on the 8-inch touch screen photo frame. The monitor and frame also show normal 2D.

High performance blade SSDs

Toshiba has announced an innovative new form factor in high capacity solid-state storage, thin, blade-shaped solid-state drive (SSD) modules: the 'Blade X-gale' series. The new drives cover 64GB, 128GB and 256GB capacities and are ideally suited for integration into space-sensitive products,



Cutting-edge storage – Toshiba's new SSDs

including mini-mobile and netbook PCs, and are claimed to give product developers greater freedom and flexibility in product design. The new drives are now available.

As mobile devices gets smaller and lighter, yet ever more feature packed, the SSDs inside them must be even smaller, and much thinner. Toshiba's new 64GB and 128GB SSDs are the thinnest yet, only 2.2mm thick, 42% thinner than that of a typical mSATA form factor. Advanced wiring technology has assured optimised wiring layouts and data transfer rates in this new form factor. Toshiba's base design technology also minimises board warpage during thinning, yielding a 256GB capacity when memory is mounted on both sides, the largest density in the industry for small type modules.

The devices use the SATA 2.6 (3Gps) interface; operate at 3.3V and have a transfer rate of: 220MBps (read), 180MBps (write).

Take the next left, luvvie

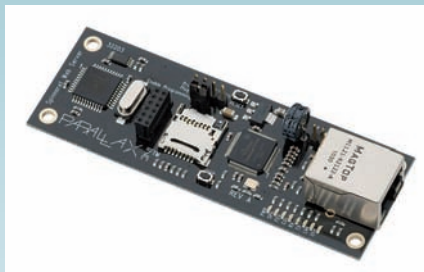


Drivers can now have the booming voice of Brian Blessed as their personal map reader. After a Facebook campaign attracted 25,000 supporters, the king-sized Yorkshireman agreed to record driving

instructions in his distinctive stentorian tones – and the Brian Blessed sat nav voice has been released by TomTom.

'Why have a boring old computer voice when you can have a beardy old me,' laughed Brian.

New Parallax Propeller devices



Parallax has launched two new interesting products for fans of their innovative Propeller system.

Spinneret web server

The Spinneret Web Server may be small — at less than 1½ by 4 inches — but it is a feature packed development platform. The built-in MicroSD card socket and real-time clock allow ample room for time-stamped file and data storage, and the oversized EEPROM can store non-volatile data for use when there is no MicroSD card present.

As an open-source hardware device, all design data, including layout, schematics, and firmware are available under licenses that allow free distribution and reuse. This means that the Spinneret Web Server's design can be incorporated into new applications royalty free and without a non-disclosure agreement.

The Spinneret Web Server is an Ethernet-based development board for the Propeller microcontroller. Web page content, files, and logs can be stored on a MicroSD card. The serial EEPROM has 32KB for storing a Propeller program and 32KB for non-volatile data storage, independent of the MicroSD card.

There is a real-time clock controller for time stamping files and events, and a backup capacitor that will keep the clock running through extended power outages. There is a serial programming header and two auxiliary I/O connections, one for level-shifted open-collector communications over a three-pin data/power/ground cable, and the second is a 12-pin socket for direct 3.3V I/O connections.

There are eight status LEDs on the PCB, plus two that are repeated on the Ethernet jack. One of the status LEDs is user controllable and shares a line with a button that can be read under user control. A second button resets the Propeller to reload the firmware from the EEPROM.

Propeller Platform USB

Combining a 64KB EEPROM, 5MHz removable crystal, 1.5A power regulation, USB, and a microSD card slot on a compact, breadboard and protoboard friendly module, the Propeller Platform USB is an easy-to-use development tool for the multicore Propeller microcontroller. All 32 Propeller I/O are available via pin sockets, along with 5V and 3.3V regulated power.

Other features include:

- 80MHz 8-Core Parallax Propeller P8X32A with removable 5MHz crystal
- Ultra-LDO voltage regulators accept 5.5V minimum power input
- USB-to-serial interface for loading and communication
- 2.8 x 2.5-inch footprint with pin sockets to add additional Platform modules or connect to a breadboard.

Both devices have a retail price of \$49.99, see: www.Parallax.com.

Fluke's new iFlex high-current AC/DC clamp



Fluke have introduced their new '376 clamp meter', which offers improved performance for a wide range of current measurement situations. With true-rms voltage and current measurements, the Fluke 376 can read up to 1000V and 1000A in both AC and DC modes.

Additionally, the Fluke 376 includes the new iFlex flexible current probe, which expands the measurement range to 2500A AC, while providing increased display flexibility, ability to measure around awkward sized conductors and improved wire access.

E Ink gets colour

Hanvon Technology, based in Beijing, has launched the world's first large-screen high-resolution color E Ink display. 'E Ink' screens have two important advantages over traditional LCD versions — they use far less battery power and they are readable in the glare of direct sunlight. The downside is that the new colour E Ink displays are not as sharp or saturated as LCD. The colours resemble a faded colour photograph. Plus, at the moment, E Ink cannot handle video well.

The most popular E Ink applications are in e-book readers such as Amazon's Kindle, but these are black and white. It remains to be seen whether the attractiveness of colour will transfer this new technology to the Kindle and other E Ink devices, but competition from the more expensive Apple iPad, which uses a colour LCD display and includes an e-book application will be hard to ignore.

The fastest chips in the East



Intel has revealed that its Intel Xeon 5600 series processors, announced earlier this year, are at the heart of the world's most powerful supercomputer, the Tianhe-1A. Located at the National Supercomputing Center in Tianjin, China, Tianhe-1A contains 14,396 Intel processors accompanied by accelerator cards, and has demonstrated groundbreaking performance of 2.57 petaflops (1012, or quadrillions of calculations per second).

In partnership with Inspur, a computer manufacturer in China, Intel worked with the National Supercomputing Center and its technology partners to achieve this performance.

The 36th edition of the TOP500 list of supercomputers, as announced at supercomputing event 'SC10', in New Orleans, shows that nearly 80 percent of the world's top 500 systems have Intel processors inside. Such machines are increasingly featured in computers designed for geophysics, financial calculations and scientific research focusing on mainstream applications, such as improving the safety of football players and enhancing medical imaging.

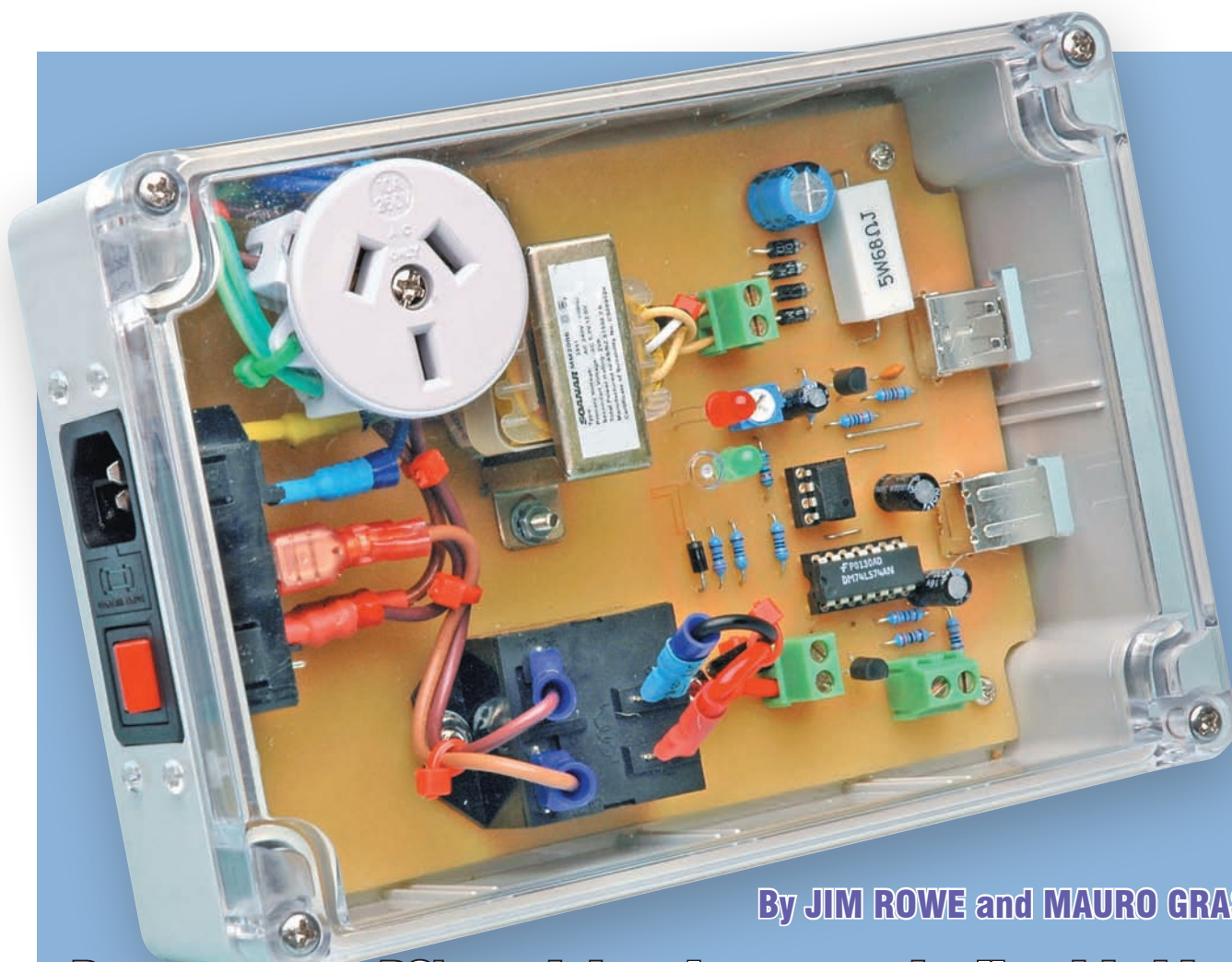
According to the list, Intel chips now power four of the top six systems — in addition to the No. 1 system. Xeon 5600 series processors are a key building block in the No. 3 system (Shenzhen), and the newly listed No. 4 system at the Tokyo Institute of Technology. The New Intel Xeon Processor 7500 series is featured in the Bull Super-node system at CEA, newly listed at No. 6. Overall, 398 new systems on the list feature Intel processors. According to the list, Intel processors are in 90 percent of the systems newly listed in 2010.

The semi-annual TOP500 list of supercomputers is the work of Hans Meuer of the University of Mannheim, Erich Strohmaier and Horst Simon of the US Department of Energy's National Energy Research Scientific Computing Center, and Jack Dongarra of the University of Tennessee. The complete report is available at: www.top500.org.

EP3 EVERYDAY PRACTICAL ELECTRONICS

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By JIM ROWE and MAURO GRASSI

Power up your PC's peripherals automatically with this ...

USB-Sensing Mains Power Switch

Do you have to manually switch your PC's peripherals on (and later off again) each time you boot your PC? If so, this project will make life a lot easier. It monitors your PC's USB port and automatically turns all that other gear on and off as required.

MANY early PCs had an IEC-type 240V outlet socket on the back of the box that was switched by the PC's own on/off switch. This allowed you to automatically switch power to the computer's monitor, printer and other peripherals when the PC itself was switched on or off.

All you had to do was plug a power distribution board into this outlet and then plug the peripherals into this board. The power switch on the front of the PC then controlled everything – all very neat and convenient.

Unfortunately, this handy switched power outlet disappeared

when the PC manufacturers changed over to software-controlled power supplies. So with most new PCs, you're now forced to use a power distribution board with its own master power switch if you want to control all your peripherals with a single switch.

Of course, that means you have to remember to manually switch on the peripherals when you switch on your PC, and vice versa. And that can be a real nuisance. If you forget to turn the peripherals on, the computer won't recognise the monitor or any USB peripherals when it boots and may have to be restarted.

Apart from that, having to manually switch everything on and off at the wall socket can be a real nuisance. Not only that, it can also be impractical if the wall socket is inaccessible because it's hidden behind a desk or some other piece of furniture.

That's where this USB-Sensing Power Switch comes in. It connects to one of your PC's USB ports and when it detects activity on that port, it automatically switches mains power through to a socket on its front panel. By connecting a powerboard to this socket, you can automatically switch on all your peripherals (including the monitor) when the PC itself is switched on, and then off again when the PC is powered down.

This not only relieves you of having to manually switch gear on and off, but also means that the wall socket can be left on.

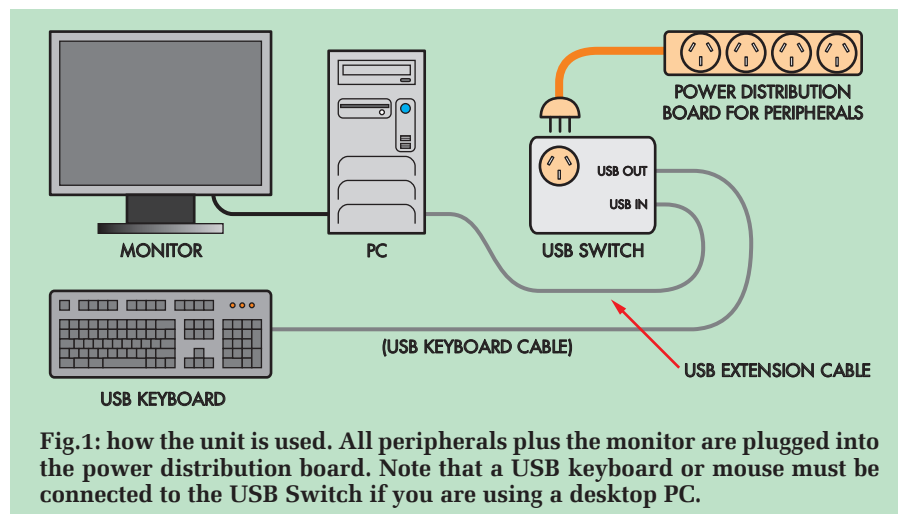
Life ain't easy

At first glance, the circuitry required to do the job should be quite simple – just monitor the USB port's +5V line and use it to turn a transistor on when the PC is switched on. This transistor could then turn on a relay to switch the mains power through to the outlet socket each time the PC was switched on.

Unfortunately, it's not that easy in practice, unless you use a laptop (more on this later). The reason is very simple – most desktop PCs maintain +5V standby power on their USB ports, even when they are powered down. And that would mean that our USB Sensing Power Switch would never switch off if we simply sensed the +5V USB rail.

In fact, the only way to 'kill' the +5V standby power on the USB ports is to switch the PC off at the wall socket (or at the back of the computer itself), hardly the most convenient solution.

So why do desktop PCs do this? Well, there are a couple of reasons. First, by maintaining power to the USB ports, it allows the computer to



be booted simply by double-clicking a USB mouse or by typing a password into a USB keyboard. This is set up in the PC's BIOS (eg, 'Power On By Mouse' or 'Power On By Keyboard') and is a very convenient way of starting the machine if the computer is tucked away under a desk.

Second, it allows you to recharge the batteries in a range of devices via a USB port, even when the computer is off. These devices include MP3 players, iPods, some GPS units and cordless keyboard/mouse receiving stations.

Laptops are different

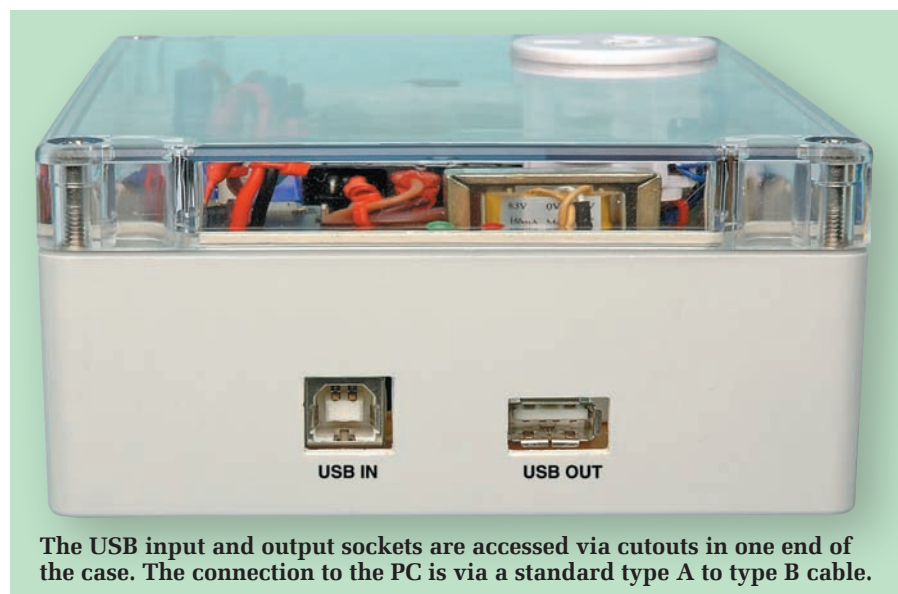
By contrast, laptop computers do shut down the standby power to their USB ports when they are powered down. Presumably, this is done to conserve the battery. Our tests on a number of laptops indicate that power-

ing them via a mains adaptor makes no difference either – the USB ports are still powered down when the machine is switched off.

For laptops then, simply monitoring the +5V USB line is valid and our circuit has an option to do just this. That means that laptops are easy to cater for. A few desktop machines also have a jumper option on the motherboard to disable USB standby power. However, most don't, so we need to use some other method to determine when the machine is switched on.

Monitoring a data line

The answer for desktop machines is to monitor the D- data line of the USB port instead. To do this, however, we must have a USB device plugged into the USB port that the PC recognises, typically a mouse or keyboard.



The USB input and output sockets are accessed via cutouts in one end of the case. The connection to the PC is via a standard type A to type B cable.

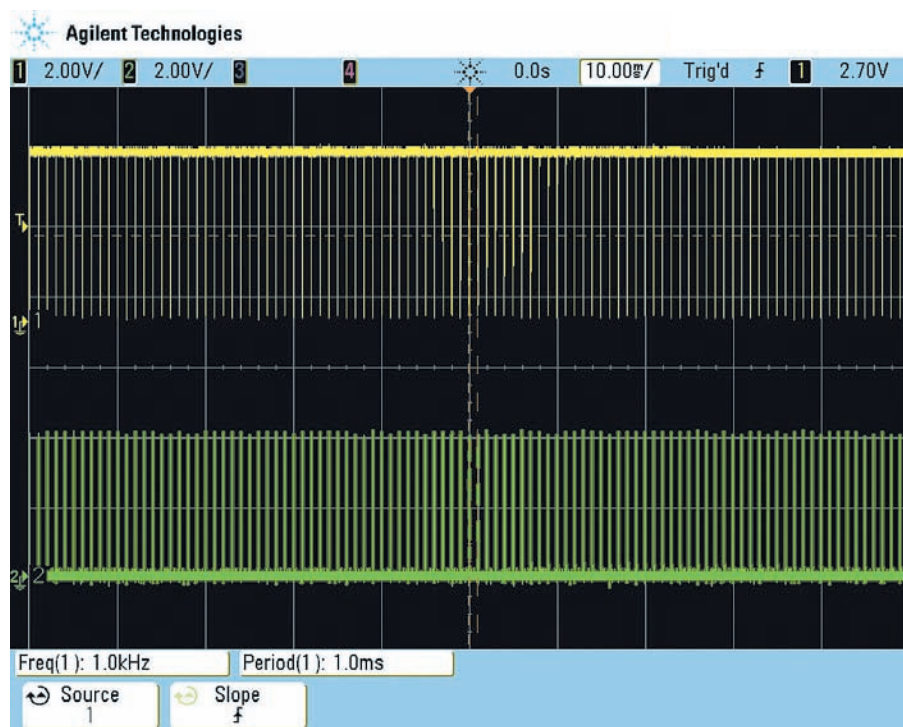


Fig.2: this scope grab shows the polling signals with a full-speed USB device connected to the USB-Sensing Power Switch. The green trace is the signal on the D- line of the USB port, while the yellow trace is the signal at the collector of transistor Q1. The polling frequency is 1kHz, as specified in the USB standard.

The reason for this is that when a recognised device is plugged in, the USB host (ie, in the PC) regularly 'polls' that USB port for activity. This polling signal takes place at a 1kHz rate (ie, 1ms frames) for low-speed and full-speed devices, and has an amplitude of 3.3V.

By contrast, high-speed USB devices use a differential 8kHz polling signal that has an amplitude of just 0.3V. This type of device cannot be used with this project – only low-speed and full-speed devices can be used.

Polling signal

Fig.2 shows the USB polling signal with a full-speed USB device connected. This signal appears shortly after the machine is switched on. What happens then depends on whether you have USB mouse (and/or keyboard) support enabled in the system BIOS. If it isn't enabled, then the polling signal almost immediately ceases again and stays off during the boot period until well into the Windows splash screen, at which point Windows loads its own driver.

When that happens, the polling signal reappears and remains on until the machine is powered down again. However, the polling gap during boot-up

can typically be 30-40 seconds long or more, depending on how long it takes Windows to load its driver.

Alternatively, if USB mouse (or keyboard) support is enabled in the BIOS, the polling signal remains present as the machine boots and only briefly ceases towards the end of the splash screen as the Windows driver takes over. So, in this case, the polling signal is almost continuous from switch on.

By detecting the polling signal on the D- line, we can thus reliably detect when a desktop PC has been switched on. But what about the gap in the polling signal that occurs during boot-up, particularly if USB mouse/keyboard support is not enabled in the BIOS? Unless precautions are taken, the peripheral devices would power up shortly after the PC was switched on, only to almost immediately switch off again when the polling signal ceased.

They would then remain off until the Windows driver loaded for the particular device that was plugged into the USB port. For a plug and play monitor, that could be a real problem – if it isn't turned on, Windows cannot recognise it and so loads a default low-resolution desktop.

Fortunately, this problem is easily solved by designing a circuit that

remains on by default after the polling signal is detected and by then using a timer to turn it off a set period after the polling signal ceases. In the case of the USB-Sensing Power Switch, this delay period can be set anywhere between 33s and 67s, but can easily be extended if your computer is slow to boot.

Note that using the delay circuit also means that the peripherals remain powered up for a brief period after the computer is turned off. So, if the delay period is 40s, for example, the peripherals will remain on for 40s after shut down.

Loop through sensing

Fig.1 shows how the unit is used with a desktop computer. Basically, it uses 'loop through' sensing via two USB ports (one for USB in and one for USB out).

As already mentioned, you must have a USB mouse or keyboard (or some other low-speed or full-speed USB device) plugged in. You cannot use a high-speed device, and that includes most USB flash drives and disk drives (the USB device itself will work, but the USB Sensing Power Switch won't).

Alternatively, for a laptop, all you need to do is connect the unit to a USB port on the computer and configure it to monitor the +5V rail. In this case, you don't have to have a peripheral connected to the USB Out socket, but you can if you wish. What's more, you can connect any type of USB device you want, including high-speed devices – they will all function normally.

By the way, whichever method you use to monitor the USB port, this unit will also power down your peripherals if the PC goes into hibernation. It will then automatically turn them back on again when the machine comes out of hibernation.

How it works

OK, let's see how the unit works. Fig.3 shows the circuit details, and as you can see, there's not a lot to it.

The first thing to note is that the electronic switching circuitry must be electrically isolated from the mains, so that there's no risk of 230V AC getting back into the computer via its USB port. That's done by using a transformer in the power supply, plus a relay to switch the mains through to the mains outlet socket (GPO).

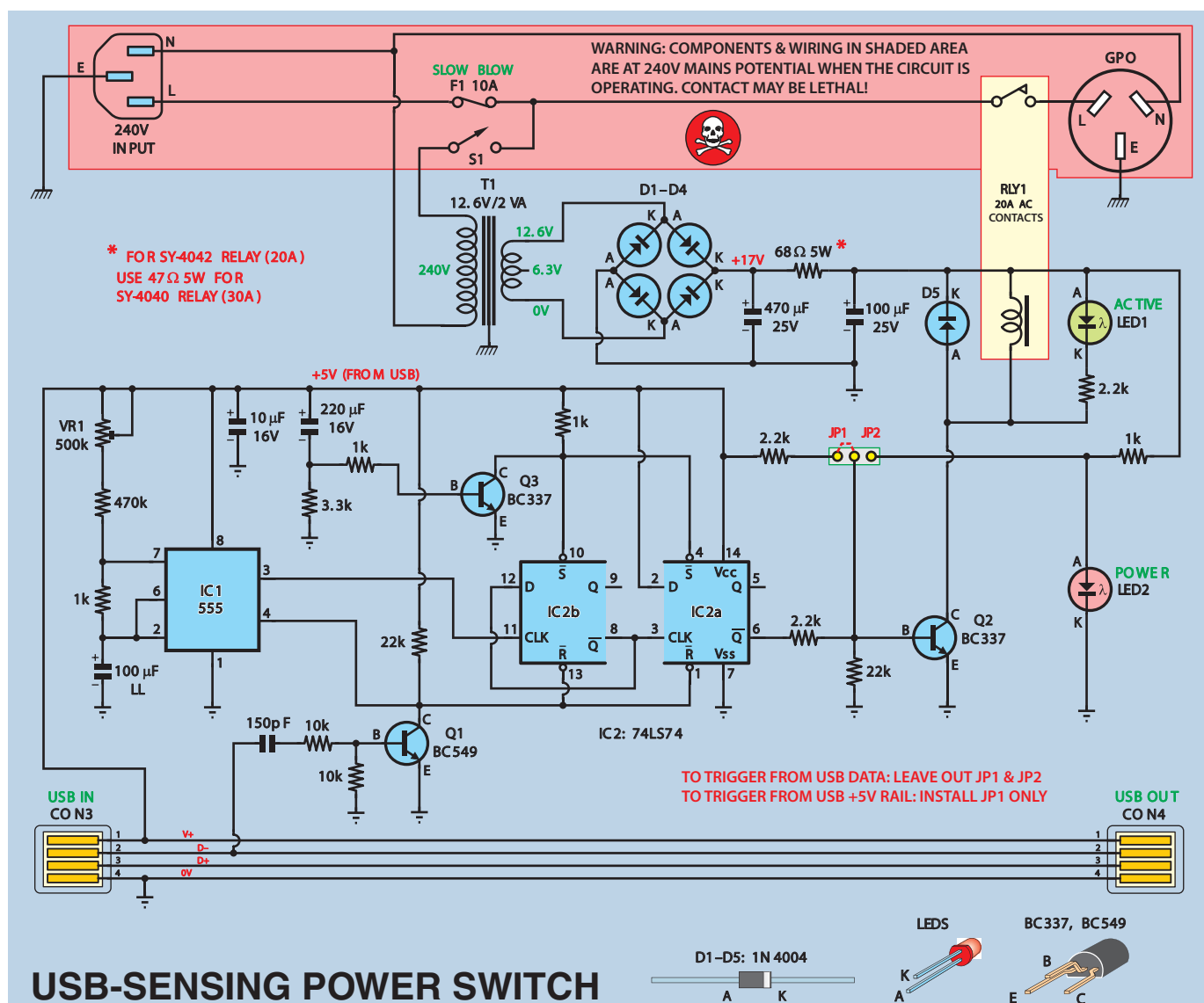


Fig.3: the circuit can be triggered either from the +5V USB line (JP1 in) or from the D- data line (JP1 out) using transistor Q1 and dual D-type flip-flop IC2. When triggering occurs, Q2 turns on and this turns on relay RLY1 to switch mains power through to the GPO (mains outlet socket). Transistor Q3 and its associated parts form the reset circuit for IC2, while 555 timer IC1 switches the unit off after a preset time if no data is detected on the D- line.

As shown, a pair of standard USB sockets, CON3 and CON4, allow the unit to be connected between the PC and an external peripheral using standard USB cables. All of the USB connections go 'straight through', so the added circuitry is essentially 'transparent' as far as USB communication is concerned.

Let's start by considering the simplest configuration, in which the unit is used to monitor the USB 5V (V+) rail (ie, it's being used with a laptop). In this case, jumper JP1 is installed and IC1, IC2a, IC2b and transistors Q1 and Q3 are effectively bypassed and have no role in the circuit's operation.

When the laptop is powered up, +5V DC appears on pin 1 of each of its USB ports. We simply 'steal' a couple of milliamps from this convenient source of 5V DC and use this to turn on transistor Q2 via a 2.2kΩ resistor and jumper JP1.

Transistor Q2 in turn switches on relay RLY1. As a result, RLY1 closes its contacts (which are in the live line) and so power is switched through from the mains input socket to the GPO (general purpose outlet) socket. In addition, Q2 turns on LED1 (green) to indicate that the relay is on.

Conversely, if the laptop is turned off, the +5V DC disappears from USB pin 1 and this removes the forward

bias on Q2 (its base is pulled down to ground via the 22kΩ resistor). Q2 therefore stops conducting, turning off the relay (and LED1) and in turn switching off the power to the mains output socket (GPO) – simple.

Monitoring the D- line

Now let's consider the more complicated case, where we monitor the 'D-' data line (ie, the unit is to be used with a desktop machine). In this case, link JP1 is left open so that the unit cannot be triggered by the +5V USB line. Instead, IC1, IC2a, IC2b and transistors Q1 and Q3 now come into play, and transistor Q2 is driven from the Q output of D-type flip-flop IC2a.

Parts List – USB-Sensing Mains Power Switch

1 PC board, code 788, size 151mm × 109mm	8 M3 hex nylon nuts
1 IP65 ABS sealed polycarbonate enclosure with clear lid, 171mm × 121mm × 55mm (Jaycar HB-6248 or equivalent)	2 6.4mm insulated spade connectors for 1mm ² wire
1 2851 12.6V 150mA (2VA) mains transformer	7 4.8mm insulated spade connectors for 1mm ² wire
1 chassis-mount 12V coil SPST relay with 20A contacts (Jaycar SY-4042)	1 4.8mm insulated piggyback spade connector for 1mm ² wire
2 PC-mount 2-way terminal blocks (CON1, CON2)	1 5.3mm ID eyelet terminal for 1mm ² wire
1 PC-mount Type B USB connector (CON3)	1 72 × 38 × 1mm sheet steel or aluminium (for IEC connector mounting plate)
1 PC-mount Type A USB connector (CON4)	1 3-pin header
1 snap-fit fused male IEC connector with switch	1 jumper link
1 M205 10A slow-blow fuse	1 14-pin machined IC socket
1 10A flush-mounting mains outlet socket, with side wire entry	1 8-pin machined IC socket
1 300mm length of 10A brown mains wire	
1 150mm length of 10A blue mains wire	
1 150mm length of 10A green/yellow mains wire	
12 nylon cable ties	
4 M3 × 6mm machine screws	
2 M3 × 10mm machine screws	
2 M4 × 10mm machine screws, pan head	
2 M3 hex nuts	
3 M3 star lockwashers	
2 M4 hex nuts	
2 M4 star lockwashers	
2 M4 flat washers	
4 M3 × 10mm nylon screws, pan head	

Semiconductors

- 1 555 timer (IC1)
- 1 74LS74 dual D-type flip-flop (IC2)
- 1 BC549 NPN transistor (Q1)
- 2 BC337 NPN transistor (Q2, Q3)
- 1 5mm green LED (LED1)
- 1 5mm red LED (LED2)
- 5 1N4004 1A diodes (D1-D5)

Capacitors

- 1 470µF 25V PC electrolytic
- 1 220µF 16V PC electrolytic
- 2 100µF 25V LL PC electrolytic
- 1 10µF 16V electrolytic
- 1 150pF ceramic

Resistors (0.25W, 1%)

- 1 470kΩ
- 3 2.2kΩ
- 2 22kΩ
- 2 1kΩ
- 2 10kΩ
- 1 68Ω 5W
- 1 3.3kΩ
- 1 500kΩ miniature horizontal mount trimpot (VR1)

It works like this: normally, when the PC is off, the pin 6 $\bar{Q}$ output of D-type flip-flop IC2a is low and transistor Q2 and the relay are off. However, if the PC is turned on, transistor Q1 is rapidly pulsed on and off by the polling signal that appears on the D- line. Q1 inverts this polling signal and applies a train of brief low-going pulses to the reset pins (13 and 1) of IC2b and IC2a.

As a result, IC2b and IC2a are reset, thus forcing their Q outputs low and their $\bar{Q}$ outputs high. This turns on transistor Q2 via a 2.2kΩ resistor at pin 6 of IC2a and activates the relay, which now remains on.

IC1 is a 555 timer that is wired to operate in astable mode. It is also reset each time Q1 is briefly pulsed on by the timing signal (ie, pin 4 is pulled low). This sends pins 3 and 7 of IC1 low and discharges the 100µF timing capacitor on pins 2 and 6 via the 1kΩ resistor.

After the first brief reset pulse, Q1 turns off for a period of 1ms and so pin 3 of IC1 switches high for 1ms and clocks IC2b. Because IC2b's $\bar{Q}$ output is connected to its D input, its outputs immediately toggle, with Q now going high and its $\bar{Q}$ output switching low (ie, a rising-edge clock signal transfers the logic state on its D input through to its Q output). This has no effect on

IC2a though, since the flip-flops only respond to high-going clock pulses.

At the end of this 1ms period, Q1 is pulsed on again by the polling signal and IC1, IC2b and IC2a are again reset. As a result, both Q2 and the relay remain on whenever polling pulses are present.

No polling signal

Now let's see what happens if the polling signal ceases. When that happens, IC1's pin 3 output immediately switches high and clocks IC2b, sending its $\bar{Q}$ output low. At the same time, IC1's 100µF timing capacitor begins charging towards the supply rail via trimpot VR1 and the 470kΩ and 1kΩ resistors.

The timing period for IC1 can be set anywhere from 33s to 67s, depending on the setting of VR1. If another polling pulse occurs within this timing period, then the circuit is reset and the relay remains on. However, if no polling pulse is detected (ie, the PC has been powered down), the timing capacitor continues to charge until it reaches 2/3Vcc. At this point, pin 3 switches low and the 100µF timing capacitor quickly discharges into pin 7 via the 1kΩ resistor.

When the voltage on the timing capacitor discharges to 1/3Vcc, pin 3 switches high again and the 100µF capacitor begins recharging. This high-going output from IC1 clocks IC2b again, sending its Q output (pin 8) high. This in turn clocks IC2a and switches its $\bar{Q}$ output low.

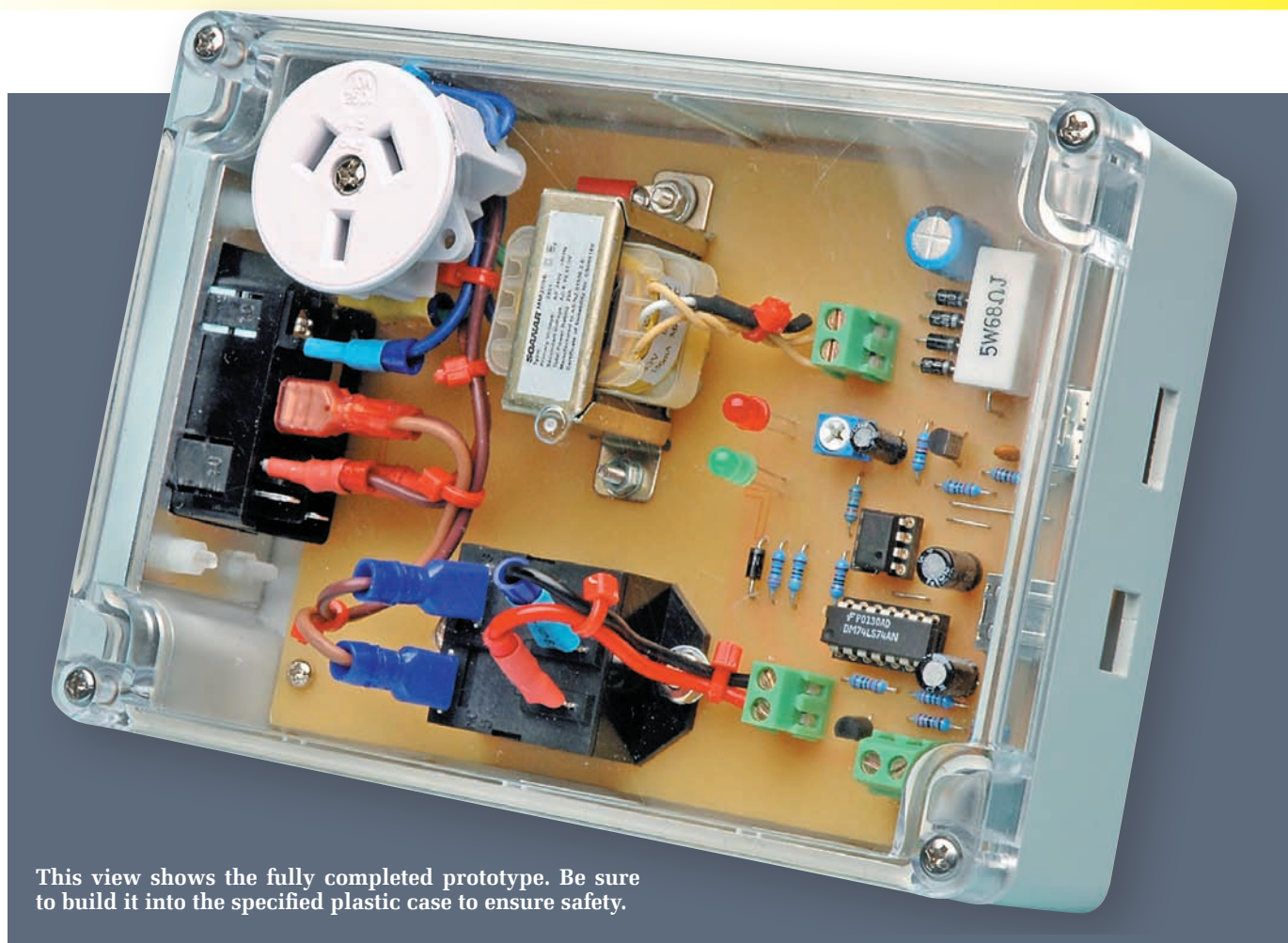
As a result, both Q2 and the relay switch off, as does LED1.

Further clock pulses from IC1 now have no further effect on IC2a. That's because its D input (pin 2) is tied high and any further clock pulses simply transfer this logic high to its Q output, and so $\bar{Q}$ remains low.

In effect, IC1 functions as a missing pulse detector. If the polling signal is absent for longer than its timing period, it applies two clock pulses to IC2b – one almost immediately and the other at the end of the timing period.

IC2b simply prevents this first clock pulse from reaching IC2a and turning off the relay prematurely.

Transistor Q3 and its associated parts form a power-on reset circuit for IC2b and IC2a. This might seem rather complicated for a reset circuit, but it is necessary to give a long time constant (about 0.7s). This prevents the USB



This view shows the fully completed prototype. Be sure to build it into the specified plastic case to ensure safety.

reset pulse, which appears on the D-line almost immediately after power is applied from falsely triggering the unit (ie, before the computer is turned on).

Note that we originally used a simple RC reset network here, but were forced to use the more complicated circuit when we discovered this problem. This accounts for some of the differences between the unit shown in the photos and the final version.

Power supply

All the circuitry involving IC1, IC2, Q1 and Q3 is powered directly from a +5V rail, which is derived from the USB port. By contrast, the relay circuit (including transistor Q2 and LED1) is powered from a 12V rail.

This 12V rail is derived from a simple power supply based on mains transformer T1. Its 12.6V AC secondary is rectified using bridge rectifier D1 to D4, the output of which is then filtered by a 470μF electrolytic capacitor.

This supply provides about 17V DC, so a 68Ω 5W dropping resistor is used to reduce the effective relay voltage to around 12V when it's energised. The specified relay draws about 75mA.

Note that it is also possible to use a similar relay (Jaycar SY-4040) with contacts capable of switching 30A AC. However, this relay needs 100mA of energising current, so if it's used, then the dropping resistor value must be reduced to 47Ω. There is no real advantage in using the higher rated relay however, as the IEC mains input connector is only rated for 10A.

In any case, it's very unlikely that the current drain of the peripherals connected to your PC will total 10A – which corresponds to 2300W. So the 20A relay we're using is already overkill.

Diode D5 is connected across the relay coil to protect transistor Q2 from the back-EMF voltage that's generated

by the relay's coil when it switches off. LED1 (green) indicates when the relay is on and mains power is present at the GPO socket, while LED2 (red) indicates when mains power is applied to the unit.

Finally, switch S1 (which is integral with the IEC socket) allows you to manually turn off the mains power. This is handy if you want to boot the computer, but you don't want to power up certain peripherals, such as a printer or external disk drive.

Construction

All of the parts used in the project are housed in a sturdy polycarbonate enclosure (171mm × 121mm × 55mm) with a clear lid and a neoprene

What happens during hibernation?

ONE FEATURE of this device is that it will power down the peripherals plugged into it if the computer goes into hibernation. That's because all data activity ceases on the USB data line during hibernation and because laptop machines power down their USB ports.

This allows you to save power while the computer hibernates, which is worthwhile over long periods. The peripherals will automatically start up again when the machine comes out of hibernation.

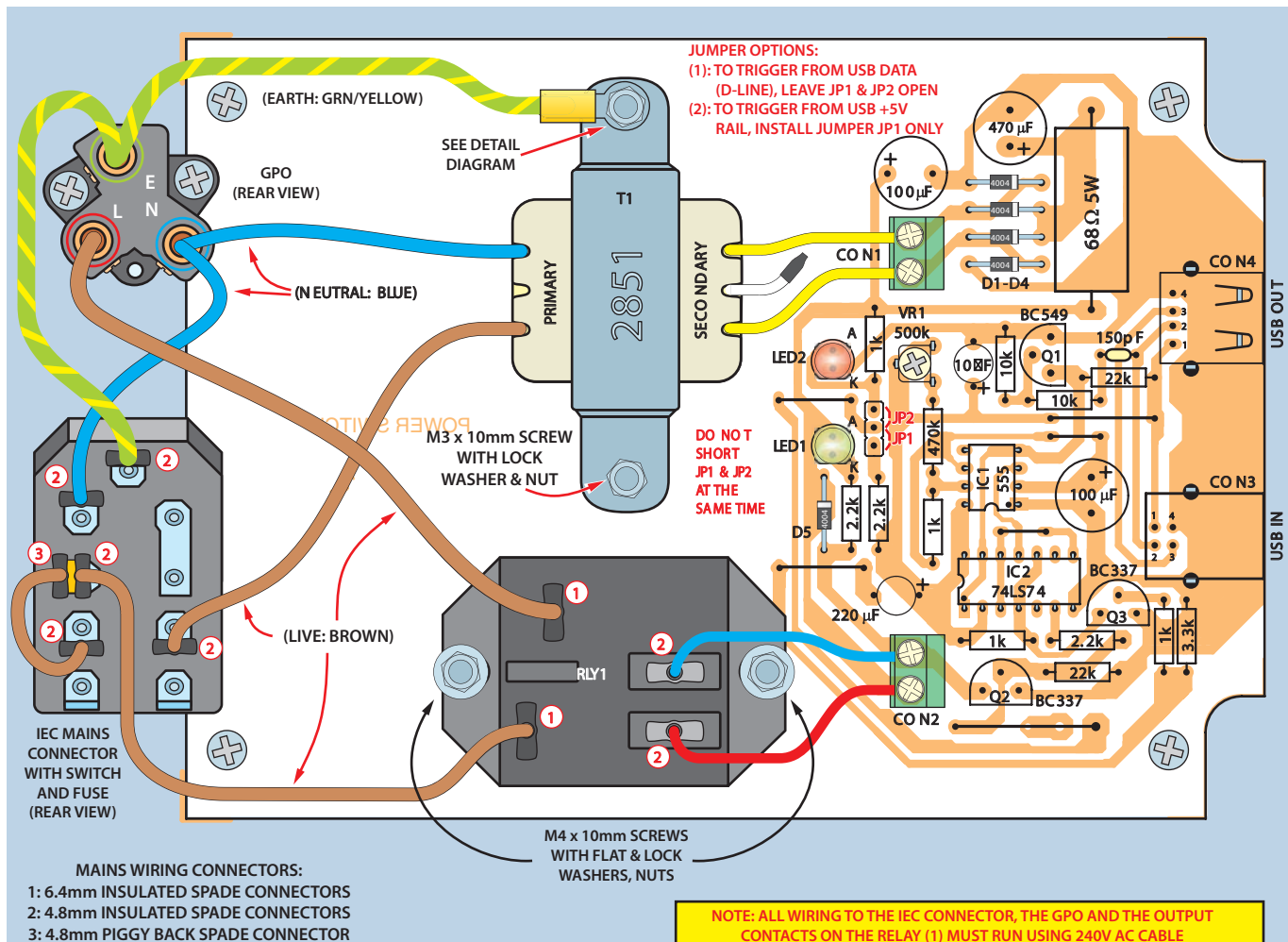


Fig.4: follow this parts layout and wiring diagram to build the unit. Note that all wiring to the GPO, IEC connector and relay contacts must be run using mains-rated cable, and this wiring must be secured using cable ties (see photos)

lid-sealing gasket. **Note that you must use the specified plastic case for safety reasons – do not use a metal case.**

As shown in the photos, the IEC mains input connector (with inbuilt switch S1 and fuse F1) mounts on one end of the enclosure, while the 3-pin mains output socket (GPO) mounts in the lid. Everything else is mounted on a PC board coded 788. This board measures 151mm × 109mm and has corner cut-outs at one end to allow it to sit on the base of the box.

Fig.4 shows the parts layout and wiring. All the low-voltage circuitry is mounted at the right-hand end of the board and there are square cutouts in the end of the case to provide access to the USB connectors. The indicator LEDs are viewed through the transparent lid of the enclosure.

Two-way terminal blocks CON1 and CON2 are used to terminate the connections from the secondary winding

of mains transformer T1 and the coil of relay RLY1, respectively. By contrast, one of T1's primary leads and the relay contacts are connected to the mains wiring via insulated spade connectors.

Board assembly

Begin the assembly by installing the six wire links on the PC board, then install the resistors. Table 1 shows the resistor colour codes, but you should also check each one using a digital multimeter before soldering it to the board. The 68Ω 5W resistor should be mounted with its square-section ceramic body spaced about 3mm up from the board, so that the air can circulate beneath it (you can use a cardboard spacer to do this).

Diodes D1 to D5 can go in next, followed by the three transistors (Q1-Q3). Be sure to use the correct transistor at each location. Q1 must be a BC549,

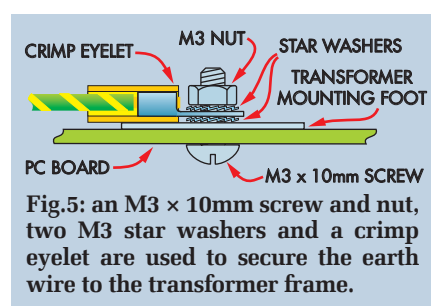


Fig.5: an M3 × 10mm screw and nut, two M3 star washers and a crimp eyelet are used to secure the earth wire to the transformer frame.

while Q2 and Q3 are BC337s. Note that the transistors and diodes are all polarised, so be sure to install them with the correct orientation.

Follow these parts with the two ICs. We used good-quality machined IC sockets on the prototype, but you can solder these devices directly to the PC board if you wish. Be sure to orientate these devices as shown on Fig.4 (the dot or notch on each device is at the pin 1 end).

The electrolytic capacitors are next on the list, again taking care with their orientation. Once they are in, install the 150pF capacitor and the two LEDs (flat side as shown). You can either mount the LEDs close to the board, or leave their leads reasonably long so that they will later sit close to the lid of the case for improved visibility.

The 3-pin header can now be soldered in place, followed by screw terminal connectors CON1 and CON2 and the two USB connectors (CON3 and CON4). Be sure to install CON1 and CON2 with their entry holes facing towards the transformer and relay.

Transformer and relay mounting

The board assembly can now be completed by installing transformer T1 and the relay. First, transformer T1 is mounted using two M3 × 10mm long screws with lockwashers and nuts. Note that the screw fitted to the transformer's 'rear' foot is fitted with an additional lockwasher, because this screw is also later used to attach the crimp eyelet of a mains (safety) earthing lead for the transformer frame.

Note: the enamel must be scraped off the transformer foot for a good contact.

Once the transformer has been mounted on the board, the white 'centre tap' secondary wire can be cut short and fitted with a short length of heatshrink sleeving. The two yellow secondary leads go to CON1. Keep these two leads short and secure them together using a couple of cable ties.

Relay RLY1 is mounted using two M4 × 10mm machine screws with flat washers, lockwashers and M4 nuts. Short leads fitted with 4.8mm



Inside the completed prototype – note how the mains wiring is firmly secured using cable ties, as are the leads to the transformer secondary and relay coil. Note also that the PC board used in this prototype version differs in several respects from the final version shown in Fig.4.

Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
□	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
□	2	22kΩ	red red orange brown	red red black red brown
□	2	10kΩ	brown black orange brown	brown black black red brown
□	1	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
□	1	68Ω 5W	not applicable	not applicable

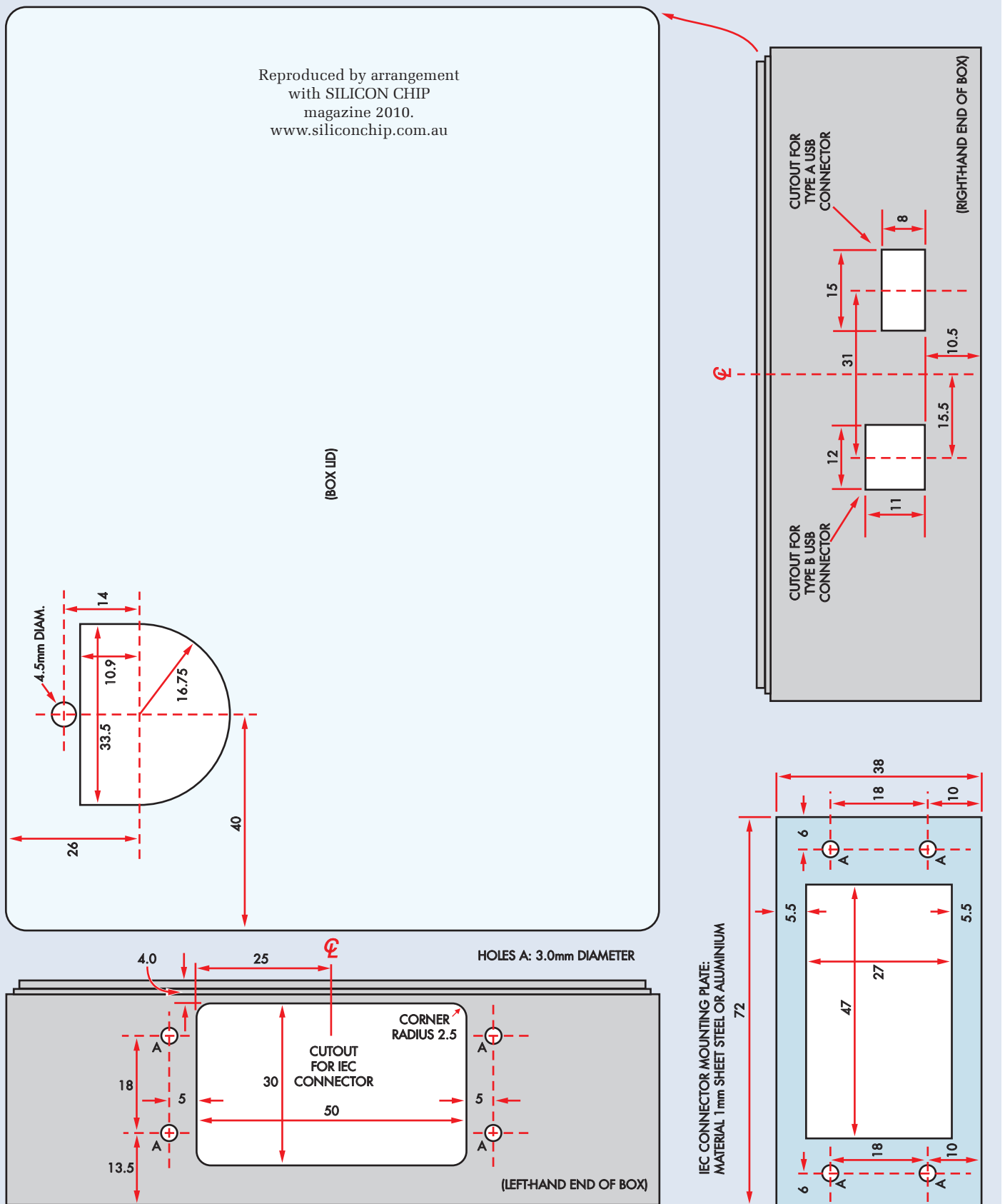
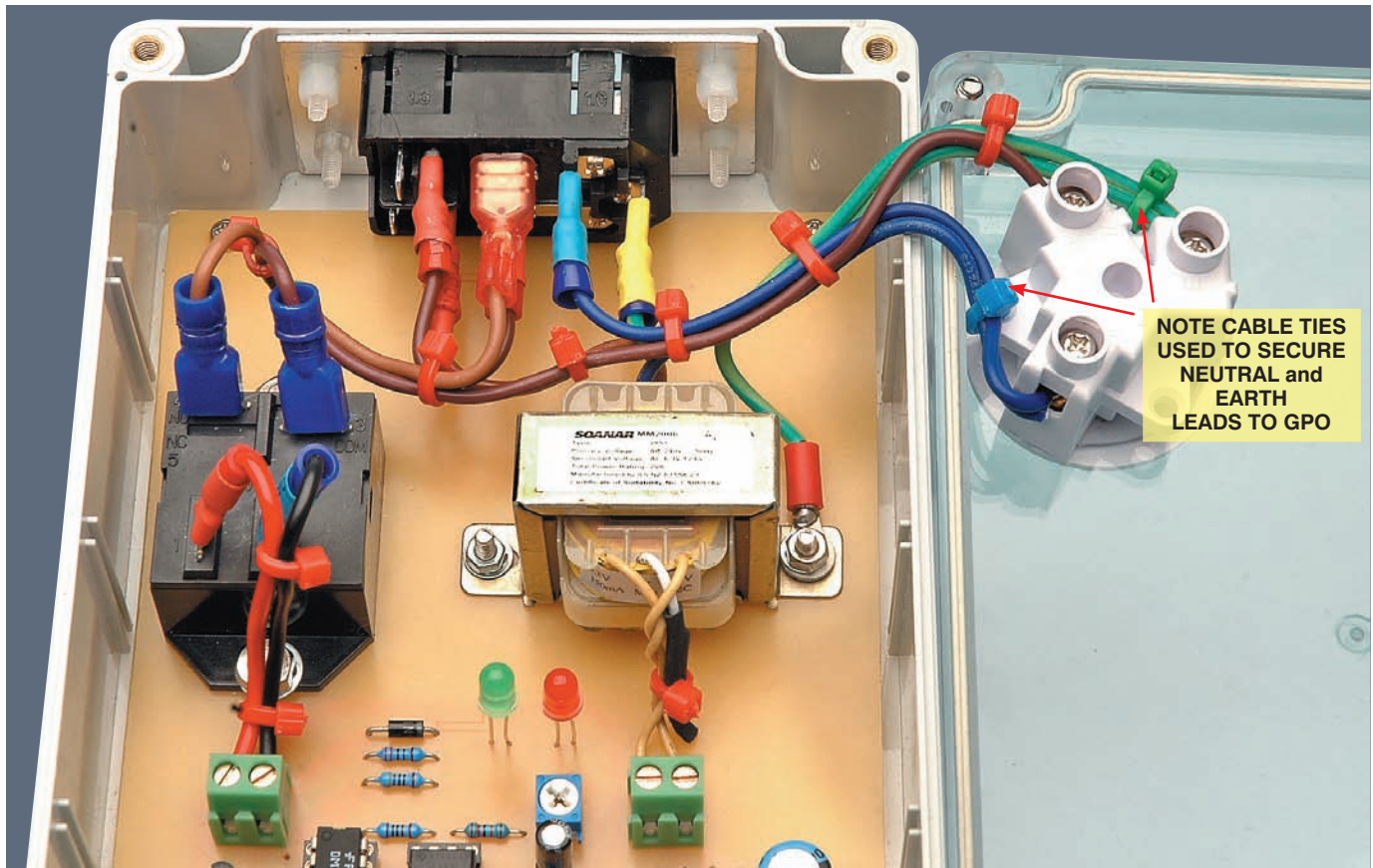


Fig.6: this diagram shows the cutout and drilling details for the GPO socket in the case lid, the access holes for the USB connectors (righthand end), the IEC connector (lefthand end) and the metal mounting plate for the IEC connector. A large cutout can be made by drilling a series of small holes around the inside perimeter, then knocking out the centre piece and carefully filing the job to a smooth finish. **The cutout for the mains output socket (GPO) will, of course, depend on the type used.**



This view inside the prototype unit shows how the mains wiring is installed and secured. It's a good idea to fit two nylon nuts to each nylon screw that's used to secure the IEC connector bracket, to firmly lock it into place.

insulated spade connectors at one end are used to connect its coil terminals to CON2. Once again, secure these leads together with cable ties, as shown in the photos.

Preparing the enclosure

Once the board assembly has been completed, it can be placed aside while you cut the various holes in the enclosure and its lid. The size and locations of all of these holes are shown in Fig.6.

In summary, there are two small rectangular cutouts at one end of the case for access to USB connectors CON3 and CON4, plus a single large rectangular cutout at the other end for the IEC mains input connector. In addition, there are two holes in the lid to mount the GPO socket. This will, of course, depend on the type of mains output socket you use.

The IEC fused male connector and switch is a snap-in type intended for use with a mounting plate thickness of about 1mm. Unfortunately, the specified IP65 box has a wall thickness of 3mm, so the IEC connector

cannot be mounted directly to it. Instead, it is fitted to a 1mm-thick metal plate and this plate is secured to the inside of the box using four M3 × 10mm nylon screws and eight nylon nuts.

As a result of this arrangement, the flange of the IEC socket is mounted flush with the surface of the box, giving a neat finish.

As well as the box cut-outs, Fig.6 also shows the dimensions of the metal plate for the IEC connector. It should be made from 1mm-thick sheet steel or aluminium.

Having made the plate, the next step is to snap the IEC connector into it and then attach this assembly inside the enclosure using the four M3 × 10mm nylon screws and nuts. It's also a good idea to then install an additional nylon nut on each mounting screw. These will firmly lock the first nuts into position and ensure that the assembly cannot possibly come loose.

That done, mount the PC board assembly inside the enclosure and secure it using four M3 × 6mm

machine screws. These screws go into the integral threaded mounting bushes on the base of the box.

The GPO outlet can now be fitted to the lid. That's done by first unscrewing the centre screw holding the front plate to the rear moulding and then screwing the outlet back together with the enclosure lid sandwiched between the two sections.

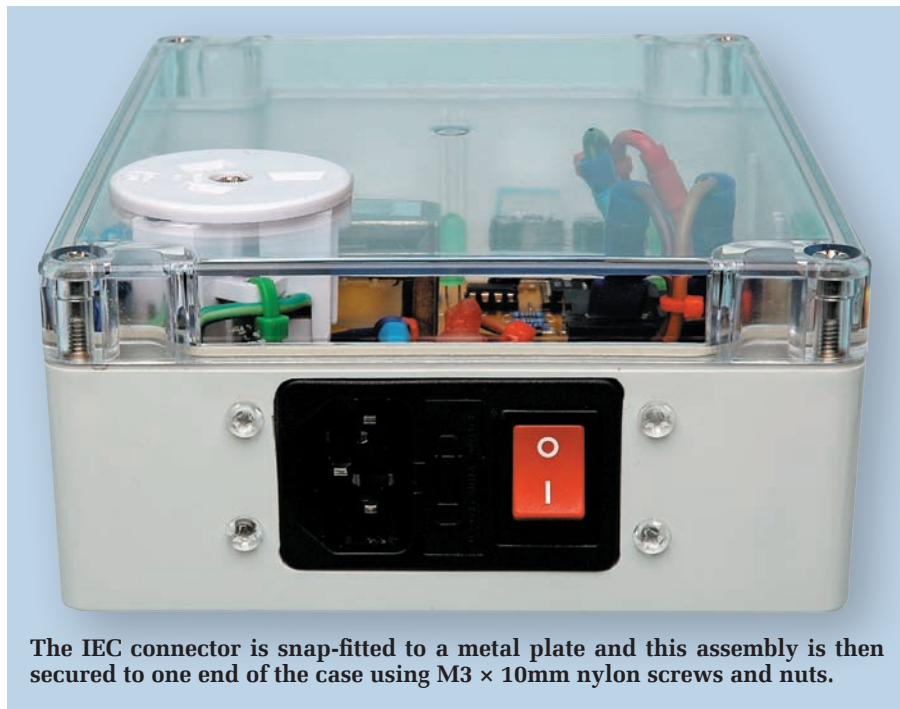
Mains wiring

The final assembly step is to install the mains wiring. This involves all wiring to the IEC input connector, the relay contacts and the mains output socket, plus the primary winding of T1.

Note that all this wiring must use 250V AC 10A rated wire. Brown wires are used for the live connections, blue for neutral and green/yellow for the earth wiring – see Fig.4. Fig.5 shows how the earth lead is attached to the transformer mounting foot via a 5.3mm ID crimp eyelet terminal.

All leads to the IEC connector and to the relay are terminated

Constructional Project



The IEC connector is snap-fitted to a metal plate and this assembly is then secured to one end of the case using M3 × 10mm nylon screws and nuts.

using insulated spade connectors. **You must use a ratchet-driven crimp connector to fit these. Do not use a cheap automotive-style crimp tool, as this will not give reliable connections.** The earth wire terminations, in particular, must be well made in the interests of safety.

Fig.4 shows what type of spade connector to fit to each wire. Use 4.8mm spade connectors to the IEC connector as indicated. These spade connectors must all be fully insulated.

If you are unable to obtain fully insulated 4.8mm connectors, then use non-insulated connectors, but be sure to fully insulate each one using 6mm-diameter heatshrink tubing after its lead is crimped in place.

Note that the connector at the terminal marked '3' on the IEC connector is a piggyback type. Again, it should be fully insulated using heatshrink tubing. Note also that some IEC connectors may have 6.4mm lugs and will require 6.4mm spade connectors.

As shown in the photos, all this mains wiring must be neatly installed and secured using eight cable ties. This is necessary to make it impossible for any leads to come loose and make contact with the low-voltage components on the PC board.

Note that the neutral and earth wires are also tied to the GPO socket using

the holes in its moulding as anchor points (see photo).

Additional cable ties are used to secure the leads to CON1 and CON2. Again, the idea is to ensure they cannot come loose and contact mains voltages.

Initial checks

Before doing anything else, use your multimeter (set to a low ohms range) to check between the earth pin of the IEC connector and the earth outlet of the mains output socket (GPO). You should get a reading of zero ohms here (this checks the integrity of the earth connection). Similarly, you should get a reading of zero ohms between the earth pin of the IEC connector and the transformer frame.

Having verified the earth connection, fit the 10A fuse to the fuseholder in the IEC socket. Note that this fuse should be a slow-blow type.

Testing

It's now time to test the unit. Here's the step-by-step procedure:

- 1) Rotate trimpot VR1 fully anti-clockwise (this sets the timing period to minimum).
- 2) If you are using a laptop, install jumper JP1 to trigger off the +5V

USB rail. If you are using a desktop machine, leave JP1 out so that the unit triggers off the D- line.

- 3) Attach the lid to the case. This is important – **we strongly advise against connecting this unit to mains power without the lid in place, to eliminate the risk of an electric shock.**
- 4) Connect the unit to a mains power outlet, then switch on the mains outlet and switch on the IEC connector's switch (S1). The red LED should light to indicate that the power is on but nothing else should happen – ie, the relay and LED1 (green) should remain off.
- 6) Connect the unit to your computer using a standard USB type-A to type-B cable. If you are using a desktop computer, then connect your USB mouse or keyboard to the USB Out socket (CON4) as well.

7) Power up the computer. After a brief delay (no more than several seconds), you should hear a click as the relay operates and the green LED should light to indicate that mains power has been switched through to the mains output socket.

8) If you have a desktop computer, check the green LED as the computer boots. If it goes out and then comes back on again towards the end of the Windows splash screen, then the delay period is too short.

To adjust the delay, **first unplug the mains cord from the IEC connector, then open the lid and adjust trimpot VR1 slightly clockwise. Be sure to replace the lid before testing the unit again.** Repeat this procedure if necessary, so that the green LED remains on while the computer boots.

9) Power down the computer. If you are using a laptop, the green LED should go out as soon as the machine shuts down. You should also hear a click as the relay switches off.

Alternatively, if you are using a desktop machine, the green LED and relay should remain on for the delay period after the computer switches off. This period will be somewhere between about 33s and 67s, depending on the setting of VR1.

Using the USB-Sensing Mains Power Switch

DESKTOP COMPUTER: trigger from the D- data line. Leave all jumpers out, connect the device to the computer via a standard USB cable and plug a USB mouse or keyboard into the USB Out socket (see Fig.1). Set trimpot VR1 so that the green LED (LED1) stays on continuously while the computer boots. Enabling USB mouse or USB keyboard support (depending on which device you have plugged into the USB Out port) will allow you to set VR1 to minimum (ie, to give the minimum delay period).

LAPTOP COMPUTER: trigger from the USB +5V line. Install jumper JP1 and connect the device to the computer via a standard USB cable. Use of the USB Out socket is optional and you can plug in any device you wish. Note that plugging in a USB mouse or keyboard will introduce a switch-off delay (as set by VR1), unless you leave out IC2.

Points To Check

- 1) Be sure to use the specified ABS plastic case. Nylon screws must be used to secure the IEC connector plate to ensure safety.
- 2) Use mains-rated cable for all connections to the IEC socket, the GPO and the relay contacts. Secure this wiring using cable ties – see photos.
- 3) Use fully-insulated spade connectors to terminate the leads to the IEC connector and to the relay contacts. A ratchet-driven crimping tool is necessary to fit the spade connectors.
- 4) Do not touch any part of the 230VAC wiring while this device is plugged into the mains. Also, **DO NOT attempt to build this device unless you know what you are doing and are familiar with high-voltage wiring.**

Note: if your desktop computer is very slow to boot and 67s isn't long enough, increase the value of the 470kΩ resistor in series with VR1. Alternatively, enable USB mouse or USB keyboard support in the system BIOS, depending on which device you have plugged into CON4.

If this all checks out, your USB-Sensing Power Switch is working and can be put into service. All you have to do is plug a power distribution board into the mains output socket (GPO) on the top of the enclosure, and then plug your peripherals into this distribution board.

Don't forget to connect a USB mouse or keyboard to the unit if you are triggering the unit from the D- line of the USB port.

That's it. Your peripherals will now be automatically turned on and off with the computer. **EPE**

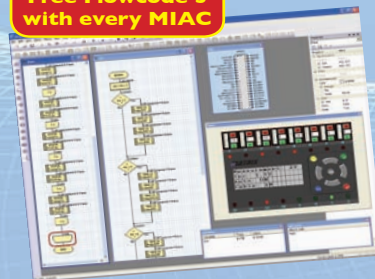
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New Year, New Futures

TechnoTalk

Mark Nelson

To open the New Year we examine a new wonder material that's set to transform electronics, along with a new fashion in body-worn wireless networks. And if you feel like exploring an alternative to eBay, Mark shows you the way.

Graphene mania takes off

BACK in October '10, it was almost impossible not to read about graphene after two scientists involved with graphene won the 2010 Nobel Prize in Physics, even though the 'new' carbon foil electronic material has been under serious investigation since the 1980s.

The key feature of graphene is that it's a sheet or layer of carbon just one atom thick (you need to stack three million of them to make a layer one millimetre thick). It also has some remarkable electronic, optical and thermal properties, and it differs from most conventional three-dimensional materials. It is very flexible and also appears to be one of the strongest materials ever tested.

Because electrons flow faster in graphene than in silicon, it has many potential application for making more efficient transistors and integrated circuits. It is believed that graphene could be used to produce ultra-capacitors with a greater energy storage density than is currently available.

Biodevices are another application, for mammalian and microbial detection, as well as rapid and inexpensive electronic DNA sequencing. Sheets of graphene oxide are highly effective at killing bacteria, meaning that graphene could be useful in applications such as hygiene products or packaging that will help keep food fresh for longer.

Multitasking

Researchers have already made blisteringly fast graphene transistors, states the Massachusetts Institute of Technology's *Technology Review*, and now they could produce configurable triple-mode transistors. Researchers at Rice University in Houston, Texas, have used graphene to make a transistor that can carry out three different modes of operation that in conventional circuits would have to be performed by three separate transistors.

Trade paper *EE Times* clarifies that these triple-mode graphene transistors can conduct both electrons and holes, depending upon whether a positive or negative voltage is applied. This would permit simpler ICs to be constructed, potentially shrinking the size and complexity of common analogue functions when using graphene transistors.

But is it new?

This new research is absolutely current, but investigation into carbon electronics goes back longer. According to www.graphenetworks.com, graphene research

evolved from work on carbon nanotubes.

Early research showed that nanotubes had fabulous electronic properties, but the inability to manufacture well-controlled tubes and scale them up from single-tube transistors to large-scale integrated circuits prevented serious technological applications. In 2001, Walt de Heer realised that two-dimensional graphene (essentially unrolled nanotubes) would have many of the same properties as carbon nanotubes, and this idea has opened the way to a new approach to carbon electronics.

Going back in history, German scientist H P Boehm investigated the adsorption properties of ultra-thin carbon foils back in 1962, and the excellent conductive properties of graphite had been employed in carbon potentiometers for many decades. A researcher by the name of D C Brodie was aware of the highly lamellar (layered) structure of thermally-reduced graphite oxide as far back as 1859. It was studied in detail by V Kohlschütter and P Haenni in 1918, who also described the properties of graphite oxide paper.

BodyNets

BodyNets is a forum where engineers, scientists and medical professionals exchange ideas on using low-power sensor networks in and around the human body for clinical and health monitoring; the study of human computer interactions; education and entertainment. The goal is the development of practical systems for physiological monitoring, human-computer interaction and the provision of entertainment. Last September, they held their fifth international conference in Corfu, where delegates heard and discussed 80 technical papers.

A month later, engineers at Queen's University Belfast announced a new development project that could have us all wearing novel body sensors as part of new mobile Internet networks. Sounds like an April Fools' Day joke? Maybe, but the university's website is adamant that wearable sensors could create new, ultra high bandwidth, mobile internet infrastructures, and reduce the density of mobile phone base stations.

Their engineers are working on this groundbreaking project in the rapidly developing science of body-centric communications. Social benefits from their work could include vast improvements in mobile gaming and remote healthcare, along with new precision monitoring of athletes and real-time tactical training in team sports.

The researchers in Belfast are investigating how small sensors carried by members of the public, in items such as next generation

smartphones, could communicate with each other to create potentially vast body-to-body networks (BBNs). These sensors would interact to transmit data, providing 'anytime, anywhere' mobile network connectivity.

Dr Simon Cotton, from the university's wireless communications research group explains: 'The availability of body-to-body networks could bring great social benefits, including significant healthcare improvements through the use of body-worn sensors for the widespread, routine monitoring and treatment of illness away from medical centres. This could greatly reduce the current strain on health budgets, and help make the government's vision of healthcare at home for the elderly a reality. If the idea takes off, BBNs could also lead to a reduction in the number of base stations needed to service mobile phone users, particularly in areas of high population density.'

Dr Cotton concludes: 'Success in this field will not only bring major social benefits, but could also bring significant commercial rewards for those involved. Even though the market for wearable wireless sensors is still in its infancy, it is expected to grow to more than 400 million devices annually by 2014.'

Bay or Bid?

Do you use eBay to buy electronic components and other goods? If you do, you helped boost the company's last quarterly revenues to £722 million. This was up three per cent compared with the same period a year before. Revenue from PayPal followed close behind, reaching £530 million, up a massive 22 per cent on the previous year.

There are now more than 93 million active accounts on eBay, with a million new users joining every month. Not bad for a company that started out in 1995 as a web page advertising a collector's surplus Pez dispensers (allegedly). I say 'allegedly' because the origins of eBay and the derivation of its name are disputed; the company's corporate website (www.ebayinc.com) does not discuss details of this kind.

Certainly eBay is a great place for doing business, but you should not overlook its latest competitor – eBid (www.ebid.net/). Although it's inevitably smaller than eBay, the prices are keener there, no doubt because it's much cheaper to sell on eBid.

Listing is free and you can leave items on the system until they are sold. I have found some really good bargains buying electronic components on eBid, and you may well be able to share my good luck.

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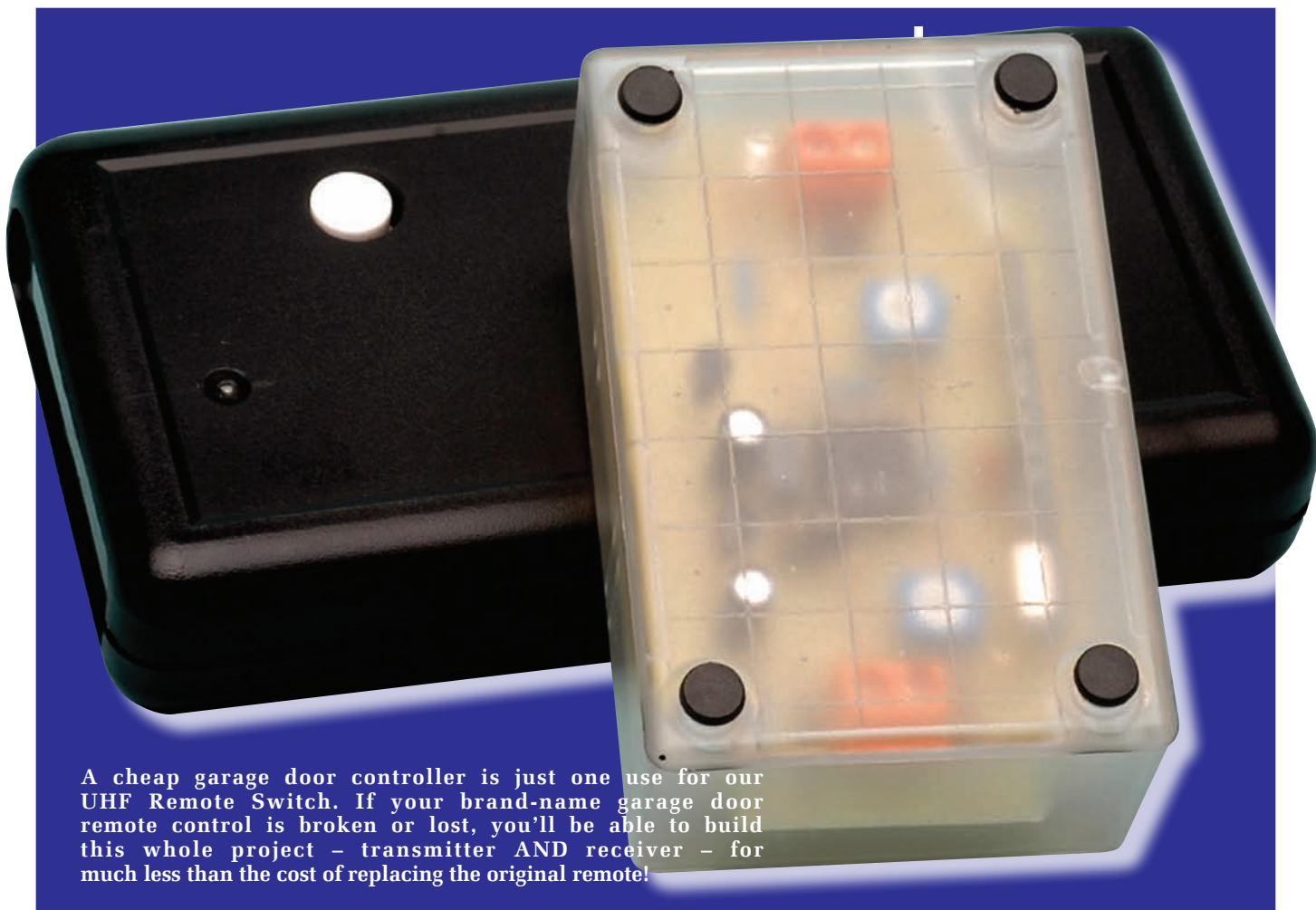
Ideal for remote control of practically anything you like and with a range of more than 200m, this wireless transmitter and receiver pair use pre-built UHF modules that make it easy to construct and use.

433MHz UHF Remote Switch

by John Clarke

Features

- Range over 200m (tested using Jaycar UHF modules)
- Receiver has momentary or toggle output
- Adjustable momentary period
- Receiver can drive a 12V relay
- Transmitter draws no standby current from 9V battery
- Transmit and receive indication
- Up to five receivers can be used in the same vicinity



A cheap garage door controller is just one use for our UHF Remote Switch. If your brand-name garage door remote control is broken or lost, you'll be able to build this whole project – transmitter AND receiver – for much less than the cost of replacing the original remote!

THERE are quite a few 433MHz transmitter and receiver modules around these days. Relatively inexpensive, they are ideal for remote control applications as well as their more usual tasks, wireless data links. While the majority offer only fairly short range (tens of metres), some can work over a 200m+ range.

Even a tens of metres range is a considerable improvement over infrared transmitter and receiver pairs that not only have limited range (<10m) and usually don't work well in sunlight, but more importantly, have strictly line-of-sight reception. A wall, a filing cabinet, even a vase of flowers can stop infrared dead – just like your TV/video infrared remote control.

On the other hand, UHF modules can operate where there is no line-of-sight between the transmitter and receiver. They'll even work through (most!) walls, although walls with interior aluminium insulation or similar will cause them grief.

Commonly known as 433MHz data transceivers, they operate on the 433.050MHz to 434.790MHz band, at a level of 25mW. Classified as 'low interference potential devices' (LIPD), they are widely used for sending wireless industrial, medical and scientific data.

However, these days you are more likely to find them in wireless consumer applications such as door openers, doorbells and weather stations.

We have used these devices in the past for various wireless applications, including the *Water Tank Level Meter*

featured in *EPE* between April and June 2010.

Jaycar Electronics sell a version of the transmitter and receiver pair. The best part about them is that they are pre-assembled and aligned – you don't even need a multimeter to get them going!

As LIPD devices, they have no legal protection against interference from other LIPD devices on the same or similar frequencies. The trade-off is that they are one of the few radio frequency transmitters that can be used without a licence.

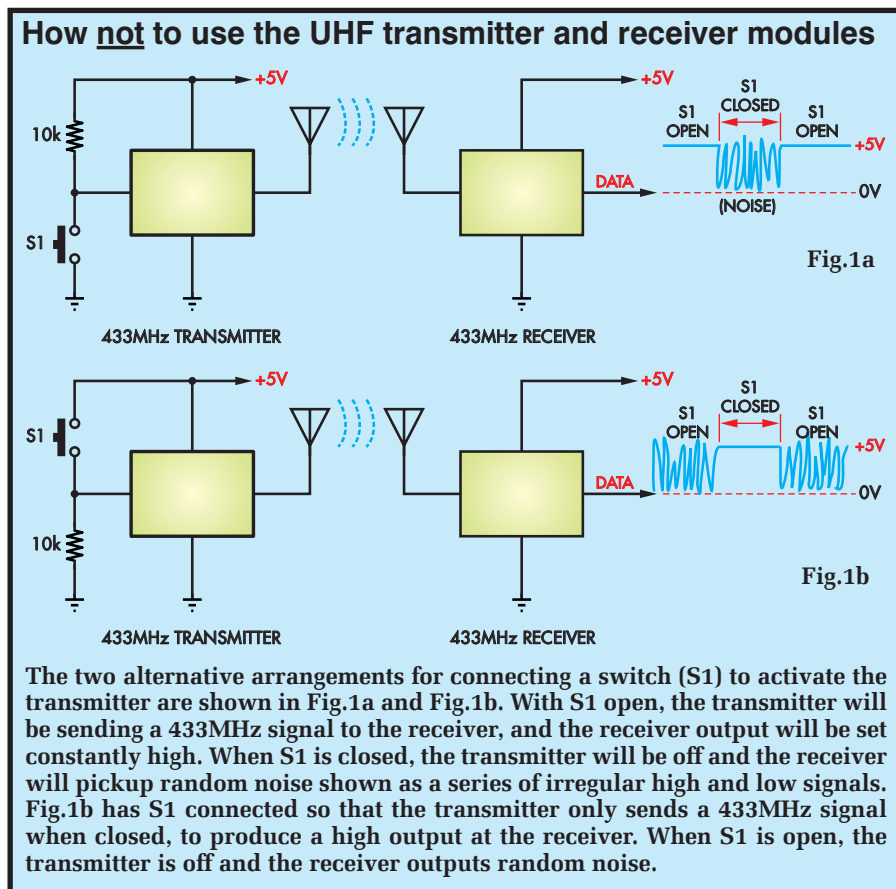
SECURITY NOTE

While this UHF Remote Switch has protection against unauthorised access via its 'identity' settings, there is little to prevent someone with a similar transmitter stepping through these identities if the basic operation is known. Therefore, it should not be placed in locations where security could be compromised – eg, used on a garage door opener where the garage gives access to the rest of the home.

ASK

The 433MHz modules send data by a method known as amplitude shift keying, or ASK. This simply means that to send data, the transmitter sends bursts of a 433MHz signal. When the transmitter is sending the 433MHz signal, the data is a '1' and when the transmitter is off, and not sending a 433MHz signal, the data is a '0'. The receiver

Constructional Project



responds to the transmitted signal by producing a high output when the data sent is a '1' and a low output when the data sent is a '0'.

It may seem easy to use the UHF transmitter/receiver modules just to do simple switching, by simply connecting them as shown in Fig.1a. This is where the transmitter is set to continuously send a signal with the data input held at 5V. The receiver then responds by outputting a high.

It follows that the data output from the receiver would go low when the transmitter ceases transmitting its signal.

The alternative arrangement, with the transmitter off and S1 open is shown in Fig.1b. In this case, the output from the receiver would go high when S1 is closed.

However, neither of these arrangements will work. The reason is that the data rate must be a minimum of 300 bits per second and a maximum

of 10k bits per second. So, for slow speed use where the switch remains open or closed for longer than the minimum rate, there are problems.

Noise

The first problem is that with no signal sent by the transmitter, the receiver outputs a continuous stream of noise. This is seen as random high and low signals at the receiver output.

The reason for this effect is that the receiver has automatic gain control (AGC). In the absence of a 433MHz signal, the receiver increases its amplification (or gain) until it begins to receive a signal. If there is no 433MHz signal, the gain will become so high that the receiver just detects noise. This noise is then what is applied to the receiver output.

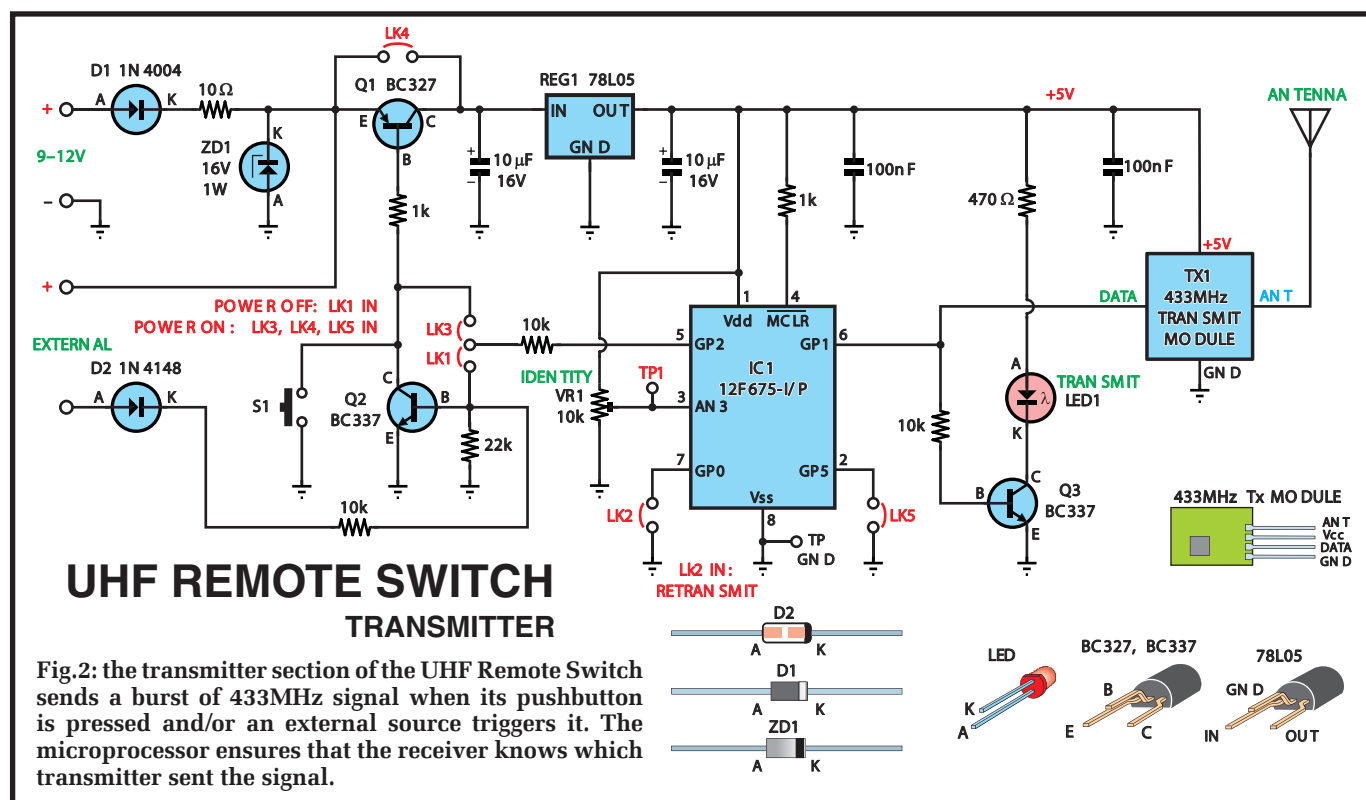
When there is a 433MHz signal transmitted, the receiver gain is reduced so that the signal is received correctly without detecting the background noise. The AGC action is designed to work if the 433MHz signal is modulated (switched on and off) at the correct 300Hz to 10kHz range.

The second problem is that the receiver will respond to any 433MHz signal that occurs in its range. So if your next-door neighbour's garage door is being activated using a 433MHz remote control, then the receiver will also provide an output. So some form of encoding is needed so that the receiver will only work in conjunction with its transmitter and not from another transmitted signal.

Signal conditioning

As a consequence, UHF modules cannot be used without some form of





signal conditioning. For transmission, the signal needs to be processed so that a signal with the correct bit rate is sent to the transmitter module. For reception, the signal needs to be processed to ignore the noise from the receiver module in the absence of signal and to only respond to a valid transmission.

The complexity of the signal conditioning means that a microcontroller is almost a prerequisite, and we chose an 8-pin PIC12F675-I/P device for both the transmitter and receiver.

Using the microcontroller also allows extra features, such as the ability to have momentary or toggle output, an adjustable momentary delay and you can also have up to five different transmitter and receiver pairs working in the same vicinity without interfering with one another.

Presentation

Both the transmitter and receiver are quite flexible in their presentation. We elected to fit the transmitter into a handheld remote control case, which also houses the 9V battery in a separate battery compartment. A pushbutton switch is used to start transmission of signal.

However, the transmitter could be housed in a smaller plastic case or even in no case at all, ie, just as a PC board, depending on the application

(eg, behind the dashboard of your car with just the pushbutton seen on the dash).

Similarly, the receiver may be housed in a small plastic case or perhaps inside a garage door remote controller case. Even if the case was metal, which would normally stop the signal, the antenna wire could emerge through a suitable hole.

The receiver PC board has input terminals for power and two output terminals that can drive a 100mA load, such as a relay coil. The relay contacts can drive low voltage items such as motors and lamps. An LED indicates when the output is on. This receiver includes link options for momentary or toggle output, and an adjustable momentary delay adjustment.

Both transmitter and receiver include an identity control that sets one of five possible identities. The identity of the transmitter and the receiver must be the same for the receiver to respond to the transmitter.

Transmitter circuit

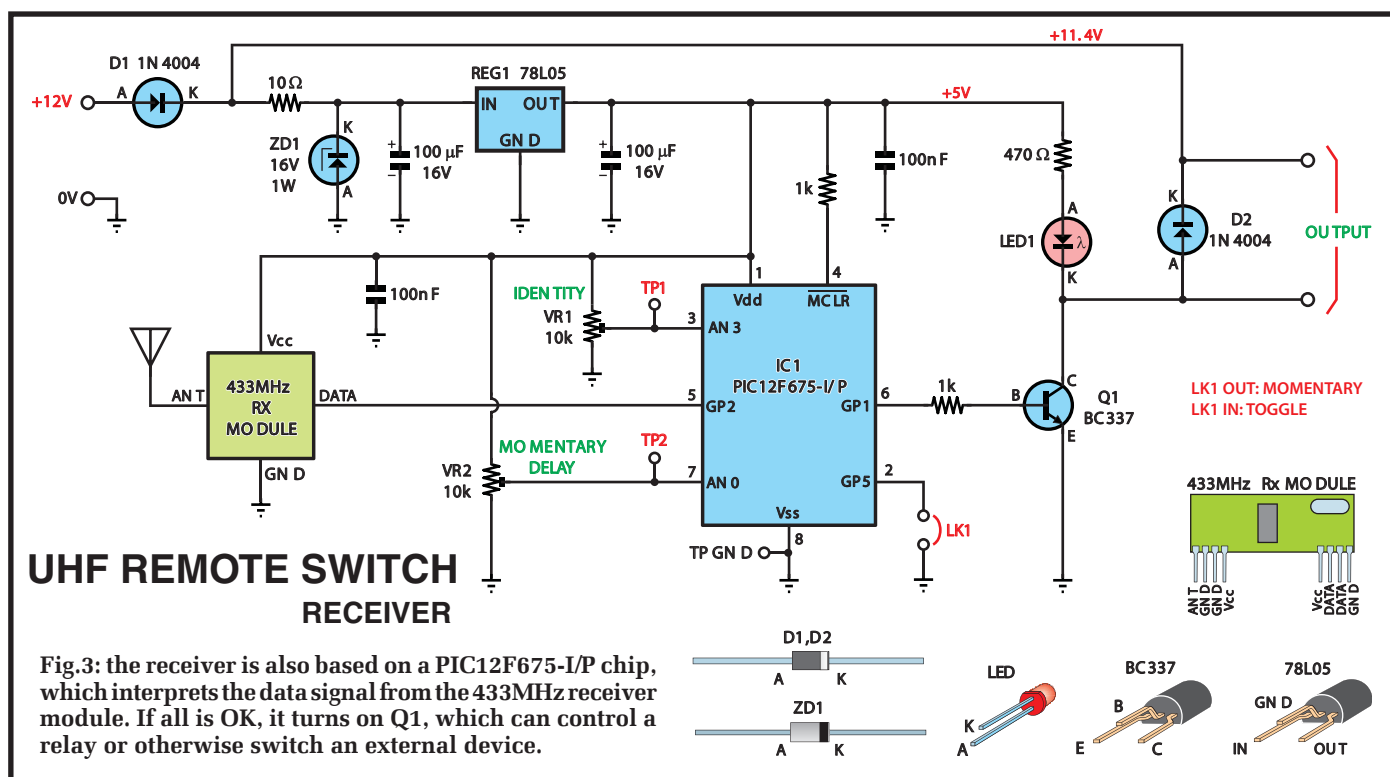
The transmitter circuit is shown in Fig.2. As previously stated, it is based on a PIC microcontroller (IC1) and a 433MHz transmitter module (TX1). The PIC12F675-I/P microcontroller includes an internal oscillator and up to five general-purpose input/

outputs (GPIO). Four of these GPIOs can be used as analogue-to-digital inputs.

The circuit is designed to run from a power supply between 7V and 12V with very low power drain, suiting battery use. Normally, we would assume a 9V battery would be used, but it could be wired into a vehicle's 12V supply. Absolutely no power is drawn when the transmitter is in its standby state – that is, when the transmit switch has not been pressed.



One form of transmitter mounting is inside a handheld case, complete with a 9V battery compartment, as shown here.



When the transmit switch (S1) is pressed, the power drawn is less than 20mA and this is only for a short period while the switch is held closed and the unit is transmitting.

Power is applied to the circuit via diode D1 and a 10Ω resistor to the emitter of transistor Q1. The diode provides reverse polarity protection (essential when used with a 9V battery) while the 10Ω resistor in conjunction with the 16V Zener diode (ZD1) protects against transient voltages. Transient voltages are not likely when used with a battery supply, but the protection is included should the circuit be powered from an automotive 12V supply.

Pressing switch S1 connects the base (B) of transistor Q1 to ground (0V) via the 1k Ω resistor. This allows current to flow from the emitter to base, and so the transistor switches on. Power is then connected to the input of regulator REG1, which supplies +5V to IC1 and the UHF transmitter module TX1.

Pressing S1 is not the only way to trigger the transmitter – other methods are available to suit many different applications. For example, connecting the two ‘External’ inputs together will turn transistor Q2 on, having the same effect as if switch S1 is closed.

A further alternative is to apply a voltage (as low as 1.8V) to the anode

(A) of diode D2 to trigger Q2. The input current at 1.8V is 60 μ A.

With power now connected to IC1, the program begins to run and the GP2 output at pin 5 goes to 5V. This high output drives the base of transistor Q2 via the 10k Ω resistor and link LK1, so the transistor switches on. Power to the circuit is now maintained, even if the switch is released.

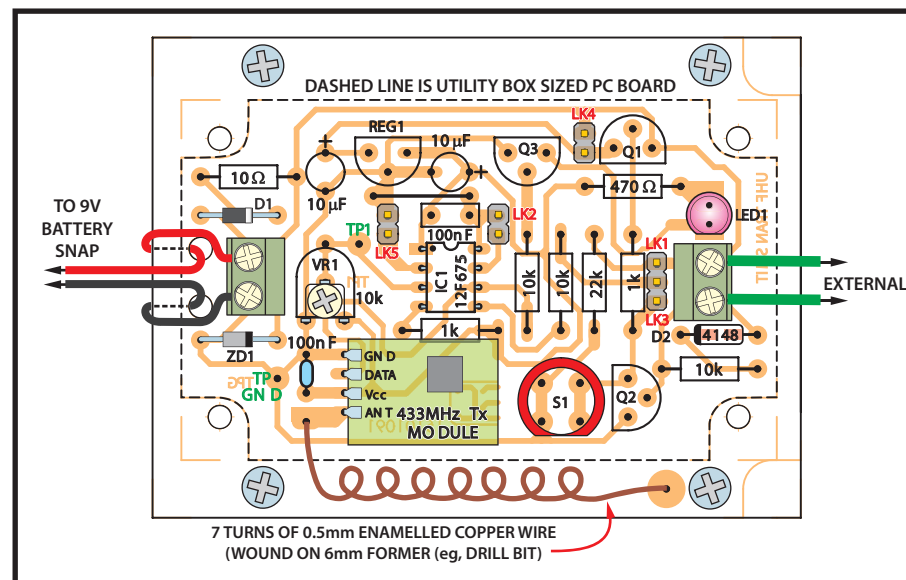
Identity code

IC1 now reads the voltage applied to its AN3 input from trimpot VR1, connected across the 5V supply.

Voltage from this trimpot is divided up into five equal divisions, where each division represents its own identity:

0-1V = Identity 1
1-2V = Identity 2
2-3V = Identity 3
3-4V = Identity 4
4-5V = Identity 5

The identity is sent as part of the code in the transmission. As noted previously, the receiver *must* be set to the same identity as the transmitter before it will respond to the signal.



For Identity 1, the sent code has the value of 8. Identity 2 has the code 16, Identity 3 is 32 and 64 and 128 for Identities 4 and 5. The microprocessor looks for these values in the signal and matches them with values it has stored as part of the program.

The signal from IC1's GP1 output drives both the DATA input of the UHF transmitter and the base of transistor Q3 via a 10k Ω resistor. Q3 powers the LED via a 470 Ω resistor and this LED flashes as a signal is sent to the transmitter module.

Initially, GP1 is set high for 50ms. This sends a burst of 433MHz signal from the transmitter and sets up the UHF receiver so that it is ready to receive data without producing noise. GP1 then goes low for 1ms before going high again for 16ms.

The 16ms allows the receiver to lock on to the data rate of the transmitter. The data rate between the transmitter and receiver needs to be locked because we are using the internal oscillators of the microcontrollers rather than crystal oscillators. The 2% accuracy of the oscillators can affect whether the data is received correctly.

After the 16ms burst of 433MHz is a 1ms low. This is followed by an 8-bit encode value, an 8-bit on/off signal and an 8-bit stop value. The receiver must receive all bits correctly before it will act upon the signal. The 8-bit on/off signal has the value 120 and the stop bit value is 240.

When transmission is completed, output GP2 goes low (to 0V), switching off Q2. If switch S1 is also open, then power is removed from the circuit, as Q1 would also be switched off.

Setting the links

As an alternative to having power switched on only during transmission of the signal, you can have power permanently connected to IC1 and the transmitter module. This may be required if you power the unit from an existing 5V supply or if you want to use the 5V supply from REG1 to power another circuit that requires permanent power.

A change of jumper links is all that is required to make the changes. Swap the link for LK1 to LK3 and fit links to both LK4 and LK5. If using an existing 5V supply, REG1 is not necessary and can be omitted: simply connect +5V to what was REG1's 'out' position.

Link LK5 signals to the IC1 microcontroller that the power arrangement is different and transmission is not required when power is connected. The transmission in this case is initiated by a closure of S1 or a signal at the external input. This is detected by IC1 as a low-going level at the GP2 input.

Link LK2 is used to set repeat transmission at a nominal 200ms rate. The idea of this option is to allow the receiver to provide an output whenever the transmission is being sent and to cease the output when the signal stops.

Receiver circuit

The receiver circuit, shown in Fig.3, also uses a PIC12F675-I/P microcontroller, which works in conjunction with the 433MHz receiver module controller.

The circuit is powered from a 12V supply. It's much the same as the transmitter: diode D1 protects from reverse

polarity connection, while the 10 Ω resistor and Zener diode ZD1 prevent any transient voltages from reaching the 5V regulator, REG1.

This supplies power to both the microcontroller IC1 and the 433MHz wireless receiver module (RX). Overall current consumption is around 7mA with the LED off, and 14mA with the LED on. More current is required from the supply if a relay is connected to the output.

Regulator REG1 includes two 100 μ F bypass capacitors, one at its input and the other at its output. Both IC1 and the 433MHz module have their supply decoupled by a 100nF capacitor close to the supply pins for each.

IC1 has two analogue inputs (AN0 and AN3) to monitor the voltage set by trimpots VR1 and VR2. The voltages at each input are converted to a digital value within IC1. VR1 sets the identity, and this is adjusted to match the identity of the transmitter. VR2 sets the timeout period of the output when it is set for momentary action.

Data from the UHF receiver module is monitored by the GP2 input of IC1. When it receives a signal it compares the values embedded in the code with the identity value set by VR1 and for the correct on/off and stop bit codes. If the values are correct, it sends its GP1 output high, which turns on transistor Q1.

With Q1's collector now low, LED1 is connected virtually across the 5V supply (via its 470 Ω current-limiting resistor), so the LED lights.

Q1's collector (C) is connected to one of the output terminals. This can

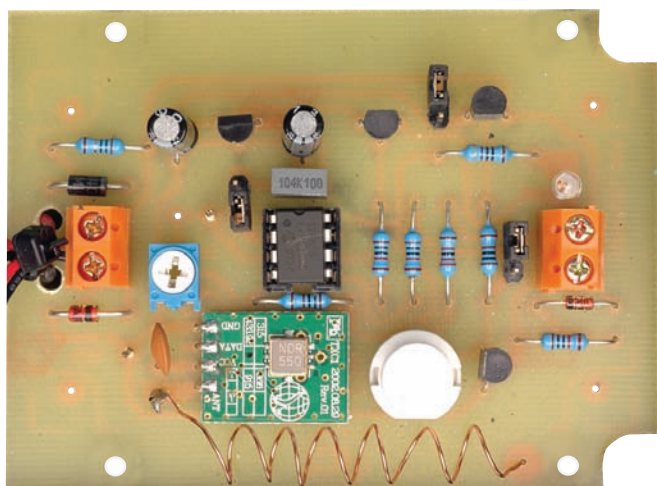
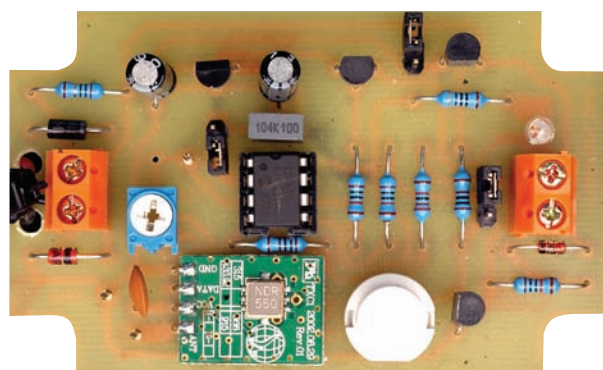


Fig.4 (opposite) is the component overlay for the full-sized transmitter PC board, which matches the photo above.



Here's the mini version, intended for mounting in a utility box. It doesn't have the spiral wire antenna; instead, a 170mm length of hookup wire is soldered to the antenna pin (lower left of the green UHF module).

Constructional Project

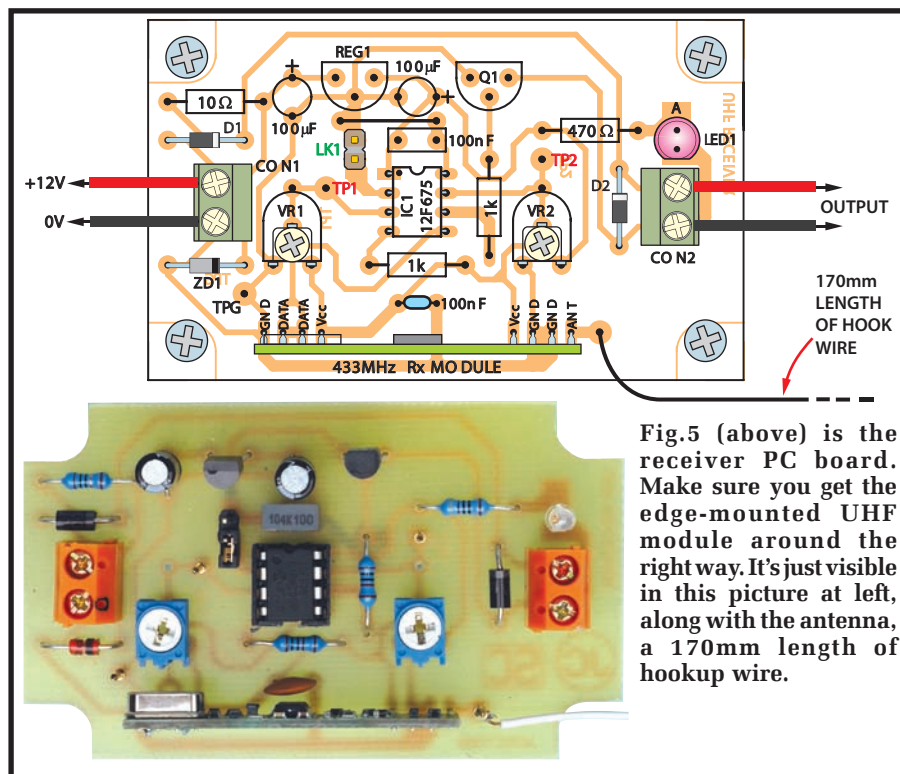


Fig.5 (above) is the receiver PC board. Make sure you get the edge-mounted UHF module around the right way. It's just visible in this picture at left, along with the antenna, a 170mm length of hookup wire.

be used as an output itself for any device capable of being switched by a low (<1V) level, or it can drive a 12V relay connected across the output terminals. Diode D2 protects Q1 from the voltage spike likely when the relay switches off.

The output can be either momentary or toggled, as selected using link LK1.

When LK1 is out, operation is momentary and Q1 is initially turned on only when it receives a valid transmission from the transmitter. It stays turned on for a period set by trimpot VR2.

Timeout periods can be set from 0.2s through to about 50s. If the transmitter is set to retransmit, then Q1 can be held on for as long as the transmitter switch is held down. The timeout needs to be set long enough so that Q1 does not momentarily switch off between each retransmission of signal from the transmitter. Q1 switches off when the transmitter switch is released and after the timeout period.

Software

The software files are available for free download via the *EPE* Library site, accessed via www.epemag.com.

Construction

We'll start with the transmitter which, as we mentioned before, is designed to fit into either a small remote control case measuring 135mm × 70mm × 24mm or into a 83mm × 54mm × 31mm utility box.

The PC board, coded 789, measures 85mm × 63mm. An alternative outline, measuring 79mm × 48mm for the utility box version, is also shown.

Fig.4 shows the parts layout. Begin by checking the PC board for shorted tracks or breaks in the copper. Also, check the hole sizes. The corner mounting holes should be 3mm in diameter, as should the two holes to anchor the battery snap leads.

Now work can begin with the board component assembly. Install the link

and resistors first. Check each resistor value using a digital multimeter before soldering it onto the PC board.

Next, install the PC stakes for the test points and antenna connection, followed by the jumper header pins.

Capacitors can now be installed, making sure the electrolytic capacitors are oriented as shown on the overlay (Fig.4). The ceramic capacitor is located near to the transmitter module

When soldering in diodes D1 and D2 and Zener diode ZD1, take care to orient them as shown in Fig.4. Likewise the 8-pin IC socket – it is oriented with its notch as shown on the overlay. Q1 (BC327), Q2 and Q3 (BC337) and REG1 (78L05) must also be installed the right way around – and in the right positions (the transistors all look the same!).

LED1, as well as being the right way round, must sit up higher than the transistors so that it can be seen through its hole in the case. The top of the LED should be 15mm above the PC board.

The last components to mount before the UHF transmitter module (TX1) are trimpot VR1, the two-way screw terminals and switch S1. Note that the switch must be installed with its flat side toward the edge of the PC board.

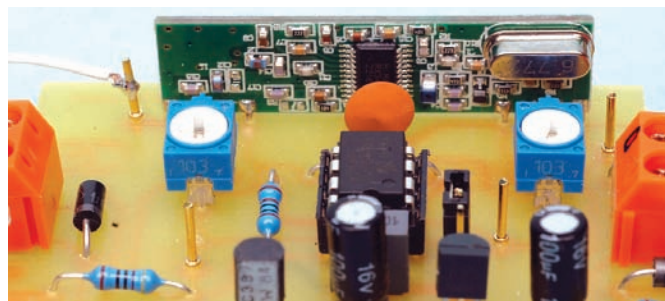
Transmitter module

The UHF transmitter module is mounted horizontally on the PC board and its leads will have to be bent over at 90° before inserting it into the PC board holes. Make sure the transmitter is oriented correctly before bending the leads. The pinouts for the module are screen printed on its PC board.

As you can see from the photos and diagrams, the transmitter antenna is a small coil, made by winding seven turns of 0.5mm enamelled copper wire around a 6mm (1/4in) drill bit.

Each end of the wire should be stripped of its insulation and soldered to the antenna PC stake at one end and the PC board pad at the other. If you have cut down the PC board to suit the smaller (utility) case, then an alternative antenna can be made using a 170mm length of insulated hookup wire attached to the antenna PC stake.

The 9V battery leads pass through one of the battery compartment holes in the handheld remote case before being looped through the holes in the PC board and into the screw terminals. A cable tie secures the wires in position. The PC board is secured



This shot gives a better idea of how the 433MHz UHF receiver module is mounted. Note the capacitor in front of the chip on the module – it is the 100nF ceramic disc type.

Parts List – UHF Remote Switch

TRANSMITTER

- *1 PC board coded 789, size 85mm × 63mm
- 1 remote control case, size 135mm × 70mm × 24mm (Jaycar HB-5610 or equivalent)
- 1 433MHz wireless transmitter module (TX1) (Jaycar ZW-3100 or equivalent)
- 2 2-way PC mount screw terminals with 5.04mm pin spacing (CON1, CON2)
- 1 8-pin DIL IC socket
- 1 9V battery
- 1 9V battery snap connector
- 1 SPST PC board mount snap action switch (S1)
- 3 2-way pin header with 2.54mm pin spacings
- 1 3-way pin header with 2.54mm pin spacings
- 4 jumper plugs
- 1 100mm cable tie
- 4 M3 × 6mm screws
- 2 PC stakes
- 1 170mm length of 0.5mm enamelled copper wire
- 1 20mm length of 0.7mm tinned copper wire

Semiconductors

- 1 PIC12F675-I/P preprogrammed microcontroller (IC1)
- 1 78L05 low power 5V voltage regulator (REG1)
- 1 BC327 PNP transistor (Q1)
- 2 BC337 NPN transistors (Q2, Q3)
- 1 1N4004 1A diode (D1)
- 1 1N4148 signal diode (D2)
- 1 16V 1W Zener diode (ZD1)
- 1 3mm green LED (LED1)

Capacitors

- 2 10µF 16V radial electrolytic
- 1 100nF MKT polyester (code 104 or 100n)
- 1 100nF ceramic (code 104 or 100n)

Resistors (0.25W, 1%)

- 1 22kΩ 3 10kΩ 2 1kΩ 1 470Ω 1 10Ω
- 1 10kΩ horizontal trimpot (VR1)

RECEIVER

- *1 PC board coded 790, size 79mm × 48mm
- 1 plastic utility box 83mm × 54mm × 31mm
- 1 433MHz wireless receiver module (RC1) (Jaycar ZW-3102 or equivalent)
- 2 2-way PC mount screw terminals with 5.04mm pin spacing (CON1, CON2)
- 1 8-pin DIL IC socket
- 1 2-way pin header with 2.54mm pin spacings
- 1 jumper plug
- 4 PC stakes
- 1 170mm length of light duty hookup wire
- 1 20mm length of 0.7mm tinned copper wire

Semiconductors

- 1 PIC12F675-I/P preprogrammed microcontroller (IC1)
- 1 78L05 low power 5V voltage regulator (REG1)
- 1 BC337 NPN transistor (Q1)
- 2 1N4004 1A diodes (D1, D2)
- 1 16V 1W Zener diode (ZD1)
- 1 3mm green LED (LED1)

Capacitors

- 2 100µF 16V radial electrolytic
- 1 100nF MKT polyester (code 104 or 100n)
- 1 100nF ceramic (code 104 or 100n)

Resistors (0.25W, 1%)

- 2 1kΩ 1 470Ω 1 10Ω
- 2 10kΩ horizontal trimpots (VR1, VR2)

* Available from the *EPE PCB Service* as a pair

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to the case with four M3 screws that screw into the integral support bushes of the case.

Receiver

All receiver components mount on a second PC board, coded 790 and measuring 79mm × 48mm. It can be housed in a plastic utility box that measures 83mm × 54mm × 31mm (the same size as the alternative transmitter case). The PC board doesn't have any mounting holes – it is designed to clip into the horizontal slots in the side guides of the box.

Fig.5 shows the parts layout. Again, begin by checking the PC board for

shorted tracks or breaks in the copper. Before soldering any components in, check that the PC board fits neatly into the box as shown. It may require a little filing to narrow the PC board for a good fit without bowing out the side of the box.

Construction is similar to the transmitter: install the link, resistors (use a digital multimeter to confirm values), capacitors, PC stakes, jumper header pins, IC socket and finally the semiconductors. Once again, make sure any polarised components (eg, electrolytic capacitors and semiconductors) are soldered in the right way round.

As with the transmitter, the LED should be mounted so its top is 15mm above the PC board surface. Trimpots VR1 and VR2 can be installed along with the two-way screw terminals.

Unlike the transmitter, the UHF receiver module is mounted vertically on the PC board – make sure the receiver is oriented correctly. The pinouts for the module are screen printed on its PC board.

The receiver antenna is simply a 170mm length of insulated hookup wire, with a 2mm bared end soldered to the antenna PC stake.

With the exception of the ICs, which will be placed after testing, that

Constructional Project

completes assembly. Before moving on to the testing stage, thoroughly check both transmitter and receiver boards for component misplacement (or polarity errors) and bad or missing solder joints. If you are satisfied that all is well, move on!

Testing

Set your multimeter to a low DC voltage (6V to 10V or thereabouts) and connect the 9V battery to the transmitter. Connect the probes to pin 1 and pin 8 of the IC socket.

Press S1 and check that the multimeter reads somewhere between 4.75V and 5.25V. If there is no voltage, check the battery, battery connections and also that Q1 and Q2 are indeed in the right way around and in the right places.

Check the receiver in a similar way (except there is no S1 to press!). Again, the voltage across pins 1 and 8 of the IC socket should be between 4.75V and 5.25V when 12V DC is connected to the power input terminals.

If the voltages in both these checks are incorrect, disconnect power and trace through the circuit until you find the error or problem.

Kit suppliers tell us that 80% of problems in project construction are poor soldering while the other 20% are incorrect component placement or polarity.

If the voltages are correct, switch off power and insert the microcontrollers for both transmitter and receiver into their sockets – dare we say it – the right way around!

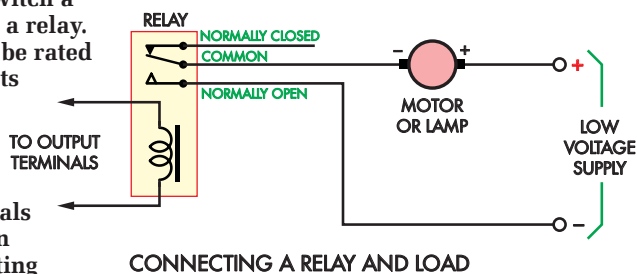
First, the transmitter PC board: insert jumper LK1 and adjust VR1 fully anticlockwise. Reapply power and check that the transmitter flashes its transmit LED when S1 is pressed. So far, so good.

Now apply power to the receiver and press S1 on the transmitter again. The receiver LED should light for around 200ms (ie, a brief flash). Note that the receiver will not work if it is too close to the transmitter (the transmitter is overloading the receiver). You need to have the transmitter and receiver apart by about 1m before it will work reliably. Close up operation is possible if the receiver antenna is disconnected.

You can test the momentary delay by rotating VR2 to mid setting. The LED should light for around five seconds. Note that the delay values from VR2 are not linear with respect to rotation so that you can select closer spaced delays at the lower periods.

Fig.6: here's how to switch a low voltage load with a relay. The relay coil should be rated at 12V and the contacts rated to suit the load.

If using as a garage door opener controller, the NO and common relay terminals would be connected in parallel with the existing (low voltage) pushbutton switch.



Values that can be selected are approximately 200ms, 400ms, 600ms, 800ms, 1s, 1.2s, 1.4s, 1.6s, 1.8s, 2.0s, 2.2s, 2.4s, 3s, 4s, 5s, 6s, 8s, 10s, 12s, 15s, 18s, 21s, 25s, 27s, 30s, 32s, 35s, 38s, 41s, 44s and 50s. These values are spaced about 156mV apart as measured at TP2.

The two lowest 156mV settings will only give the 200ms period because trimpots are not very easy to set much below 200mV at the fully anticlockwise end. The upper end adjustment may not access the 41 and 44s position depending on the trimpot linearity.

If you want the output to toggle where the output alternates between on or off for each transmission, insert the jumper plug for LK1. The momentary delay has no effect for this setting.

Identity

If you are using more than one UHF transmitter and receiver pair, or if you receive a valid signal from a neighbour's transmitter, then you may wish to have a separate identity. This will prevent another transmitter from operating the receiver.

Remember, however, that each transmitter and receiver pair must have the same identity in order to work together. There are five possible identities, selected using trimpot VR1 in both the transmitter and receiver.

The easiest selections are Identity 1, where VR1 is set fully anticlockwise, Identity 3 where VR1 is to set mid-position and Identity 5 where VR1 is set fully clockwise. Positioning of VR1 for Identity 2 is mid way between fully anticlockwise and mid setting while Identity 4 is between mid setting and fully clockwise.

Further options for the transmitter include 'retransmit' using link LK5. This sets the transmitter to continue repeating a transmission while S1 is closed or while the external trigger is applied. This will keep the receiver

output activated provided that the momentary delay is sufficient to prevent LED1 dropping out between transmissions. The setting is ideal if you want the receiver to 'follow' the closure of S1.

Finally, the transmitter includes supply options where the circuit can be continuously powered. To do this, swap the jumper LK1 into LK3. Also insert LK4 and LK5. Note that for this arrangement, transistor Q1 and its 1kΩ base resistor are not required and can be left off the PC board.

Connecting a relay

A 12V relay can be driven via the output terminals of the receiver, provided the receiver is powered by a 12V supply with a 100mA or higher current capability. The contacts can be used to drive a load, as shown in Fig.6.

For general 12V to 24V use, with loads up to about 3A for a motor and 10A for a lamp, a standard 12V horn relay could be used. These are available from Jaycar – SY-4068 for a single pole changeover (SPDT) version or SY-4070 for the double pole (DPDT) version. These relays are rated at 30A.

Higher rated relays are also available, such as the 60A-rated Jaycar SY-4074.

If using as a garage door controller, most openers have a 'local' low-voltage pushbutton switch. The relay contacts would simply wire in parallel with this switch and the receiver set to 'momentary' mode.

Note that the relay is not recommended to drive mains appliances unless you are proficient with using mains wiring.

A mains-rated relay is obviously required. The contacts of the relay must be rated for the load and, of course, any 230V wiring must be adequately isolated. Switching motors will require a higher rated contact than the stated running current because start-up currents are much higher. **EPE**



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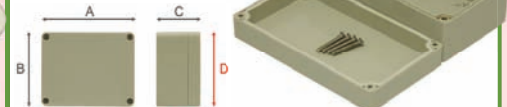
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AM (MW) broadcast band portable loop antenna

Lamenting the passing of local AM radio? Unable to clamber up on the roof for a long wire aerial anymore? Here's a simple medium wave tunable loop that, even indoors, will bring signals out of thin air!

by Stan Swan

WAY back in 1965, country music star Connie Smith sang about a 'tiny blue transistor radio'. The 'trannie' was then the height of desirable consumer hi-tech. The ability to take pocket music and news with you was near-revolutionary in an era when almost everything electronic was wired to the mains.

These early portable radios were AM (amplitude modulation) only, covering the 520kHz to 1650kHz medium wave (MW) broadcast band, with a significant part of their appeal due to the inbuilt radio-signal-concentrating ferrite rod antenna. Mains powered MW radios prior to this era had used bulky wire loops or lengthy external aerials, neither of which suited portability.

Ferrites are iron-based magnetic materials and an aerial coil wound around such a rod could be brought to resonance via a variable tuning capacitor within the radio circuitry itself. They're convenient, very compact and offer good broadside directivity, arising from response to the magnetic component of the radio signal.

However, their efficiency is much less than a traditional antenna, a fact now often forgotten. Although ferrite rods are further hindered by an upper frequency limit of just a few MHz, almost all portable radios made in the last 50 years have used them for MW reception.

Tuning a signal

But how does a ferrite rod antenna coil pick up a signal of a specific frequency? In truth, it doesn't – it picks up a great range of frequencies at the same time. It must be made resonant at a particular frequency, so that it allows signals at that frequency to pass through, while rejecting all others.

And how is it made resonant? By adding capacitance in parallel with the coil. If either the coil or the capacitor is made variable, the frequency of the signal which passes through can also be made variable.

It's more usual to have a variable capacitor than a variable inductor, though variable inductors are available, or at least they were once.

Coil/capacitor electrical resonance is related to frequency by a well-known formula:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

f = frequency in Hertz
C = capacitance in farads
L = inductance in henries

For a signal to cause *LC* resonance at 1MHz (which, incidentally, is right in the middle of the MW broadcast band), a capacitor of 100pF could be used with a coil of 250µH inductance.

Neither the *L* nor *C* values are very high – we're talking picofarads (10^{-12} of a farad) and microhenries (10^{-6} of a henry), and even stray capacitance or a few extra turns of wire can significantly shift the resonant frequency.

Tuning capacitors traditionally used to complete the *LC* resonance were a mechanical marvel, typically presenting capacitance values of 10pF to 415pF, or 30pF to 300pF as the interleaving air-spaced insulated plates meshed. The drive for

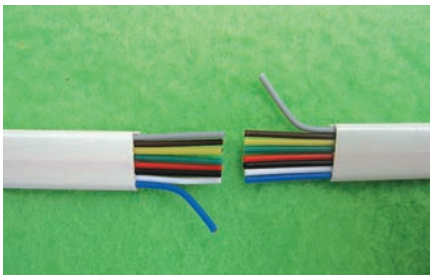




1. Medium wave (MW) AM broadcast band loop antenna, built using cheap 4-pair (8 wire) telephone 'ribbon' cable, and (optionally) housed in cheap garden 13mm irrigation plastic hose. The more rigid self-supporting version is better suited to serious use, as it can better null offending local noise or stations and even DF (direction find) when rotated towards remote signals.



2. The compact version allows easy storage – suitable for portable and travelling needs. Three metres of cheap 8-wire cable will resonate nicely over most of the upper 500kHz to 1.7MHz MW broadcast band with a common 60pF to 160pF miniature variable tuning capacitor (eg, Jaycar RV-5728). However, you should use longer lengths for stations at lower MW frequencies, or add a second capacitor in parallel to the variable one.



3. Rather than tediously winding multiple strands of wire around a frame, the approach here is to simply connect the cables offset wire ends (eg, white to blue, black to white, red to black and so on), thus making an 8-wire loop! Classic gray computer ribbon cable could also be used, but the coloured wires of the phone cable used here make for much easier assembly and less confusion.

compactness again produced superior 'dielectric' insulating layers: plastics have hence long been used instead of air between the plates. It's now quite hard to locate larger value variable tuning capacitors, with the limited C range (60pF to 160pF) Jaycar RV-5728 almost the only available offering.

Wheeler's formula

But back to the L side of things. During the golden age of AM radio before WW2, aerial coils were mostly air wound on hollow formers, and Wheeler's Formula was developed to estimate this inductance for a given number of wire turns on a coil of known radius and length:

$$L = \frac{N^2 R^2}{9R + 10H}$$

L = inductance in microhenries
 N = number of turns of wire
 R = radius of coil in inches
 H = height of coil in inches

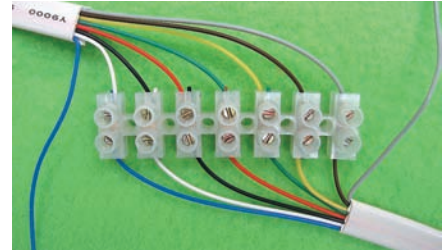
Yes – it's shown using inches, but this classic formula essentially says that larger coils need fewer wire turns (or vice versa) for the same inductance. (Note that here, 'H' represents coil thickness perpendicular to the plane of the coil.) Thus, hoop-sized coils of diameter around $\frac{1}{2}$ m can be wound to resonate in the MW band with just a few dozen turns of wire – even hula hoops have been persuaded to act as coil supports!

Mmm – interesting, but why do you need such a large coil? Although classic radio theory, the reasons still appeal. Naturally, larger antenna coils capture more of the passing radio signal, but they also show desirable orientation effects, allowing users to beam on to weak stations or interference reduction.

Being magnetic devices – they're coils after all – they respond to the magnetic component of the electromagnetic (EM) radio wave, rather than the electrical portion picked up by a long wire antenna. Hence, since many interference sources are electrical in nature, this magnetic response can give some useful immunity to locally produced electrical noise.

Enhanced reception

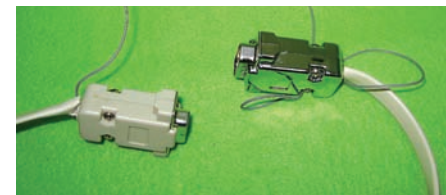
Aha! – keen minds may already see where this is leading, and they'd join the legions of those who've long appreciated that a large tuned loop



4. If you find soldering tricky, the wire ends can be joined by cheap two-way screw terminal blocks. This will give design versatility, especially if you want to shorten the loop to cover higher frequencies.



5. When trimmed with a scalpel, these terminals will also just fit (perhaps end to end) inside the 13mm plastic pipe.



6. A serial D9 pair could also be used, but these are tricky to solder and more costly.



7. Just basic household tools will do – the compact version can be mounted on a short piece of trellis offcut.



8. Cut off three metres and remove about four finger widths of the outer insulation.

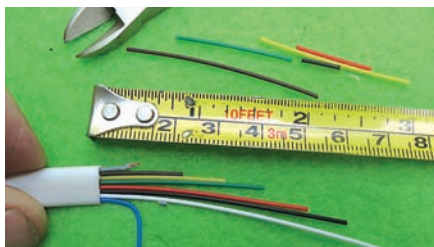
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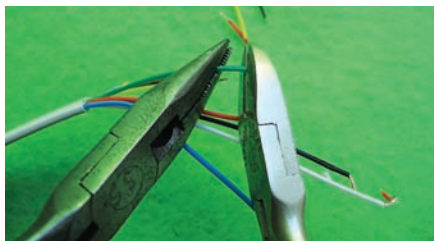
9. Avoid nicking (and thus weakening) the eight inner wires; carefully bend back the outer insulation as you cut.



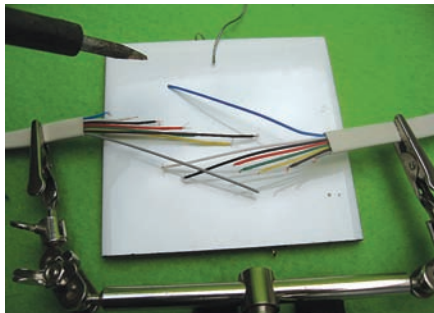
10. A scalpel will often do this most cleanly – side-cutters are usually too savage.



11. If soldering the pairs, 'stagger' each join by about 10mm to avoid adjacent wires shorting each other.



12. Use both fine pliers and side-cutters to reveal the copper wire.



13. A 'third hand' or 'helping hand' will greatly assist in holding the wires steady during soldering. The soldering doesn't have to be especially neat, but avoid shorts or weakened joints.

antenna can enhance MW radio performance. For almost a century, insulated magnet wire has been lovingly wound onto wooden supports and websites still abound showing ambitious loop constructional details.

Aside from radio DX hobbyists (DX means distance) chasing rare stations, sports fanatics trying to hear a distant game or perhaps listeners after weak 1.7MHz 'X' (extended) band ethnic or school stations, serious MW reception needs arise in remote mountainous and ocean regions where urban radio signals are elusive.

Daytime lower frequency radio signals tend to just follow the earth's surface, being little influenced by the sort of terrain or vegetation that blocks VHF or microwave signals. At night, ionospheric reflection can boost MW ranges to thousands of kilometres – east coast Australian (and even west coast USA) MW stations are often received after dark in New Zealand with a decent communications receiver and external antenna – and vice versa. You could be based on a desert island or outback mining camp and still follow global events on MW radio.

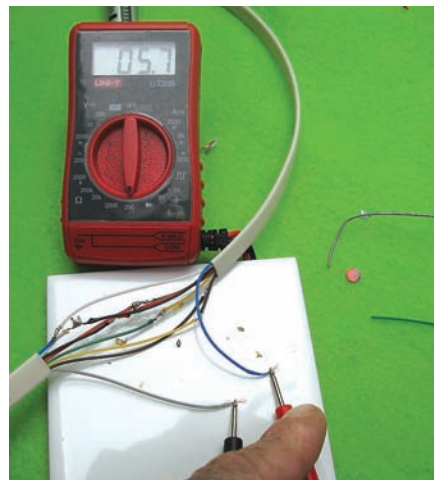
In the wilds

The ability to tune into MW news and weather forecasts in the wilds can be extremely convenient and maybe even life saving. It's easy for city dwellers to assume cell phone, Internet, FM and TV coverage is near universal, but when just a few hours away in the outdoors, the plight of much of the 'out of touch' world soon becomes apparent.

This was brought home to me recently when camping with a sports-mad group at an isolated New Zealand beach, as radio coverage of the Saturday evening big football match was thwarted by no one having an AM radio with them.

Predictably, cell phones and FM radios abounded, but the site's remoteness precluded VHF/UHF reception. Cell phone and MP3 Li-Ion batteries will go flat after a few days usage as well, and often are unique to the device, preventing swap-outs with common AA cells.

The few pocket AM radios still on sale usually have pathetic sensitivity and audio quality, but decent



14. After soldering (or connector joining), use a DMM on resistance to check the wires are not shorted or broken. About 5Ω resistance is normal.



15. Rather than forcefully pushing the wires into the protective irrigation hose, it's probably easier to slit a short length with scissors. The hose saddles will hold it shut again afterwards,



16. Hot melt glue can be used to keep any wire joins apart. Don't use too much here or later re-soldering may be difficult!



17. Further hot-melt glue can be used at the tube ends to secure the cable.



18. Only low value (typically 60pF to 160pF) 'poly-vari-cons' (plastic insulated variable tuning capacitors) are now usually available. Mounting for these can neatly be done with aluminium sliced from a drinks can.



19. Punch a hole through the thin aluminium, trim with scissors and fold the wings to suit the mount. Even use two such brackets if the first seems too flimsy.



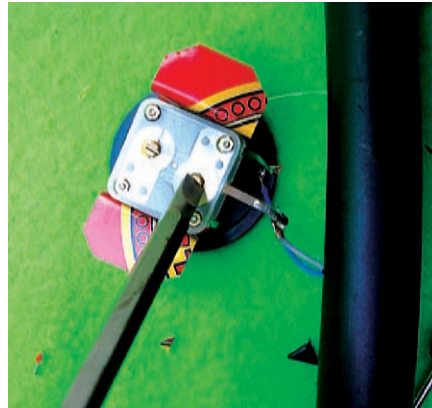
20. It looks quite professional. Discard the two topside screws, as if screwed down too far these will usually hit the plates inside the tuning capacitor and stop them moving!

compact AM sets are still cheaply available for those who look hard enough. Jaycar's AR1741 AM/FM/SW traveller clock radio even offers digital frequency displays. For purists, however, classic analogue tuning still appeals, due to lower circuit noise and reduced battery drain.

Every survival kit and offshore coastal boat should have one, if only to navigate (when all else fails) by ferrite rod direction finding (DF).

The quest

The quest for this project was to develop a simple, cheap, easily



21. Before fastening the capacitor to the mount, adjust the two small trimmers to a minimum (ie, plates NOT overlapping) – this determines the upper frequency. If you want lower MW frequencies, then adjust them to fully overlap (more capacitance).

These tuning capacitors have two sets of moving plates within, and they can be paralleled by joining the two side terminals. For most users, however, just the LH side and the centre terminal (as shown) will do – this accesses the larger variable range.

made and portable antenna that could enhance (just by inductive coupling) the performance of any MW radio placed nearby.

After assorted trials and number crunching, eight paralleled offset conductors were found most suitable – in spite of their inter-wire capacitance. The resulting loop was made from a 3m length of cheap 8-wire phone cable, supported and (optionally for the show-off version) able to be housed in budget plastic garden irrigation hose.

Conclusion

The weak signal enhancing performance (especially on classic 'deaf' AM radios) of the design was found to be absolutely outstanding – MW signals just leapt off the bench! Electronics students were astounded at the resonance effect and cynics found it hard to credit that just 'energy out of thin air' was at work.

As this loop can be built much more cheaply (and faster) than traditional laboriously wound and mounted designs, the eight-wire approach may suit tight budgets, and travelers unable



22. Finished. The portable design easily folds up for storage or travel.



23. Clothes pegs fastened to a curtain make a neat holding system. The loop doesn't need to be perfectly circular either, although if not, its directional pickup will be reduced.

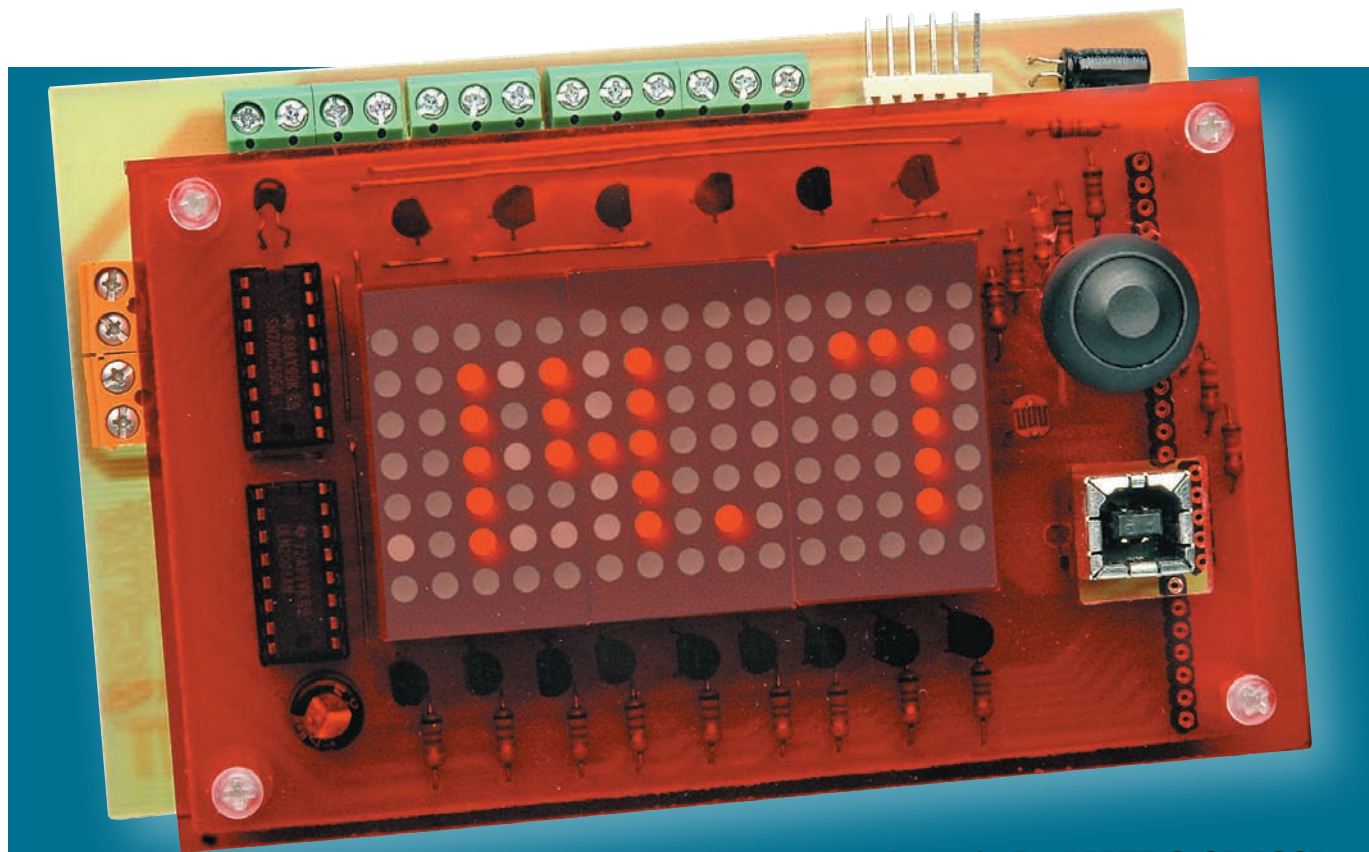


25. Simply tune the variable capacitor for maximum band signal – it can be quite sharp (consistent with a high 'Q' factor). Signal enhancement on some stations is so strong that intermodulation may develop in the receiver, indicating nearby stations on frequencies where they don't actually transmit.

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For more information, including a demonstration on the performance of the loop antenna, visit Stan Swan's 'Instructables' page at:

www.instructables.com/id/Medium-Wave-AM-broadcast-band-resonant-loop-antenn



Part 2: By MAURO GRASSI

Multi-Purpose Car Scrolling Display

Construction and software installation

In this month's article, we guide you through the construction of the Car Scrolling Display. We also show you how to install the software driver that's used to communicate with the display via a USB port on a Windows PC.

ALL THE PARTS for the Car Scrolling Display are installed on two PC boards – a main board coded 786 (134 × 86mm) and a display board coded 787 (124 × 75mm). These two boards are stacked together with a red Perspex window and are secured using nylon spacers, washers and screws.

Note that there is no wiring between the two boards. The display board simply plugs into the main board via connector CON6.

Note also that the display board is smaller than the main board. That's been done so that when the two boards are stacked together, the screw

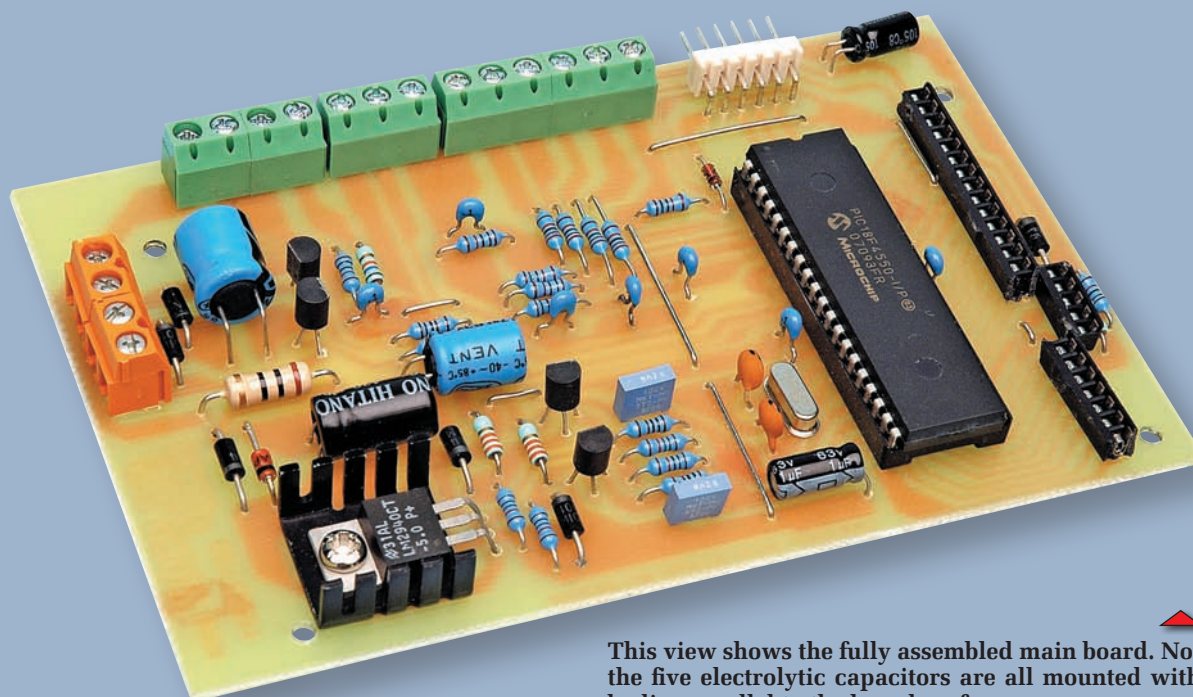
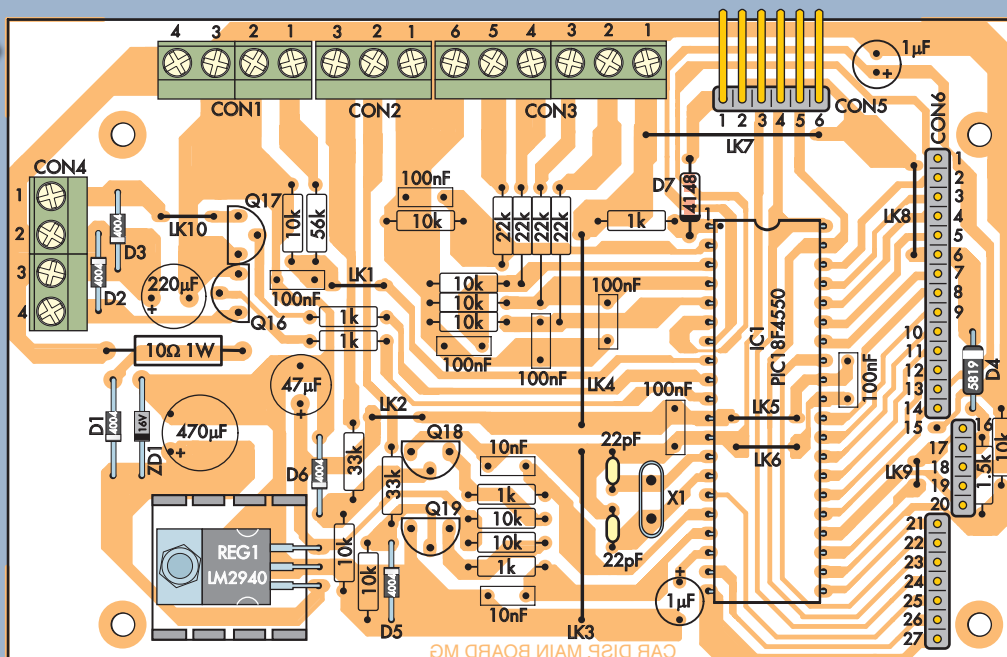
terminal blocks on the main board are exposed for easy access.

Main board assembly

Fig.6 shows the assembly details for the main board. Begin by checking the board for cracks in the tracks or any shorts between adjacent tracks. This is easier to do before installing the parts and can save you trouble later.

Once you are convinced that the PC board is OK, start the assembly by soldering in the 10 wire links. You must do this first, as two of these links (LK5 and LK6) are underneath the 40-pin IC socket.

Fig.6: follow this parts layout diagram to build the main PC board. Take care to ensure that all polarised parts go in correctly and don't install the PIC microcontroller in its socket until after the power supply has been checked – see text.



This view shows the fully assembled main board. Note that the five electrolytic capacitors are all mounted with their bodies parallel to the board surface.

These links should be installed using tinned copper wire. You can straighten this link wire by first clamping one end in a vice and then pulling on the other end with pliers to stretch the wire slightly. After that, it's simply a matter of cutting the links to length and using pliers to bend their leads down at right angles so that they fit the PC board.

There are 24 resistors on the main PC board, and they can be soldered in

next. You must make sure that the correct value is used at each location. The colour code table shows how to decipher the values, but it is also prudent to check each one with a multimeter before it is soldered in place. Note that the 10Ω resistor must be rated at 1W.

Once the resistors are in, the diodes can be installed. There are eight diodes in total, of four different types.

Begin by installing 16V Zener diode ZD1. Refer to the component overlay

for its location and orientation! Remember that the cathode of a diode is normally indicated by a stripe.

The signal diode (D7, a 1N4148) is used for ICSP (in-circuit serial programming) and is installed near CON5 (the ICSP header). You only really need it if you intend to program the microcontroller (IC1) in circuit, otherwise it can be left out.

Diodes D5 and D6 are next on the list. Note that these were shown as

Constructional Project

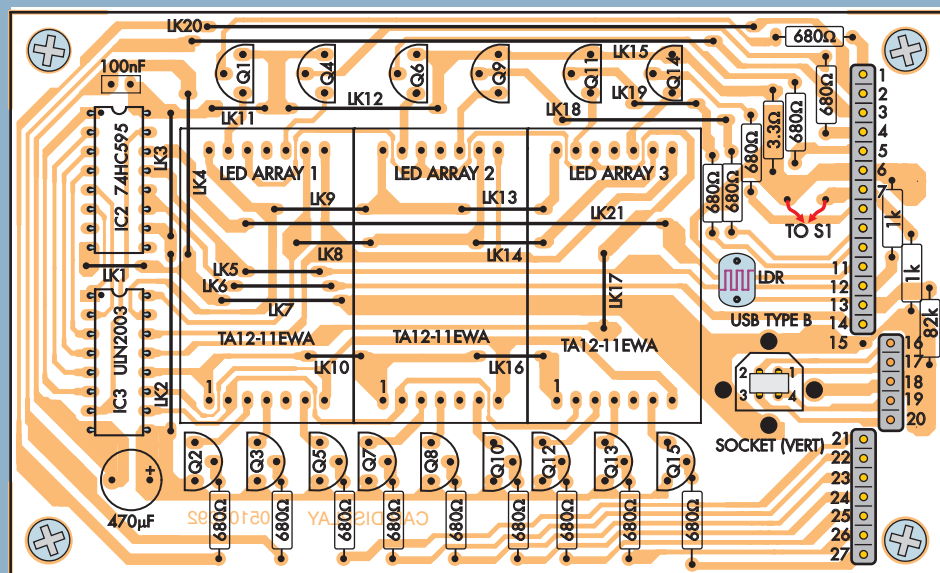
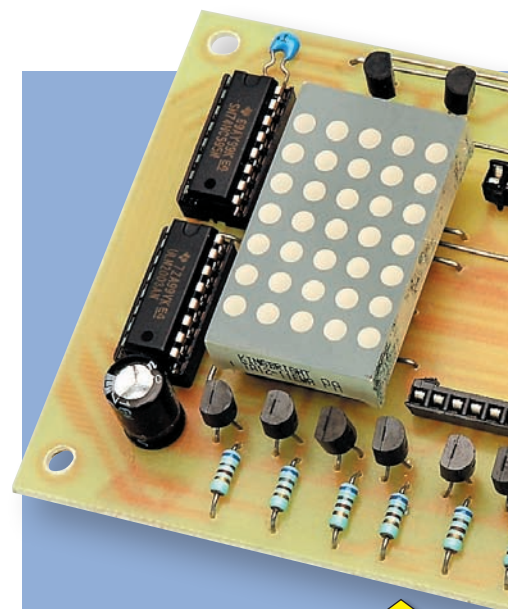
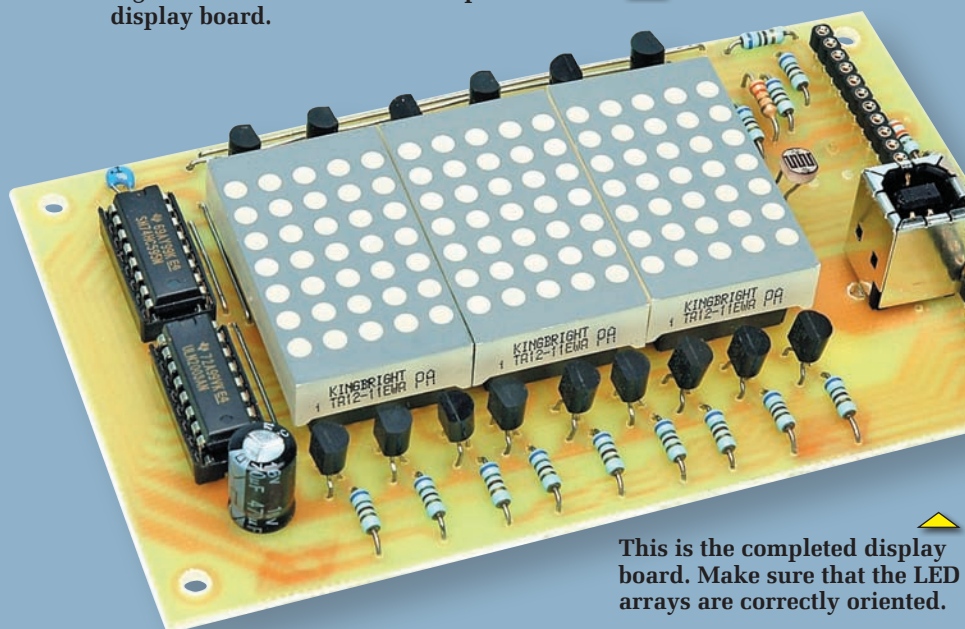


Fig.7: here's how to install the parts on the display board.



Above right: the completed display board with two of the LED arrays removed to show their 7-pin socket strips.



This is the completed display board. Make sure that the LED arrays are correctly oriented.

1N5819 Schottky types on the circuit diagram (Fig.3) last month, but in practice, 1N4004 diodes will do, and that's what are now specified in the parts list. Be sure to install them with the correct orientation.

By contrast, diode D4 must be a 1N5819 Schottky type (as originally specified). This can now be installed, followed by the five remaining diodes, which are all 1N4004s.

The four transistors can now all go in. These are all BC337 NPN types and each must be correctly oriented, as shown in Fig.6.

Now for the capacitors. The ceramic and the 100nF monolithic capacitors

are not polarised and can go in either way around. However, the electrolytic capacitors are polarised, so be sure to install them as indicated on the overlay.

Note particularly that all the electrolytic capacitors must have their leads bent by 90° so that their bodies lie horizontally on the PC board – see photo. Do not mount them vertically; if you do, they will interfere with the bottom of the display board when the boards are stacked together.

Once you've installed the capacitors, you are ready to install the connectors and the IC socket. Install the 40-pin IC socket first, making sure

that it is oriented correctly with its notched end as indicated. Note that the IC is not installed in the socket just yet. That step comes later, after some preliminary checks of the supply rail.

Install the right-angled 6-pin ICSP header (CON5) only if you intend to program the microcontroller. Note that you will need to cut away the plastic locating guide on this connector if you intend to use the PicKit2 programmer from Microchip. In addition, CON5 should be mounted about 2mm above the PC board in order to fit the PicKit2 programmer.

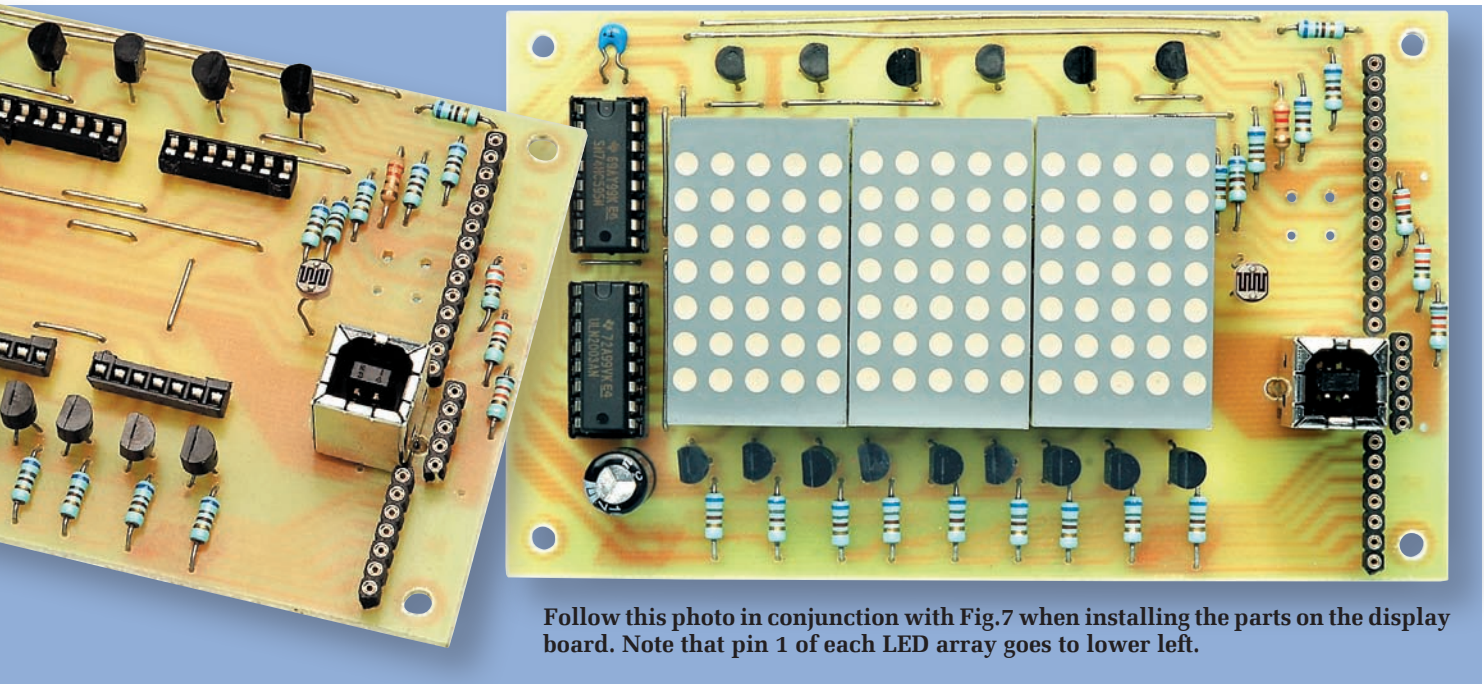
The rest of the connectors are screw terminal blocks CON1 to CON4. These consist of 2-terminal and 3-terminal blocks, which are combined by sliding their dovetailed ends together.

As shown, CON1 and CON4 are each made by sliding two 2-terminal connectors together, while CON3 consists of two 3-terminal connectors. CON2 is a single 3-terminal connector.

Making up CON6

CON6, a 27-way connector, is made by first cutting a 40-pin IC socket into two 20-pin sockets. You can use a small fine-toothed hacksaw to do this job.

As shown on Fig.6, CON6 is split into three parts. The first is a 14-pin



connector, the second is a 5-pin connector and the last is a 7-pin connector (note: pin 15 is not used). You make these by first cutting one 20-pin connector into 14-pin and 5-pin connectors. The 7-pin connector is then cut from the remaining 20-pin connector.

Regulator REG1 can go in next. As shown, this device is mounted horizontally with its leads bent down by 90°, to go through their matching PC board holes. In addition, the regulator must be fitted with a small U-shaped finned heatsink, and this is sandwiched between the regulator's tab and the PC board.

Secure this assembly to the PC board using an M3 × 10mm screw, lockwasher and nut before soldering the regulator's leads. If you solder the

leads first, the soldered joints may crack as the mounting screw is tightened down.

Note that we specified an LM-2940CT-5 low drop-out regulator in the schematic (Fig.3) published last month. However, you can also use a common (and much cheaper) 7805 regulator in its place, if you wish.

The only drawback here is that using the 7805 means that you will have to power the circuit from a 12V supply. By contrast, the LM2940CT-5 will work with supply voltages down to as low as 9V.

The LM2940CT-5 also contains in-built reverse polarity protection, but we don't use it in this circuit. That's because reverse polarity protection is provided by diode D1.

Construction of the main PC board can now be completed by installing the 20MHz crystal. It's non-polarised, so it can go in either way around.

Display board assembly

Fig.7 shows the parts layout on the display board. Begin the assembly by installing the 21 wire links (LK1 to LK21). Some of these links are quite long and run close together, so it's important that they are straight before they are installed (stretch the link wire to straighten it).

The resistors can go in next. Note that the 3.3Ω resistor must be rated at 0.5W, while the others are all rated at 0.25W.

Now solder in the two 16-pin IC sockets. These must be oriented with

Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
□	1	82kΩ	grey red orange brown	grey red black red brown
□	1	56kΩ	green blue orange brown	green blue black red brown
□	4	22kΩ	red red orange brown	red red black red brown
□	2	33kΩ	orange orange orange brown	orange orange black red brown
□	10	10kΩ	brown black orange brown	brown black black red brown
□	6	1.5kΩ	brown green red brown	brown green black brown brown
□	15	680Ω	blue grey brown brown	blue grey black black brown
□	2	330Ω	orange orange brown brown	orange orange black black brown
□	1	10Ω	brown black black brown	brown black black gold brown
□	1	3.3Ω	orange orange gold brown	orange orange black silver brown

Constructional Project

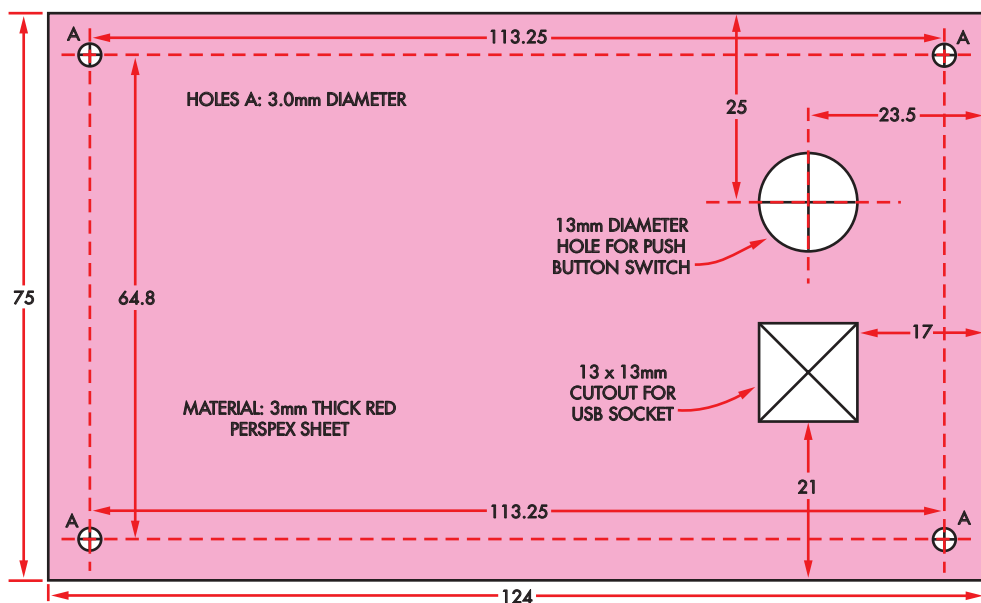


Fig.8: follow this drilling and cutting diagram to make the front panel. It's made from 3mm-thick red Perspex measuring 124mm × 75mm.

their notched ends as shown on Fig.7. Note that although these sockets are optional, we do recommend them. They make it much easier to replace the ICs, if necessary.

The next step is to install six 7-pin socket strips to accept the dot-matrix LED arrays. These are made by cutting three 14-pin IC sockets in half and then cleaning up the edges using a small file. That done, the sockets strips can be soldered in place.

These sockets are used simply to space the LED arrays off the board, so that they later sit close to the red Perspex front panel. They also make it easier to replace a module in the unlikely event that it fails.

You can now install the two ICs in their sockets, making sure they are correctly oriented. Don't get these two ICs mixed up – IC2 is the 74HC595 shift register, while IC3 is the ULN2003 Darlington array.

The three LED modules can also be installed in their sockets, each with pin

1 at bottom left. Pin 1 of each module is indicated by a digit on the side.

Once this is done, you can solder in the 15 BC327 transistors. Be sure to orient them as shown and push them down onto the board as far as they will comfortably go before soldering their leads.

Next, solder the two capacitors in place. The 100nF monolithic type is not polarised, but the 470µF electrolytic is, so take care when installing it.

The three pin connector strips that make up CON7 can now be installed. These are made from a 32-way strip that's cut into three pieces of 14, 7 and 5 pins. As shown in the photo, these are installed from the component side of the PC board.

Now install the USB type B socket. It sits vertically on the PC board and only fits one way around. Its two tabs can be bent flat against the underside of the board to secure it in position before soldering. Solder its four pins and both tabs to the PC board.

The last thing to do is to solder in the LDR. This should be installed about 10mm above the PC board, so that it later sits just below the front panel.

That completes the assembly of the two PC boards. The next step is to make the front panel.

Preparing the front panel

The front panel is made from a single piece of red Perspex measuring 124 × 75mm (ie, the same dimensions as the display board). Fig.8 shows the cutting and drilling details. There are four 3mm-diameter holes for securing it to the display board, plus a larger (13mm) hole for pushbutton switch S1.

In addition, you need to make a square cut-out to provide access to the USB socket.

Once you've cut and drilled the panel, fit the pushbutton switch in place and wire it back to the display board using two 60mm lengths of hook-up wire. The front panel is then fitted with four M3 × 12mm tapped nylon spacers, plus four nylon washers which are secured using M3 × 25mm nylon screws – see Fig.9.

The display board can now be fitted in position over the nylon screws. Another four nylon washers are then fitted, after which another four M3 × 12mm nylon spacers are wound on.

Preliminary tests

Before attaching the main board, it's a good idea to carry out a power supply check to confirm that the +5V supply rail is correct. **Note that this should be done with microcontroller IC1 OUT of its socket.**

First, connect a 12V battery to the power input terminals of CON1 (pin 4 is the +12V input, pins 2 and 3 are ground). Apply power and check the voltage at pin 1 of CON3. If it's close to +5V, then everything is in order.

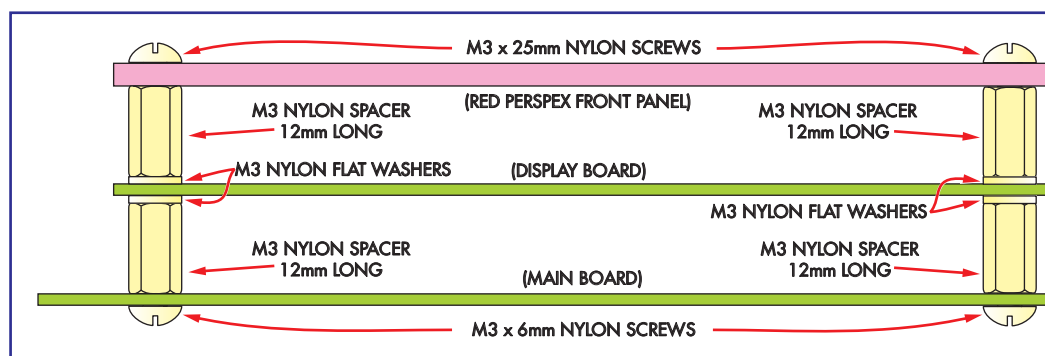
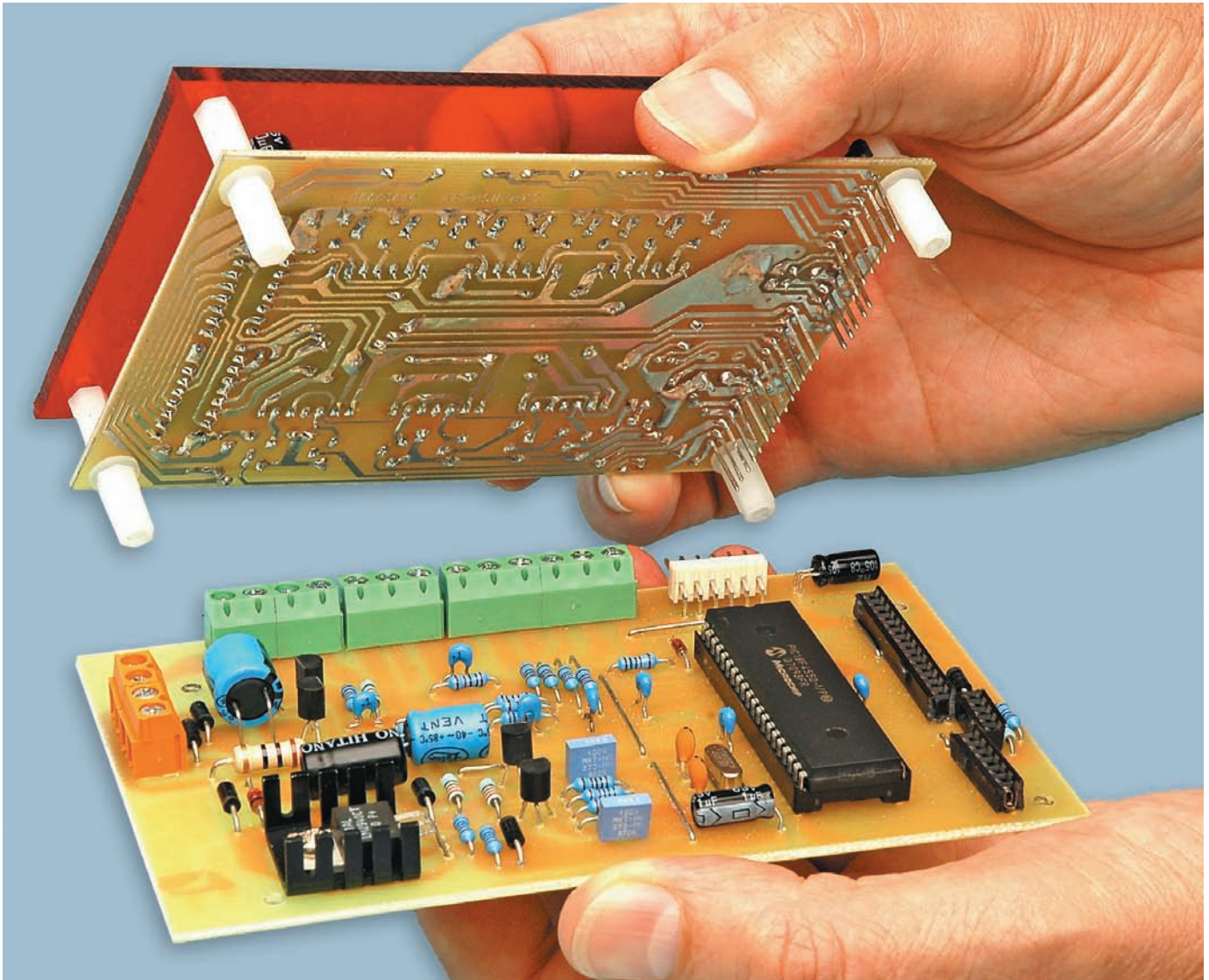


Fig.9: the two PC boards and the front panel are secured together using M3 × 12mm tapped nylon spacers, M3 nylon washers and M3 nylon screws.



The display board/front panel assembly plugs into the main board and is secured using four M3 × 6mm nylon screws. Take extra care to ensure that the regulator heatsink clears the underside of the display board.

Note that this voltage can normally range from 4.9V to 5.1V. A voltage above 6V or lower than 4.5V indicates that there is a problem and you should disconnect power immediately.

Assuming that the +5V rail measures OK, you can now disconnect power and install IC1 in its socket. Note that this IC must be programmed with the firmware hex file. If you are building this project from a kit, it will be supplied preprogrammed.

Final assembly

Having checked that the +5V rail is OK, it's time to complete the assembly. This simply involves plugging the display board into the main board and then securing the assembly using four M3 × 6mm nylon screws.

The software features in brief

In next month's article, we explain the software features in detail. In the meantime, here's a quick summary.

First, the software calibration allows you to read almost any sensor with a varying voltage, resistance, frequency or duty cycle output. Calibration involves entering a few calibration points. The software then computes a polynomial which passes through these points and that's stored in non-volatile memory.

You can therefore use this project as a 'speedo corrector', by calibrating the variable to read the correct speed (note: car speedos often intentionally read high). You can measure the output of a resistance-based sensor directly (without a voltage divider). We've held the calibration instructions over to next month's article, as they were too long to include here!

Once calibrated, you can name the variables and enter the units, as well as minimum and maximum values. You can choose which to display and in what order, as well as the number of digits after the decimal point. You can select optional averaging on each variable and the speed of scrolling and the brightness of the display.

Each of the six variables has an accumulator (for running totals) as well as delta values (showing the difference in the readings). There are also two programmable outputs (for a relay or buzzer) that can switch on limit conditions.

You can do real-time data logging of the variables via the USB port (with selectable sampling frequency) and the data can be exported to a spreadsheet to create graphs.

Other features include protection for the battery supplying power (if used in a car) and fine tuning options for greater accuracy! All will be explained, next month.

Parts List – Car Scrolling Display

Main Board

- * 1 PC board, code 786, size 134mm × 86mm
- 2 40-pin IC sockets
- 4 2-way screw terminal blocks, 5mm spacing
- 3 3-way screw terminal blocks, 5mm spacing
- 1 TO-220 mini finned heatsink, 6073B type
- 1 6-way 2.54mm right-angle locking header (Jaycar HM-3426) – optional for ICSP
- 1 20MHz crystal (X1)

Semiconductors

- 1 LM2940CT-5 regulator (REG1) (or use a 7805 – see text)
- + 1 PIC18F4550/I-P microcontroller (programmed) (IC1)
- 4 BC337 *NPN* transistors (Q16 to Q19)
- 5 1N4004 diodes (D1-D3, D5-D6)
- 1 1N5819 Schottky diode (D4)
- 1 1N4148 diode (D7) – only needed for ICSP
- 1 16V 1W Zener diode (ZD1)

Capacitors

- 1 470µF 25V radial electrolytic
- 1 220µF 50V radial electrolytic
- 1 47µF 16V radial electrolytic
- 2 1µF 16V radial electrolytic
- 7 100nF monolithic (code 104 or 100n)
- 2 10nF MKT (code 103 or 10n)
- 2 22pF ceramic

Resistors (0.25W, 1%)

- 1 56kΩ 10 10kΩ
- 4 22kΩ 6 1.5kΩ
- 2 33kΩ 1 10Ω 1W

Display Board

- * 1 PC board, code 787, size 124mm × 75mm
- 3 Kingbright TA12-11EWA dot matrix LED modules, red (Farnell Cat. 1168665)
- 3 14-pin IC sockets (cut into six 7-pin sockets to mount the displays)
- 2 16-pin IC sockets
- 1 SPST dome pushbutton switch (Jaycar SP-0657)
- 1 32-way IC socket strip
- 1 light-dependent resistor (LDR) (Jaycar RD-3480 or similar)
- 1 vertical USB Type B socket (Farnell 107-6666)

Semiconductors

- 1 74HC595 shift register (IC2)
- 1 ULN2003 line driver (IC3)
- 15 BC327 *PNP* transistors (Q1 to Q15)

Capacitors

- 1 470µF 16V radial electrolytic
- 1 100nF monolithic

Resistors (0.25W, 1%)

- 1 82kΩ 2 330Ω
- 15 690Ω 1 3.3Ω 0.5W

Miscellaneous

- 4 M3 × 25mm nylon screws
- 8 M3 × 12mm tapped nylon spacers
- 8 nylon flat washers
- 4 M3 × 6mm nylon screws
- 1 1m length of tinned copper wire for links
- 1 200mm length medium-duty hook-up wire

* available as a pair from the *EPE PCB Service*

+ The software files will be available for free download via the *EPE Library* site, accessed via www.epemag.com

the PC host program, you will need to install this driver. This section explains how to install the driver in Windows XP, although other versions of Windows will be similar.

The first step is to download the Microchip installer (MCHPFSUSB_Setup_v1.3.exe) from the *EPE* website and run it. Note that you should use version 1.3, as older or newer versions may not be compatible. The installer program will typically put the driver in the C:\MCHPFUSB\Pc\MCHPUSB Driver\Release folder.

Next, connect the Car Scrolling Display to your computer using a USB cable. Windows will recognise the device as a 'Display' and then the 'Found New Hardware' Window will appear as shown in Fig.10. Select the 'No, not this time' option and click 'Next'.

You will now be presented with a new dialog window. Select 'Install from a list or specific location' and click 'Next' again to bring up the dialog shown in Fig.11. Select 'Search for the best driver in these locations' and enable the 'Include this location in the search' box.

Now click the 'Browse' button. In the 'Locate File' window that appears, navigate to where the MCHPUSB files were installed (normally C:\MCHPFUSB\Pc\MCHPUSB Driver\Release) and select 'mchpushb.inf'. Click 'Next' and Windows will then install the driver.

If the driver is installed correctly, the 'Microchip Custom USB Device' entry should now be visible if you go into Device Manager (Control Panel -> System -> Hardware tab -> Device Manager button) – see Fig.12 (provided the device is connected).

Using the host software

Once the driver has been installed successfully, you control the Car Scrolling Display using the PC host program **cardisplay.exe**. This program allows you to change all settings and to do data logging. It is also used for calibration.

Once you've connected the Car Scrolling Display's inputs to the sensors you are interested in monitoring, you can then use a laptop in your car to perform the calibration (you only have to do this once) or change any other system settings (such as the display brightness).

Switch on

Once the assembly has been completed, apply power (ie, via CON1). You should now see a message scroll past on the LED display modules. Among other things, this default welcome message should show the firmware version.

If you see this, then everything is working correctly and you can proceed

to the next section, which explains how to install the software driver on your PC. If not, you should refer to the troubleshooting panel.

Driver installation

The USB device interface for the Car Scrolling Display uses the generic Microchip driver for Windows. Before communicating with the display using



Fig.10: this is the dialog that appears the first time the Car Scrolling Display is connected to the PC. Select the option shown and click the 'Next' button.

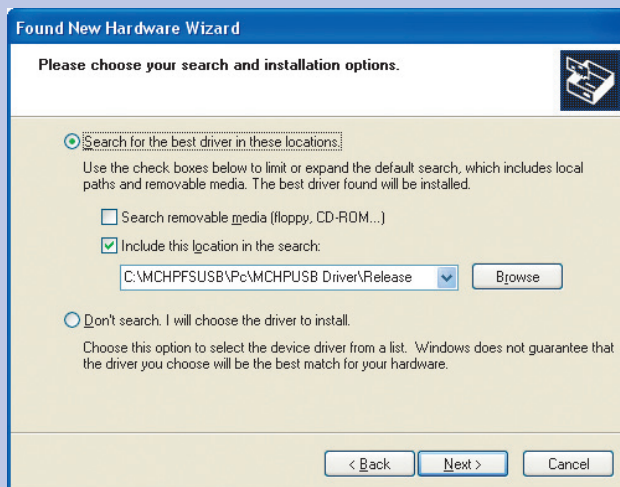


Fig.11: selecting 'Install from a list or specific location' brings up this dialog. Select the options shown and click the 'Next' button. Windows then installs the driver.

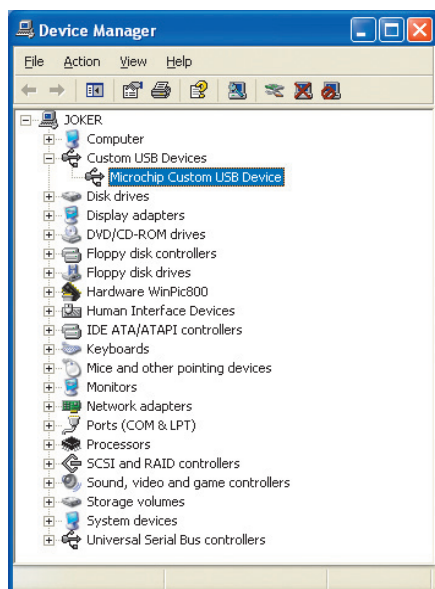


Fig.12: this entry will appear in Device Manager if the driver is installed correctly.

You can also use a laptop in your car to do real time data logging of the signals. Of course, you will need someone else to do the driving while you do this!

To install the PC host program, you first have to download the compressed file 'cardisplay.zip' from the EPE web-site (www.epemag.com). You'll find it in the downloads library section.

Extract the files in the zipped archive to a folder on your hard drive. There should be at least two files:

- 1) **cardisplay.exe** – this is the executable command line program
- 2) **cardisplay.map** – this file is used internally by the host program. It must

Troubleshooting

If the unit doesn't work correctly, the following troubleshooting tips should help resolve the problem.

Symptom: nothing is shown on the display or some columns or rows are blanked out.
What to check: there are a number of possibilities here. One is that CON6 and CON7, which connect the main PC board to the display PC board, are not making good contact. Try reconnecting the two boards to see if that clears the fault. Another possibility is that the Kingbright LED array modules have been installed with the incorrect orientation. If one column is blanked while the rest of the display seems to be working, then check its driver transistor – it may be faulty or it could be the wrong type (they should all be BC327 PNP types).

Symptom: the supply rail is not close to +5V.
What to check: if the supply rail is 0V instead of +5V, check Zener diode ZD1, reverse polarity protection diode D1 and regulator REG1. Check particularly that the diodes are all correctly oriented.

If the supply rail is noticeably higher than +5V, there is either a problem with the regulator or a short between the 12V and 5V rails. Alternatively, a component connected to one of these rails may have failed (eg, diode D2 or D3).

Symptom: the display seems to be working correctly but does not work when powered solely from the USB port.
What to check: either Schottky diode D4 is incorrectly oriented or the USB port (or hub) is not supplying power.

be in the same folder as **cardisplay.exe** for the program to recognise it. Note that the map file is produced by the C compiler of the firmware. It contains memory mapping information for the firmware produced by the linker. When and if the firmware is updated, the map file will also change and this new file must be copied to the folder containing **cardisplay.exe** in order for it to work correctly.

So, installing the PC host program is easy – just copy the **cardisplay.exe** and **cardisplay.map** files to your chosen folder. Once that's done, you simply go to a command prompt to run the program using your chosen command line option. We'll have more to say about this next month.

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Max's Cool Beans

By Max The Magnificent

How do mirrors work?

AS you may recall, in my column last month I waffled on about my latest hobby project, which is to construct a so-called 'Magic Mirror'. In this month's column I was originally intending to continue with the actual construction of this little rascal. Sad to relate, however, I got sidetracked along the way, because it suddenly struck me that – at the most fundamental level – I didn't actually know how mirrors work.

I know, I know, I can hear you chuckling to yourself saying 'The boy is a fool,' but hear me out and then we will see if you're still laughing quite so confidently. We have to start somewhere, so let's begin with the fact that 'light' is the name we give to that range of electromagnetic radiation that can be detected by the human eye. Furthermore, light travels in the form of photons, which (due to 'quantum' as Terry Pratchett would say) have a dual nature, they can exhibit characteristics of both particles and waves.

Let's consider the case of an individual atom, which consists of a nucleus formed from a bunch of relatively large particles called protons and neutrons surrounded by an orbiting 'cloud' of teeny-weeny particles called electrons (actually protons, neutrons, and electrons can all exhibit both particle and wave characteristics... but let's not even go there). It's common to visualise the electrons as orbiting the nucleus much like the moon orbits the earth. In reality, of course, things are much more complicated (aren't they always?) because the electrons occupy discrete energy levels and they can sort of be all over the place at once. I personally tend to visualize the electrons whizzing around so fast that they appear to be spherical shells surrounding the nucleus, but even this is a gross simplification, because as atoms grow larger their outermost electron shells can assume all sorts of weird and wonderful shapes.

Collision course

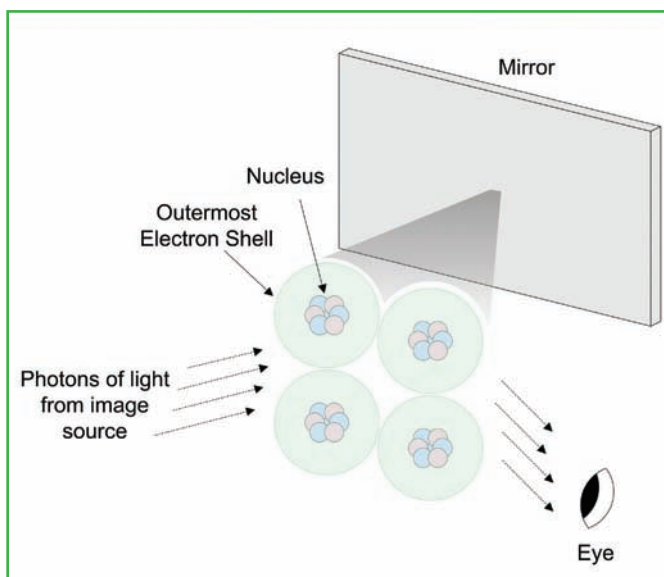
But let us not wander off into the weeds, let's assume that we have a single photon that's racing on a collision course with an individual atom of silver, for example. What happens when the photon reaches the atom? Does it ricochet off one of the outermost electron shells (in which case it might bounce off in any direction)? Can it penetrate the shells and bounce off the nucleus (in which case, once again, it might head off in any direction)?

All I remember from school and college is that a photon might cause an electron to jump up to a higher energy level. The electron may remain in this new energy level for some indeterminate amount of time before it falls back to its original level, at which point it releases a new photon which (you guessed it) may head out in any direction. (And let's not even talk about what happens if the photon has slightly more energy than is required to raise the electron to its higher energy level. What happens to the excess energy? – I said let's not talk about that!)

And that was a single atom. Now let's suppose that we have a sheet of silver that we make as flat as we can and polish it until it is as smooth as possible.

At school we were taught that: 'The angle of incidence equals the angle of reflection.' That all seemed to make sense when we were thinking of things in a macro scale of ping-pong-ball-sized particles bouncing off a smooth surface like

a table. But when you start thinking about light as photons and a mirror's surface as being formed from atoms – and you consider my musings above, you start to wonder to yourself: 'Just how does this all really work and how come the reflections we see in mirrors are so sharp, as opposed to being incredibly fuzzy, as one might expect?'



Photons of light bouncing off a mirror

The scary thing is that no one I know knows (if you see what I mean). However, someone did recommend a book called *QED: The Strange Theory of Light and Matter* by the legendary Richard Feynman. I immediately ordered a secondhand copy of this 1985 book from Amazon. It's sitting on my desk as I pen these words. Once I've perused and pondered this book, I shall report back to you in a future column. Until then, have a good one!

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SP26	4 x 741 Op-amps	SP161	10 x 2N3906 transistors
SP28	4 x Cmos 4011	SP164	2 x C106D thyristors
SP29	3 x Cmos 4013	SP165	2 x LF351 Op-amps
SP33	4 x Cmos 4081	SP166	20 x 1N4003 diodes
SP34	20 x 1N914 diodes	SP167	5 x BC107 transistors
SP36	25 x 10/25V radial elect caps	SP168	5 x BC108 transistors
SP37	12 x 100/35V radial elect caps	SP172	3 x Standard slide switches
SP38	15 x 47/25V radial elect caps	SP173	10 x 220/25V radial elect caps
SP39	10 x 470/16V radial elect caps	SP174	20 x 22/25V radial elect caps
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SP102	20 x 8 pin DIL sockets	SP183	20 x BC547B transistors
SP103	15 x 14 pin DIL sockets	SP186	8 x 1M horizontal trim pots
SP104	15 x 16 pin DIL sockets	SP189	4 x 4 metres solid core wire
SP109	15 x BC557B transistors	SP192	3 x Cmos 4066
SP112	4 x Cmos 4093	SP195	3 x 10mm Yellow Leds
SP115	3 x 10mm Red Leds	SP197	5 x 20 pin DIL sockets
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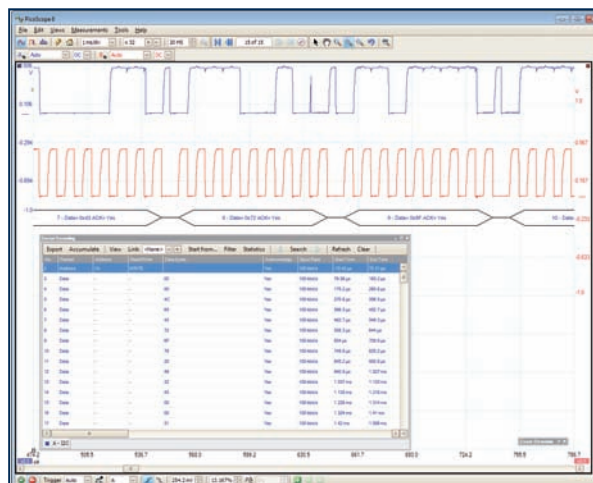
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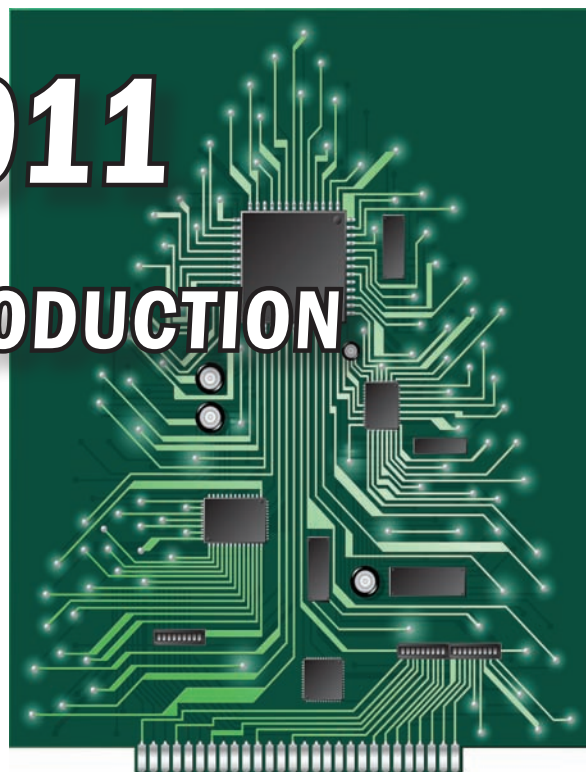
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TEACH-IN 2011

A BROAD-BASED INTRODUCTION TO ELECTRONICS

Part 3: Diodes and Power Supplies

By Mike and Richard Tooley



Our Teach-In series is designed to provide you with a broad-based introduction to electronics. We have attempted to provide coverage of three of the most important electronics units that are currently studied in many schools and colleges in the UK. These include Edexcel BTEC Level 2 awards, as well as electronics units of the new Diploma in Engineering (also at Level 2). The series will also provide the more experienced reader with an opportunity to 'brush up' on specific topics with which he or she may be less familiar.

Each part of our Teach-In series is organised under five main headings: *Learn*, *Check*, *Build*, *Investigate* and *Amaze*. *Learn* will teach you the theory, *Check* will help you to check your understanding, and *Build* will give you an opportunity to build and test simple electronic circuits. *Investigate* will provide you with a challenge, which will allow you to further extend your learning, and finally, *Amaze* will show you the 'wow factor'!

IN THIS, our third installment of *Teach-In 2011*, we shall be introducing you to a component that acts rather like a one-way street – the diode. We shall be using Circuit Wizard to investigate how different types of diode conduct when a voltage is applied to them. *Investigate* provides you with an opportunity to delve into the operation of a simple DC power supply, while *Amaze* explores some exciting developments in light emitting diode (LED) technology.

Learn

Diodes

A diode is an electronic component that allows current to flow in one direction but not in the other. In effect, it acts as a 'one-way street' for current flow, which leads to some useful applications,

including converting alternating current (AC) to direct current (DC).

A diode is formed from a junction of *n*-type and *p*-type semiconductor materials. The resulting device offers an extremely low resistance to current flow in one direction and an extremely high resistance to current flow in the other. Note that an 'ideal' diode would conduct perfectly in one direction and not at all in the other direction.

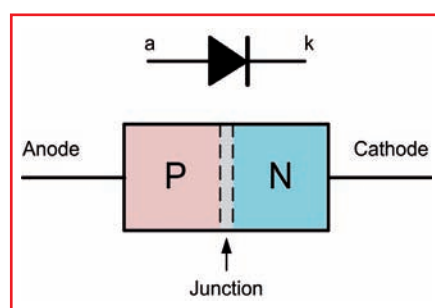


Fig.3.1. Diode construction

Connections are made to each side of the diode. The connection to the *p*-type material is referred to as the **anode** (a), while that to the *n*-type material is called the **cathode** (k), as shown in Fig.3.1.

Forward and reverse bias

If the anode of a diode is made positive with respect to the cathode (and provided that the relatively small conduction threshold voltage is exceeded) the diode will freely pass current. This condition is shown in Fig.3.2(a) and it is referred to as **forward bias**.

Conversely, when the cathode of a diode is made positive with respect to the anode, the diode will cease to conduct. This condition is shown in Fig.3.2(b) and it is referred to as **reverse bias**. In the reverse-biased condition the diode passes a negligible

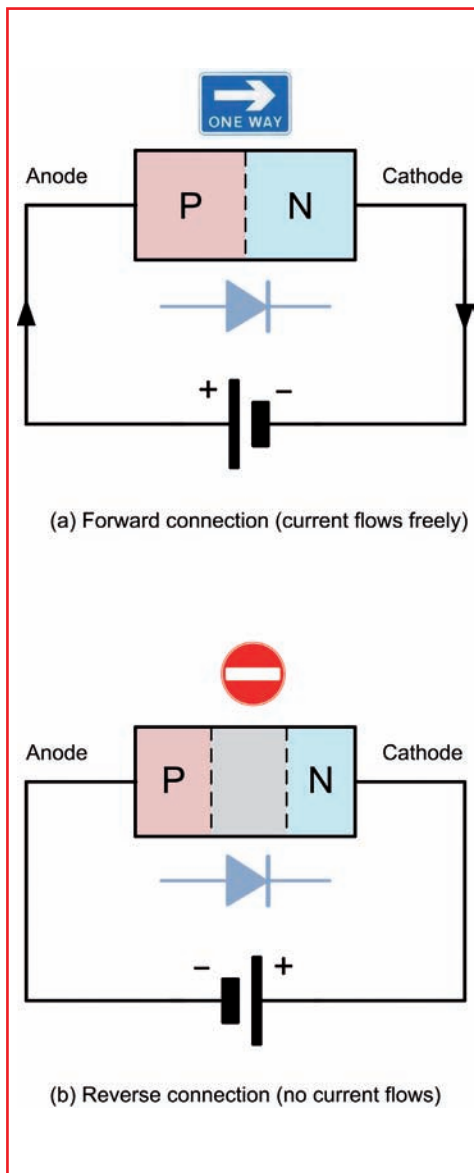


Fig.3.2. Forward and reverse connections for a diode

amount of current and behaves like an insulator.

Diode characteristics

Typical I/V characteristics for germanium and silicon diodes are shown in Fig. 3.3. If you take a careful look at these graphs you will see that the approximate forward conduction voltage for a germanium diode is 0.2V, while the voltage for a silicon diode is approximately 0.6V.

Diode types

Diodes are often divided into signal or rectifier types according to their principal field of application. **Signal diodes** require consistent forward characteristics with low forward voltage drop. **Rectifier diodes** need to be able to cope with high

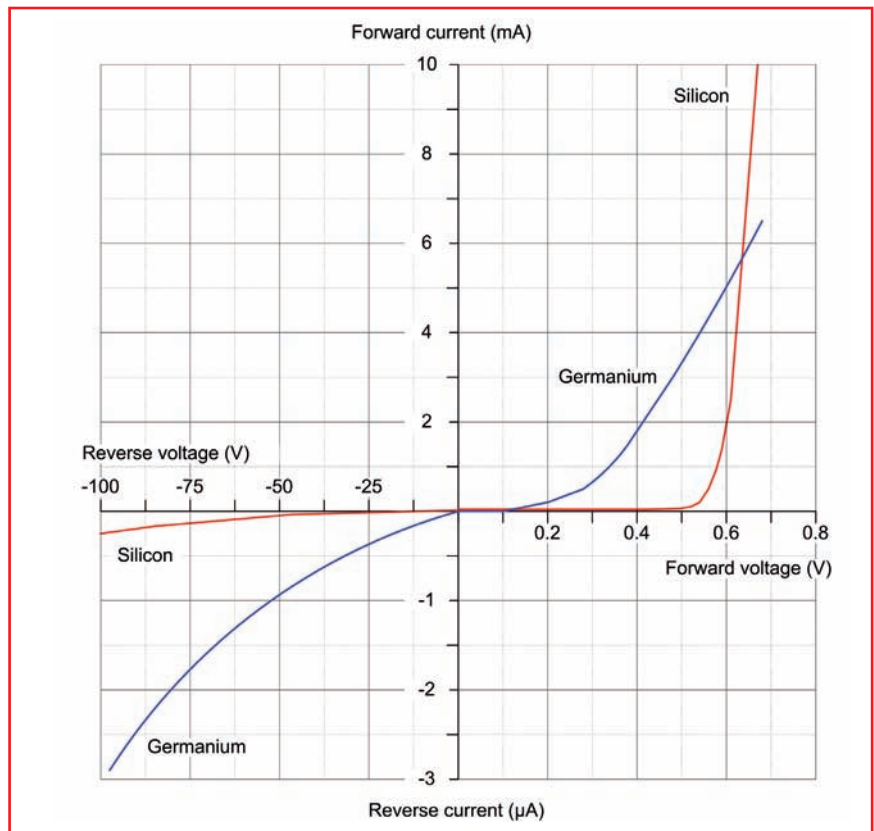


Fig.3.3. Typical voltage/current characteristics for typical silicon and germanium diodes. Note the different scales for positive and negative voltage

values of reverse voltage and large values of forward current, consistency of characteristics is of secondary importance in such applications.

Semiconductor diodes are also available connected in a four-diode bridge configuration for use as a rectifier in an AC power supply. Fig.3.4 shows a selection of various diode types, while Fig.3.5 shows the symbols that are used to represent them in electronic circuit schematics.

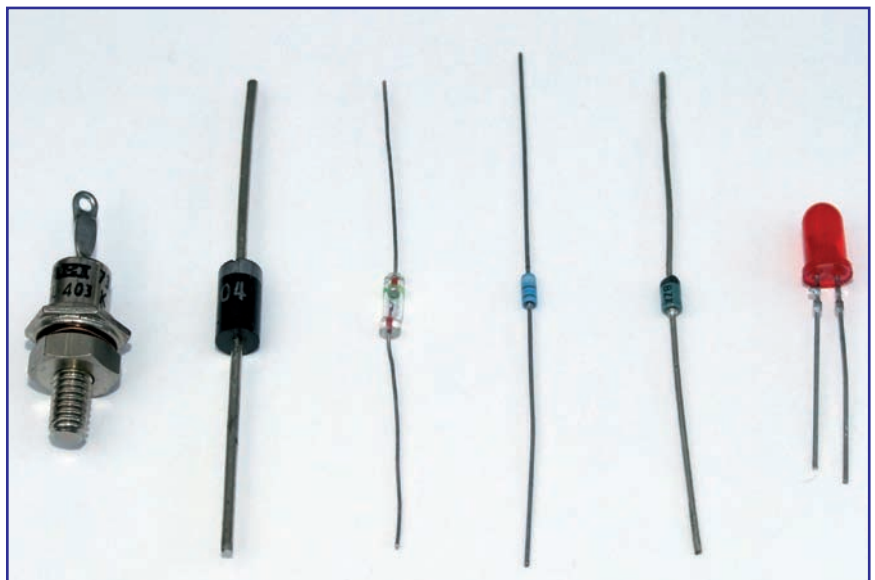


Fig.3.4. Various types of diode, including rectifier, switching and light-emitting types

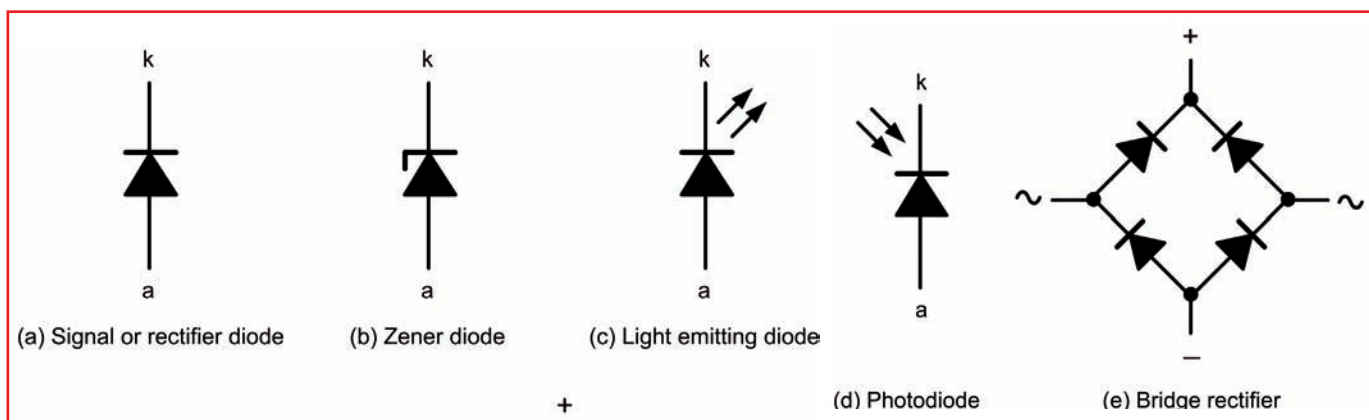


Fig.3.5. Symbols used to represent various types of diode and a bridge rectifier

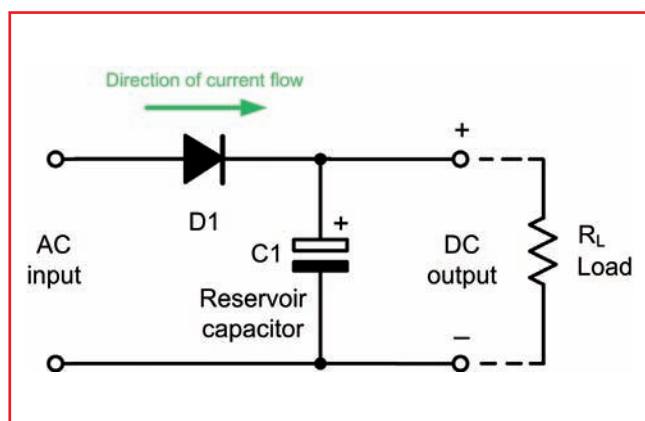


Fig.3.6. A simple half-wave rectifier

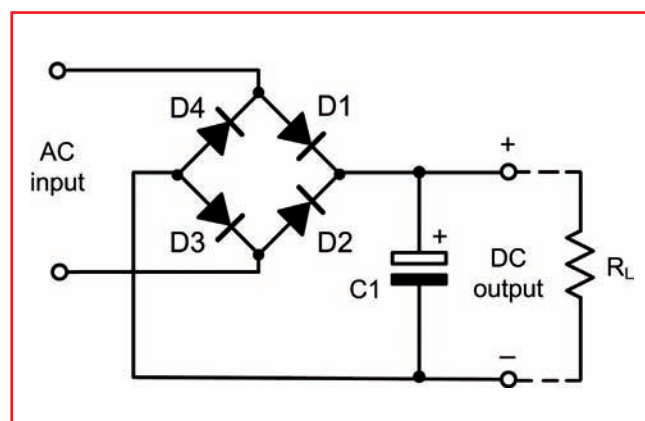


Fig.3.8. Improved full-wave bridge rectifier

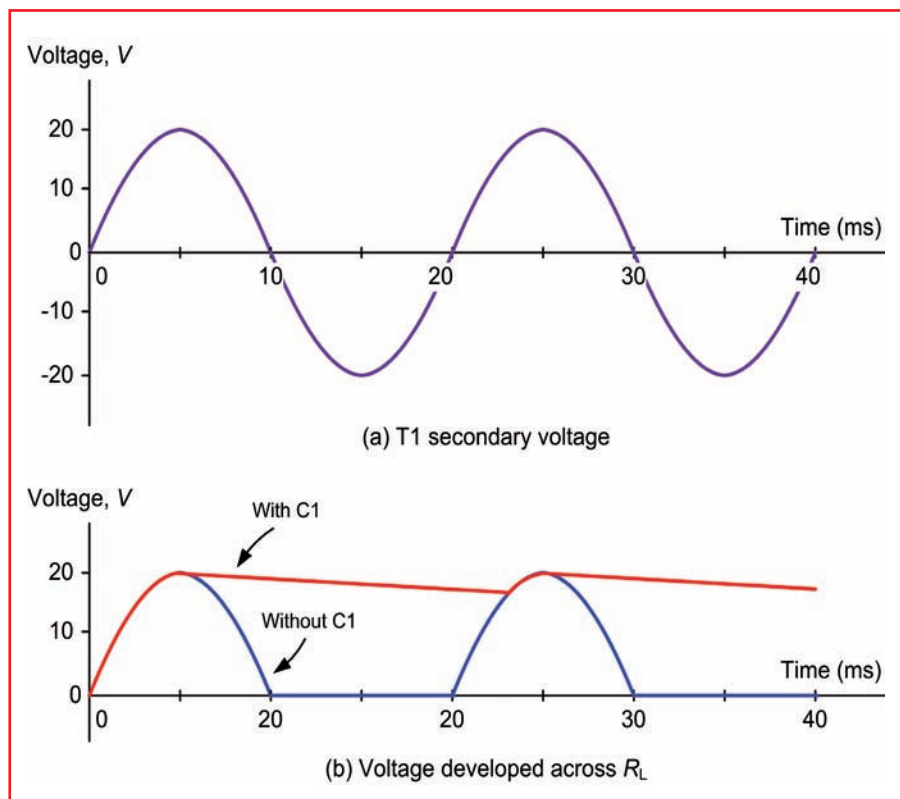


Fig.3.7. Voltage waveforms for the half-wave rectifier

Rectifiers

The most common application for a diode is that of changing alternating current (AC) into direct current (DC). Fig.3.6 shows a simple half-wave rectifier power supply in which the diode passes current when the incoming voltage is positive, but blocks current flow when it is negative. In order to maintain a constant voltage at the output, a reservoir capacitor is connected across the DC output terminals. This capacitor is charged on positive half cycles and discharges on negative half cycles, as shown in Fig.3.7.

An improved, full-wave power supply that uses a bridge rectifier is shown in Fig.3.8. In this circuit only two of the four diodes of the bridge conduct at any one time, either D1 and D3 or D2 and D4, depending on the polarity of the input voltage.

Transformers

Power supplies require some means of isolating and stepping down the AC mains supply before the rectifier and reservoir capacitor. This is achieved with the use of a step-down transformer, as

shown in Fig.3.9. The primary and secondary windings of the transformer are wound on the same laminated steel core. When current flows in the primary winding it creates an alternating magnetic flux that is coupled tightly into the secondary winding. This, in turn, induces an EMF in the secondary winding.

The relationship between the primary and secondary turns and voltages is as follows:

$$\frac{V_P}{V_S} = \frac{N_P}{N_S}$$

where V_P and V_S are the primary and secondary voltages, while N_P and N_S are the primary and secondary turns. Note also that the turns ratio for a transformer is usually quoted as $N_P : N_S$. So, for example, a transformer with 400 primary turns and 40 secondary turns would have a turns ratio of 10:1.

Zener diodes

Zener diodes are silicon diodes that, unlike normal diodes, exhibit an abrupt reverse breakdown at relatively low voltages (for example, 4.7V, 5.6V or 9.1V). The circuit symbol for a Zener diode was shown earlier in Fig.3.4, while a typical Zener diode characteristic curve is shown in Fig.3.10.

When a Zener diode is undergoing reverse breakdown, and provided its maximum ratings are not exceeded, the

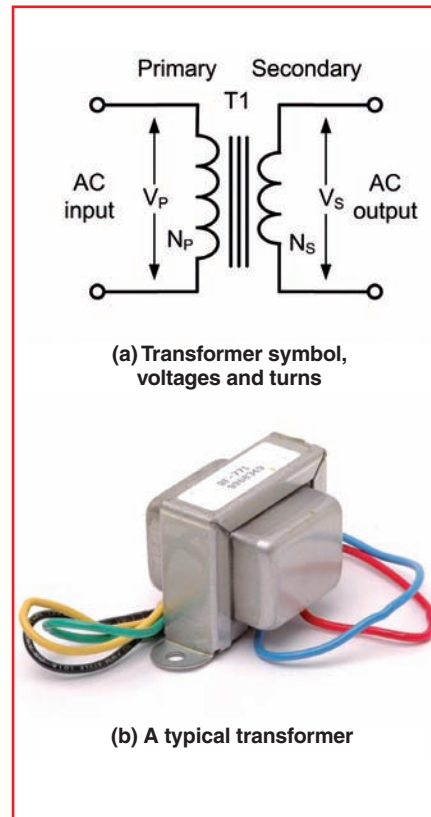


Fig.3.9. A transformer

voltage appearing across it will remain substantially constant regardless of the current flowing. This property makes a Zener diode ideal for use as a voltage regulator, as shown in Fig.3.11.

Light-emitting diodes

Light-emitting diodes (LED) can be used as general-purpose indicators. Compared with conventional filament lamps, they operate from significantly smaller voltages and currents. They are also very much more reliable than filament lamps. Most LEDs will provide a reasonable level of light output when a forward current of as little as 10mA to 15mA, at a forward conduction voltage of around 2V.

A typical LED indicator circuit is shown in Fig.3.12. The fixed resistor, R , is used to set the forward current of the LED (in this case about 15mA). The value of the resistor may be calculated from the formula:

$$R = \frac{V - V_f}{I}$$

where V_f is the forward voltage drop for the LED (typically around 2V), V is the supply voltage and I is the forward current.

Please note!

The large value reservoir capacitor in a power supply can often remain in a partially charged state long after the supply has been switched off or disconnected. Because of this, it is important to exercise great care when working on power supply circuits!

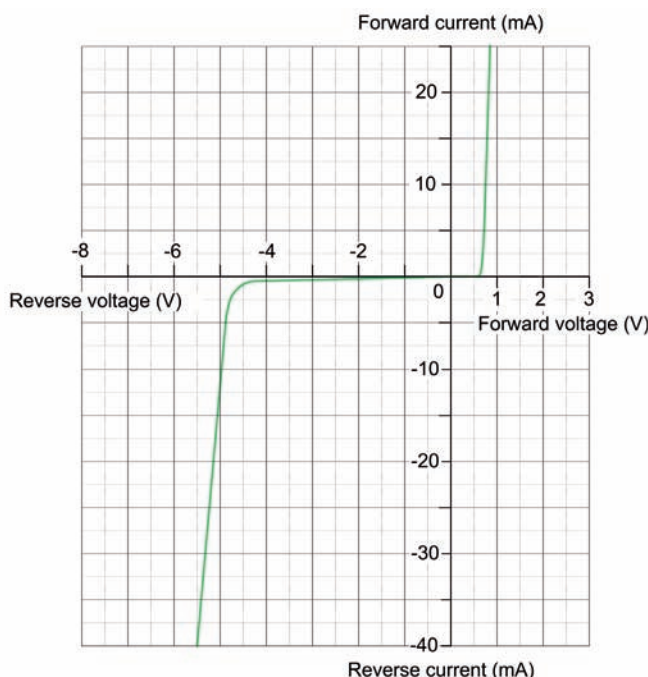


Fig.3.10. A typical set of Zener diode characteristics

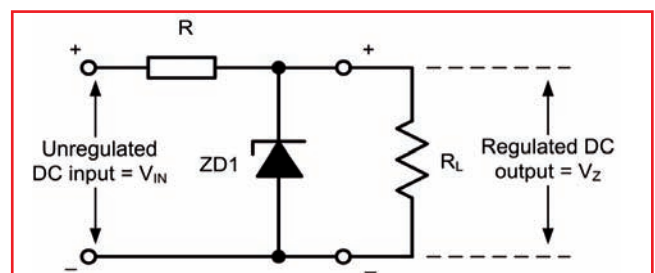


Fig.3.11. A simple Zener diode voltage regulator

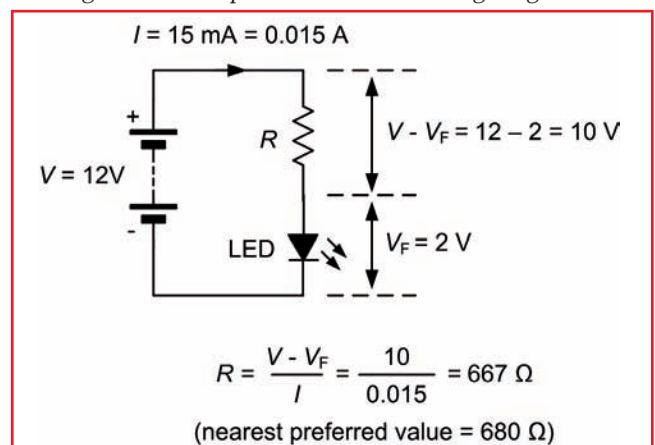


Fig.3.12. A typical LED indicator

Check – How do you think you are doing?

- 3.1. Sketch the circuit symbol for a diode and label the anode and cathode connections
- 3.2. What is (a) the forward resistance and (b) the reverse resistance of an 'ideal' diode?
- 3.3. Which of the diodes shown in Fig.3.13 is conducting?

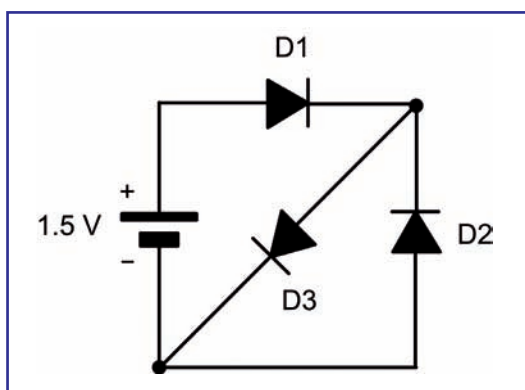


Fig.3.13. See question 3.3

- 3.4. State the forward conduction voltage for (a) a germanium diode and (b) a silicon diode
- 3.5. Explain briefly how a rectifier operates
- 3.6. Explain why a reservoir capacitor is needed in a power supply
- 3.7. Identify each of the diode symbols shown in Fig.3.14?

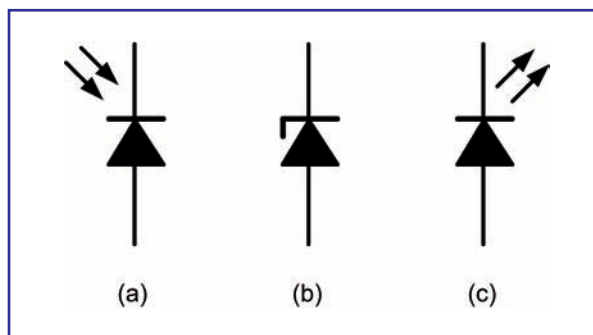


Fig.3.14. See question 3.7

- 3.8. A transformer has 1100 primary turns and 55 secondary turns. Determine the secondary output voltage if the primary is supplied from a 220V AC mains supply.

IN THIS month's 'Build' we are going to try out some of the diode theory that we discussed earlier. To start with, we'll carry out some simple experiments with ordinary silicon diodes to see how they really work.

In 'Learn' we saw how a diode acts like a one-way valve. However, by using a really high reverse voltage we can make a diode break down and let through current 'backwards'. We also know that it takes a little voltage to 'open up' a diode and make it start letting current flow through it. So let's try this out!

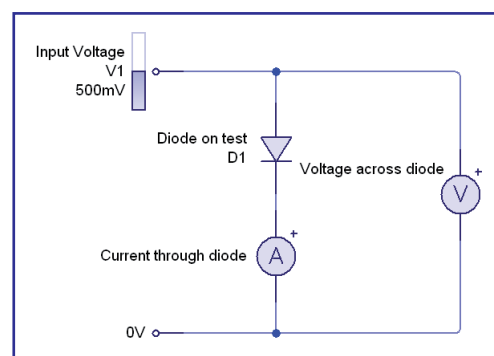


Fig.3.15. Testing a silicon diode using forward bias

Diode test circuit

Enter the circuit shown in Fig.3.15. You'll find the diode in the 'Discrete semiconductors' folder, the input voltage in 'Power Supplies' and the meters in 'Virtual Instruments'. By default Circuit Wizard will give you an

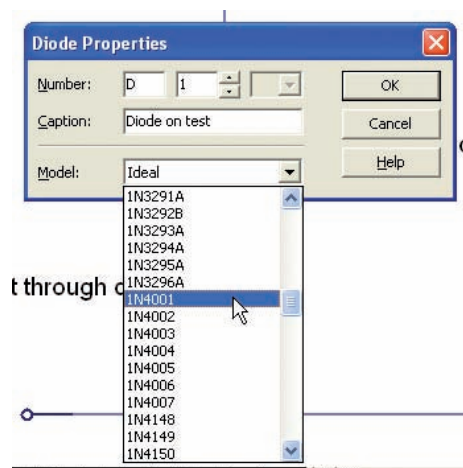


Fig.3.16. Selecting the model for a diode

Build – The Circuit Wizard way

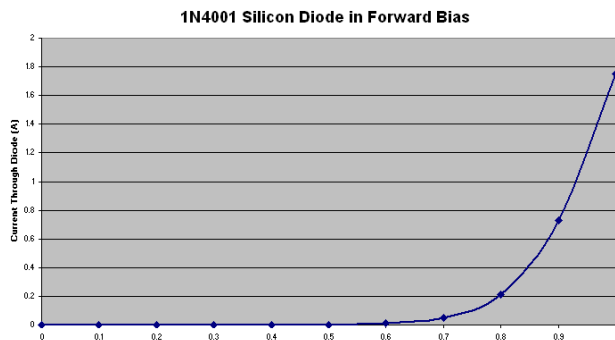


Fig.3.17. Excel graph of results for 1N4001 in forward bias

'ideal' diode. As we want to see how a real diode might work you need to select a model. To do this, double click the diode symbol and select '1N4001' from the 'Model' drop-down list (see Fig.3.16). The 1N4001 is a standard silicon rectifier diode and is very commonly used.

Test

What we have here is a really simple circuit – probably not one that you'd use in real life. However, it lets us see how much current the diode passes depending on what voltage we put across it. To carry out our test, what we'll do is slowly increase the voltage across the diode and see what current flows through it. This will tell us if the diode is conducting.

First, try starting the simulation by hitting the play button on the top bar. Use the slider to vary the input voltage and watch the effect. You'll only need to increase the voltage to about 1V, at which point the diode should be conducting nicely and you should see a large value for the current.

You might find it easier to set the limit for the input voltage to 1V (it's set

at 10V by default) – this will also help you with the next bit! You can do this by double clicking the component and changing the 10V to 1V.

Hopefully, you should notice that it doesn't simply start letting a large current pass immediately – it takes a little voltage across it to really 'open it up'. I always like to think of a diode like a sprung one-way gate; it's easy to get through it in the right direction, but you need to put a little pressure against it in order to get through.

Taking readings

Now let's get a little more scientific about things and take some readings. We can then draw up a graph of our results to see what's going on.

Starting from 0V and stepping up in 0.1V (100mV) steps, increase the voltage and record the current flowing through the diode. Once you've got a full set of results you can use them to draw a graph. Take care to make sure that all of your current readings are in the same units when you plot your graph! An example using Microsoft Excel is shown in Fig.3.17.

As you have found, once we get to around 0.6V the diode starts to let current through, and this is what we'd expect for a silicon diode. So far we've been using the diode 'the right way round' in what we call **forward bias**. Now we'll see what happens when we turn the diode around so that it's in **reverse bias** or 'backwards'.

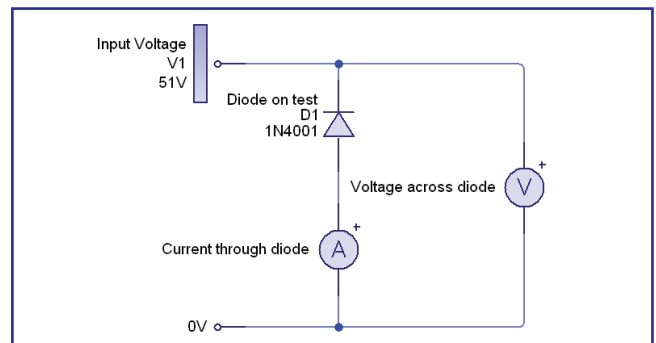


Fig.3.18. Circuit for diode testing in reverse bias

Alter your circuit to that shown in Fig.3.18. Notice that as well as the diode orientation changing, the top limit on the input voltage has been increased to 50V. Start the simulation and try experimenting with the input voltage.

You should find that it's really hard to get a diode to conduct in reverse bias! Going back to the idea of a diode as a one-way gate; if you really wanted to get through it the wrong way you would be able to do it, but you'd have to work really hard to force it open.

Therefore, it's not strictly true that a standard diode only lets current through in one direction! However, in practice, if you were using a diode in a low voltage circuit it is unlikely that a reverse voltage would ever be high enough to break it down.

Record values for the voltage and current going up in steps of 5V and graph your results (Tip: you'll also need to go to 51V to get your final reading!). You should obtain something that looks like the graph shown in Fig.3.19.

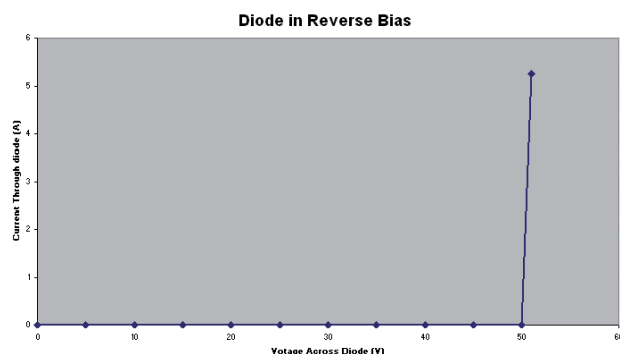


Fig.3.19. Excel graph for 1N4001 in reverse bias

**For your
copy of Circuit
Wizard –
see CD-ROM
pages**

The Circuit Wizard way

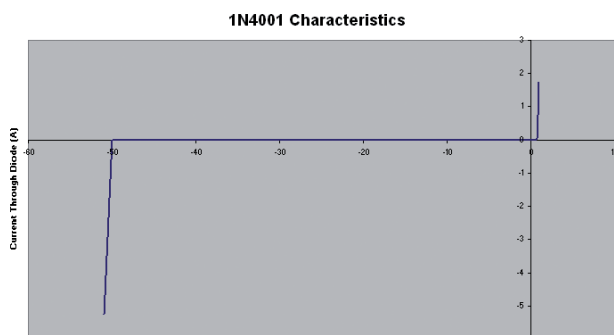


Fig.3.20. Excel graph showing 1N4001 characteristics in both forward and reverse bias

Semiconductor manufacturers often produce a graph of the characteristics of their diodes similar to those that you've created. However, they usually record the voltages and currents in reverse bias as negative, and show them both on one graph. Try this with your results and see if you can produce a manufacturer-like graph for the 1N4001. Take a look at ours, which we've shown in Fig. 3.20.

So we've seen how a standard diode lets current through in a forward direction once there is a small voltage across it, but normally blocks current in a reverse direction unless we apply a really large voltage.

Zener diodes

Diodes are a really useful device to help us control where current flows in a circuit and are essential when it comes to converting alternating current (AC) to direct current (DC); we call this voltage **rectification**. However, as you met in the 'Learn' section, there

is also another type of diode that has a special, and rather useful feature when it comes to reverse bias. These are called **Zener** diodes.

Basically, when we manufacture a Zener diode we can engineer it so that we know at exactly what voltage it will breakdown in reverse bias and conduct. You can purchase a full range of Zener diodes with different specified voltages.

So let's try our previous diode experiments, but with some Zener diodes instead of ordinary silicon diodes. Alter your reverse bias diode circuit shown in Fig.3.18 by changing the diode to a Zener diode – see Fig.3.21.

We need to specify the Zener voltage of the diode and we do this in the same way as we selected the diode model previously, by double clicking the Zener diode and selecting a voltage from the 'Model' drop-down list (see Fig.3.22).

To start with, select 3V6 (3.6V) then slowly increase the voltage across the diode taking readings every 0.25V until the current reaches around 100mA.

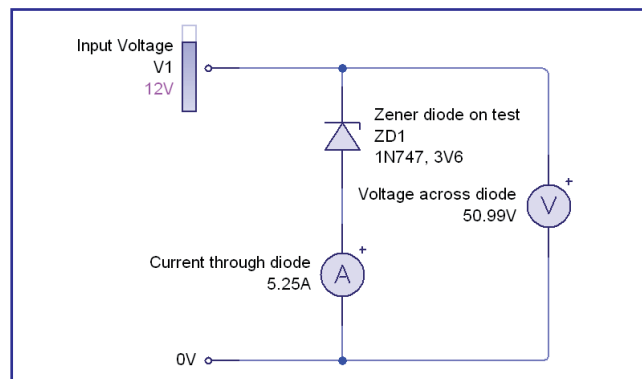


Fig.3.21. Zener diode test circuit

Now repeat this for some more Zener voltage values. Here's our results for three Zener diodes; 3V6 (3.6V), 5V1 (5.1V) and 8V2 (8.2V).

If you carried out your experiments accurately, you should be able to produce a graph similar to that shown in Fig.3.23. Notice that the current rapidly increases through the diode once it reaches the Zener voltage of the diode.

This can be extremely useful in electronic circuits. We often use Zener diodes to give us exact reference voltages and to regulate voltages down to a specific value.

For more information, links and other resources please check out our Teach-In website at:

www.tooley.co.uk/teach-in

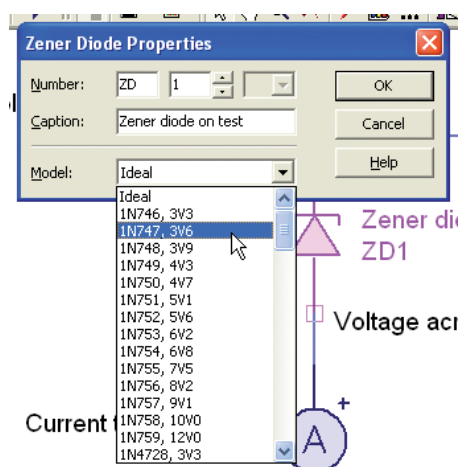


Fig.3.22. Selecting the Zener diode model

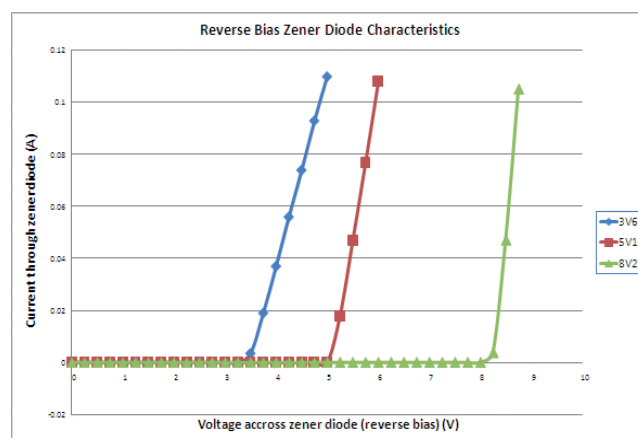


Fig.3.23. Characteristics for three different Zener diodes

Answers to Questions

1. See Fig.3.5(a)
2. (a) zero (b) infinite
3. D1 and D3
4. (a) 0.2V (b) 0.6V
5. See page 50
6. See page 50
7. (a) photodiode
(b) Zener diode
(c) light-emitting diode (LED)
8. 11V

Amaze

As you've seen, LEDs are a type of diode that emits light when the device is forward biased and passing current. LEDs have been around in various forms for quite a long time and so you will already be familiar with them and how they are used. LEDs offer some notable advantages when compared with filament lamps and fluorescent displays:

- They are extremely reliable and they can operate for many tens (or even hundreds) of thousands of hours if used at their rated current.
- They are impervious to heat, cold, shock and vibration
- They are very efficient and produce very little heat, so run cool
- They operate from low voltage and current, and can be easily interfaced to electronic circuits
- They are rugged because no breakable glass is used in their construction.

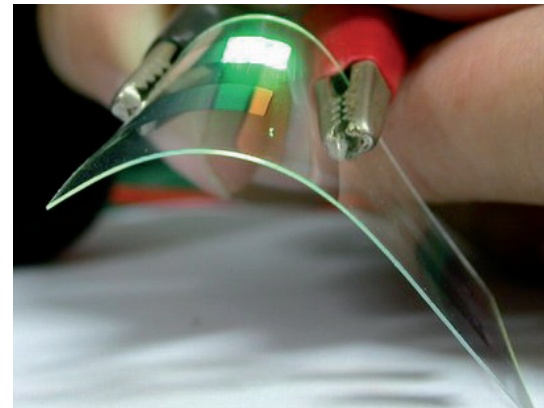


Fig.3.25. An early prototype OLED display (photo courtesy of M E Harris)

Going organic

Recent advances in semiconductor technology have seen the introduction of white 'high brightness' LEDs that can be used in groups or arrays to replace lamps used in domestic lighting applications. Developed by Kodak in the 1980s, organic light-emitting diodes (OLED) seem poised to oust the LCD display just as LCD technology has eclipsed the CRT. OLED panels are thinner, crisper, brighter and more energy efficient than their LED counterparts.

An OLED panel consists of a layer of organic, light-emitting material sandwiched between two conductors (an anode and a cathode). The resulting device is about 200 times thinner than a human hair and it emits light when an electric current is passed through it. There's no need for a backlight because the organic material emits its own light when charged.

The absence of a backlight means that OLED displays can be extremely thin. For example, the Sony XEL-1 is only 3mm thick and Sony's prototype 21-inch OLED TV uses a panel which has a thickness of as little as 1.4mm!

In the same way that inks are sprayed onto paper during printing, OLEDs can be sprayed onto substrates using inkjet technology. This reduces the cost of manufacturing and allows displays to be printed onto very large films that can be used in giant screens and electronic billboards. So, if you fancy a 100-inch TV display that rolls up for storage, or if you think it might be useful to have a display built into your clothing, you might not have to wait too long!

Next month!

In part 4, next month's Teach-In, we will look at transistors.

Investigate

Fig.3.24 shows the circuit of a power supply. Study the circuit carefully, look back at what we did in Part 2 and then answer each of the following questions:

1. What type of rectifier is used in the power supply?
2. What is the turns ratio of the transformer?

3. What AC voltage will appear at the input of the bridge rectifier?

4. If the LED has a forward voltage of 2V, what current is supplied to it?

5. What power will be dissipated in the Zener diode?

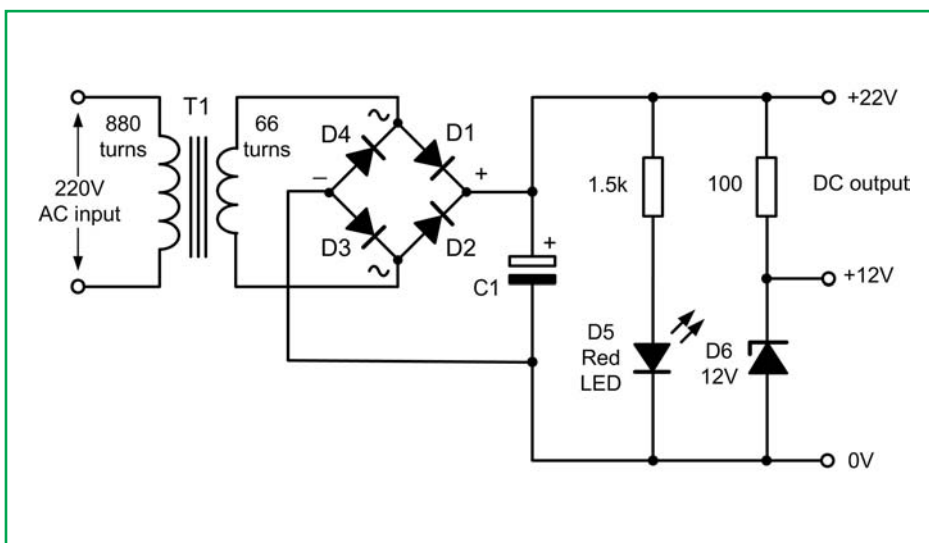


Fig.3.24. See Investigate

LED drive circuits

LED projects are very popular and this is reflected in the large number of questions we come across about LED drive circuits. The following was posted recently on *EPE's Chat Zone* forum by user **xenington**. We learnt in a later post that the LEDs are Cree XPGs (see Fig.2 for an image of the device).

I need a bit of help figuring out what is going to happen in the following circuit [Fig.1]. Would each LED be of equal brightness? Would the current split 50/50 down each string causing D1/D2 to burn out? Is this circuit a bad idea? Thank you for your help.

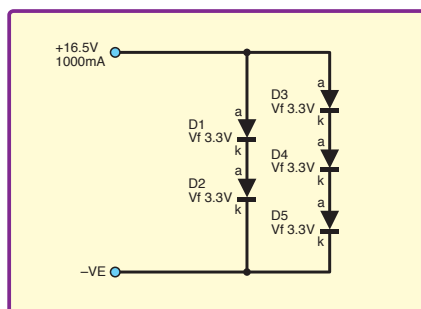


Fig. 1. Xenington's LED circuit

In response

The responses in the thread indicated that the circuit was not likely to be useful, with **phonoplug** correctly pointing out that the 'string of 3 will be very dim if lit at all'. Thus much of the discussion in the thread centred on practical concerns, such as calculation of resistor values, rather than describing exactly what would happen in the circuit presented.

However, the question of how we could work out what happens in the circuit is a useful one to pursue, and so forms the main part of our discussion this month. Our objective is not just to discuss LEDs, but to highlight the general approaches we can take to finding out what a circuit might do.

Apart from just building a circuit and 'seeing what happens', with the inherent possibility that we could destroy some of the components if we get it wrong; there are a few things we can do. First, we can use a reasoning approach, and by applying basic circuit theory ideas and general knowledge of the component characteristics, we can hopefully get a general idea of what is happening. As this may not involve any calculations, we may not get specific (or very accurate) figures for currents and voltages, but it may help guide us on what calculations to perform.

Second, we can perform some more detailed calculations, again we need basic circuit theory, but also the specific characteristic equations of the components involved. For some components the characteristic equations will be straightforward – Ohms law relating current and voltage for a resistor, for example. However, for semiconductors the equations may be more complex, and we often have a choice of approaches depending on how accurate we want to be, or the situation in the circuit.

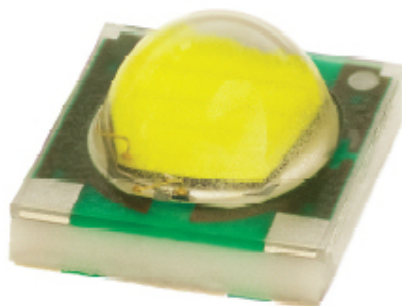


Fig. 2. Cree XPG LED (Cree data sheet)

For example, for a bipolar transistor we may be able to assume that the base-emitter voltage is more-or-less constant and that the collector current is a constant multiple (the gain) of the base current. However, this is an approximation, and in some situations we have to use the exponential equation relating (the actually varying) base-emitter voltage to collector current.

We can perform a purely algebraic circuit analysis, which will give us some deeper insight into the behaviour of the circuit, but again no specific figures. But we have equations now, so we can plug numbers in, if we can find the right values. This may be trivial, for example the resistance of a resistor, but if we are using detailed equations for semiconductors then the numbers may be harder to come by.

Simulation

We can also simulate the circuit, but this raises the question of how we accurately simulate the behaviour of the specific devices used. A similar point was made by **bruce** in a different *Chat Zone* thread:

I was trying to do a simulation of a fairly simple circuit for which I chose an NPN transistor type ZTX689B (there was one just lying around). There was no Spice model on LTspice, so I Googled. The Zetex website is called 'Diodes' as I understand it, and there is no model for this part.

In this case, a model was found by another contributor, but this is an interesting issue

and one which we may return to in a future article. As we will see later, we do not have this problem here, as Cree provides a model on their website.

Before simulating any circuit, we should have a good understanding of what to expect. Therefore, we should perform our basic reasoning and more detailed calculations first. To do this, we also need data about the devices used. This is easily obtained from the datasheet published on Cree's website (www.cree.com/products/xlamp_xpg.asp). Cree's headquarters are in North Carolina, US, and they claim to be one of the market leaders in the development of lighting-class LEDs.

Circuit schematic

The schematic supplied by xenington (Fig. 1) specifies a supply of 16.5V, 1000mA. It is not clear if this is a voltage source with a maximum current of 1A, or a current source with a maximum voltage of 16.5V (LEDs are often driven by current sources).

The LEDs are specified as having a forward voltage drop of 3.3V, which would indicate 9.9V across the three series LEDs (D3 to D5). From the electrical characteristics (Fig. 3) we see that a forward voltage of 3.3V corresponds to a current of about 900mA.

The total voltage across the two series LEDs (D1/D2) must be the same as the total voltage across D3 to D5. If we assume all the LEDs are equal, the forward voltage for D1 and D2 cannot be the same as that for D3, D4 and D5. Thus all the information on Fig.1 cannot be true at the same time, so we will have to make some assumptions.

If we assume a forward voltage of 3.3V we can apply this to either D1/D2 or D3 to D5, and then see what will happen to other diode series. This will hopefully give us a basic understanding of how the circuit will behave.

If D1 and D2 have forward drops of 3.3V then the total voltage across them will be 6.6V, and this same voltage will appear across D3/D4/D5. If we assume these three diodes are exactly the same, then each will have 2.2V across it.

From Fig.3, we see that the current in these diodes will be very small. The curve does not extend this far, but we can easily infer a current of less than 10mA, and in fact, it will probably be much smaller than this. Looking at Fig.4, which related light output to LED current, we see that a current of less than 10mA will mean the LED light will be very dim, if visible at all.

Thus we have D1/D2 brightly lit, D3/D4/D5 off, and a 9.9V supply delivering about 900mA, almost all of which is going through D1/D2.

If D3, D4 and D5 have forward drops of 3.3V, then the total voltage across them will

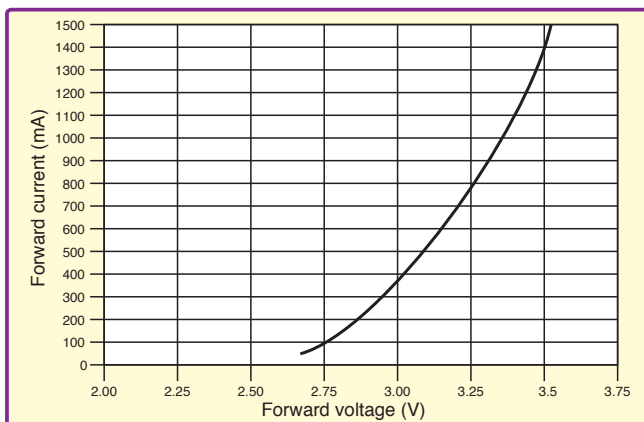


Fig.3. Cree XPG LED electrical characteristics
(Cree data sheet)

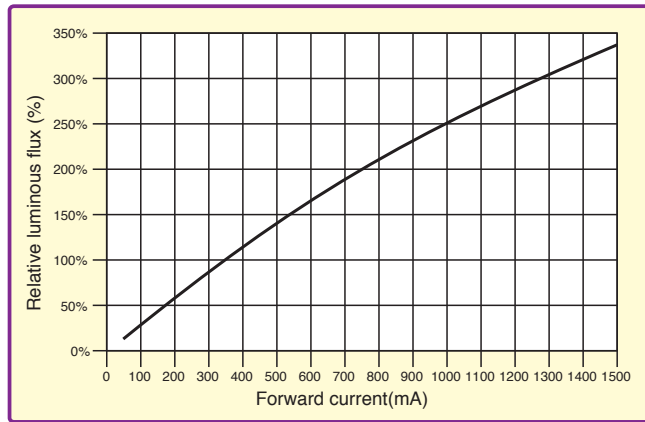


Fig.4. Cree XPG LED luminous flux characteristics
(Cree data sheet)

be 9.9V and this same voltage will appear across D1/D2. If we assume both these diodes are exactly the same, then each will have 4.95V across it. From Fig.3 we see that this voltage is not even on the graph scale and consequently the current (if we extrapolate the curve) would be enormous – the LEDs D1 and D2 would probably be destroyed.

The situation is similar to the previous case, with almost all of the total current from the supply going through D1 and D2. This is a direct consequence of the exponential voltage to current characteristic (as seen in Fig.3) of all forward biased diodes. The fact that the voltage across each of D3, D4 and D5 will be two thirds of that across both D1 and D2, together with the exponential characteristic, implies that the D1/D2 current will always be very much larger than the D3/D4/D5 current.

Detailed calculations

We can now proceed to a more detailed calculation. The characteristic equation for an idealised diode, relating the (forward bias) current through it, I_D , to the voltage across it, V_D , is:

$$I_D = I_S (e^{V_D/nV_T} - 1)$$

Where I_S is the saturation current, n is the ideality factor, and V_T is the thermal voltage. I_S and n are characteristics of individual diodes, which depend on the construction and materials used. V_T is related to temperature and basic physical constants (Boltzmann's constant and the electronic charge). V_T is about 25mV at room temperature. n is typically between 1 and 2 for silicon diodes, but may be larger for LEDs. I_S varies widely depending on the type of diode, but is typically very small compared with usual operating currents. The default value for I_S in LTspice is 1×10^{-14} A.

The equation is idealised because it does not take account of series resistance or reverse breakdown, but it is still useful in many situations. The equation can be further simplified because the exponential term is very much larger than one for all but the smallest forward voltages; we can therefore often remove the -1 term to get:

$$I_D = I_S e^{V_D/nV_T}$$

Rearranging this and taking natural logarithms we get the voltage across the diode:

$$V_D = nV_T \ln(I_D/I_S)$$

For the circuit in Fig.1 the voltage across D1 and D2 must be the same as the total voltage across D3, D4, and D5:

$$V_{D1} + V_{D2} = V_{D3} + V_{D4} + V_{D5}$$

Substituting the diode equation for each diode, and denoting the current through D1/D2 as I_{12} and the current through D3/D4/D5 as I_{345} , we get:

$$\begin{aligned} nV_T \ln(I_{12}/I_S) + nV_T \ln(I_{12}/I_S) = \\ nV_T \ln(I_{345}/I_S) + nV_T \ln(I_{345}/I_S) \\ + nV_T \ln(I_{345}/I_S) \end{aligned}$$

If all the diodes are equal we can cancel the nV_T terms:

$$\begin{aligned} \ln(I_{12}/I_S) + \ln(I_{12}/I_S) = \ln(I_{345}/I_S) + \\ \ln(I_{345}/I_S) + \ln(I_{345}/I_S) \end{aligned}$$

Given that adding logarithms is equivalent to multiplying we can write:

$$I_{12}^2/I_S^2 = I_{345}^3/I_S^3$$

So

$$I_S I_{12}^2 = I_{345}^3$$

Knowing that I_S is very small (compared with typical forward currents) we can conclude from this equation that I_{12} must be much larger than I_{345} .

For example, if I_{12} is 0.5A and I_S is 1×10^{-14} A then I_{345} will be about 14μA. In LED terms this would correspond to D1/D2 shining and D3/D4/D5 being very dim, or effectively off. So we reach the same conclusion from this more mathematical analysis as we did for our earlier basic reasoning.

Before we leave this analysis, it useful to do a reality check on the approximation we made (removing the -1 from the equation). Putting the current values into the approximate equation for diode voltage (with $n=1$ and $V_T=25$ mV) gives 0.789V and 0.526V (not values related to the Cree LED characteristics, but fine for checking here). First, we note that one is two thirds of the other, as expected (for equal diodes). Second, we can use these voltages to obtain the current values using the first equation (with the -1). On doing so, we find the values are very close to 0.5A and 14μA, justifying our approximation.

LTspice simulation

Having obtained an understanding of the circuit through basic reasoning about

its behaviour, and then through more detailed calculations, we can move on to a simulation. Using LTspice (we discussed this simulator in the previous two articles) we can draw a schematic as shown in Fig.5.

As is common practice, we are driving the LEDs from a constant current source, not a constant voltage supply, to ensure even brightness. LED brightness is related to current rather than voltage drop. Brightness is more or less linearly proportional to forward current, as shown in Fig.4; however, individual LEDs with the same current, and hence brightness, may have different forward voltages. A typical LED drive circuit is shown in Fig.6, in which a control circuit uses a small sense resistor to enable the current to be measured and regulated. If we drive a set of LEDs (in parallel) with the same voltage it is quite likely that they will not have even brightness.

A word of caution is needed about the LTspice schematic in Fig.5 – although we can place an LED symbol we do not get anything special in terms of component characteristics by doing so. The *D* next to the LED symbols on Fig.5 indicates that we are using the default diode model, exactly the same as placing a standard diode symbol.

By right-clicking on the diode symbol we can select 'Pick New Diode' and choose a model from the list of real devices included in the LTspice library. There are a number of LEDs included, but not the Cree XPGs. We will address this in a moment, but it is in fact worthwhile running the simulation using default diodes, as this should relate closely to the calculations with the diode equation which we have just done.

The simulation we require is simply an operating point calculation – we just need the DC currents and voltages in the circuit. To do this, we select 'Edit Simulation Cmd' from the 'Simulation' menu, select the 'DC

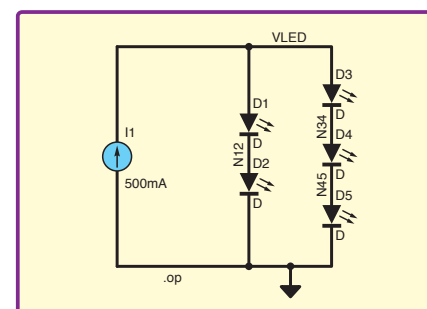


Fig.5. LTspice simulation schematic using default ideal diodes

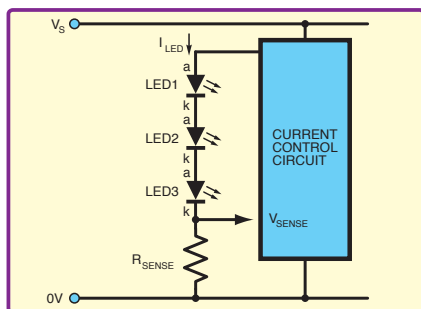


Fig.6. Driving LEDs in series using a constant current source

op pnt' tab in the dialog, click 'Ok', and place the '.op' spice directive on the schematic. On running the simulation, the results appear in a text window as follows:

V(n34):	1.08781	voltage
V(n45):	0.543906	voltage
V(vled):	1.63172	voltage
V(n12):	0.815859	voltage
I(D2):	0.499988	device_current
I(D1):	0.499988	device_current
I(D3):	1.35719e-005	device_current
I(D5):	1.35719e-005	device_current
I(D4):	1.35719e-005	device_current
I(I1):	0.5	device_current

The simulation results confirm our earlier reasoning and analysis. The values used correspond with the calculation above: about 0.5A through D1/D2 and 14µA through D3/D4/D5. The diode forward voltages are not exactly the same at 0.54V and 0.82V, but have the expected two-thirds ratio. The difference is due to the fact that LTspice is not using exactly the same approximate diode model as we did, so this is not unexpected.

Simulation with ideal diodes has confirmed the general behaviour of the circuit, but it would be better to have something based on the actual components used. This relates to the issue raised by **bruce** – that of finding SPICE models for specific components. Fortunately, in this case it is straightforward, as Cree provides a SPICE model for the XPG LED as a text file on their website. The model is shown below:

```
.MODEL XlampXPG D
+ IS=13.076E-12
+ N=4.6837
+ RS=.28172
+ XTI=42.150
+ EG=2.5000
```

There are a number of ways to add SPICE models in LTspice, something which we may discuss in more detail in a later article. Here we will simply add the text on to the schematic, as shown in Fig.7. To do this, we select the text item from the toolbar and make sure that the 'Spice Directive' option is selected in the dialog. The + characters at the start of a line indicate that the SPICE directive is continuing from the previous line of text.

Performing an operating point analysis, as before, provides the following results:

V(n34):	4.12348	voltage
V(n45):	2.06174	voltage
V(vled):	6.18522	voltage
V(n12):	3.09261	voltage
I(D2):	0.499678	device_current
I(D1):	0.499678	device_current
I(D3):	0.000321659	device_current
I(D5):	0.000321659	device_current
I(D4):	0.000321659	device_current
I(I1):	0.5	device_current

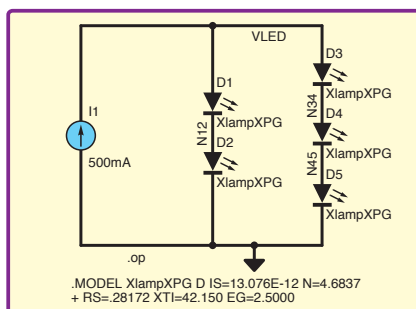


Fig.7. LTspice simulation schematic using the XPG LED model from the Cree website

Again, we see the same general behaviour, with almost all the current flowing in D1/D2. The voltage drop across these diodes is about 3.1V and the current is close to 0.5A. A look at Fig.3 confirms this is consistent with the data sheet.

Conclusion

If we try to confirm the equation we developed earlier: $I_S I_{12}^2 = I_{345}^3$; we find that the two sides are out by about a factor of ten. At first this seems like a gross error, but these values include the cube of something which is exponentially dependent on circuit voltages – so a very small shift in conditions can produce a very large change in the calculated value.

This discrepancy is not a problem; it is due to the fact that the model used by LTspice is more accurate (and hence complex) than the one used in our calculations. For example, it includes diode

series resistance. One of the advantages of simulators is that they can perform calculations which would be difficult or tedious to do manually.

In this article, we have attempted to not only solve the question posed by **xenington**, but also illustrate the approaches we can take to working out what a circuit will do. We have looked at simple reasoning based on a sound understanding of circuit theory and component behaviour, more detailed calculation using circuit theory and component characteristic equations, and simulation. Often we perform all three in that order.

Simulation should not be performed without some understanding of what the circuit will do; otherwise we can be fooled by misleading or erroneous results. Such problems could occur because of design entry errors, inappropriate models, poor simulator configuration/option settings and artefacts due to the simulation algorithm.

Similarly, we need to be aware of limitations in any approximations we use in our calculations and simulation models. Approximations are important in engineering, often making otherwise intractable calculations feasible, or quick rather than protracted. This is a different philosophy from say a physicist, who would want to know all the details of how an LED, for example, functions.

An experienced designer might look at Fig.1 and immediately dismiss it as not being viable, stating that all the current flows in D1/D2. The level of complexity at which analysis and simulation is needed of course varies with experience, but the principles are the same.

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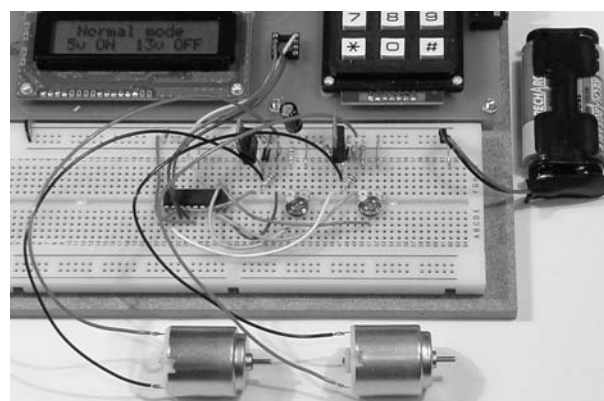
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Microchip's ICD 3 in-circuit debugger

WE take a break this month from Propeller processors to take a look at Microchip's ICD 3 in-circuit debugger, introduced last year. It's an unusual product, filling neither the low-cost hobbyist nor the professional developer markets. Like the PICKit debugger it's had a recent design refresh, so we thought it time to take a more detailed look.

Looking back

First, a bit of background information on debugging tools. In the early days of microcontroller development, the code was stored on the target system either in EPROM or, if your product was to be produced in sufficient quantities, in mask ROM on the processor itself.

A mask ROM processor is the cheapest and lowest power solution for an embedded system, but carries a very high one-off cost (often in the tens of thousands of pounds) as the code is actually incorporated into the chip manufacturing process. Not only is that expensive, but it could take three months from submitting your code image to the supplier before receiving back a test chip for verification.

Needless to say, this doesn't allow for a continuous 'crash and burn' software development process. If you were lucky, you had three attempts to get the software right, with each failure marking your career in the company!

For smaller production runs, the code would be placed in a socketed EPROM chip, which assisted development considerably – the EPROM could be taken off the board, erased under an ultra-violet lamp and then reprogrammed. The whole cycle could be repeated in about 30 minutes.

EPROM emulator

The debugging of an embedded microcontroller system fitted with an EPROM was vastly improved with the use of an EPROM emulator, a device that fully simulated an EPROM. The device had an RS232 interface for loading data and a cable with a DIL header that plugged directly into your target board. The more expensive devices could detect read accesses to certain locations, providing a crude breakpoint facility. It was an incredibly useful tool in its time and closely guarded by the senior engineers who had access to one!

Debugging mask ROM processors was a much more complex affair. A special and very expensive piece of hardware, a processor emulator, had to be used. An emulator is a device that completely replaces your microprocessor on your target board, generally via a cable with a DIL header matching the processor pinout.

These emulators were fantastically expensive (anywhere from five thousand pounds up), but provided the kind of debugging features we are now used to – complex code and data breakpoints, watch variables etc. Needless to say, hobbyists lived without such luxuries.

Thankfully, microcontroller manufacturers recognised the difficulty with developing software for their processors and started introducing on-chip debugging support; a few pins dedicated to a debug interface, with logic within the processor itself to allow for a few hardware breakpoints – the situation we are in today with processors from Microchip, Texas Instruments and the like. In a few short years the cost of debug hardware went from thousands of pounds to a few hundred, and now a PICKit 3 can be picked up for £30.

Modern low-cost debugger hardware does lack the full range of debugging facilities offered by the older emulators, but the power

of the modern processors and the large flash memory available means the developer can easily make up for the missing test features with some skillfully crafted code.

ICD 3 in-circuit debugger

Which brings us nicely back to the Microchip debugging products on offer, and the ICD 3 in particular. Where does it fit in?

Microchip currently supply three products with increasing functionality and cost. As you can see from Microchip's own marketing data in Fig.1, there is a great deal of overlap in functionality across the product range, with an order of magnitude price increase. The ICD 3 sits in the middle, between the low end PICKit 3 and the high end 'Real ICE' emulator.

We've been intrigued by the ICD series of products for some time now, as it's hard to work out what niche it fills between the £35 PICKit 3 and the £350 Real ICE. The only way to find out is to play with it (about time too we hear you say!)

First, let's find out what you get for your £150, and take it apart to find out what's inside.

The blister packaging was surprisingly weighty, but this wasn't down to the ICD 3. For some peculiar reason a heavy A5-sized notepad is included, along with a large glossy poster showing some useful getting-started tips.

There is a CD containing MPLAB, but as this was version 8.50 we put it to one side. We like to keep up with the frequent MPLAB updates on line, but the version 8.50 supplied is not that old, and will be a welcome inclusion for those with low speed Internet access and who struggle to keep up with the massive MPLAB download.

The kit comes with two cables – a standard USB lead to connect the debugger to your PC, and a short RJ11 cable to connect to your target.

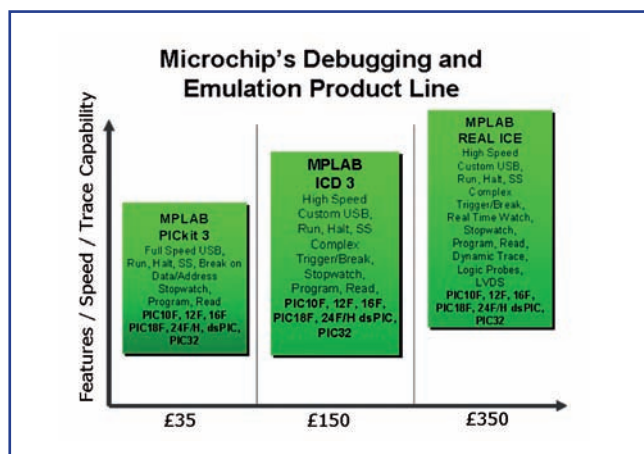


Fig.1. Microchip's debugging and emulation line-up



Fig.2. The ICD 3 in-circuit debugger kit

The RJ11 is the 'higher end' debug connector chosen by Microchip, using exactly the same signals as the PICKit SIL header, just in a more robust format. It's a slight inconvenience if you build circuits onto breadboard or stripboard, but that can be fixed by building a small RJ11 socket adaptor. You'll have to buy a socket to do that however, as one is not included in the package.

Also included is a small PCB with a PIC10F processor fitted to it. This is a simple test circuit to confirm that the ICD 3 is working – more an aid for the Microchip technical support team I suspect, but handy too during initial device setup and familiarisation. The contents are shown in Fig. 2.

Naturally, we were curious about what is inside the ICD 3, and where the £150 price tag comes from. Disassembly is simple – a single screw holds the circular case together. Gaining access does require the breaking of a seal, so we don't recommend you try this at home! The PCB is shown in Fig.3.

Circuit board

The ICD 3 consists of a single circular PCB, well designed with low cost manufacture and assembly in mind. The big surprise was to find a Xilinx Spartan 3E FPGA. This is the smallest of the spartan-3E family, but it still sports 100,000 gates – Microchip are taking no chances with this hardware design, they have added plenty of flexibility for supporting future microcontrollers!

There is a dsPIC33 processor as an overall controller, a dedicated USB2 interface chip and two 512KB SRAM chips. Plenty of processing power here. Three LEDs provide status output, nicely

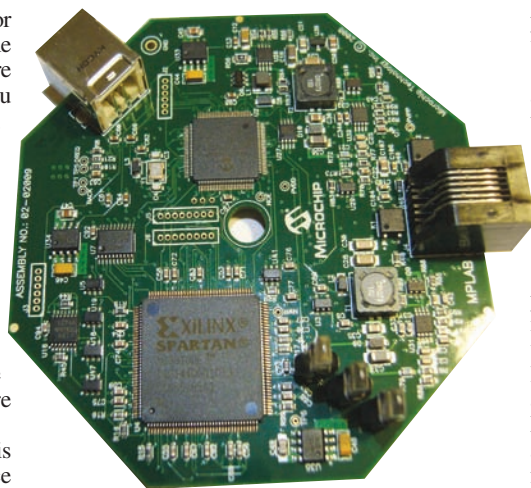
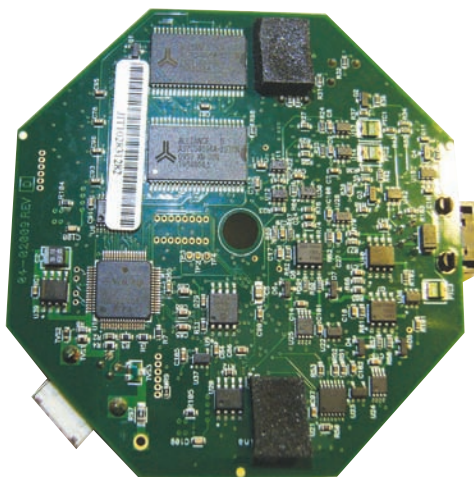


Fig.3. (below) The two sides of the PCB



positioned to give a clear indication of what is going on.

The target probe physical interface and the associated drive electronics are more robust than the PICKit's, which will be a welcome addition for those who have experienced dead debuggers (although in five years of constant use, the author's PICKit 2 is still working).

The two main benefits of the ICD 3 are its wider device support range – although the PICKit 3 is catching up – and the much faster programming and tracing speed. Programming is over 10 times faster, which if you are doing very short debugging cycles (code change, load, test, repeat) on large projects will make a considerable difference. Its integration into MPLAB is identical to the PICKit, and we were able to download and single step code within a few minutes.

Conclusion

In a way, the PICKit debugger has evolved to the stage where an ICD 3 offers only limited advantages. Indeed, at the moment, the PICKit 2 is our debugger of choice and will remain that way until an accident happens that destroys it. At that point it will be replaced by a PICKit 3.

Faster programming time is a bonus, and there may be some situations where the faster tracing facilities on the ICD 3 will help you solve a tricky design problem quicker, but those times are going to be rare. And besides, debugging an interesting problem late into the night is part of the fun, isn't it?

For those people developing PIC software professionally or just generally on tight timescales, the ICD3 will certainly be worth the extra £100. For the rest of us, in our opinion, the PICKit 3 remains the most cost-effective and invaluable development tool.

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Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

EXPERIENCED electronic project builders are unlikely to be deterred from constructing a project due to concerns about finished projects failing to work. They have the technical knowledge, equipment, and know-how to deal with practically any problem that could arise. A project would have to be extremely large or very tricky in some other respect in order to make an 'old hand' think twice before attempting to build it.

The opposite is true for beginners who, on the face of it, have little chance of dealing with projects that refuse to work. They lack fault-finding experience and expertise, and are unlikely to be equipped with the equipment needed for detailed checking of even a fairly basic circuit. Doubts about successfully completing a project are probably the main reason for would-be constructors failing to 'take the plunge'.

Rise to the challenge

While it would be an exaggeration to claim that the reservations of beginners are totally unfounded, and that first-time success is virtually guaranteed provided you go about things the right way, the chances of building a working project at the first attempt are actually very good.

Pre-publication checking of articles containing electronic projects has virtually eliminated the chances of being led astray by printing errors. Any error that does manage to find its way into an *EPE* article will be spotted quite early and corrected one or two issues later.

Modern components go through vigorous testing before leaving the factory, and they are very reliable. Provided you follow the plans and instructions 'to the letter', the chances of success are high and the likelihood of failure is very low.

Electronic project construction is a creative pastime, and as with any creative endeavour, you

have to be prepared to put in some effort and learn some new skills. Although it is a technical hobby, you do not need to understand the operation of each circuit in detail. In fact, you can largely ignore many of the technicalities, and initially you will probably have to do so, but it will still be necessary to learn plenty of new names and terms.

Electronics would not be a worthwhile hobby if perfect results were guaranteed every time with no skills or mental effort required. To some extent, it is the challenge of building a project that makes it worthwhile.

Simplicity itself

It is something that has been mentioned many times over the years in this series of articles, but it is worth repeating once again. It is important to choose for a first project, something that is reasonably simple and straightforward. While it is tempting to dive straight in with a 'mega' project that will impress your family and friends, this is a high risk strategy.

The more complex the project, the greater the chance of a mistake or several mistakes being made. It is not necessary to know how a project works in order to build it successfully, but you do need to have a reasonable understanding of what it is supposed to do, and how to use the finished device.

Something like a simple novelty project or a household gadget is a

more appropriate starting point than an advanced piece of scientific equipment, where you need a great deal of specialist knowledge in order to set it up and get it to the stage where it is ready to actually do something! Try to avoid projects where the mechanical side of construction is difficult or awkward in some respects. It is better to choose something more straightforward so that you can concentrate your efforts on mastering the new skills required for the electrical aspect of construction.

Beware of the mains

Another important point that is worth reiterating is that the mains supply is potentially lethal, as are projects that connect to it. Only those with a reasonable amount of experience at project construction should attempt projects that connect direct to the mains supply.

No matter how simple a project may be, if it connects to the mains supply it is **NOT** suitable for a beginner. Start with projects that are battery powered, or are mains powered by a separate battery eliminator that conforms to the standard safety regulations. Some of the components in the project could be damaged if a mistake is made, but you should be perfectly safe.

Hole in one

Modern electronic gadgets are based on printed circuit boards. The two types of board used in electronic projects are stripboard and custom printed circuit boards (PCBs). Stripboard is a versatile proprietary circuit board that has a regular matrix of holes, plus copper strips on one side of the board. Stripboard is quite straightforward in use, but with most projects only a few percent of the holes are actually used. The hundreds of unused holes in a typical stripboard project tend to encourage mistakes. The

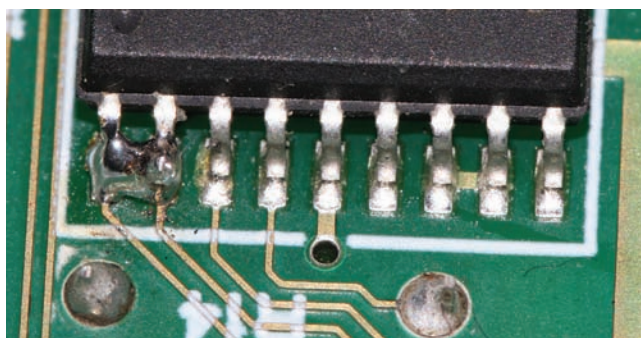


Fig.1. In most cases any solder bridges will be easy to spot. In this example a minute blob of solder spilled from the iron is causing the problem

unused holes are good at hiding any mistakes that are made, and some very careful checking is needed in order to detect any errors.

As its name suggests, a custom printed circuit board is specifically designed for one particular circuit. A custom board has just one hole per leadout wire or pin, making it relatively foolproof. There is relatively little risk of making a mistake in the first place, and any errors that should creep in, such as a component in the wrong place, are likely to be spotted almost immediately. Most modern projects are based on a custom circuit board, which represents the easier option for beginners.

If you are new to electrical soldering, as will probably be the case, it is a good idea

It is then a matter of rechecking the component layout, and wiring. I say 'rechecking' rather than checking, as this sort of thing should have been very carefully checked during construction. Discovering errors early in the proceedings can save a lot of hassle later. It is often necessary to partially dismantle a project in order to get proper access to the circuit board and check it properly.

Practical experience suggests that the first place to look for problems should be the soldered connections on the underside of the circuit board. Short-circuits between copper tracks on the underside of the circuit board are the most common cause of problems. Custom printed circuit boards are often coated with a solder resist that is designed

vigorous brushing with a small brush such as an old toothbrush seems to do a good job.

Even if you have good eyesight there is no guarantee that you will be able to see all solder bridges. A magnifier should be part of your standard electronics toolkit, and using even a small magnifying glass will vastly increase the chances of finding minute solder trails. An 8× or 10× loupe (also known as a 'lupe') is even better for this application. These are sold as photographic accessories for viewing slides and negatives, and an inexpensive type is more than adequate for checking circuit boards.

A careful visual inspection of a clean board using a magnifier should reveal any solder bridges. Pay particular

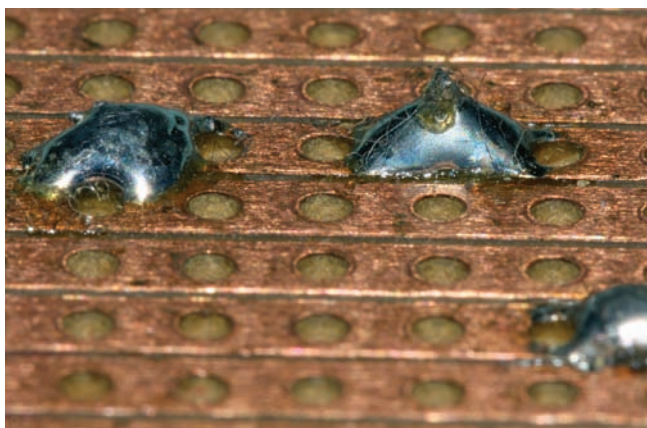


Fig.2. The joint on the right is reasonable, and is providing a good connection. The leadout wire has been cut too short with the joint on the left, resulting in the solder flowing all over the place, and no connection being made

to practice soldering before attempting your first project. Expect to write-off your first one or two projects if you decide to learn this skill as you go along! It is well worth spending some money on a small piece of stripboard and some cheap components such as resistors, so that you can get some experience at fitting components to a printed circuit board before progressing to the real thing. Also, try fitting some solder pins to the board and then solder some pieces of multi-lead connecting wire to the pins. There is an excellent soldering guide on the *EPE* website (www.epemag.com), and this is well worth a visit.

Bridging the gap

Having carefully put together your first project, what do you do if the finished unit fails to work? Leaving a faulty project switched on is not advisable, and could result in damage to some of the components. If a project is clearly not functioning correctly it should be switched off immediately.

to discourage solder bridges. However, no solder resist can guarantee perfect results, and with a really intricate board it is likely that at least one or two solder bridges will be produced.

In most cases the excess solder will be fairly obvious (Fig.1), and will be spotted while you are constructing the board. The excess solder can usually be wiped away using the bit of the soldering iron, but a desoldering tool should be used if there is a lot of excess solder to be removed. An inexpensive desoldering pump is ideal for this type of thing. Remove as much solder as possible and then resolder the joint.

Unfortunately, many solder bridges are not easily spotted, and in some cases it can be quite tricky to detect them. The trails of excess solder can be very narrow, and the situation can be made worse by the trails being hidden under excess flux from the solder. The underside of a circuit board tends to get a liberal splattering of excess flux during construction, and can end up looking a bit of a mess. Various flux removal products are available, but



Fig.3. This connection looks all wrong, and it is. The leadout wire is corroded, and too much solder has been applied in an attempt to get the solder to flow over the joint properly, resulting in a dubious connection and two tiny solder bridges

attention to parts of the board where there are a large number of connections in a small area, and to components that have very narrow pin spacing, such as most integrated circuits. Try not to be fooled by large blobs of solder that appear to be an ordinary joint, but are actually completely covering two joints. It is advisable to clean and visually check all circuit boards before installing them in the case.

Shining examples

As with any skill, good soldering is a case of 'practice makes perfect'. Even the most experienced project constructor is not immune from producing the occasional bad soldered joint, but it is more likely to cause problems for beginners. Probably the most common cause of so-called 'dry' joints is the soldering iron being left unused for a few minutes before starting a new set of connections. The flux will soon burn away if there is any solder left on the bit, and the solder itself will probably start to oxidise.

The correct procedure is to clean the bit and tin it with fresh solder before starting the next batch of connections. If you fail to do this it is likely that the next joint produced will contain a significant proportion of old solder. There could be insufficient flux, and the solder could fail to flow over the joint properly.

Joints produced in this way usually provide only intermittent electrical contact or no contact at all, and are likely to be lacking mechanical strength as well. They might look much the same as proper joints, but there will often be tell-tale signs that all is not well. Larger than normal amounts of excess flux around a joint are sometimes indicative of a problem, but this evidence is no longer available once the board has been cleaned.

Good quality soldered connections are usually mountain shaped and the surface of the solder is quite shiny (Fig.2). 'Dry' joints are often more spherical or rather irregular in shape (Fig.3). The surface of the solder tends to be relatively dull in appearance, and there might be some crazing as well. If you try to pull the component away from the board you may well succeed if there is a 'dry' joint. Checks with some form of continuity tester should locate dry joints, but fully checking even a small circuit board can be quite time consuming.

With any joints that look at all doubtful it is probably best to desolder them and try again. However, before making a second attempt, carefully inspect the end of the leadout wire and the copper pad. The flux in electrical solders is very efficient at dealing with contaminants, and modern components are resistant to corrosion on the leadout wires and tags.

Consequently, it is unusual for dirt or corrosion on the surfaces to cause

problems. There can still be occasional problems though, and if there is any hint of contamination on the surfaces it is a good idea to clean them before re-soldering the joint. The surfaces can be cleaned by gently scraping them with the small blade or a penknife, a miniature file, or something of this type.

The ultimate 'dry' joint is the one that has no solder at all! A close visual check of the board should soon detect any missing joints, but they can be difficult to find with stripboard where there are numerous unused holes that help to hide them. Firmly pulling on resistors, capacitors, diodes, etc., should soon reveal any joints that are absent.

Heat of the moment

Most modern components are reasonably tolerant of heat, but practically any component will be damaged if you take too long to complete the soldered connections. A component that has been damaged by overheating will usually show some obvious signs of heat damage, such as a change in its colour or change in its shape. Any 'off colour' or deformed components should be replaced.

Although semiconductors are mostly fitted in holders, transistors and diodes are often soldered direct to the board. Extra care should be taken when fitting these in place, because semiconductors are more vulnerable to heat damage than most other components.

Thoroughly check the hard wiring against the wiring diagram. With modern projects there may be very little hard wiring to check, but it should still be given your undivided attention. Bad soldered connections are more easily made when fitting the hard wiring,

so carefully check all the soldered connections. Check for silly problems, such as a battery connector that does not connect properly. In these days of hi-tech gadgets there are often problems with lo-tech battery connectors that have dirty contacts, or have become bent out of shape and do not fit reliably.

An inexpensive multimeter is useful for checking that the battery voltage is actually getting through to the circuit board, and that the battery is in a usable state. It can also be used for making other simple checks, such as continuity checks on switches, testing cables for short-circuits or broken leads, and checking that plugs and sockets connect together properly.

Even some of the cheaper types have the ability to check resistors, capacitors, transistors and diodes. A multimeter is a piece of equipment that project builders should own sooner rather than later.

Denial

If the project still refuses to work, methodically check that every component on the circuit board is in the right place and has the correct value, and that nothing is missing. Pay special attention to any components that must be fitted a particular way around. With a stripboard project, make sure that any link wires are present and correct.

When something fails to work, there is a tendency to blame others and not accept that you could be responsible for the problem. If at all possible, get someone else to check the unit against the construction diagrams. Having missed a mistake once, there is a tendency to go on fooling yourself. A fresh pair of eyes might spot something that you have consistently overlooked.

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EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE ELECTRONICS CD-ROMS



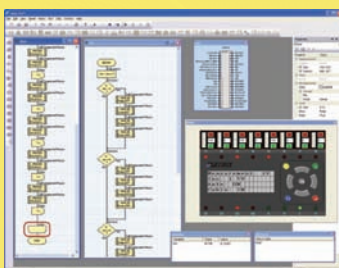
Flowcode 4 is one of the World's most advanced graphical programming languages for microcontrollers. The great advantage of Flowcode is that it allows those with little experience to create complex electronic systems in minutes.

Flowcode's graphical development interface allows engineers to construct a complete electronic system on-screen, develop a program based on standard flow charts, simulate the system and then produce hex code for PICmicro® microcontrollers, AVR microcontrollers, ARM microcontrollers, dsPIC and PIC24 microcontrollers.



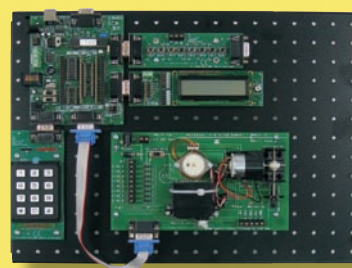
Design

Flowcode contains standard flow chart icons and electronic components that allow you to create a virtual electronic system on screen. Drag icons and components onto the screen to create a program, then click on them to set properties and actions.



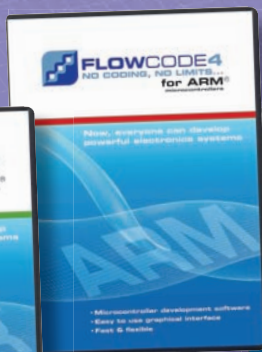
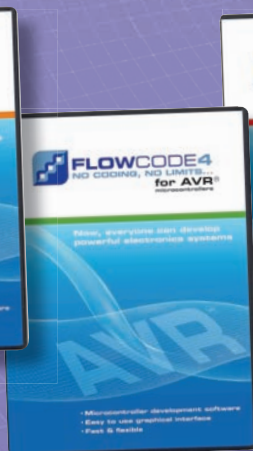
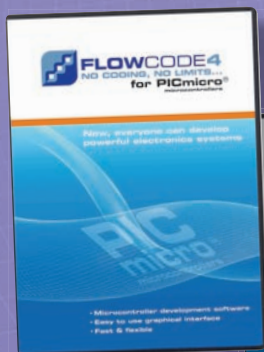
Simulate

Once your system is designed you can use Flowcode to simulate it in action. Design your system on screen, test the system's functionality by clicking on switches or altering sensor or input values, and see how your program reacts to the changes in the electronic system.



Download

When you are happy with your design click one button to send the program directly to your microcontroller based target. Targets include a wide range of microcontroller programmers, upstream E-blocks boards, the Formula Flowcode robot, the MIAC industrial controller, or your own system based on ECIO technology.



FlowKit

The FlowKit can be connected to hardware systems to provide a real time debug facility where it is possible to step through the Flowcode program on the PC and step through the program in the hardware at the same time. The FlowKit can be connected to your own hardware to provide In-Circuit Debug to your finished designs.

PRICES

Prices for each of the CD-ROMs above are: (Order form on third page)

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Hobbyist/Student	£45	inc VAT
Professional (Schools/HE/FE/Industry)	£149	plus VAT
Professional and Flowkit bundle	£175	plus VAT

PICmicro TUTORIALS AND PROGRAMMING

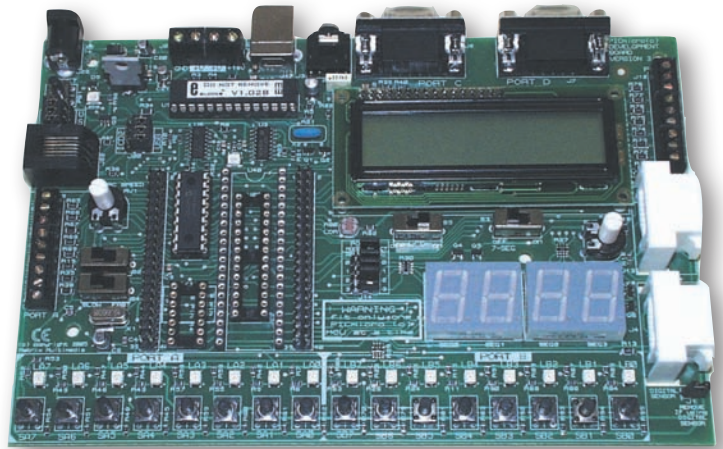
HARDWARE

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 LEDs, quad 7-segment display and alphanumeric LCD 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)



£158 including VAT and postage, supplied with USB cable and programming software

SOFTWARE

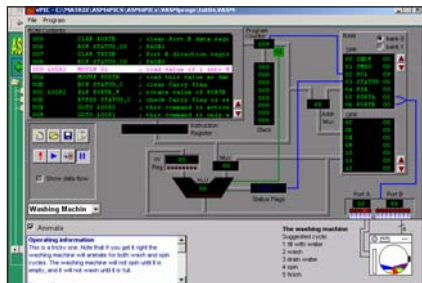
ASSEMBLY FOR PICmicro V3

(Formerly PICTutor)

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

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro 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.

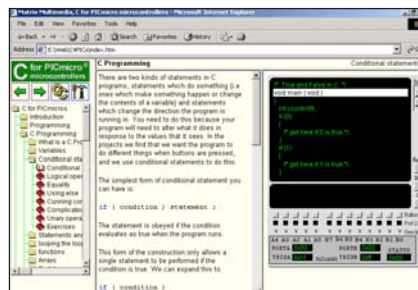


'C' FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD-ROM 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, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

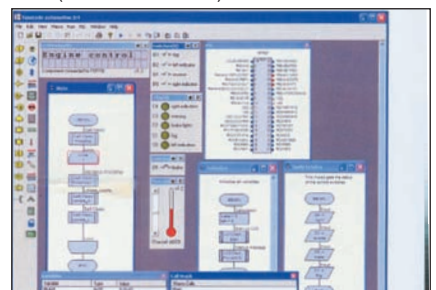
Flowcode will run on XP or later operating systems

FLOWCODE FOR PICmicro V4

Flowcode is a very high level language programming system based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and LCDs. The use of macros allows you to control these devices without getting bogged down in understanding the programming. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

- Requires no programming experience
- Allows complex PICmicro applications to be designed quickly
- Uses international standard flow chart symbols
- Full on-screen simulation allows debugging and speeds up the development process.
- Facilitates learning via a full suite of demonstration tutorials
- Produces ASM code for a range of 18, 28 and 40-pin devices
- 16-bit arithmetic strings and string manipulation
- Pulse width modulation
- I2C.

New features of Version 4 include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



PRICES

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(Order form on next page)

(UK and EU customers add VAT to 'plus VAT' prices)

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Professional 10 user (Network Licence)	£350	plus VAT
Site Licence	£699	plus VAT
Flowcode Professional (Schools/HE/FE/Industry) ..	£149	plus VAT
Flowcode 10 user (Network Licence)	£399	plus VAT
Flowcode Site Licence	£799	plus VAT

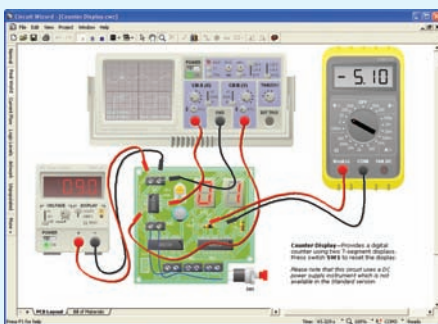
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- * Virtual instruments (4 Standard, 7 Professional)
- * On-screen animation
- * PCB Layout
- * Interactive PCB layout simulation
- * Automatic PCB routing
- * Gerber export



Special EPE Offer - Standard version only.

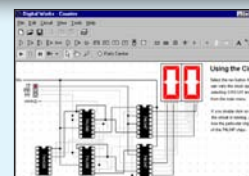
EPE is offering readers a 10% discount on Circuit Wizard Standard software if purchased before Jan 31, 2011. This is the software used in our Teach-In 2011 series.

Standard (EPE Special Offer) ~~£59.99~~ £53.99 inc. VAT
Professional £89.99 inc. VAT

Special EPE Offer ends Jan 31, 2011

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

DIGITAL WORKS 3.0



Counter project

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

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Note: The software on each version is the same, only the licence for use varies.

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The total cost of upgrading

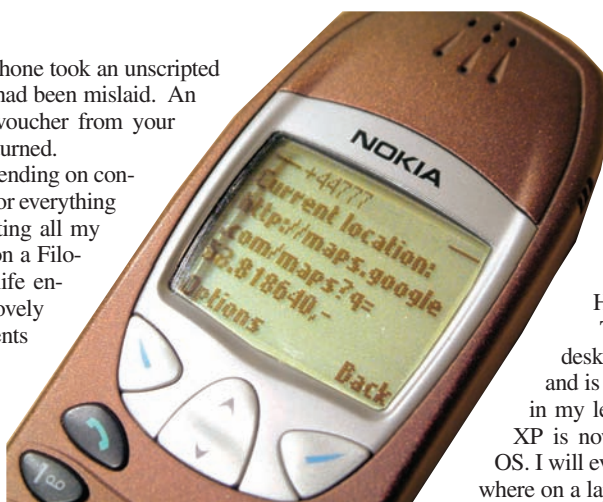
Last month I mentioned how my mobile phone took an unscripted tour of the supermarket car park in which it had been mislaid. An honest citizen (since rewarded with a gift voucher from your grateful scribe) handed it in and normality returned.

This made me question the wisdom of depending on converging mobile electronics. There are 'apps' for everything but personally, I recoil from the idea of putting all my eggs into one basket and so I don't depend on a Filo-fax, smartphone or iPhone to organise my life entirely: I'm rather disjointed like that. I use a lovely Palm Tungsten E2 for addresses, appointments and anniversaries.

Apart from obviously making phone calls on the move, or for hands-free in-car or satnav use, I generally use my phone to help keep track of email. It's hard for a technology buff like me to admit, but I believe smartphones and PDAs are best used as tools to keep things moving along rather than depending on them entirely as one's nerve-centre of productivity.

I also believe the total cost of ownership of all such devices extends far beyond the market-rigged price of a phone or the data tariff itself. Such gadgets can be technological time-sinks. For example, I have just spent five hours helping a friend to update her TomTom XL satnav and we both agreed that the time needed to update and configure these things made us wonder why we'd bothered. Or is it that we think our time is worthless?

This blinkered view will doubtless change; I can already see how the new creed of mobile applications is starting to offer something that's of real value, making technological convergence more rewarding. The advent of the Android operating system also holds great appeal, especially compared with hoary old Windows Mobile 6.x. Despite a myriad of desirable 'apps' being available though, 3G signal coverage and bandwidth are still too sketchy to enable consistently productive use to be made of smartphones: mobile technology is still a bit hit and miss, but it's looking promising.



F-Secure Mobile Anti-Theft can text back to you the location of your missing or stolen phone in the form of a Google Maps hyperlink. (See text.)

The general functionality in Windows Mobile 6.x left much to be desired and eventually I will consider replacing it, possibly with Android for fun or probably Windows Phone 7, Microsoft's grossly overdue OS for a new generation of Windows smartphones. Until then, there is some mileage in my bulky but versatile HTC Tytn II phone.

The same is true of my Windows XP desktop suite. While Windows 7 beckons and is very highly regarded, there is life yet in my legacy system, even though Windows XP is now largely a decade-old unsupported OS. I will eventually introduce Windows 7 somewhere on a laptop and W7 will gradually percolate throughout my IT system.

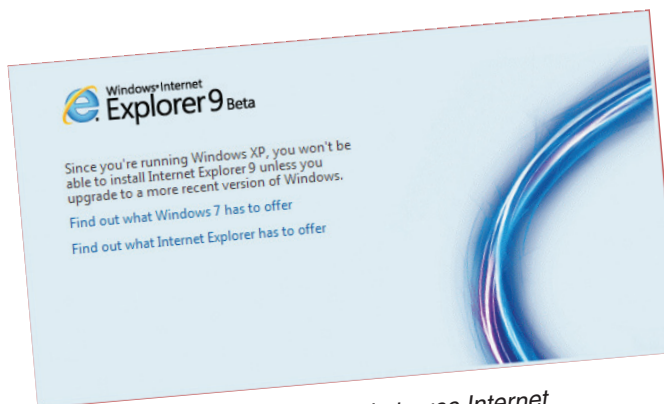
Microsoft's Windows 7 PC Upgrade Advisor compatibility checker can be fetched from <http://tinyurl.com/no4xb7>.

Note that Windows XP users will not be able to upgrade beyond Internet Explorer 8 anyway: to experience IE9 (Beta) you'll need Vista SP2 or Windows 7, see www.beautyoftheweb.com/co.uk where a trial or a 25MB PDF guide can be downloaded.

With constant pressure on us to throw time and money at upgrades, my advice is to 'sweat the assets' and resist the urge to splash out on an upgrade – use what works for you, but keep one eye on that 'total cost of ownership'.

Keeping you on track

Following my episode last month, I mentioned F-Secure Mobile Security, a free download for Windows, Symbian and Android phones from www.f-secure.com which enables a phone to be located, locked or wiped remotely – if the phone's powered up and reachable at the time,



Windows XP users won't be able to use Internet Explorer 9 – you'll need Vista SP2 or Windows 7



Blekko is a new search engine in beta that promises to interpret your search terms more intelligently using 'slashtags'

that is. I have since tested the 'Locate' feature of this software: by texting a secret code to the phone, it will respond with an SMS containing the hyperlink of the locations, viewable in Google Maps.

This worked on one or two occasions, but often as not, an SMS was received unhelpfully stating 'location information is not available'. This may be due to poor GPS coverage or the target phone may be securely locked out, or lying crushed under the wheels of a supermarket shopping trolley. When I did get a successful response though, I pasted the URL into a web browser (eg on another smartphone), and Google Maps did point the finger at the phone's position.

Another useful application is that of tracking the current position of a device on a map. Realtime location mapping was once the stuff of *The Man From Uncle*, but it is now a commercial reality. For consumers, tracking one's journey is readily achievable using a mobile phone with built-in GPS (global positioning system). Android users can try MyTracks from <http://mytracks.appspot.com/> which my colleague Keith Dye (whom regulars will recall was the co-designer of the *EPE Teach-In 1993* Mini and Micro Labs) recently tried with some success on his new HTC Desire.

The BuddyWay

Windows Mobile, Symbian S60, Blackberry and iPhone users can head along to **BuddyWay.com**, a GPS tracking service which is currently free to use. A Palm OS version is also promised. After subscribing and installing the small app. on your phone, GPS data is sent to the BuddyWay server where your journey's itinerary can be viewed privately in your account or published for all to see. Route notes and images can also be added.

I'm still testing it on my Windows Mobile phone, I did struggle initially to install, but it eventually sprang into life. Details of a test trip were successfully uploaded into my BuddyWay account, which I could view online. Buddyway is in Beta, so expect some teething problems, but maybe it's worth experimenting with for fun. Let us know how you get on. Other systems and subscription services, such



BuddyWay for Windows Mobile, Android, Blackberry and iPhone is a free journey tracking app that uses GPS to upload location data for private or public viewing.

as **TraceAMobile.co.uk** use triangulation techniques on the GSM network instead.

Finally this month, news of a new search engine that may be just the ticket for those who tire of trawling through pages of Google hyperlinks. Blekko (<http://blekko.com>) is in beta and it has some promising features that help users to home in on their content. Whereas Google would return myriad links for any term imaginable, Blekko can use 'slashtags' to feed you relevant links having interpreted the slashtag. Take a look at an excellent video is at <http://vimeo.com/14593120> and give it a try.

You can write to the author at alan@epemag.demon.co.uk or share your views with the Editor for possible publication in *Readout*: email editorial@wimborne.co.uk.

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READOUT

Email: editorial@wimborne.co.uk

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

All letters quoted here have previously been replied to directly



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★ LETTER OF THE MONTH ★

On the buffers

Dear Editor

I've been thinking about a train controller design for some time, and it was very interesting to see your new system in October's *EPE*, especially your design choices. For me, the problem with many commercial controllers (and so the impetus to build my own one) lies in the lack of 'feel' of realistic control; the fact that the loco is being controlled as if it is inertialess and its brakes are perfect. Experience with good simulations, or with real locos, quickly shows neither is true, and in my view it's the imperfection – the fact that it's a challenge to control – that makes it interesting.

Consequently, I have been thinking along the lines of three engine control surfaces. – reverser, brake and regulator. I want to include display of acceleration (no throwing passengers off seats!) and brake pressure; plus controls for train power and length, to better simulate the real experience. I wonder if a Mark V might be forthcoming, a design that would do this and also just use back-EMF to linearise the model's motor (and also permit double-heading) and so enable the controller to simulate the loco better, rather than allowing it to stop or go on a whim.

A controller could be built using passive components, but it's much more interesting to do it using a microcontroller, although the PIC in the Mark IV has too few pins to add in the required controls – maybe a 16F883 or 24F16KA102 would do the job?

Finally, in the Mark IV, you've got back-EMF control, which is good for permanent magnet motors, but not so good for the coreless motors that are also commonly used. Would it be possible to auto-detect coreless designs (when using DC) and switch to conventional control?

Ruth Ivimey-Cook, Cambridge, by email

Ruth, thank you for your interesting letter and questions. At present, there are no plans for a Mark V, but the design may well be revisited in a few years. I certainly agree that a microcontroller is the best way to implement any intelligent train controller and would appreciate hearing from you again when you have made progress with your own design.

DAB radio conversion

Dear Editor

John Ellis's letter (*EPE*, Oct 2010) prompts me to make a plea for a DIY project to build DAB 'front-ends' for my many analogue radios.

If such a project is not feasible or viable it would be interesting to have an article saying why not.

Geoffrey Evans, by email

I'm sure it is feasible, but it would be interesting to hear from readers what challenges would need to be overcome. Can you use the same aerial for example?

than incandescent lamps). I may have missed some topics, but I'd like to know the answer.

Enrico Figurelli, by email

Good point Enrico, and I must confess I have not seen figures comparing the scenario you ask about. You are correct in your thinking, because by and large, electronic equipment prefers to be left on. However, this is unrealistic, not to mention wasteful for many systems, so a degree of robustness must be built in to survive regular switching cycles. I would hope and assume that when comparing incandescent and CFL technologies the conditions are assumed to be similar.

number of quite respectable performance capacitor types for less cost than dynamic ones.

Perhaps I'm just getting fussy in old age!

Chris Woods, by email

Nothing wrong with being fussy Chris, it often leads to better designs! In this case though, I think the designer wanted to keep the circuitry and power supply as simple as possible – but I do agree, it would have been a useful improvement to have included phantom power and we will see if a future design can include your suggestion.

Lighting conundrum

Dear Editor

For several years I have been an avid reader of *EPE* (formerly *ETI*) and I like both the construction articles and technology updates.

Some very interesting articles have been published in recent years concerning CFL technology (compact fluorescent lamp, also known as a compact fluorescent light or energy saving light). They are widely used now and it looks like the future of incandescent lamps is limited.

A question that I have not seen addressed about CFL is: are, just like normal fluorescent tubes, the life of these devices shortened with frequent switching on and off – and if so, by how much? If this is the case, then part of CFL's energy saving claims would be offset by the reduced life (even if it is still greater

Phantom power missing

Dear Editor

When I saw the contents for the issue in the October list, I was really looking forward to the design for the balanced microphone adaptor, as it seemed ideally suited for my needs. I was, therefore, disappointed that it does not provide the requirement for professional capacitor microphones of 48V phantom power. This prevents the use of such microphones with older equipment that only have unbalanced inputs.

Also, most budget mixers, if they provide phantom power, switch this globally making some set-ups a bit of a nightmare. If this unit had the facility it could be used for those occasions when perhaps only one or two capacitor microphones would be used in an otherwise dynamic set-up. It is possible to now buy a

EPE artwork

Dear Editor

I'm a fan of *EPE* projects, especially audio projects. I have a simple question. Which application do you use to make the electronic schematics?

César Fuoco, by email

I do like simple questions! The answer is equally simple, we use Adobe Illustrator. This is a general-purpose vector graphics program, so we had to build up our own library of components and develop techniques to produce the images you see. I have used it extensively and can certainly recommend it, although I am sure other cheaper packages would work just as well. Do note that these programs are not CAD – there is no electronic intelligence or simulation capacity built into the images of the circuits or PCBs, they are just 'pictures'.

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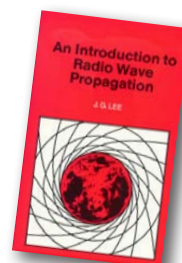
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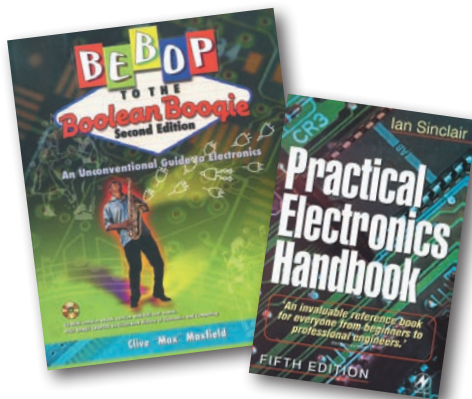
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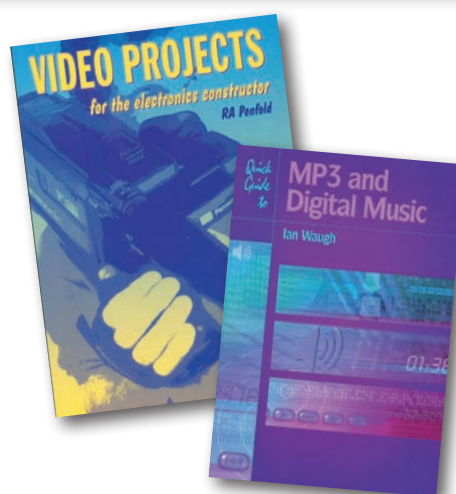
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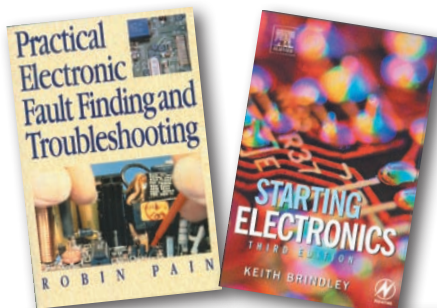
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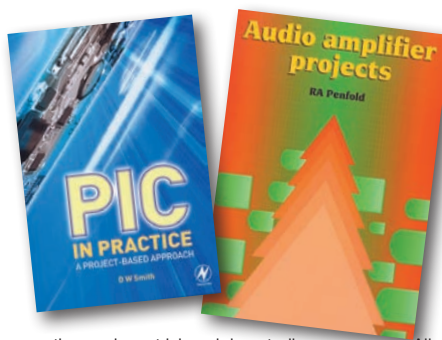
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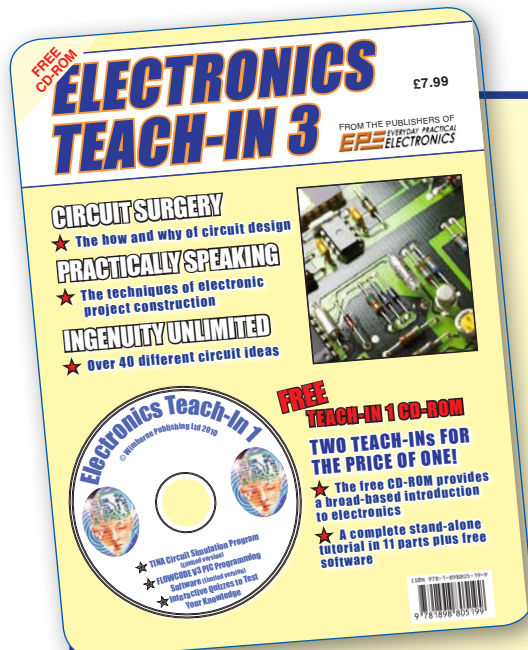
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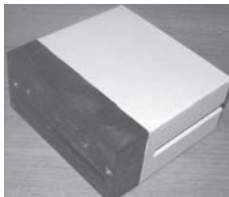
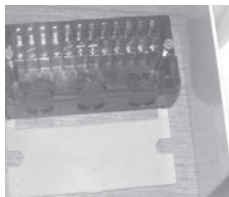
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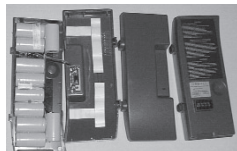
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