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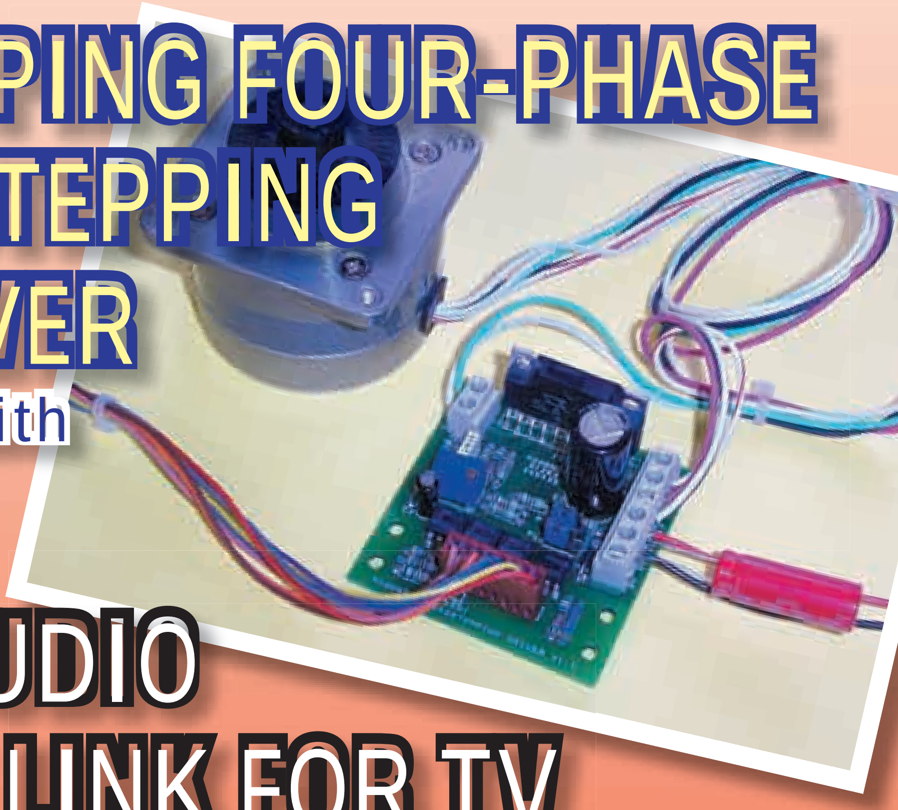

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EVERYDAY PRACTICAL ELECTRONICS

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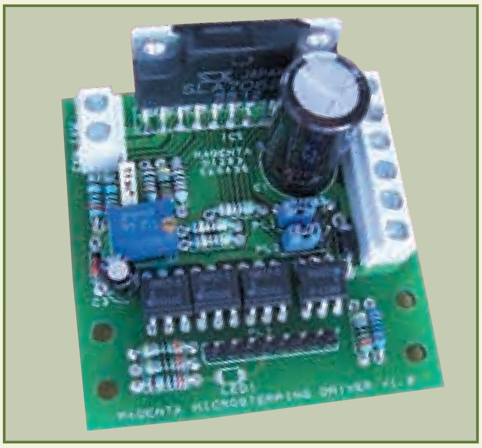
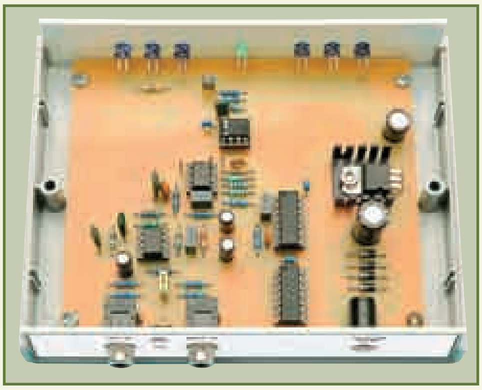
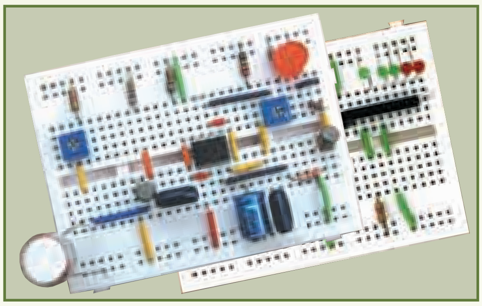






Projects and Circuits

Series and Features

Regulars and Services

Our June 2009 issue will be published on Thursday 14 May 2009, see page 72 for details.

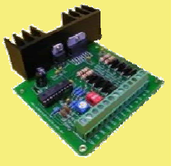
Hot New Products!

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

40 Second Message Recorder

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

Bipolar Stepper Motor Chopper Driver

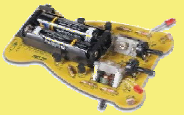


New bipolar chopper driver gives better performance from your stepper motors. It uses a dual full bridge motor driver based on SGS Thompson chips L297 & L298. Motor current for each phase is set using an on-board potentiometer. Can handle motor winding currents of up to 2 Amps per phase. Operates from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

Shaking Dice

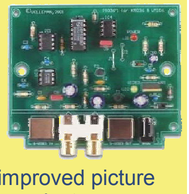
This electronic construction kit is great fun to build and play with. Simply shake and watch it slowly roll to stop on a random number. Great fun project.
Kit Order Code: MK150KT - **£12.95**

Running MicroBug



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

Video Signal Cleaner



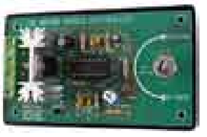
Digitally cleans the video signal and removes unwanted distortion in video signal. In addition it stabilises picture quality and luminance fluctuations.
You will also benefit from improved picture quality on LCD monitors or projectors.
Kit Order Code: K8036KT - **£32.95**
Assembled Order Code: VM106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

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

Motor Speed Controllers

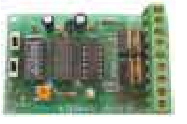
Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

DC Motor Speed Controller (100V/7.5A)



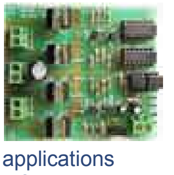
Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£17.95**
Assembled Order Code: AS3067 - **£24.95**

Computer Controlled / Standalone Unipolar Stepper Motor Driver



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

Computer Controlled Bi-Polar Stepper Motor Driver



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

Bidirectional DC Motor Speed Controller

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

AC Motor Speed Controller (700W)

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

See www.quasarelectronics.com for lots more motor controllers

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

Tools & Test Equipment

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

Two-Channel USB Pc Oscilloscope

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

Personal Scope 10MS/s

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

See website for more super deals!

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EVERYDAY PRACTICAL ELECTRONICS
FEATURED KITS

May '09

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

Jaycar Electronics

4 CHANNEL VERSATILE GUITAR MIXER KIT

KC-5448 £28.75 plus postage & packing

This is an improved version of our popular guitar mixer kit and has a number of enhancements that make it even more versatile. The input sensitivity of each of the four channels is adjustable from a few millivolts to over 1V., so you plug in a range of input signals from a microphone to a line level signal from an CD player etc. A headphone amplifier circuit is included for monitoring purposes. A three stage EQ makes this a very versatile mixer that will operate from 12VDC, 45mA.

- Kit includes case, PCB with overlay and all electronic components

* As published in EPE Magazine April 2009

RADAR SPEED GUN MKII KIT

KC-5441 £29.00 plus postage & packing

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

- Kit includes PCB and all specified electronic components

* As published in EPE Magazine January 2009

AUDIO VIDEO BOOSTER KIT

KC-5350 £31.95 plus postage & packing

When running AV cables for your home theatre system, you may experience some signal loss over longer runs. This kit will boost your video and audio signals preserving them for the highest quality transmission to your projector or large screen TV. It boosts composite, S-Video, and stereo audio signals. Kit includes case, PCB, silk screened & punched panels and all electronic components.

- 9VAC @ 150mA required - Maplin GU09K £9.99

* As published in EPE Magazine March 2006

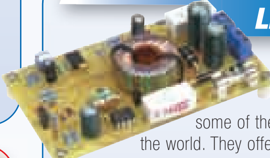
STUDIO 350 HIGH POWER AMPLIFIER KIT

KC-5372 £50.75 plus postage & packing

The Studio 350 power amplifier will deliver a whopping 350WRMS into 4 ohms, or 200WRMS into 8 ohms. Using eight 250V 200W plastic power transistors, it is super quiet, with a signal to noise ratio of -125dB(A) at full 8 ohm power. Harmonic distortion is just 0.002% & frequency response is almost flat (less than -1dB) between 15Hz & 60kHz! Kit supplied in short form with PCB & electronic components. Kit requires heat sink & +/- 70V power supply (a suitable supply is described in the instructions).

* As published in EPE Magazine November 2006

LUXEON STAR LED DRIVER KIT



KC-5389 £8.75 plus postage & packing

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

* As published in EPE Magazine April 2007

3V TO 9V DC TO DC CONVERTER KIT

KC-5391 £4.75 + postage & packing

Allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, this kit will pay for itself in no time. You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell.

- Kit supplied with PCB & all electronic components

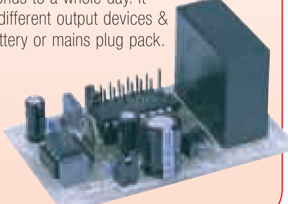
* As published in EPE Magazine June 2007

THE FLEXITIMER KIT

KA-1732 £6.00 plus postage & packing

This kit uses a handful of components to accurately time intervals from a few seconds to a whole day. It can switch a number of different output devices & can be powered by a battery or mains plug pack.

- The kit includes PCB & all components



* As published in EPE Magazine September 2007

SUPER BRIGHT 1 WATT LED STAR MODULES

ZD-0508 £3.75 ea plus postage & packing

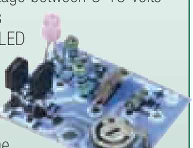
These LEDs are just as bright as the leading brand but cost a whole lot less. They are increasingly finding their way into general and architectural lighting applications and with a service life of 100,000 hours, will virtually never need replacing. They provide up to 25 lumens per watt and are available in a number of colours.

ZD-0500 - Red
ZD-0502 - Amber
ZD-0504 - Green
ZD-0506 - Blue
ZD-0510 - Warm White

LOW VOLTAGE BATTERY WARNING KIT

KG-9000 £3.00 + postage & packing

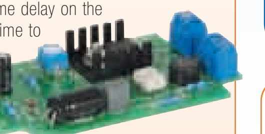
This circuit monitors any battery voltage between 3-15 volts once set. Whenever the voltage falls below a predetermined value a red LED lamp lights up. It does not, however, automatically disconnect the battery. Uses a tiny amount of power from the battery being monitored. Could save you embarrassment or a fortune by avoiding battery damage.



COURTESY INTERIOR LIGHT DELAY KIT

KC-5392 £6.00 plus postage & packing

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



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

* As published in EPE Magazine Feb 2007

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SCI-FI KITS FOR ELECTRONIC ENTHUSIASTS

GALACTIC VOICE KIT

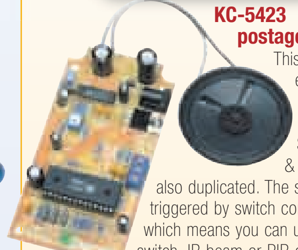
KC-5431 £13.50 plus postage & packing

Effect and depth controls allow you to vary the voice to simulate everything from C-3PO to the hysterical ranting of Daleks. The kit includes PCB with overlay, enclosure, speaker and all components.

* As published in EPE Magazine August 2008

STARSHIP ENTERPRISE DOOR SOUND EMULATOR KIT

KC-5423 £11.75 plus postage & packing



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

- Requires 9-12VDC power

* As published in EPE Magazine June 2008

CLOCK WATCHERS CLOCK KIT WITH BLUE LEDS

KC-5416 £55.00 + post & packing

This facinating unit consists of an AVR driven clock circuit, and produces a dazzling display with 60 blue LEDs around the perimeter. It looks amazing, and can be seen in action on our website. Kit supplied with double sided silk screened plated through hole PCB and all board components as well as the special clock housing. Red display also available KC-5404 £37.50

JACOB'S LADDER HIGH VOLTAGE DISPLAY KIT MKII

KC-5445 £12.50 plus postage & packing

With this kit and the purchase of a 12V ignition coil (available from auto stores and parts recyclers), create an awesome rising ladder of noisy sparks that emits the distinct smell of ozone. This improved circuit is suited to modern high power ignition coils and will deliver a spectacular visual display. Inspired by the good doctor's laboratory in the Frankenstein movie, use this kit for theatre special effects or just to impress your friends. Kit includes PCB with overlay, pre-cut wire/ladder and all electronic components.

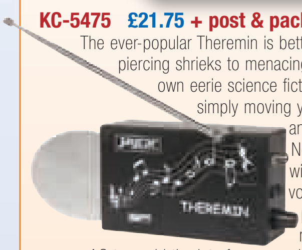
- 12V automotive ignition coil and case not included
- 12V car battery, 7Ah SLA or >5Amp DC power supply required and not included

Warning: The Jacobs Ladder Kit uses potentially dangerous voltage.

THEREMIN SYNTHESISER KIT MKII

KC-5475 £21.75 + post & packing

The ever-popular Theremin is better than ever! From piercing shrieks to menacing growls, create your own eerie science fiction sound effects by simply moving your hand near the antenna.



Now easier to set up with extra test points for volume adjustment and power supply measurement, it also runs on AC to avoid the interference switchmode plugpacks can cause. It's also easier to build with PCB-mounted switches and pots to reduce wiring to just the hand plate, speaker and antenna and has the addition of a skew control to vary the audio tone from distorted to clean.

NEON TUBE SOUND DISPLAY KIT

KC-5322 £6.00 plus postage & packing

Following the tremendous success of the original 1997 Sound Mod kit, this latest version overcomes some of the original's limitations. With this latest kit you can now use any output from your car stereo - it is not limited to being exclusively driven by a subwoofer output, unlike its predecessor. This kit drives any colour neon tube in the Jaycar range (see website) and has the option of turning the tube either on or off to the beat of the music. Kit supplied with PCB plus all specified electronic components.

- Requires 12VDC

KIT CONSTRUCTORS MANUAL

BI-8200 £0.55 plus postage & packing

A must for amateur constructors. Contains much useful information for the more experienced. Huge amounts of information on construction and identification of parts.

- 8 pages

FLICKERING FLAME LIGHTING KIT

KC-5234 £5.00 plus postage & packing

Theatrical productions often call for flaming torches and similar real flame lighting effects. The problem is that for obvious safety reasons, most theatres and halls have strict rules regarding the use of naked flames. Enter The Flickering Flame kit. This lighting effect uses a single 20W halogen lamp (the same as those used for domestic down lights) to mimic its' namesake. Mounted on a compact PCB, it operates from 12V DC and uses just a handful of readily available components.

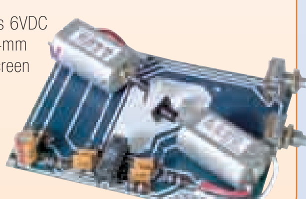
- Kit includes 20W halogen lamp, ceramic base socket, PCB with overlay plus electronic components

LASER LIGHT SHOW KIT

KG-9098 £11.75 plus postage & packing

Generate a dazzling laser display using our new laser module Cat. ST-3115 and ST-3117. Using two speed adjustable motors that are fitted with mirrors, patterns similar to a spirograph toy can be projected onto a wall. Great for parties!

- Operating voltage is 6VDC
- PCB size 100 x 74mm
- Kit supplied with screen printed gold-plated PCB, 2 motors and mirrors plus all electronic components
- Laser not included



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VOL. 38 No. 5 MAY 2009

Batteries – the unsung heroes of electronics

Power supplies always seem to be an afterthought. What would you rather do, design and build a state-of-the-art amplifier, or the power supply for that circuit? And yet, without the 'right kind' of electrons on tap, our whole hobby would grind to a halt. Bottom of the pile of uninteresting power supplies must be the battery, a humble device, which we seldom give much thought to. I'm as guilty as the next man when it comes to taking them for granted, but even a brief glance at recent advances shows that there is some fascinating and important work in the world of batteries.

This work is being driven by two very different markets – consumer electronics and electric vehicle manufacturers. Let's take a brief peek at the former. Not long ago, if you wanted portable communications via radio then you needed something the size of a large rucksack, as shown in many a Second World War film. Nowadays, mobile phones are so small we often lose them. While it's true that mobiles are a fine representative of the low-power designer's art, they are also a stunning example of the improvements in the energy density of batteries, typically lithium ion batteries.

However, battery designers are not resting on their laurels. Two important trends are starting to make real differences to the quality of batteries. First, it's worth remembering that many 'batteries', especially in computers, are actually an array of cells. Each cell is slightly different and these differences reduce the overall effectiveness of the whole battery. Now though, designers are making batteries 'smart' – each cell is monitored and its charge/discharge cycle is individually tweaked to get the best performance.

Even more revolutionary is a new lithium technology recently reported in the journal Nature, which promises full charging in a few minutes or even seconds. Perhaps now, it's time to give credit where it's due and acknowledge the worth of the humble battery.

Matt

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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.

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NEWS

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

Two-meg broadband

The UK government wants everyone to have two-meg broadband by 2012. A new two-way broadband-by-satellite service from Astra and UK company Eurosat should help achieve this. Barry Fox reports.

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

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

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

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

No software is installed on the PC. The receiver/modem connects to the PC by Ethernet cable and is accessed by a web browser in the same way as a DSL modem.

This avoids the problems Astra encountered five years ago with a one-way service that used a dial-up phone line as the return link to control satellite downloading, and required complex control software on the PC.

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

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

Velleman Scope and Function Generator

ESR Electronic Components have introduced the new Velleman PCSGU250 Oscilloscope and Function Generator. It offers many features, such as a two-channel scope, spectrum analyser, data recorder, function generator and bode plotter.

With the function generator you can create your own waveforms using the integrated signal wave editor. For automated measurements, it is even possible to generate wave sequences, using file or computer RS232 input.

Oscilloscope bandwidth is DC to 12MHz with maximum input voltage of 30V (AC and DC), sensitivity 0.3mV, range from 10mV to 3V/division. Input coupling: DC, AC and Ground. Function generator frequency 0.005Hz to 500kHz. PCSGU250 derives its power supply from the computer USB port.

The Velleman PCSGU250 is supplied with a comprehensive manual and CD ROM, with PcLab200-LT software. It includes Oscilloscope probe, USB connection lead and BNC to RCA adaptor.

For more details browse, ***www.esr.co.uk/velleman/pcsgu250****.*

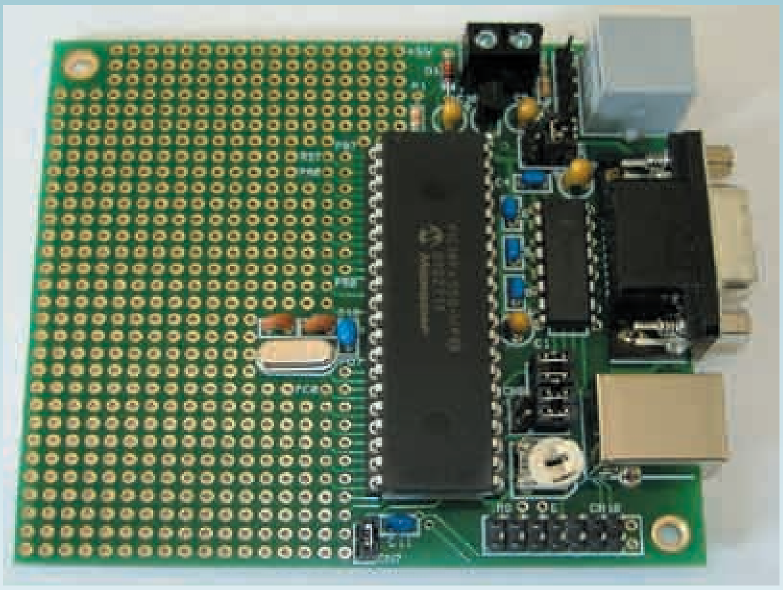
PIC prototyping board

CS Technology Ltd have just released a PIC prototyping board in kit form for 40- pin PIC microcontrollers, including the 18F4550 USB version.

The board includes a large prototyping area, RS232 and USB connectivity, a five-pin programming header and Microchip ICD2 compatible connector, together with selectable on-board 5V regulator and an LCD display connector.

This new kit adds to their range of 18- and 28-pin PIC prototyping kits, CTCSS and DTMF kits.

The complete kit of parts, including PCB, costs just £14.99. Further details can be obtained from their website: ***www.cstech.co.uk***



SchmartBoard's regulated power modules

SchmartBoard has announced the release of six single voltage regulated power SchmartModules, which are designed to offer a quick, easy and inexpensive option for users to power up their circuits. The purpose of SchmartBoard's prototyping system is to allow users to easily hand solder components onto SchmartBoards using 'ez' technology, which makes soldering any surface mount component easy.

"SchmartBoard is similar in approach to software development, but for electronic circuit prototyping," says Neal Greenberg, SchmartBoards VP of sales and marketing.

"In software, one may design the core code and add popular software blocks around it rather than rewriting code that already exists. These SchmartModules are the equivalent of software blocks that an engineer would source and glue to his code. We now have power and I/O SchmartModules and will be adding many more modules over the coming months."

The Regulated Power Modules come in 1.5V, 1.8V, 2.5V, 3.3V, 5V and 9V. The suggested retail price for each is $20.

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

No Doom and Gloom!

Forget the 'doom and gloom', say Light Tape Ltd, commenting that their product also called Light Tape, could reduce $C0_2$ *output by 100s of 1000s of tons every year, save millions of pounds worth of electricity, and that it is also less expensive to buy, install and maintain than traditional display lighting.*

Light Tape is said to use less than one tenth of the power and is half the price of Neon and Cold Cathode display lighting. It is flexible, reduces light pollution, produces no waste heat or infrared light, is fully recyclable, and uses no gas, glass or mercury. It is easy to install, requiring virtually no maintenance compared to alternative lighting technologies.

It is also claimed to be the longest and brightest electroluminescent lamp in the world and can be supplied in a range of colours and widths, in lengths up to 300ft. Driven by specially devised power supplies, it can be used in flashing or steady state modes in indoor or outdoor applications. It is made up of metal ribbon coated in Sylvania phosphor and encapsulated in a Honeywell laminate.

The company's web site at ***www.lighttape.co.uk*** *includes picture, animation and video galleries, plus applications.*

Microchip's PIC18F87J90 Family

Microchip has announced the PIC18F87J90 8-bit direct LCD-drive microcontroller with nanoWatt Technology, the first 8-bit MCU to include Real-Time Clock and Calendar and Charge Time Measurement Unit peripherals, enabling capacitive touch-sensitive appli-cations or precise time measurement.

The PIC18F87J90 offers 64- to 128kbyte of Flash and 4kbyte of RAM and is pin-compatible with PIC18F85J90 devices, providing an easy migration path across Microchip's entire LCD-drive MCU family, simplifying application upgrades.

The on-board LCD module contains a software-controlled contrast controller, providing display boost or dimming to compensate for environmental variations, such as lighting or temperature. Microchip's unique nanoWatt Technology helps systems maintain a low power profile, even allowing the display driver to continue operating during sleep mode.

The RTCC also operates in sleep mode, ensuring real-time tracking isn't impeded by low-power operation. With this peripheral set, engineers can quickly and easily add user interface features such as capacitive or inductive touch-sensing to their display applications.

To start designing with the PIC18F87J90 family, customers can use the PICDEM LCD 2 Demo Board (part no. DM163030 – $125) in combination with the PIC18F87J90 Plug-in Module (part no. MA1 80025 – $25), which includes capacitive-touch buttons. Both are available from, **www.microchipdirect.com**.

The PIC18F87J90 family is supported by Microchip's standard development tool suite, including the free MPLAB Integrated Development Environment, MPLAB C Compiler for PIC18 and the MPLAB ICD 3 in-circuit debugger (part no. DV164035). The MPLAB IDE now comes with the free Segmented Display GUI, making it easier to generate the code needed to drive LCD displays.

For further information, visit **www.microchip.com/LCD**.

Parallax Propeller new supplier

Spinvent tell us that they have become a new UK supplier of the Propeller microcontroller from Parallax, stocking a wide and growing selection of Propeller chips, kits and accessories.

The Propeller microcontroller has free programming tools and ready-made software objects for monitors, keyboard, mice, serial comms, displays, sensors and more. The Propeller represents many years of research and development; here's what Parallax have to say about it:

"The Propeller chip makes it easy to rapidly develop embedded applications. Its eight processors (cogs) can operate simultaneously, either independently or cooperatively, sharing common resources through a central hub. The developer has full control over how and when each cog is employed; there is no compiler-driven or operating system-driven splitting of tasks among multiple cogs. A shared system clock keeps each cog on the same time reference, allowing for true deterministic timing and synchronization. Two programming languages are available: the easy-to-learn high-level Spin, and Propeller Assembly which can execute at up to 160Mips (20Mips per cog).

"Due to its diversity, the Propeller Chip may be used for many types of applications. Most users appreciate the overall processing power and I/O capabilities. Hobbyists like the powerful yet easy language, while robot builders and process control engineers appreciate the parallel processing capabilities. Many find the on-board video generation and easy connection to popular PC peripherals reduces the need for additional support components."

More information and further links on the Parallax web-site: **www.parallax.com**. Spinvent's site is at **www.Spinvent.co.uk**

Infrared audio headphone link for TV

By JIM ROWE

Do you have trouble understanding what's being said on the TV? Do you need the volume cranked up too loud for everyone else? Do you have a hearing aid as well? If you said yes to any other these questions, here is your answer: an infrared transmitter and receiver to let you listen to the TV sound via headphones. That way, you can listen as loudly as you like, without disturbing anyone else.

IT HAPPENS all the time. One of the older members of the household is getting a bit deaf and needs the TV sound turned well up. But then it is too loud for everyone else. It's worse at night when people go to bed, but one family member wants to watch the late-night movie – or whatever.

The problem can be even worse if you have a hearing aid because it also tends to pick up extraneous noises – coughs, heater fans, a radio in another room, toilets flushing, planes flying overhead, cars and trucks passing in the street and people washing up the dishes, to list just a few irritations.

The real answer is to listen via headphones – preferably good 'surround your ears' muff-type headphones, which not only deliver the wanted sounds directly to your ears and hearing aid(s) but also cut back the competing sounds at the same time. If you pick the right kind of headphones, with some acoustic damping in the earmuffs, they don't cause your hearing aid(s) to emit feedback and whistle sounds either.

The result is comfortable listening at a volume level that's right for you, where you can hear and understand everything that's being said.

Headphone jack

Some TV sets do have earphone jacks, so you could simply fit a pair of stereo headphones with their own volume control (if necessary), plus a long cord and plug to mate with the jack on the TV. But many sets do not have a headphone jack, and many that do have it wired so that when

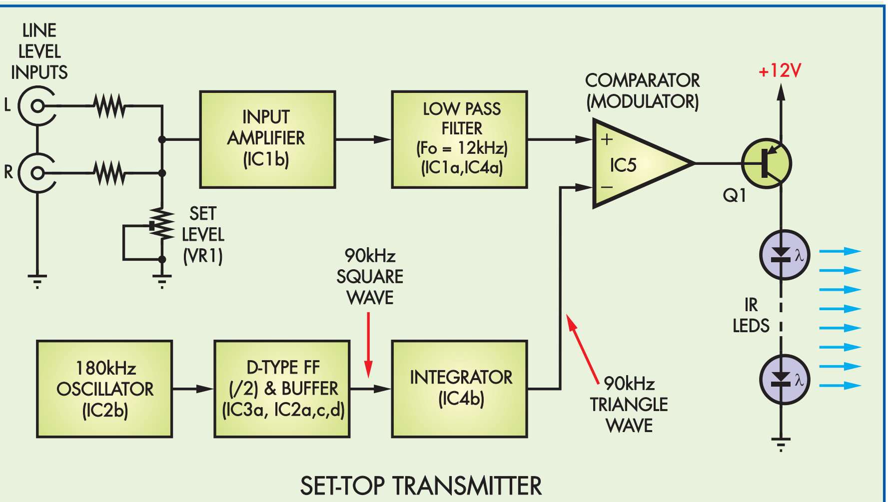


Fig.1(a): how the transmitter works. The left and right channel audio signals are converted to mono, amplified and fed to comparator stage IC5 where they are compared to a 90kHz triangle wave (the sampling signal). The resulting PWM signal then drives transistor Q1 to pulse a string of infrared (IR) LEDs.

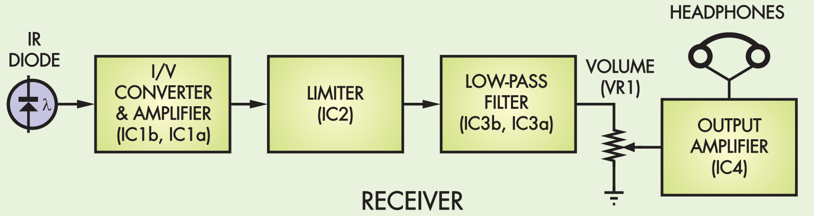


Fig.1(b): at the receiver, the transmitted signal is picked up by an IR diode and the resulting current pulses converted to voltage pulses (and amplified) by IC1b and IC1a. This amplified pulse waveform is then fed through a limiter and filtered to recover the audio waveform. This is then fed via volume control VR1 to an audio output amplifier (IC4).

headphones are plugged in, the speakers are disabled.

That's fine for you, but no good for everyone else. In any case, being hooked up to the TV via a long cable has its own problems: you can forget to take 'em off when you get up for a comfort break or someone else can trip on the cable when they move about the room.

Cordless headphones

A much better solution is to use 'cordless' headphones, either via a UHF or infrared link. This means that you have a transmitter or sender unit that sits on the top of the TV, plus a small battery-operated receiver to drive the headphones at your end.

Of course, IR-linked cordless headphones are available commercially and these can give you some improvement. But there are drawbacks, the main one being that the receiver unit is built into the actual earphones and/or their headband, so it can't be used with any other headphones. That means you're stuck with the ones you get and in most cases, they are not the 'surround-your-ears' muff type. Nor do they have any acoustic damping.

As a result, you not only have to throttle back your hearing aid to stop it from whistling, but also the headphones allow quite a lot of competing sounds to enter as well.

So that's the reasoning behind the development of this project – by building it, you get to choose the best type of headphones. However, there is one more feature – it works in mono only. This has been done deliberately because stereo sound is a real drawback to those who have trouble making out speech from the TV.

This applies particularly to those films, documentaries and sportscasts where there is a lot of background music or other sounds. By using a mix of the left and right channels, we cancel most of these extraneous sounds, making the speech much easier to discern. In addition, we have applied a small amount of treble boost to the audio signal, which further improves intelligibility on speech – see Fig.6.

There's one more bonus with using mono sound – it also simplifies the circuit considerably.

How it works

The method of transmission is simple and effective. Basically, the signal is transmitted using pulse-width modulation (or PWM). This converts the audio signal directly into a pulse stream of constant frequency, but with the pulse width varying with the instantaneous amplitude of the audio signal.

Fig.1(a) shows the method. First, the left and right stereo signals are mixed together to give a mono signal. This signal is then passed through an input amplifier stage (IC1b) and then

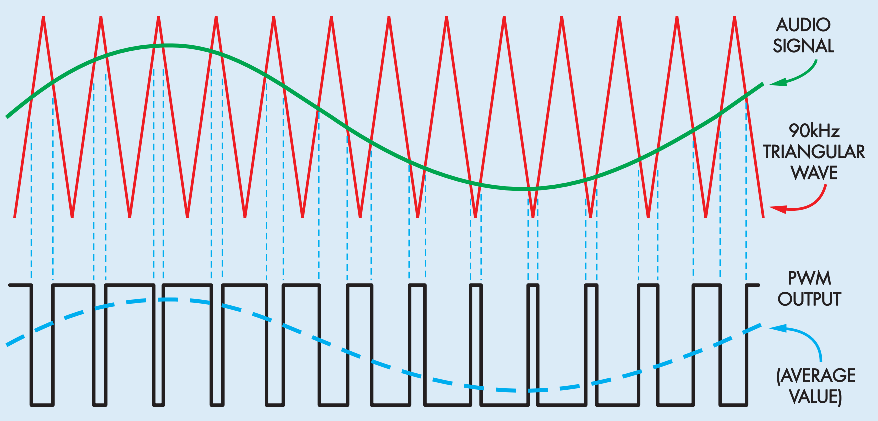


Fig.2: this diagram illustrates how the audio signal that's fed into the transmitter is compared to a 90kHz triangular waveform (the sampling signal) to produce the pulse width modulated (PWM signal). As shown, the PWM output is high when the audio signal level is higher than the sampling signal.

via a four-pole low-pass filter (IC1a and IC4a), which sharply rolls off the response just above 12kHz.

This is done for two reasons. First, if you are partially deaf, signals above 12kHz are not much use anyway. Second, it prevents any spurious 'alias' signals from being generated during the digital modulation process – which is equivalent to digital sampling. We are using a fairly high sampling frequency of about 90kHz which tends to reduce aliasing, but the low-pass filtering is also worthwhile, because it ensures that virtually no signal frequencies above 15kHz are fed to the modulator.

Sampling signal

Next, the audio is fed directly to the non-inverting input of a comparator (IC5) where it is compared with a 90kHz triangular wave 'sampling' signal on the inverting input. This 90kHz triangular wave signal is generated by feeding a 180kHz clock signal into a D-type flip-flop.

This then produces a very symmetrical square-wave signal at half the clock frequency, or 90kHz. This 90kHz signal is buffered and fed through an active integrator stage, which converts it into a linear and very symmetrical triangular wave.

But how does the comparator use this 90kHz triangular wave to convert the audio signal into a PWM stream? To see how this works, take a look at the waveforms of Fig.2. Here the green sinewave represents the audio signal fed to the positive input of the comparator, while the higher frequency red triangular wave shows the sampling signal fed to the comparator's negative input.

In operation, the comparator's output is high when the audio signal level is higher than the 90kHz sampling signal. Conversely, the comparator's output is low when the sampling signal's level is the higher of the two. A switching transition occurs when ever the two waveforms cross.

The resulting PWM output waveform from the comparator is shown as the lower black waveform.

Note that the comparator output is a stream of 90kHz pulses, with the pulse widths varying in direct proportion to the audio signal amplitude. The average value of the pulse stream is directly proportional to the instantaneous value of the incoming audio, as shown by the dark blue dashed curve.

Referring back to Fig.1, this PWM pulse stream is fed to a *PNP* switching transistor, which drives a string of IR-emitting LEDs. As a result, the digitised audio is converted into a stream of IR light pulses, directed towards the receiver unit.

Receiver block diagram

The receiver is even simpler than the transmitter because of the fact that the average value of the PWM pulse stream varies in direct proportion to the audio modulation.

As shown in Fig.1(b), a silicon PIN photodiode is used to detect the IR pulse stream from the transmitter. Its output current is then passed through a current-to-voltage (I/V) converter and amplifier stage (IC1b and IC1a) to boost its level. The resulting pulse waveform is then fed through a limiter stage (IC2) to produce a stream of clean, rectangular pulses of constant amplitude.

Next, the pulses are fed through a multi-stage low-pass filter (IC3b and IC3a) to remove all traces of the 90kHz sampling/modulating signal. This simply leaves the audio signal which was carried in the average signal level of the pulses.

From there, the recovered audio passes to a volume control pot and finally to a small audio amplifier (IC4) to drive the headphones.

Power for the receiver circuit comes from four AA cells, which can be of either alkaline or NiMH rechargeables.

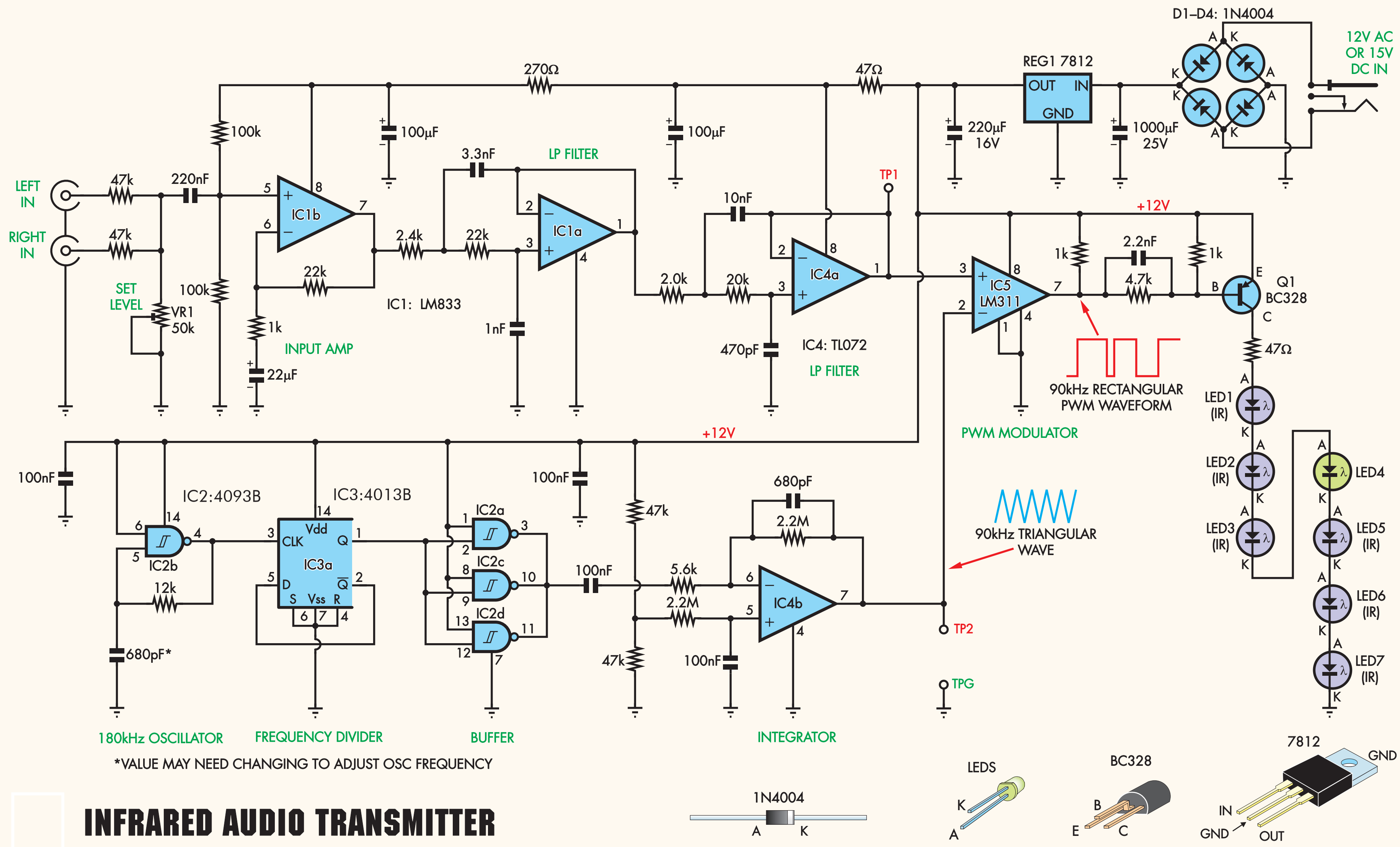
Circuit description

Refer now to the full circuit for the transmitter – see Fig.3. As shown, the incoming line level stereo signals are mixed together using two 47kΩ resistors, while trimpot VR1 sets the level. The resulting mono signal is then fed to op amp stage IC1b, which operates with a gain of 23, as set by the 22kΩ and 1kΩ feedback resistors.

Next, the signal is passed through op amps IC1a and IC4a, which form a 4-pole low-pass filter (or two 2-pole active filters in cascade, to be more precise). Together, these roll off the response above 12kHz. The filtered signal then emerges from pin 1 of IC4a and is fed directly to the non-inverting input of comparator IC5.

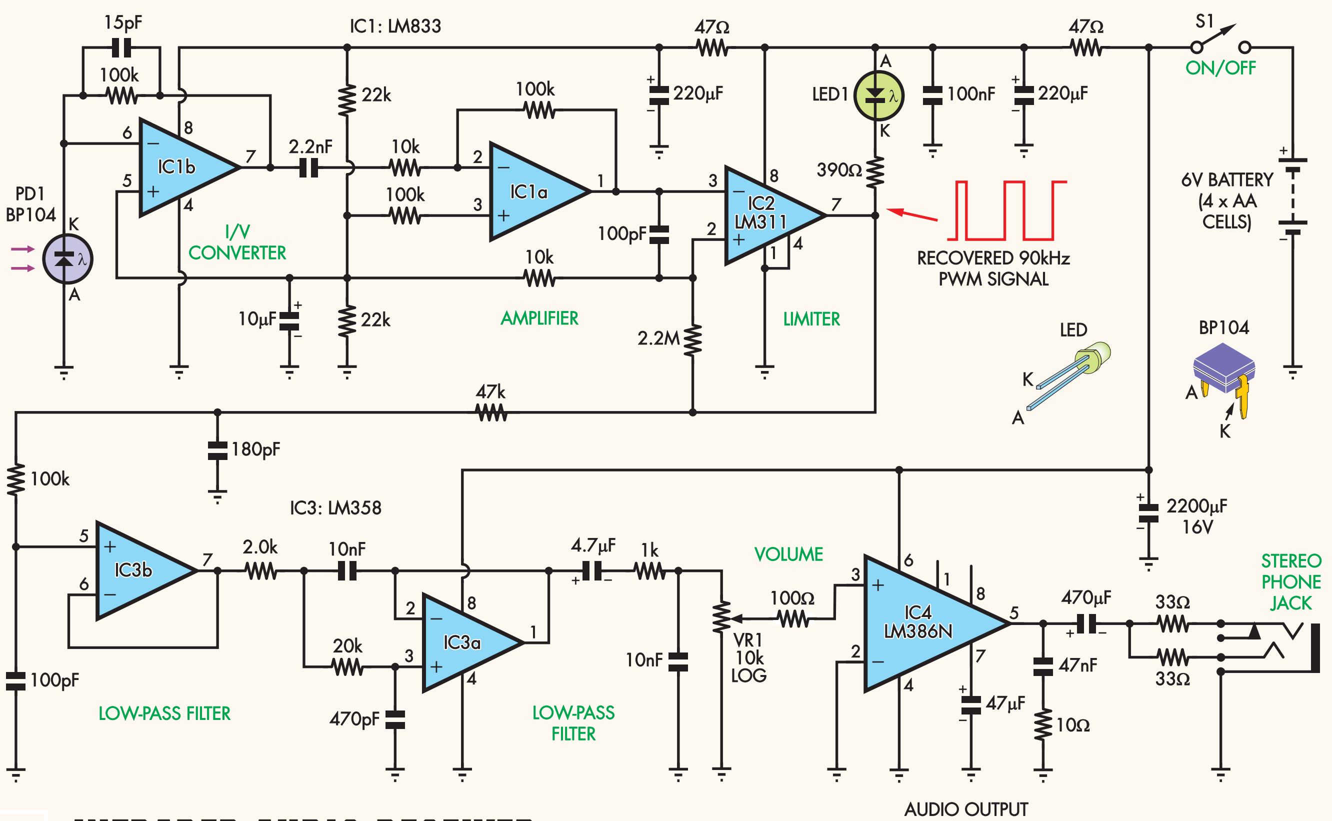
The 180kHz 'twice sampling clock' signal is generated by IC2b, a 4093B CMOS Schmitt NAND gate wired as a simple relaxation oscillator. A 12kΩ resistor and 680pF capacitor set the operating frequency. This is not particularly critical, although for best performance it should be between 160kHz and 200kHz (corresponding to a sample frequency of 80 to 100kHz).

Flipflop stage IC3a is used to divide the clock pulses by two and generate the symmetrical 90kHz square wave. Its output at pin 1 is then passed through Schmitt NAND gates IC2a, IC2c and IC2d which are connected in parallel as a buffer. The buffer output is then coupled via a 100nF capacitor to op amp IC4b.



INFRARED AUDIO TRANSMITTER

Fig.3: the circuit for the transmitter. The incoming stereo audio signals are first mixed together to form a mono signal, which is then amplified by IC1b. IC1a and IC4a then filter this signal and drive pin 3 of comparator stage IC5. IC2b is the 180kHz clock. Its output is divided by two using IC3a, buffered by IC2a, IC2c and IC2d and fed to integrator stage IC4b to produce the 90kHz triangular waveform. This waveform is then fed to the other input of IC5 and compared with the audio waveform. The resulting PWM waveform from IC5 then drives transistor Q1, which in turn pulses a string of six infrared LEDs, plus a power indicator LED.



INFRARED AUDIO RECEIVER

Fig.4: the receiver circuit. Photodiode PD1 picks up the incoming PWM IR signal and IC1b converts the resulting current pulses to voltage pulses. IC1a then amplifies these voltage pulses, while IC2 is the limiter. The resulting PWM signal from the limiter is then fed to low-pass filter stages IC3b and IC3a and finally to audio amplifier stage IC4.

IC4b is configured as an active integrator to convert the 90kHz square-wave into a linear symmetrical triangular waveform of the same frequency. This triangular wave is then fed directly to the inverting input of comparator IC5, to sample and convert the audio signal into the PWM pulse stream.

IC5's PWM output appears at pin 7 and is used to drive transistor Q1 (BC328). This in turn drives series-connected infrared LEDs (LEDs 1 to 3 and LEDs 5 to 7), along with LED4 (green) which serves as a 'power on' indicator. The 47Ω resistor in series with the LED string limits the peak pulse current to around 45mA, resulting in an average current drain for the complete transmitter circuit of about 25mA.

Transmitter power supply

Power for the transmitter circuit is derived from a 12V AC or 15V DC plugpack. This feeds diode bridge D1 to D4, which rectifies the output from an AC plugpack. Alternatively, the bridge rectifier allows a DC plugpack to be used with either polarity.

The output from the bridge rectifier is filtered using a 1000µF capacitor and then fed to 3-terminal voltage regulator REG1 to produce a 12V DC supply rail.

Receiver circuit

OK, so much for the transmitter circuit. Now let's take a look at the receiver circuit – see Fig.4.

In operation, the transmitted PWM infrared signal is picked up by PIN photodiode PD1 (BP104). This device produces output current pulses in response to the incoming IR signals and these are then fed to the inverting input (pin 6) of op amp IC1b. The non-inverting input (pin 5) of IC1b is biased to half-supply (ie, 3V) by two 22kΩ resistors connected in series across the 6V supply rail.

IC1b operates as an active I/V (current-to-voltage) converter. In operation, it converts the input current pulses to voltage pulses, which appear at its pin 7 output. These pulses are then coupled via a 2.2nF capacitor to op amp stage IC1a, which operates with a gain of –10. The resulting amplified output pulses appear at pin 1 and are fed directly to pin 3 of IC2.

IC2 is an LM311 comparator and is used here as the limiter. Note that its non-inverting input (pin 2) is biased to half the supply voltage using the same voltage divider (2 × 22kΩ resistors) that's used to bias IC1a and IC1b. This ensures that the pulses from IC1a are compared with a voltage level corresponding to their own average DC level. And that in turn ensures that the limiter 'squares up' the pulse stream in a symmetrical fashion.

In addition, the 2.2MΩ feedback resistor and the 10kΩ resistor in series with the bias for IC2 together provide a small amount of positive feedback hysteresis, to ensure clean switching.

Because the LM311's output (pin 7) is an open collector, it must be provided with a resistive pull-up load. This is provided by power-on indicator LED1, together with its 390Ω series resistor.

The restored PWM pulse stream appears at pin 7 of IC2 and is then fed through the receiver's low-pass filter circuitry. This comprises passive 47kΩ/180pF and 100kΩ/100pF RC filter stages, voltage follower IC3b, active low-pass filter stage IC3a and finally, a 4.7µF coupling capacitor and a 1kΩ/10nF passive filter connecting to the top of volume control VR1.

As a result, the signal appearing across VR1 is a very clean replica of the original audio signal fed into the transmitter unit.

IC4 is the audio amplifier output stage and is based on an LM386N. It amplifies the signal from the volume control (VR1) and drives a stereo phone jack via a pair of 33Ω current limiting resistors (one to the tip and one to the ring).

Finally, the receiver is powered from a 6V battery consisting of four AA cells connected in series. These cells can be either standard alkaline primary cells or rechargeable NiMH (or NiCad) cells if you prefer. The average current drain is typically around 20mA, so even ordinary alkaline cells should give at least 80 to 100 hours of listening.

Construction

Building the Infrared Audio Link is straightforward, with all the parts mounted on two PC boards – one for the Transmitter (code 708) and one for the Receiver (code 709). The two boards are available as a set from the *EPE PCB Service*.

The transmitter board fits inside a standard low-profile ABS instrument box measuring 140 × 110 × 35mm, while the receiver board goes inside a standard UB3-size box (130 × 68 × 44mm), along with its 4×AA cell battery pack.

Fig.7 shows the assembly details for the transmitter unit. Begin by installing the resistors and diodes D1 to D4, taking care to ensure that the latter are all correctly oriented. An accompanying table shows the resistor colour codes, but you should also check each resistor using a digital multimeter before installing it, just to make sure.

Next, install the small ceramic and monolithic capacitors, then install trimpot VR1, transistor Q1 and the electrolytic capacitors. Make sure that the electrolytics and transistors all go in the right way around.

Follow these parts with the five ICs. Be sure to use the correct IC type at each location and again check that they are all oriented correctly. IC sockets were used on the prototype, but we suggest that you solder the ICs directly to the PC board.

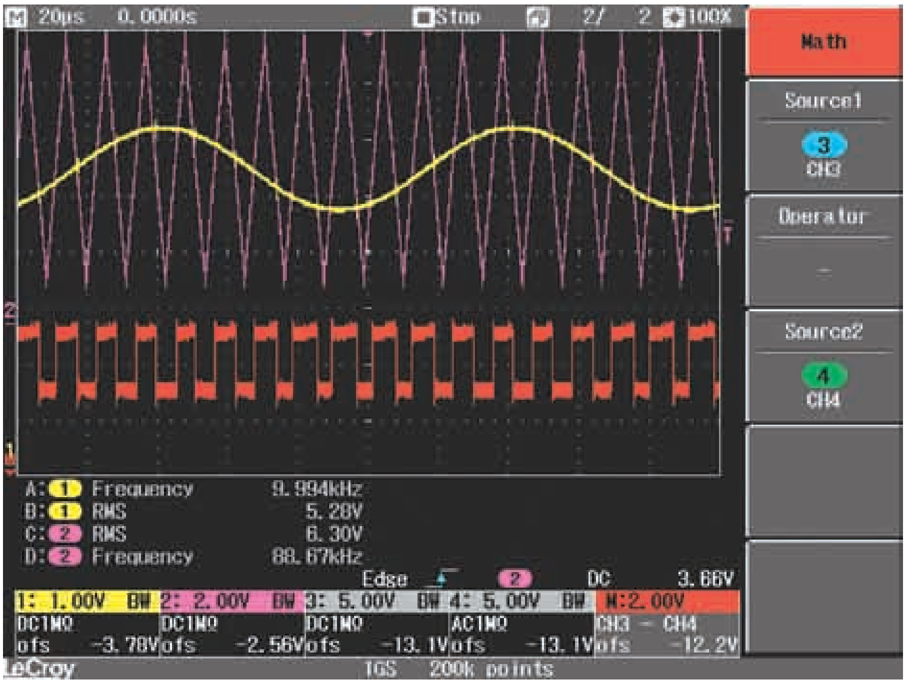


Fig.5: this screen grab (taken on a LeCroy WaveJet 324 oscilloscope) shows three waveforms. The purple trace at top is the 90kHz 'sampling' triangular waveform (the carrier frequency), as measured at TP2. The yellow trace is the audio input to the transmitter, in this case a 10kHz sinewave (at TP1). And the red trace shows the signal across the 47Ω resistor at the emitter of Q1 (this signal is proportional to the current driving the transmitter's infrared LEDs). As can be seen, the pulse width of this waveform is modulated by the audio input.

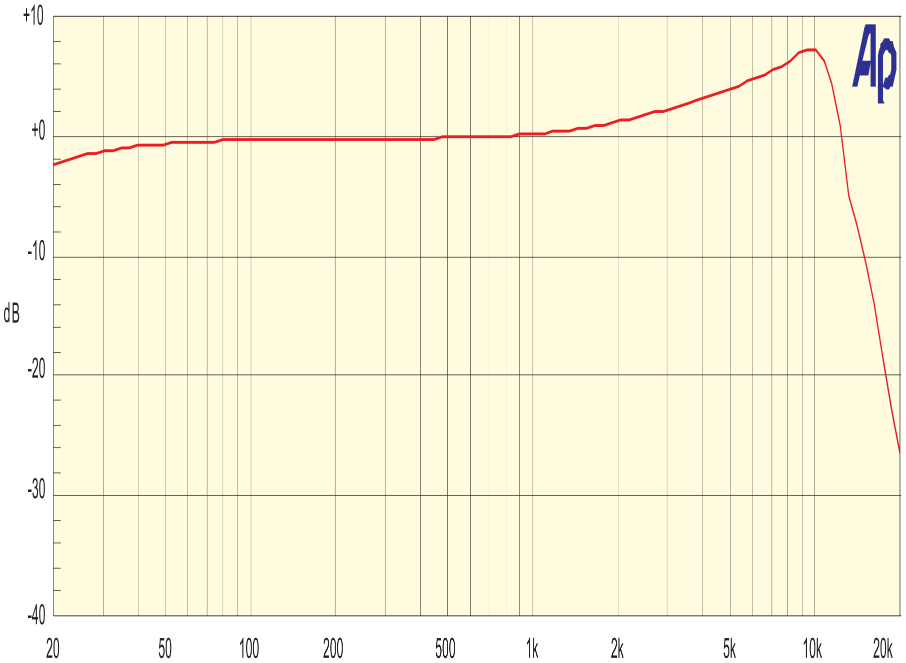


Fig.6: this graph plots the audio frequency response of the system. Note that a small amount of treble boost is applied from about 1kHz (rising to a maximum of 7dB at 8kHz) to improve intelligibility on speech.

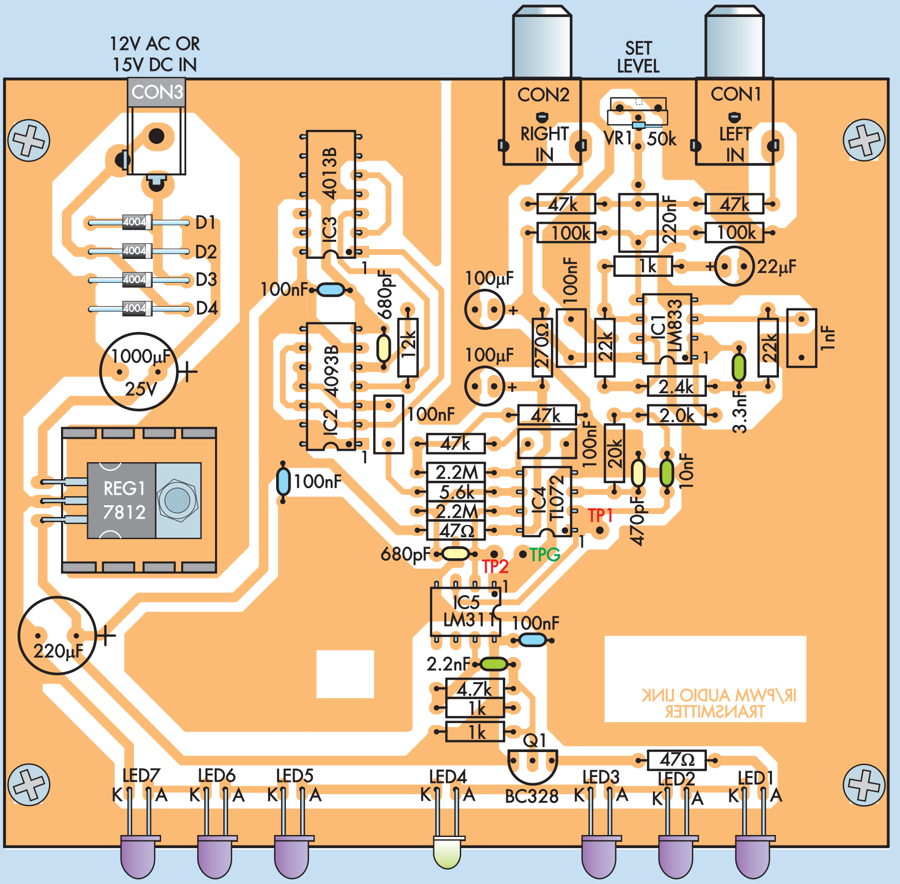
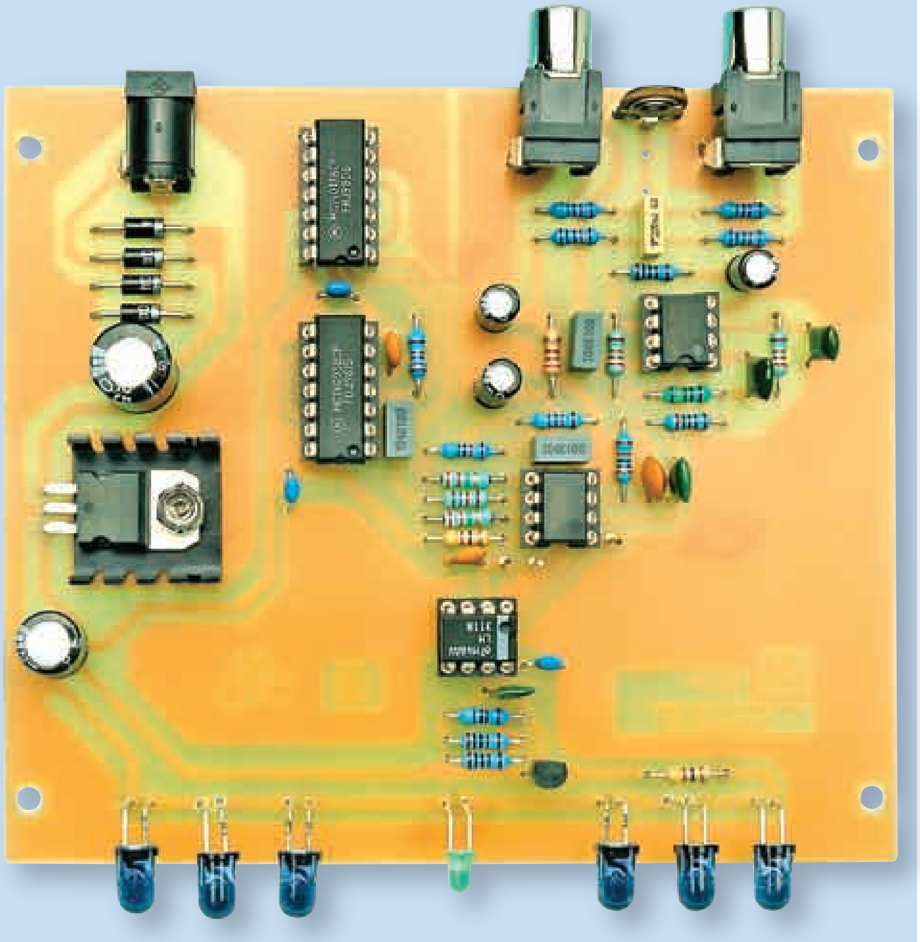


Fig.7: install the parts on the transmitter board as shown here, taking care to ensure that all polarised parts are correctly orientated. Below is a full-size photo of the assembled PC board.



Capacitor Codes (Trans.)

Value	µF Code	IEC Code	EIA Code
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
3.3nF	0.0033µF	3n3	332
2.2nF	0.0022µF	2n2	222
1nF	0.001µF	1n0	102
680pF	NA	680p	681
470pF	NA	470p	471

Regulator REG1 is next on the list. As shown, this is fitted with a small U-shaped heatsink and mounted flat against the PC board.

The correct procedure here is to first bend the regulator's leads down by 90°, about 5mm from the device body (use a pair of needle-nose pliers to grip the leads while you bend them). That done, the regulator and its heatsink are secured to the PC board using an M3 × 6mm machine screw, nut and lock washer.

Mounting the LEDs

As can be seen on Fig.7 and in the photos, LEDs 1 to 7 are all mounted with their leads bent down through 90°. This is done so that the LED bodies later protrude through their matching holes in the front panel.

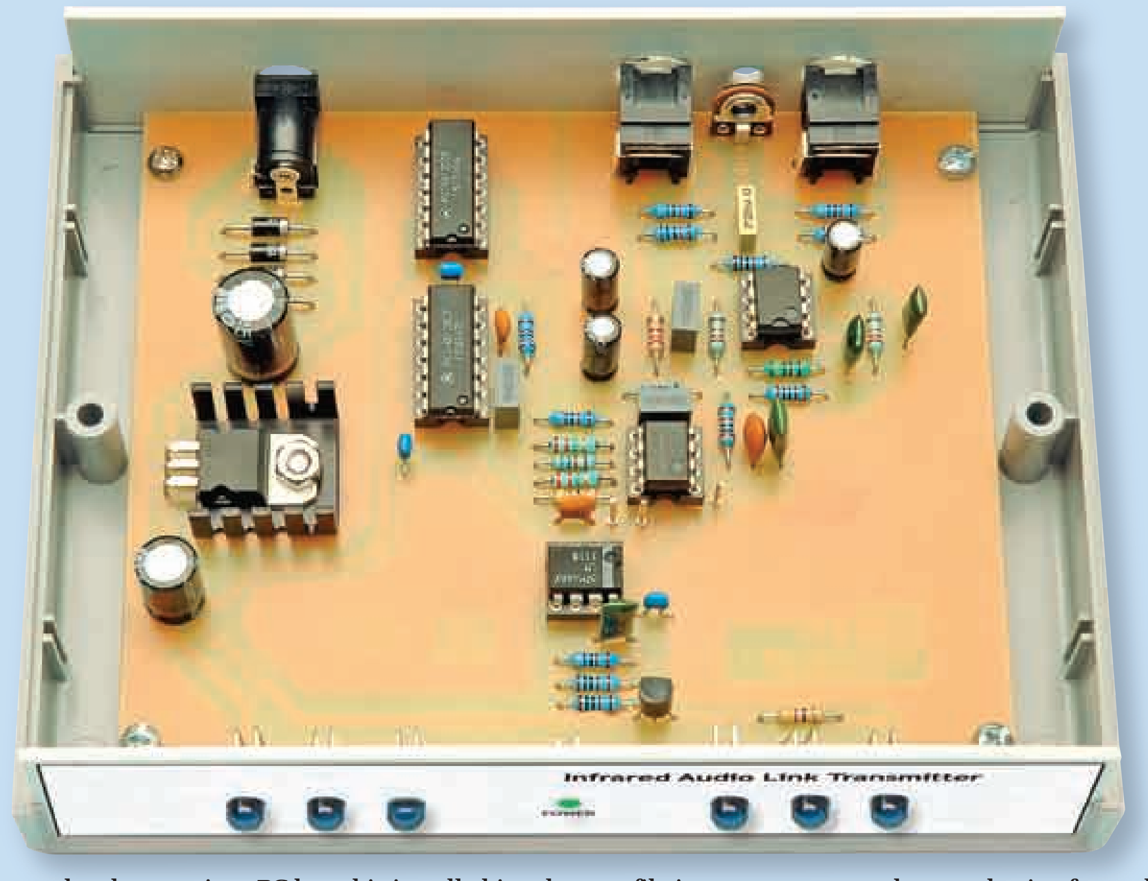
In each case, it's simply a matter of bending the leads down through 90° exactly 5mm from the LED's body, then installing the LED with its leads 8mm above the PC board (see photo). Make sure that each LED is correctly orientated – the anode lead is the longer of the two.

The easiest way to get the LED lead spacings correct is to cut two cardboard templates – one 5mm wide and the other 8mm wide. The 5mm template is then used as a lead bending guide, while the 8mm template is used to correctly space the LEDs off the board.

The transmitter board assembly can now be completed by installing the two RCA phono connectors (CON1 and CON2) and the DC power socket (CON3).

Receiver board assembly

Fig.8 shows the assembly details for the receiver board. Once again, begin by soldering in the resistors and the small non-polarised capacitors, then install



The completed transmitter PC board is installed in a low-profile instrument case and secured using four self-tapping screws that go into integral mounting posts in the base. We used IC sockets for the prototype, but you can solder the ICs directly to the PC board.

the larger electrolytics and the ICs. Note that the large 2200µF electrolytic capacitor is mounted on its side, with its leads bent down through 90°.

Note also that the ICs are all different, so don't mix them up. Take care to ensure they are correctly orientated.

Once the ICs are in, install the volume pot (VR1), the headphone socket and power switch S1. Follow these by installing PC pins at the A and K positions for PD1 (the BP104 photodiode) and at the power supply inputs.

The BP104 photodiode can now be installed by soldering its leads to its PC pins (see side-view diagram in Fig.8). Be sure to install this part the right way around. Its cathode (K) lead has a small tag, as shown on its pinout diagram in Fig.4.

Resistor Colour Codes (Transmitter)

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	2	2.2MΩ	red red green brown	red red black yellow brown
❏	2	100kΩ	brown black yellow brown	brown black black orange brown
❏	4	47kΩ	yellow violet orange brown	yellow violet black red brown
❏	2	22kΩ	red red orange brown	red red black red brown
❏	1	20kΩ	red black orange brown	red black black red brown
❏	1	12kΩ	brown red orange brown	brown red black red brown
❏	1	5.6kΩ	green blue red brown	green blue black brown brown
❏	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❏	1	2.4kΩ	red yellow red brown	red yellow black brown brown
❏	1	2.0kΩ	red black red brown	red black black brown brown
❏	3	1kΩ	brown black red brown	brown black black brown brown
❏	1	270Ω	red violet brown brown	red violet black black brown
❏	2	47Ω	yellow violet black brown	yellow violet black gold brown

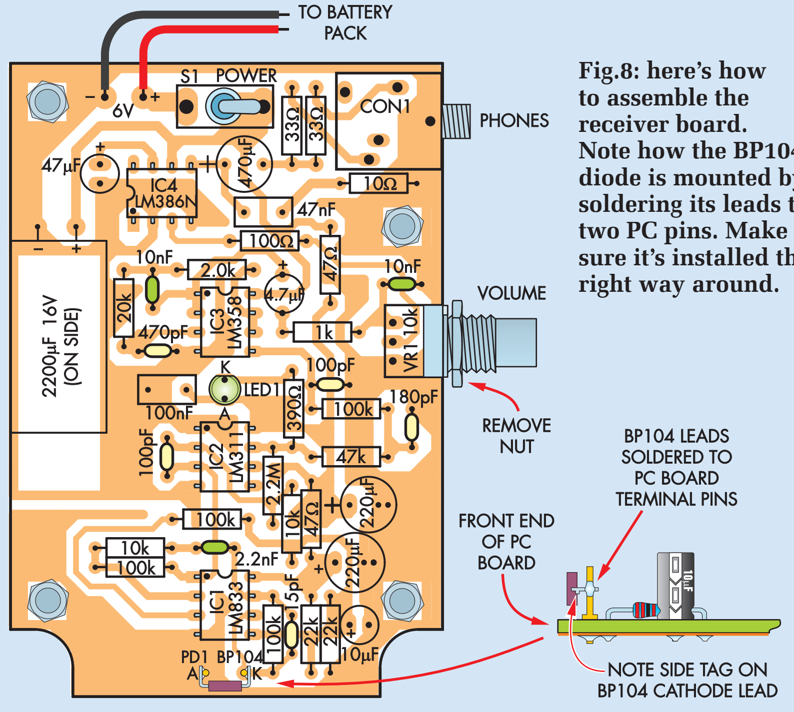
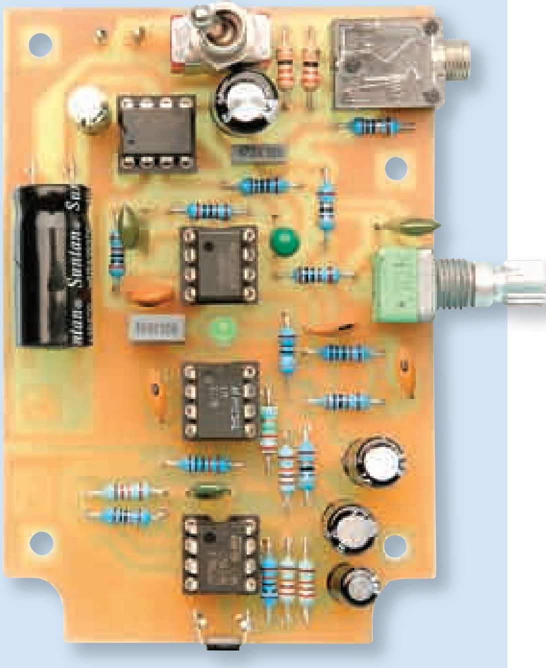


Fig.8: here's how to assemble the receiver board. Note how the BP104 diode is mounted by soldering its leads to two PC pins. Make sure it's installed the right way around.



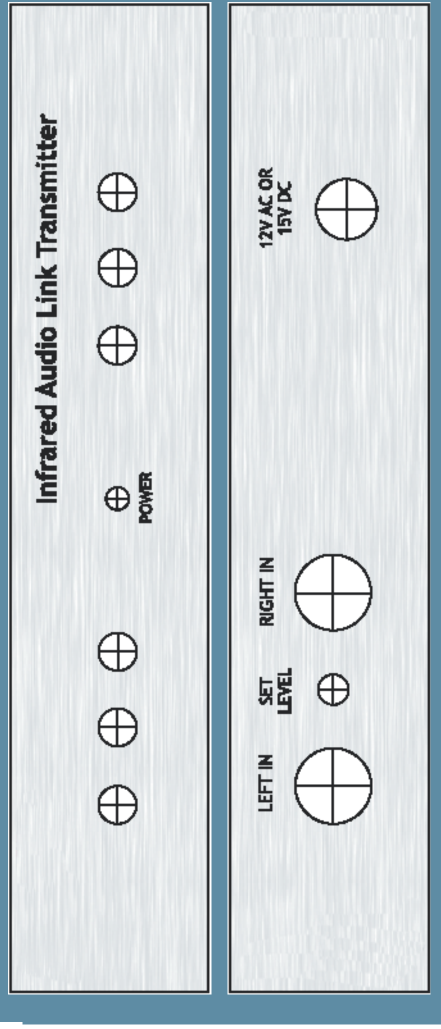
It's also vital to install this device with its sensitive front side facing out from the PC board.

Finally, LED1 can be mounted in position. This part must be mounted with 13mm lead lengths, so that it will later protrude through the lid of the case. A 13mm wide cardboard template makes a handy spacer when mounting this LED. Be sure to orientate it with its anode (A) lead (the longer of the two) towards IC2.

Final assembly – transmitter

The final assembly involves little more than installing the PC boards inside their respective cases.

If you are building the unit from a kit, the transmitter's front and rear panels may come pre-drilled (and with screen-printed lettering). In this case, it's just a matter of first slipping these panels over the LEDs and input sockets on the PC board. That done, the entire assembly is then slipped into the bottom section of the case



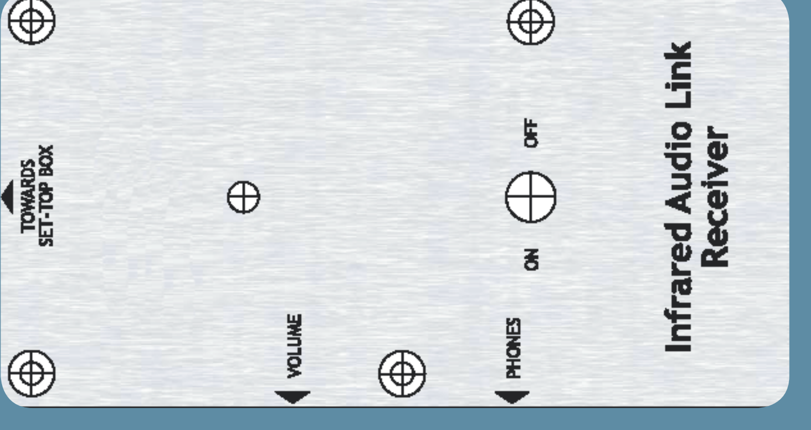
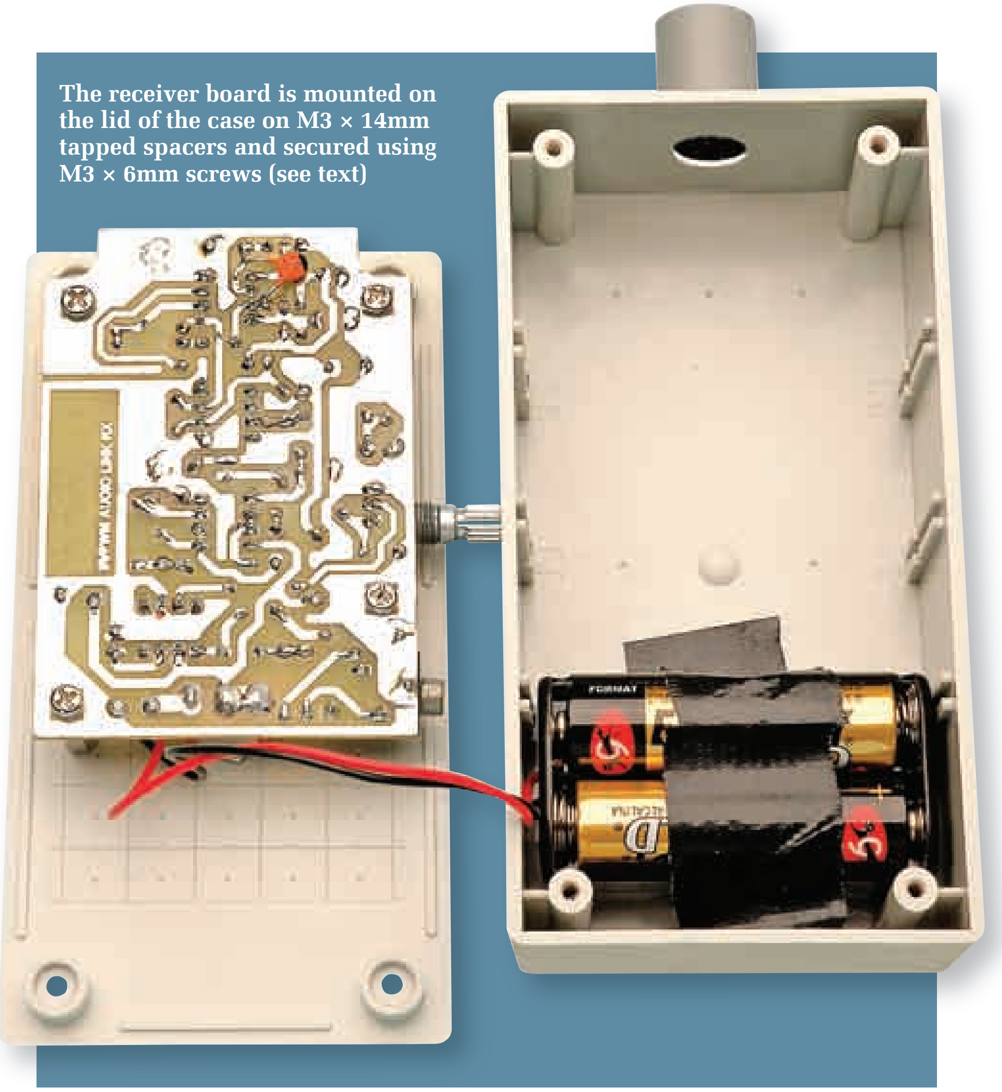


Fig.9: these full-size front panel artworks can be photocopied and applied to the front and rear panels of the transmitter and to the lid of the receiver. Use wide strips of self-adhesive film to protect them from damage – see text.

Capacitor Codes (Rec.)

Value	µF Code	IEC Code	EIA Code
100nF	0.1µF	100n	104
47nF	0.047µF	47n	473
10nF	0.01µF	10n	103
2.2nF	0.0022µF	2n2	222
1nF	0.001µF	1n0	102
470pF	NA	470p	471
180pF	NA	180p	181
100pF	NA	100p	101
15pF	NA	15p	15



The receiver board is mounted on the lid of the case on M3 × 14mm tapped spacers and secured using M3 × 6mm screws (see text)

and secured using four self-tapping screws that go through the PC board and into integral matching stand-offs in the base.

If you are not building from a kit, then you will have to drill these panels yourself. Fig.10 shows the drilling details. The best approach is to photocopy these diagrams and then attach them to the panels so that they can be used as drilling templates. Note that hole 'D' is the adjustment access hole for trimpot VR1.

Once the panels have been drilled, they can be dressed by attaching the relevant artworks. These artworks are attached using double-sided adhesive tape. Once they are attached, they can be protected by covering them with clear self-adhesive film (eg, wide sticky tape) and the holes cut out with a sharp utility knife.

Final assembly – receiver

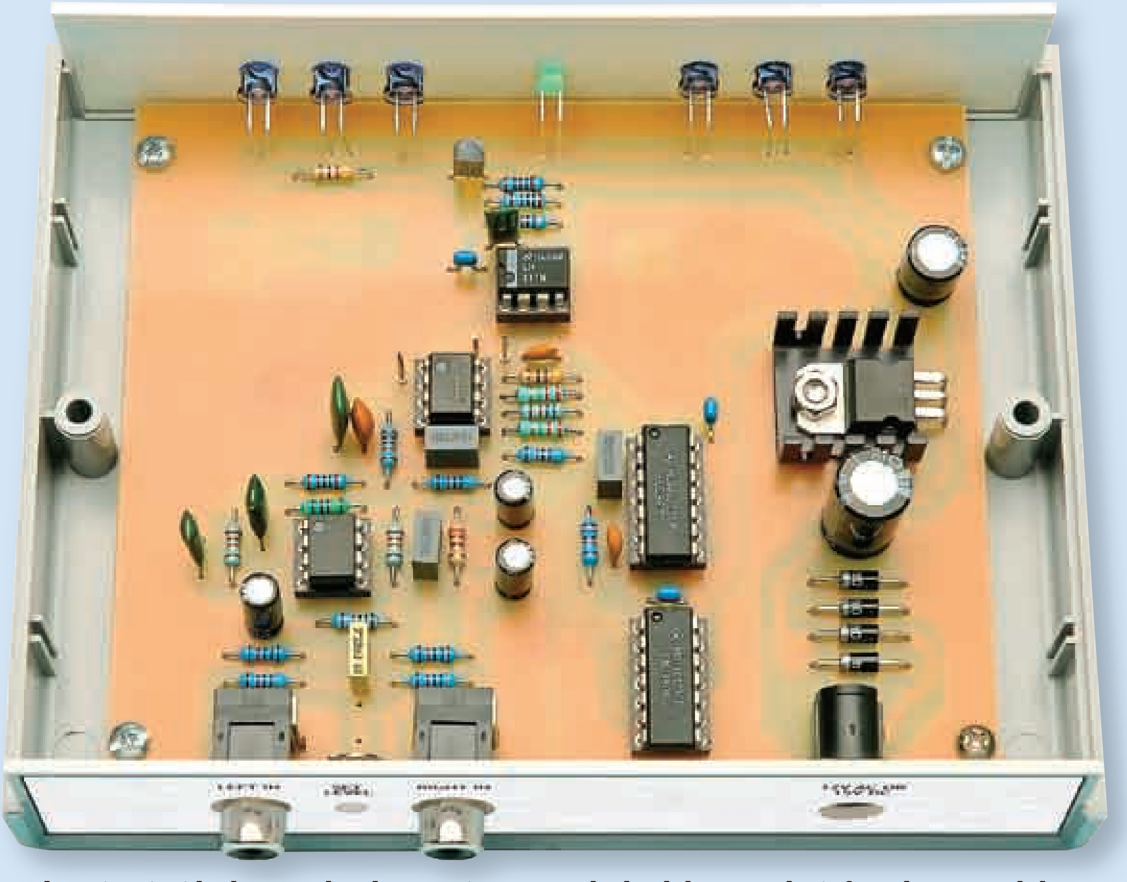
Now for the final assembly of the receiver. If you're not using a kit, use Fig.11 as a drilling template and attach the front panel artwork as described above.

As shown in the photos, the PC board is mounted on the underside of the lid on four M3 × 15mm tapped spacers. Four M3 × 6mm countersink-head screws secure the spacers to the lid, while the PC board is secured using four M3 × 6mm pan-head screws.

The power LED (LED1) and toggle switch (S1) both protrude through

Resistor Colour Codes (Receiver)

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	2.2MΩ	red red green brown	red red black yellow brown
❏	4	100kΩ	brown black yellow brown	brown black black orange brown
❏	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❏	2	22kΩ	red red orange brown	red red black red brown
❏	1	20kΩ	red black orange brown	red black black red brown
❏	2	10kΩ	brown black orange brown	brown black black red brown
❏	1	2.0kΩ	red black red brown	red black black brown brown
❏	1	1kΩ	brown black red brown	brown black black brown brown
❏	1	390Ω	orange white brown brown	orange white black black brown
❏	1	100Ω	brown black brown brown	brown black black black brown
❏	2	47Ω	yellow violet black brown	yellow violet black gold brown
❏	2	33Ω	orange orange black brown	orange orange black gold brown
❏	1	10Ω	brown black black brown	brown black black gold brown



Here's another view inside the completed transmitter. Note the lead dress on the infrared LEDs and the green indicator LED, so that they protrude through their matching holes in the front panel.

The rear panel of the receiver has clearance holes for the two audio input phono sockets, plus access holes for the 'Set Level' trimpot and the power socket. Power can come from a 12V AC or 15V DC (regulated) plugpack.

matching holes in the lid. Once the PC board is in place, one of the switch nuts is fitted to the top of the threaded ferrule, to help hold everything securely together.

The two holes in the side of the box accept the shaft of the volume control (VR1) and the collar of the headphone socket (CON1). Another hole at one end of the box provides the 'window' for photodiode PD1.

As shown in the photos, a short length of PVC conduit was fitted around this hole, on the end of the box, to make a light shield 'hood'. Although not strictly necessary, it does improve the signal-to-noise ratio of the link when you are using it in a fairly large room that's lit with compact fluorescent lamps (CFLs) – ie, when there's a long link path. CFLs produce a significant amount of noise at IR wavelengths and the hood stops most of this noise from reaching PD1.

Parts List – Infrared Audio Headphone Link For TV

Transmitter Unit

1 low profile ABS instrument case, size 140 × 110 × 35mm
★1 PC board, code 708 (Trans.), size 117 × 102mm
2 PC-mount RCA phono sockets (CON1, CON2)
1 2.5mm PC-mount DC socket (CON3)
1 19mm square heatsink, 6073 type
3 8-pin DIL IC sockets (optional)
2 14-pin DIL IC sockets (optional)
1 M3 × 6mm machine screw, pan head
1 M3 nut with star lockwasher
4 self-tapping screws, 4g × 6mm long
3 PC board terminal pins, 1mm diameter
1 50kΩ vertical trimpot, 5mm (VR1)

Semiconductors
1 LM833 low-noise op amp (IC1)
1 4093B quad CMOS Schmitt NAND (IC2)
1 4013B dual flipflop (IC3)
1 TL072 dual op amp (IC4)
1 LM311 comparator (IC5)
1 7812 +12V regulator (REG1)
1 BC328 *PNP* transistor (Q1)
6 5mm IR LEDs (LED1 to LED3, LED5 to LED7)
1 3mm green LED (LED4)
4 1N4004 1A diodes (D1-D4)

Capacitors
1 1000µF 25V radial electrolytic
1 220µF 16V radial electrolytic
2 100µF 16V radial electrolytic
1 22µF 16V radial electrolytic
1 220nF metallised polyester
3 100nF metallised polyester
3 100nF multilayer monolithic ceramic
1 10nF metallised polyester
1 3.3nF metallised polyester
1 2.2nF metallised polyester
1 1nF metallised polyester
2 680pF disc ceramic
1 470pF disc ceramic

Resistors (0.25W 1%)

2 2.2MΩ	1 4.7kΩ
2 100kΩ	1 2.4kΩ
4 47kΩ	1 2.0kΩ
2 22kΩ	3 1kΩ
1 20kΩ	1 270Ω
1 12kΩ	2 47Ω
1 5.6kΩ	

Receiver unit

1 UB3-size plastic box, size 130 × 68 × 44mm
★1 PC board, code 709 (Rec.), size 57 × 84mm
1 battery holder, 4 × AA cells (square)
1 SPDT mini toggle switch (S1)
1 PC-mount 3.5mm stereo jack socket (CON1)
4 8-pin DIL IC sockets (optional)
1 small knob, push-on (for VR1)
1 15mm length of 16mm OD PVC tubing (optional)
4 M3 × 6mm machine screws, countersink head
4 M3 × 6mm machine screws, pan head
4 M3 ×15mm tapped spacers
4 PC board terminal pins, 1mm
1 10kΩ log pot, 9mm square PC-mount (VR1)

Semiconductors
1 LM833 dual low-noise op amp (IC1)
1 LM311 comparator (IC2)
1 LM358 dual low power op amp (IC3)
1 LM386N audio amplifier (IC4)
1 BP104 IR sensor diode (PD1)
1 3mm green LED (LED1)

Capacitors
1 2200µF 16V radial electrolytic
1 470µF 16V radial electrolytic
2 220µF 16V radial electrolytic
1 47µF 16V radial electrolytic
1 10µF 16V radial electrolytic
1 4.7µF 25V tag tantalum
1 100nF metallised polyester
1 47nF metallised polyester
2 10nF metallised polyester
1 2.2nF metallised polyester
1 470pF disc ceramic
1 180pF disc ceramic
2 100pF disc ceramic
1 15pF disc ceramic

Resistors (0.25W 1%)

1 2.2MΩ	1 1kΩ
4 100kΩ	1 390Ω
2 22kΩ	1 100Ω
1 20kΩ	2 47Ω
2 10kΩ	2 33Ω
1 2.0kΩ	1 10Ω

★ Printed circuit boards available as a pair from the *EPE PCB Service*

For the prototype, the hood was made using a 15mm length of 16mm OD PVC conduit. This was glued to the box end (concentric with the hole) using fast-setting epoxy cement.

The battery holder, with its 4 × AA cells, is mounted at the other end of the box. This can be held in place using a strip of electrical insulation tape. It's then wedged firmly in position by the end of the PC board when the lid goes on.

Note that the lid assembly must be introduced into the box at an angle, so VR1's shaft and the headphone socket can enter their matching holes. It's then swung down and fastened to the box using self-tapping screws.

Set-up and adjustment

Getting the transmitter unit going is straightforward. Basically, it's just a matter of connecting the audio input leads and applying power. However, if you have an oscilloscope or a frequency counter, it's a good idea to check the frequency of the clock oscillator before you close up the case.

This is easiest done by checking the frequency of the triangular wave signal at test point TP2 (just behind IC5). The frequency here should be between 80kHz and 100kHz. If it's well outside this range, then you'll need to change the value of the 680pF oscillator capacitor to correct it.

The capacitor concerned is easy to find on the transmitter board – it's just to the right of IC2.

In practice, a value of 680pF (as shown on the circuit) should be suitable if a Motorola MC14093B device is used for IC2. However, if an ST Micro 4093B is used, this capacitor will probably have to be reduced to 470pF or 390pF. Conversely, for a Philips 4093B,

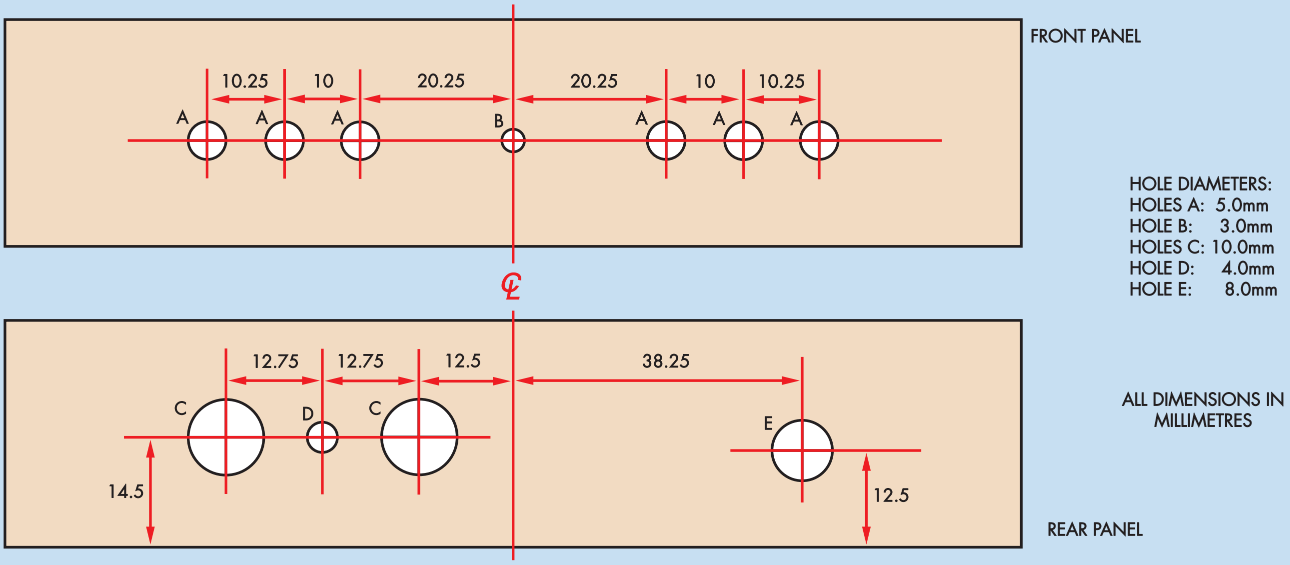


Fig.10 (above): these are the drilling diagrams for the front and rear panels of the transmitter case. They can be photocopied or downloaded from our website and directly used as drilling templates if required.

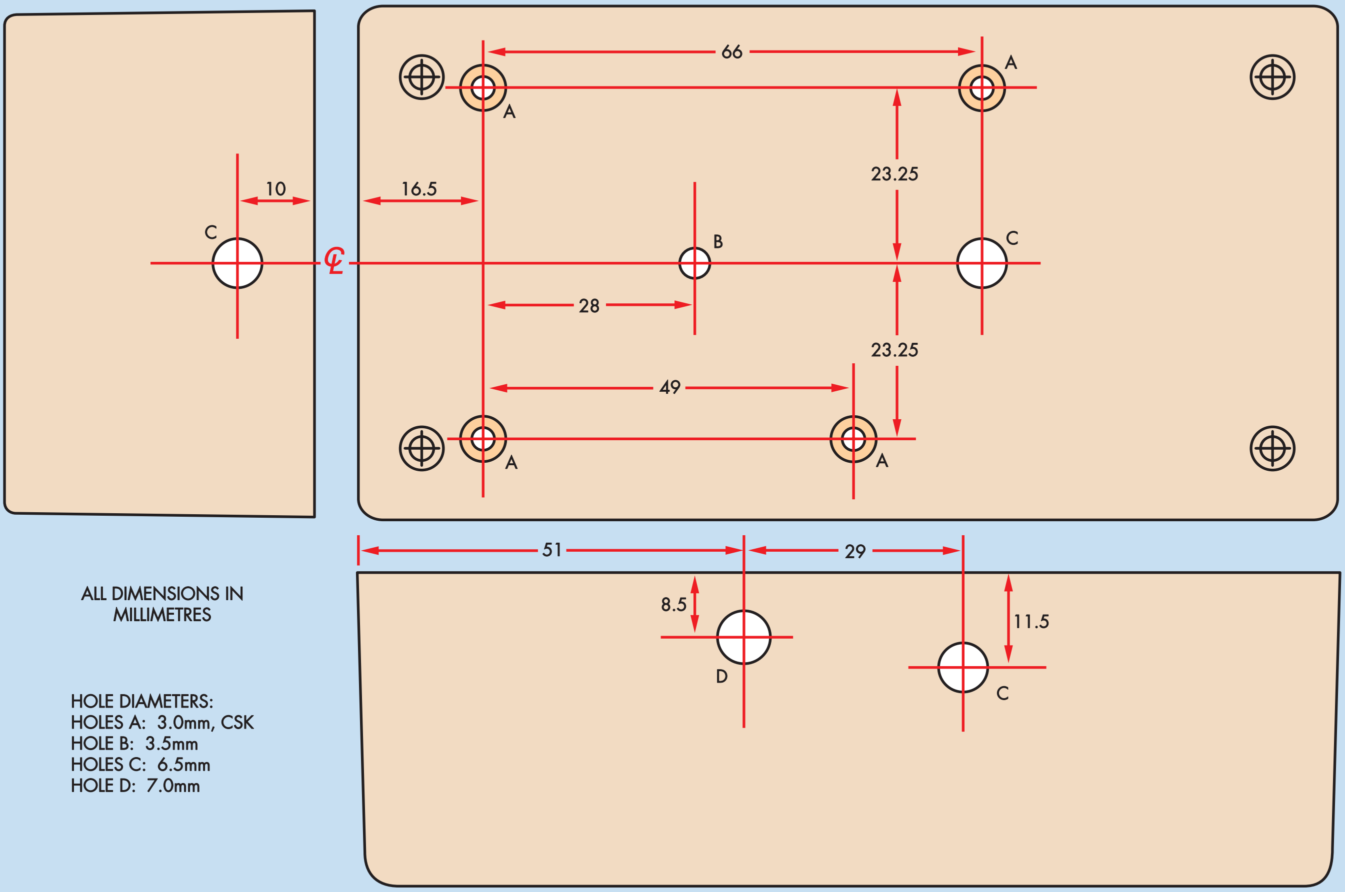


Fig.11: here are the drilling details for the receiver case. It's important to get all holes in their correct locations, so that everything lines up correctly when the receiver board is installed.

the capacitor may need to be increased to 820pF or even 1nF.

The basic idea is that you increase the capacitor's value to lower the clock frequency, and reduce its value to increase the frequency.

If you don't have a frequency counter, but have a modest uncalibrated oscilloscope, you can still check and adjust the clock frequency fairly easily by using the waveform at TP2 as a guide. The waveform here should be a very linear and symmetrical sawtooth, with a peak-to-peak amplitude of about 10.5V and only a very tiny 'pip' on each positive and negative peak.

If you find that the waveform is a clean sawtooth, but much lower in amplitude than 10.5V p-p, this means that the clock oscillator's frequency is too high. To fix this, simply increase the value of the 680pF capacitor.

On the other hand, if the waveform does have an amplitude of 10.5V p-p or more but is clipped or truncated rather than being a clean sawtooth, this means that your clock oscillator's frequency is too low. That's fixed by reducing the value of the 680pF capacitor.

If you don't have a counter or an oscilloscope, leave the capacitor's value at 680pF and wait to see if the link's performance is satisfactory. We'll discuss this option shortly.

The receiver unit needs no adjustments; all you have to do to get it going is to plug in your headphones, switch it on and point it towards the transmitter. The small green power LED should light and it's then simply a matter of adjusting the volume control for a comfortable listening level.

Specification

A cordless audio headphone link for the hard of hearing.

Provides a single channel audio link via infrared (IR) light, using pulse-width modulation (PWM).

Overall frequency response restricted to 20Hz to 12kHz, with a small amount of treble boost (maximum of 7dB at about 8kHz).

Signal-to-noise ratio approximately 50dB.

Transmitter Unit

Small set-top box accepts line level audio (either mono or stereo) from a TV receiver, VCR or DVD player, etc.

Input impedance: 47kΩ.

PWM output via six infrared LEDs

Range: about five metres.

Power supply: 12V AC or 15V to 18V DC, with an average current drain of approximately 25mA.

Receiver Unit

A small portable box which responds to the modulated IR light beam from the transmitter, demodulates the audio and drives a standard pair of stereo headphones (2 × 32Ω impedance).

Power supply: four AA cells (either alkaline or rechargeable NiMH).

Average current drain: approximately 20mA, giving a battery service life of 80 to 100 hours or more.

Controls: local volume control and a power on/off switch, plus a power/signal indicator LED.

Testing the link

To test the link, first connect the left and right channel audio signal leads to the transmitter's inputs. These signals can come from the stereo line outputs on your TV. You can also use the line outputs on your VCR or DVD player, but only if you are actually using this equipment.

Note that piggyback RCA phono socket leads may be required to make these connections if the audio outputs are already in use (eg, Jaycar WA-7090).

Next, use a small screwdriver to adjust the 'Set Level' trimpot (VR1) at the rear of the transmitter to mid-position. That done, position the transmitter (eg, on top of the TV) so that it faces towards your viewing position and apply power. The transmitter's green centre LED should immediately light (assuming an audio signal is being applied) but the IR LEDs will remain dark to your eyes.

It's now just a matter of checking that the link actually works. To do this, initially set the receiver's volume control to minimum, then plug the headphones in and switch the receiver on. The receiver's green power LED should either blink briefly (if you're not pointing the receiver towards the transmitter) or light steadily if PD1 is able to 'see' the infrared signal.

The idea now is to place the receiver in a convenient position so that it gets an unobstructed 'view' of the transmitter. In most cases, it can simply be positioned on an armrest, an adjacent coffee table on even on the back of the sofa.

Now turn up the volume control and you should be able to clearly hear the TV sound. If so, your link is finished and ready for use.

If the sound is overly loud and distorted, even when the receiver's volume control is down near zero, it's probable that the audio input signals from the TV are overloading the transmitter. In that case, try adjusting trimpot VR1 anticlockwise using a small screwdriver, to lower the input level. This should allow you to remove any audible distortion and bring the volume down to a comfortable level.

If you find that distortion is still present, even when the audio level is turned well down, this probably means that your clock frequency is either too high or too low. This can occur if you weren't able to previously check the transmitter's oscillator frequency – eg, if you don't have a counter or an oscilloscope.

In this case, try altering the 680pF capacitor's value one way or the other, to see if the distortion gets better or worse. If it gets worse, go back the other way. If it gets better, keep changing the value in that direction.

In practice, you shouldn't need to increase the capacitor value above 1nF or reduce it below 390pF in order to remove all audible distortion. *EPE*

The Maverick March Of Progress

TechnoTalk

Mark Nelson

Progress – you can't predict it, nor can you prevent it. Disruptive influences make absolutely certain that it's anybody's guess who will be the winners and losers in the technology race. Mark Nelson examines some of the form.

Remember when Motorola was *numero uno* in mobile phones? Or when Epson had the PC printer market so tightly sewn up that the other manufacturers emulated Epson protocols? When JVC was tops in home video (and Philips before that?). Or when Dynatron was slugging it out with Bang and Olufsen for the status of most aspirational brand of hi-fi .

It doesn't matter whether you do or don't, as times change regardless. We can admire the new winners who thrust their way to the top of the pile, or 'mourn' the mighty that are fallen. Just ponder a moment: how much longer can the mighty Microsoft dominate the software market? Will Maplin retain its top slot in the home electronics market or go the way of Tandy?

Will RS and Farnell retain the lion's share of the professional supply sector, as they have done so successfully for the past 30 years or more?

Fraud

Your guess is as good as mine, maybe better, and we'll all have to wait and see. But why do these giants fall from grace? Three reasons spring to mind: poor management, disruptive technologies and fraud. We needn't dwell long on the last-named, as outright fraud is a relatively uncommon cause of collapse in the electronics business.

One I do remember is when Ferranti International was forced into bankruptcy in 1993, after its disastrous purchase of the American defence contractor International Signal and Control. Unwittingly, the 1882-founded Ferranti company had bought a near-worthless company involved in illegal arms sales. Eventually, the co-chairman of the merged company pleaded guilty to massive fraud and the company collapsed. Its semiconductor division survives as the successful Zetex organisation.

Disruptive technologies are something we have discussed before. In a nutshell, they are totally new products and processes that can ruin some suppliers and make the fortunes for others. Sometimes these disruptive technologies can also increase overall market size without causing substitution of one purchase for another.

A classic disruptive technology is Skype, the supplier of voice over Internet Protocol (VoIP) software that lets millions of users make free phone calls over the Internet or over their mobiles. As Skype co-founder Niklas Zennström says, "Disruptive technology is great because it's a quantum leap in competitive advantage. You change the nature of the game and you get the advantage."

Natural victims

Firms without the flexibility to protect their markets from disruptive technologies are the natural victims of these newcomers. This tunnel vision goes side-by-side with poor management, as Christian Sandström knows only too well. Christian is a PhD candidate at Chalmers University of Technology in Gothenburg, Sweden, as well as a public speaker and consultant. He specialises in disruptive innovations and how established firms can manage these challenges.

His expertly presented case studies make fascinating but somewhat uncomfortable reading, with wacky titles like *Jealous of her transistor radio* (the decline of Grundig) and more prosaically *Why Nortel Networks went bankrupt*. It's worth reading his insights in full, but I cannot resist sharing some of his magical nuggets with you. Many companies and industries, he explains, encounter difficulties in achieving the technological shift from mechanics to electronics, despite recognizing the threat at an early point.

'In Switzerland, more than 1000 small watch manufacturers went out of business in fifteen years from 1970 to 1985. At the same time, the number of employees in the industry decreased from 90,000 to 30,000. Given that quartz technology was invented in Switzerland, it is somewhat surprising that the Swiss had so much trouble handling the technological shift.

After having sold its electronics division to General Electric, Olivetti suffered greatly when electronic calculators came to the market in the early 1970s. The same thing happened at camera company Leica. In 1997, the company launched a digital camera with 75-megapixels and then decided to cut off digital development.'

He sums up this apparent madness with the observation that the more crucial electronics became for the long-term survival of a company, the less is spent on it! Yet this strange behaviour takes place time and time again, in so many industries. If you would like to read his individual case studies (and indulge in schadenfreude) you can visit Christian's website at **www.christiansandstrom.org/disruptivestories.php**

Subterfuge

A firm that has survived and grown massively is RS Components. However, its success has more to do with evolution than revolution. Over the past forty years it has transformed itself from an over-the-counter and mail order business going by the name of Radiospares. It was notable for its small printed catalogue punched at top left to hang on a loop of string from the top of your workbench.

Today, the company has an international presence on the web and has broadened its product range into areas as diverse as mechanical handling and office stationery. What's more, over half its UK business is carried out over the Internet, eclipsing the print catalogue and telesales channels.

Another way that RS has changed with the times is the way it will now do business with anybody. Well into the 1980s it was a strictly trade-only supplier and fringe customers like me had to go to great lengths to convince the area rep (who interviewed potential new clients before opening an account for them) that I was a legitimate consultant and designer who just happened to work from home. I got away with this subterfuge, but not so long afterwards, RS opened a parallel operation called Electromail for hobby customers. These days, RS Components are not so fussy about who they do business with!

Watch this…

Reverting to intrusive technologies, what will be the next big thing? One disruption that might make the big time is the blossoming of digital photo frames into something far more functional and fulfilling. Global sales of these somewhat overpriced and underperforming devices trebled from 2006 to 2007 and nearly doubled in 2008.

Now that these gadgets are becoming capable of connecting to the web with wifi, they are being renamed 'digital media frames' and poised to become the new 'third screen' in the home. An article in trade journal *Electronic Engineering Times Europe* states that developers and marketers of photo frames are already proposing 'a dizzying array of variations'.

This includes: a kitchen counter top frame, with digital cookbook and Internet access; a visual messaging board on the fridge and a reminder screen on the bedside radio/alarm clock. Richard Yeh, marketing director of Samsung Electronics, even believes the digital picture frame could become "the centrepiece of the connected home".

One of the companies jockeying to exploit the digital picture frame market for all it's worth is Kodak, whose product line manager Jack Rieger concedes that the still evolving nature of these products may deter customers. "Consumers first need to understand what it does and what it's capable of doing. The price has to come down, but we are seeing some activities that could bring wifi frames to go under $100."

Learn About Microcontrollers

P928 PIC Training Course £164

The best place to begin learning about microcontrollers is the PIC16F627A. This is very simple to use, costs just £1.30, yet is packed full of features including 16 input/output lines, internal oscillator, comparator, serial port, and with two software changes is a drop in replacement for the PIC16F84.

Our PIC training course starts in the very simplest way. At the heart of our system are two real books which lie open on your desk while you use your computer to type in the programme and control the hardware. Start with four simple programmes. Run the simulator to see how they work. Test them with real hardware. Follow on with a little theory.....

Our PIC training course consists of our PIC programmer, a 318 page book teaching the fundamentals of PIC programming, a 262 page book introducing the C language, and a suite of programmes to run on a PC. The module uses a PIC to handle the timing, programming and voltage switching. Two ZIF sockets allow most 8, 18, 28 and 40 pin PICs to be programmed. The programming is performed at 5 volts, verified with 2 volts or 3 volts and verified again with 5.5 volts to ensure that the PIC works over its full operating voltage. UK orders include a plugtop power supply.

P928-V PIC Training & Development Course comprising.....
Enhanced 16C, 16F and 18F PIC programmer module
+ Book Experimenting with PIC Microcontrollers
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+ PIC assembler and C compiler software on CD
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and PIC18F2321 test PICs
+ USB adaptor and USB cable. £164.00
(Postage & insurance UK £10, Europe £18, Rest of world £27)

Experimenting with PIC Microcontrollers

This book introduces PIC programming by jumping straight in with four easy experiments. The first is explained over seven pages assuming no starting knowledge of PICs. Then having gained some experience we study the basic principles of PIC programming, learn about the 8 bit timer, how to drive the liquid crystal display, create a real time clock, experiment with the watchdog timer, sleep mode, beeps and music, including a rendition of Beethoven's Fur Elise. Then there are two projects to work through, using a PIC as a sinewave generator, and monitoring the power taken by domestic appliances. Then we adapt the experiments to use the PIC16F877 family, PIC16F84 and PIC18F2321. In the space of 24 experiments, two projects and 56 exercises we work through from absolute beginner to experienced engineer level using the most up to date PICs.

Experimenting with PIC C

The second book starts with an easy to understand explanation of how to write simple PIC programmes in C. Then we begin with four easy experiments to learn about loops. We use the 8/16 bit timers, write text and variables to the LCD, use the keypad, produce a siren sound, a freezer thaw warning device, measure temperatures, drive white LEDs, control motors, switch mains voltages, and experiment with serial communication.

Web site:- www.brunningsoftware.co.uk

PH28 Training Course £189

PIC training and Visual C# training combined into one course. This is the same as the P928 course with an extra book teaching about serial communication.

The first two books and the programmer module are the same as the P928. The third book starts with very simple PC to PIC experiments. We use PC assembler to flash the LEDs on the programmer module and write text to the LCD. Then we learn to use Visual C# on the PC. Flash the LEDs, write text to the LCD, gradually creating more complex routines until a full digital storage oscilloscope is created. (Postage & ins UK £10, Europe £20, rest of world £34).

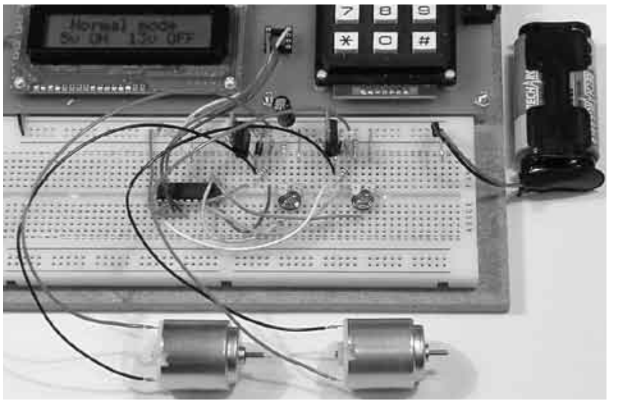
Assembler Book 2

Experimenting with PIC Microcontrollers Book 2 is an optional extra. We delve deeper into PIC assembler but use library routines to keep it simple. We flash LEDs using the internal oscillator, use the keypad to control the LEDs, and write to the LCD. We experiment with simple time delays then use the PICs timer to create a precise delay. We experiment with the real time library routines and consider how to use real time to switch house lights to give the appearance of being at home. We study the problems of using triacs to switch the lights. Lounge light on, go to the bathroom, lounge light on, go to the bathroom, bedroom light on, all lights off. Finally we consider the problems of using a radio frequency link for simple control and data exchange, and study the principles of Manchester encoding. See web site for more information and prices.

Ordering Information

Our P928 course is supplied with a USB adaptor and USB lead as standard but can be supplied with a COM port lead if required. All software referred to in this advertisement will operate within Windows XP, NT, 2000, Vista etc (For Windows 98, ME or DOS order P928-BS £159+pp).

Telephone with Visa, Mastercard or Switch, or send cheque/PO. All prices include VAT if applicable.



White LED and Motors

Our PIC training system uses a very practical approach. Towards the end of the second book circuits need to be built on the plugboard. The 5 volt supply which is already wired to the plugboard has a current limit setting which ensures that even the most severe wiring errors will not be a fire hazard and are very unlikely to damage PICs or other ICs.

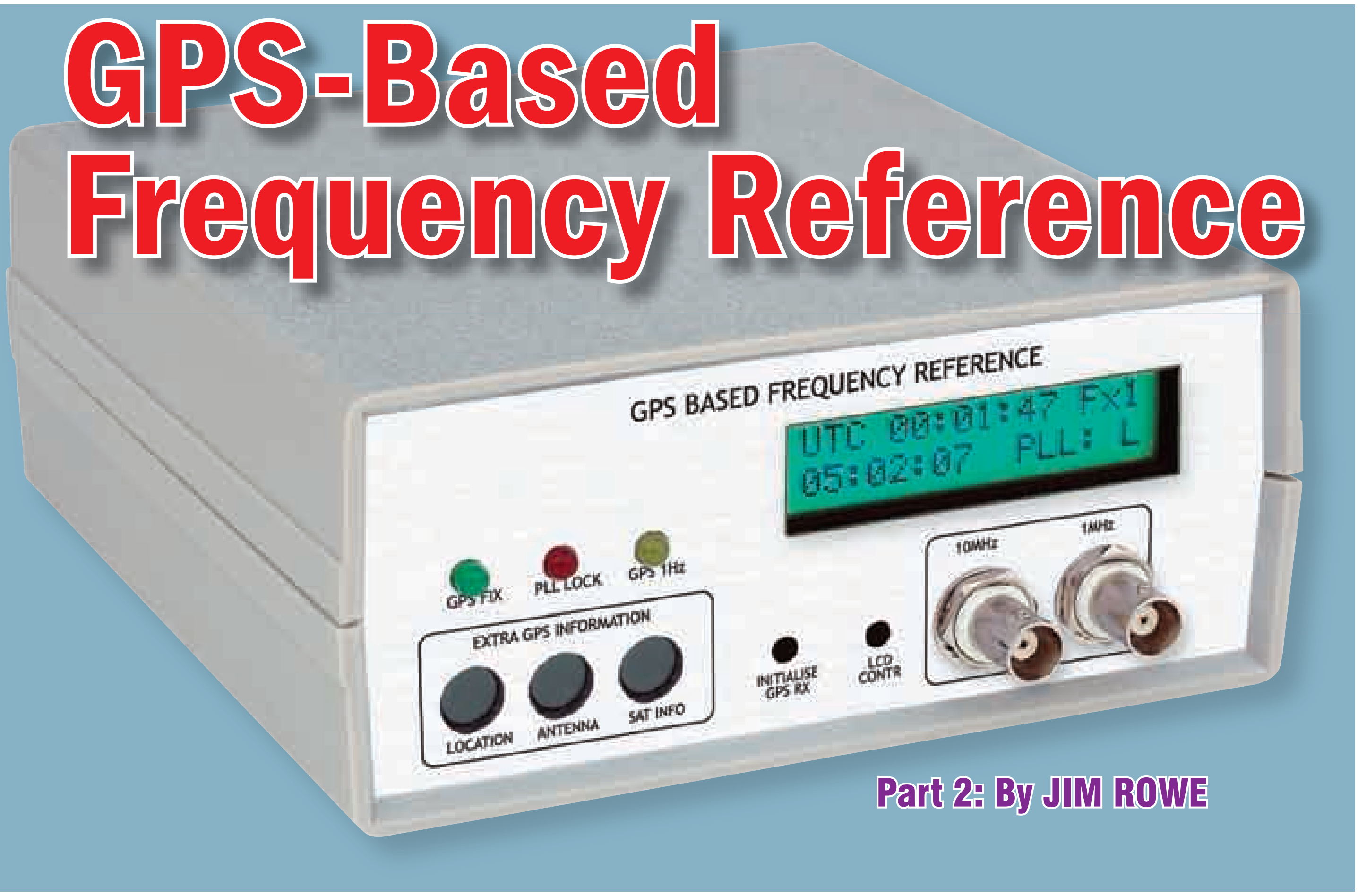
We use a PIC16F627A as a freezer thaw monitor, as a step up switching regulator to drive 3 ultra bright white LEDs, and to control the speed of a DC motor with maximum torque still available. A kit of parts can be purchased (£31) to build the circuits using the white LEDs and the two motors. See our web site for details.

Mail order address:

Brunning Software

138 The Street, Little Clacton, Clacton-on-sea, Essex, CO16 9LS. Tel 01255 862308

GPS-Based Frequency Reference



Part 2: By JIM ROWE

Last month, we published the circuit for our GPS-Based Frequency Reference and described how it works. This month, we show you how to build and adjust it.

BUILDING the GPS-Based Frequency Reference is quite straightforward, since all the parts are mounted on two PC boards: the main board measures 143mm × 123mm and is coded 706, and the smaller display board, coded 707, measures 145 × 58mm. The circuit boards are available as a set from the *EPE PCB Service*. All wiring between the two boards is via a short 16-way ribbon cable, fitted with an IDC line socket at each end (to link CON6 and CON9).

Everything fits snugly inside an ABS plastic instrument case measuring 158 × 155 × 65mm, the display board is mounted vertically at the front. As you can see from the diagrams and photos, the main board has a small rectangular extension at front right for the 10MHz and 1MHz output connectors (CON1 and CON2), while the display board has a matching rectangular cutout to fit around these connectors.

In addition, the display board has a small cutout at upper left, to provide clearance for the interconnecting cable between the two boards.

When the case is assembled, output connectors CON1 and CON2 are accessible via the front panel, while the remaining connectors are all accessible via the rear panel. The LCD and status LEDs are also at the front, along with the three main control pushbutton switches (S1 to S3). The GPS receiver initialisation button (S4) is operated via a small access hole in the front panel, along with a similar access hole for adjusting the display contrast (via trimpot VR2).

Main board assembly

Fig.6 shows the parts layout on the main board. Begin construction by installing the wire links, then install PC stakes at test points TP1 to TP3 and the adjacent TPG and GND terminals.

Follow these with the resistors, diodes and the polyester and ceramic capacitors. Table 1 shows the resistor colour codes, but you should also check them using a DMM, as some colours can be difficult to read. Note that the 10kΩ and 20kΩ resistors in the resistor ladder DAC (just to the left of IC12) are mounted in an 'inverted-V' layout, to fit them all in. Table 2 shows the capacitor codes.

Take care to ensure that the diodes are all correctly oriented and be sure to use the correct type at each location.

Next, fit the IC sockets, the IDC header pin connectors CON6 and CON7, followed by BNC connectors CON1 to CON4, power input connector CON5 and RCA phono connector CON8.

The finned heatsink for regulator REG1 is next on the list. Make sure it's seated all the way down on the PC board, before soldering its mounting pins to the board's copper pads.

Regulator REG1 is mounted vertically against the heatsink and is attached to it using an M3 × 6mm machine screw (this goes into a tapped hole in the heatsink). Apply a thin smear of heatsink compound to both the back of the regulator and the heatsink surface before screwing them together, to ensure a good thermal bond. Tighten the mounting screw firmly, then solder the regulator's leads to its board pads.

The remaining smaller parts can now all be installed. These include trimpot VR1, trimcap VC2 and quartz crystals X1 and X2.

Making the mini oven

The first step in making the oven is to fit the second finned heatsink. Before doing this, however, it needs to have a chamfer cut along both inner edges of the two centre fins, to clear the small flange around the bottom of the crystal can – see Fig.7. Basically, you need to remove enough material so that the outer fins rest on the top of the PC board.

A small low voltage rotary 'hobby grinder' can be used to make these chamfers, or you could use a small dental burr or milling cutter.

After cutting the chamfers, apply a small smear of heatsink compound to both sides of the crystal can and to both sides of the centre slot in the heatsink. This ensures a good thermal bond between the two when the heatsink is fitted. It's now just a matter of slipping the heatsink into position over the crystal and soldering its mounting pins to the board pads.

Mini-oven heater transistor Q1 is in a TO-126 package. As shown, it's fastened

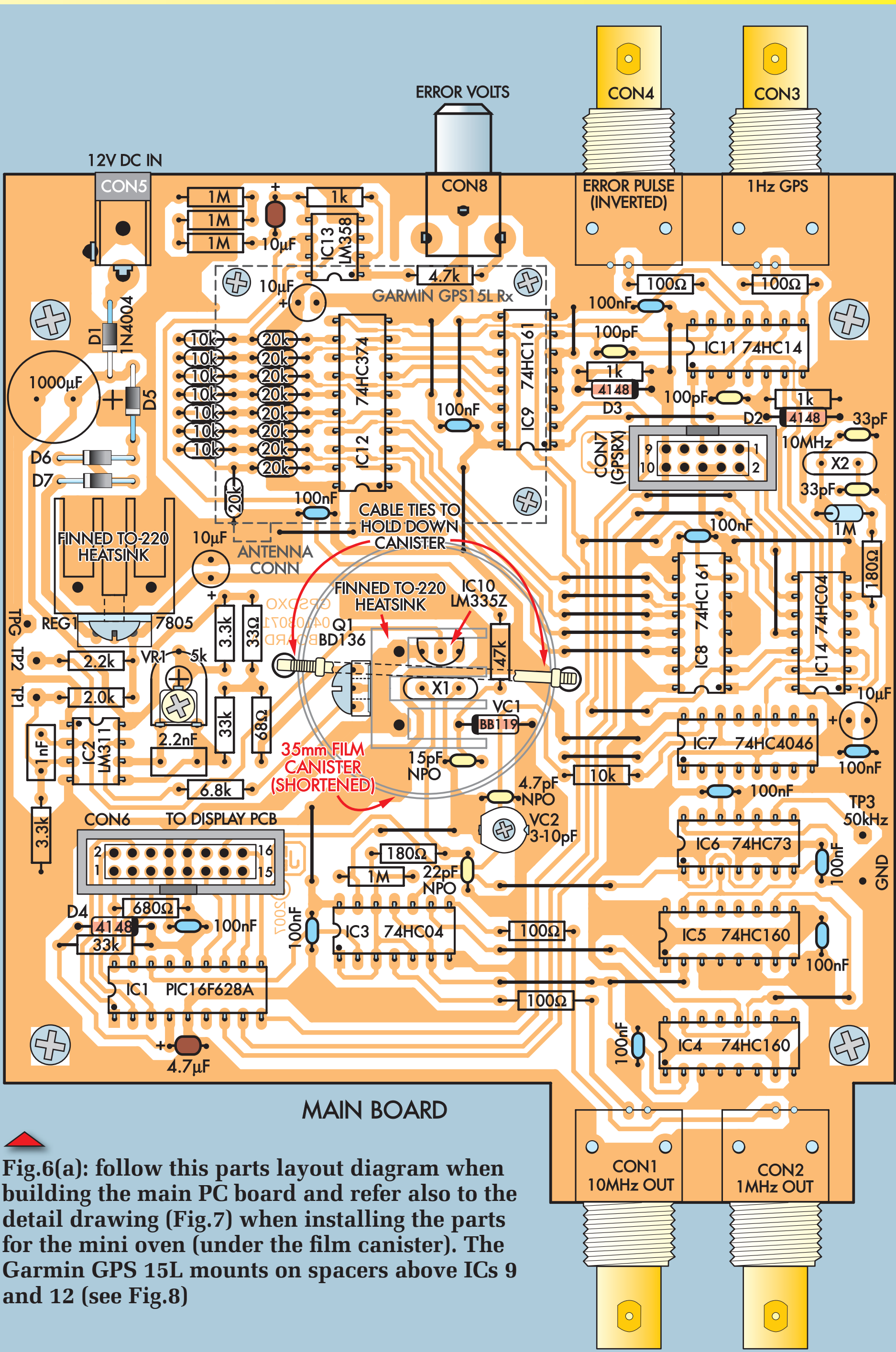


Fig.6(a): follow this parts layout diagram when building the main PC board and refer also to the detail drawing (Fig.7) when installing the parts for the mini oven (under the film canister). The Garmin GPS 15L mounts on spacers above ICs 9 and 12 (see Fig.8)

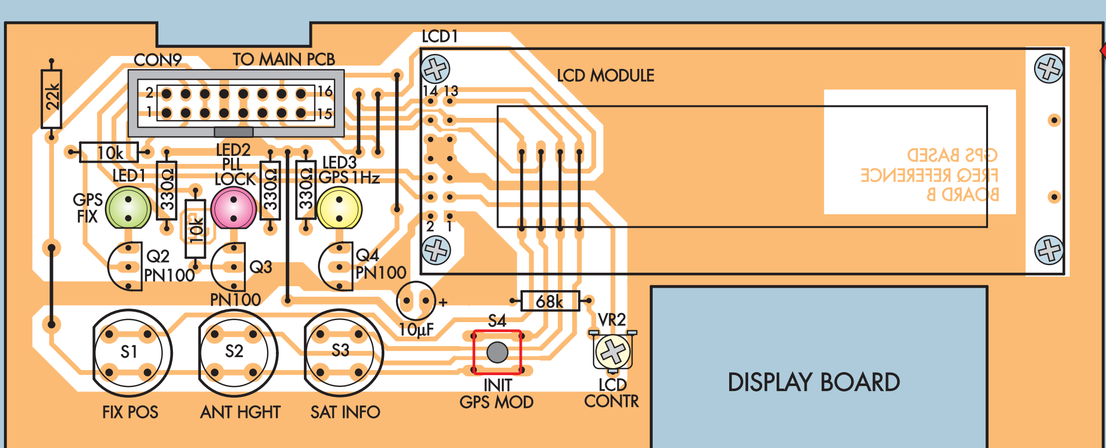
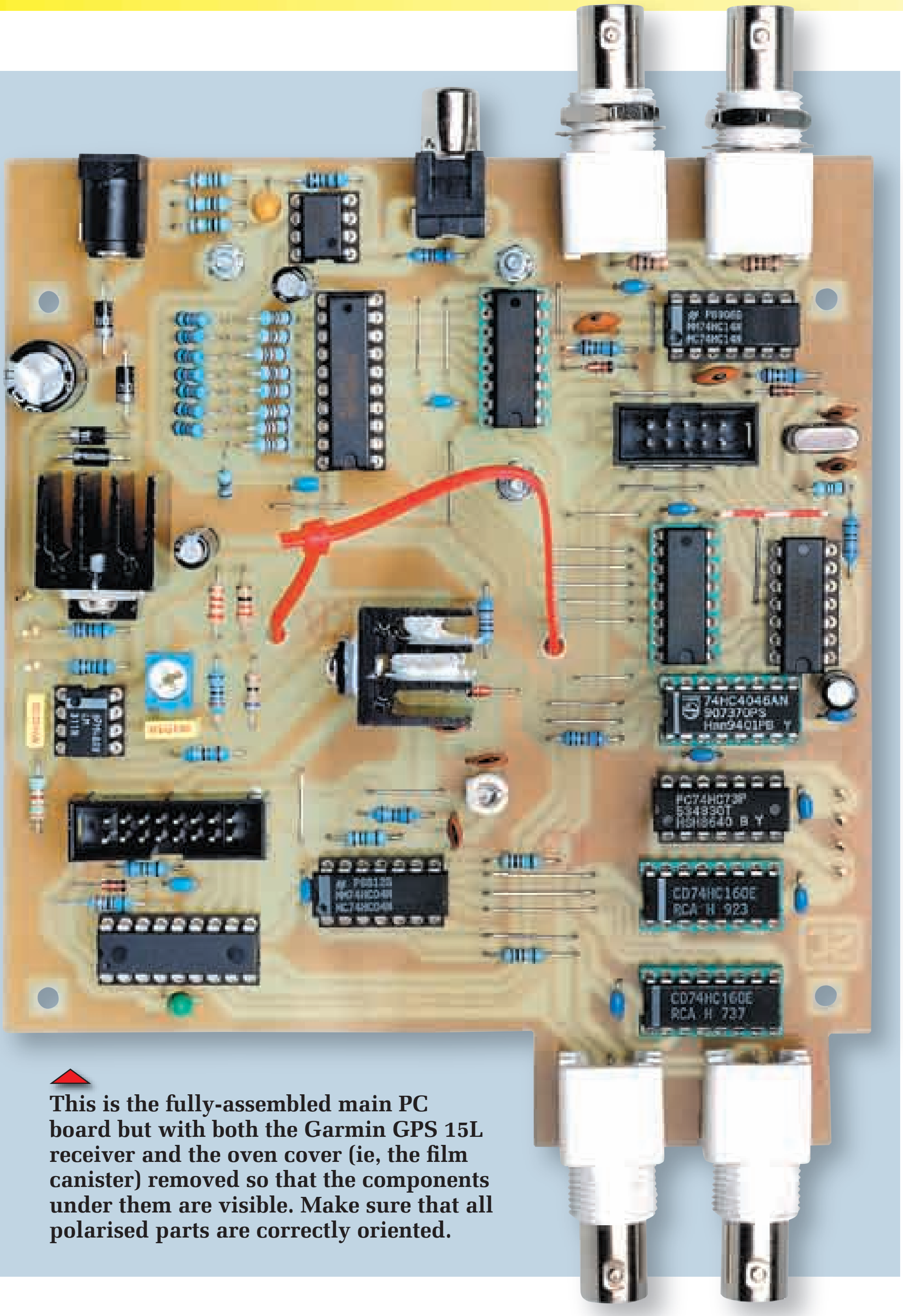


Fig.6(b): assemble the display PC board as shown here. Switches S1 to S3 must be mounted with their flat sides as shown, while LEDs 1 to 3 should sit 11mm above the board surface. Note also that the 10µF capacitor must be mounted flat against the board (see photo).



This is the fully-assembled main PC board but with both the Garmin GPS 15L receiver and the oven cover (ie, the film canister) removed so that the components under them are visible. Make sure that all polarised parts are correctly oriented.

to the end of the oven heatsink, again using an M3 × 6mm machine screw. Smear both the transistor and heatsink mating surfaces with heatsink compound before slipping the transistor into position.

Take care with the orientation of Q1 – its metal surface goes towards the heatsink. Don't forget to solder its leads to the board after tightening its mounting screw.

The LM335Z temperature sensor (IC10) is next on the list – see Figs.6 and 7. It's in a plastic TO-92 package and slips easily into place between the heatsink fins. Before doing this though, give it a generous coating on both sides with heatsink compound. That done, slide it down between the heatsink fins so that its body sits about 6mm above the PC board before soldering its leads to the board.

Assuming you've already fitted varicap VC1, its 15pF series capacitor and the 47kΩ isolating resistor, the inside of the mini oven is now complete. All that remains is to fit its outer casing.

This casing is made from a 33mm-diameter plastic film canister (you can get one from a photo processing store) and lined with expanded polystyrene foam sheet about 3mm thick. It's built as follows:

(1) Shorten the canister to about 32mm long, using scissors or a sharp knife.

(2) Cut a 31mm diameter disc from an expanded polystyrene foam sheet and push it right down to the bottom of the canister.

(3) Cut another piece of foam into a 28 × 70mm strip and make a series of shallow cuts across the strip on one side, so that it can be rolled lengthwise into a tubular shape. Fit this inside the canister to form the wall lining.

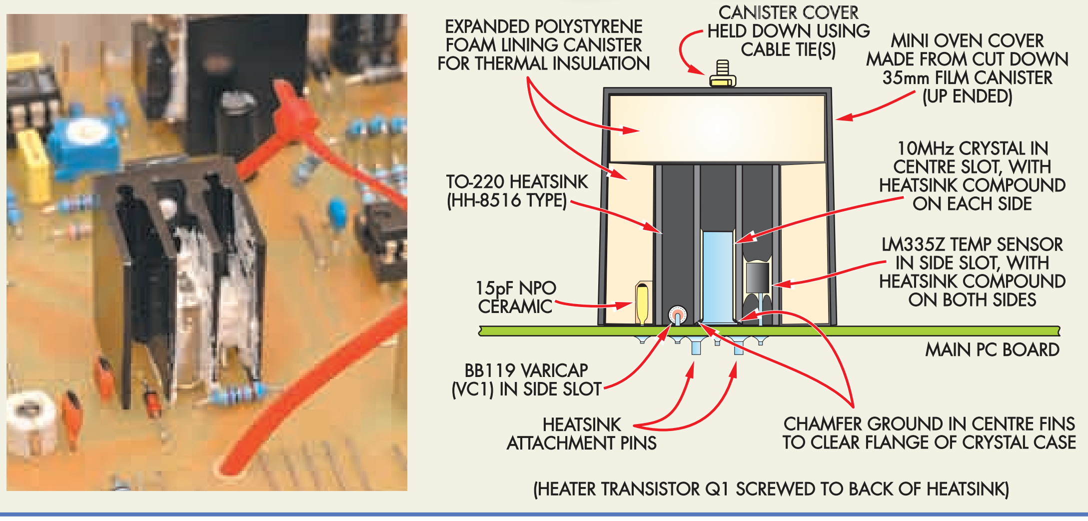
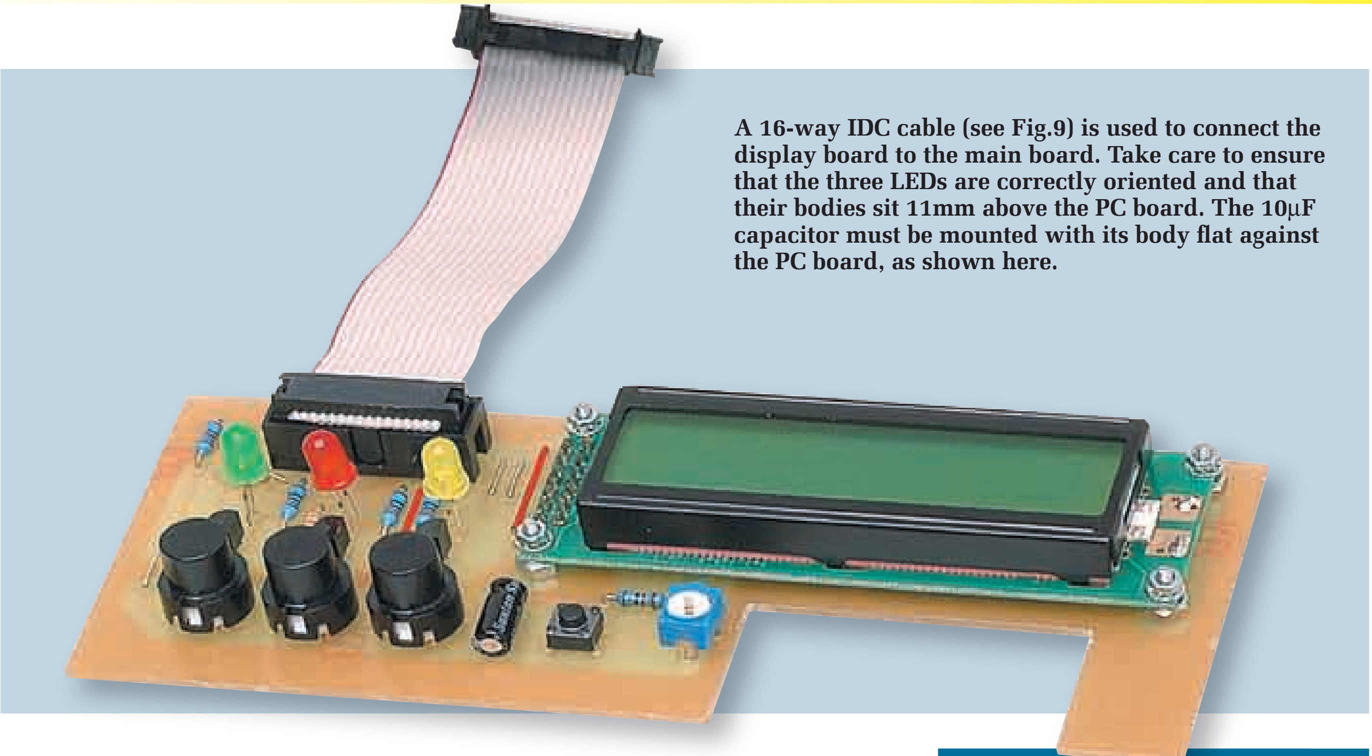


Fig.7: this detail drawing and the photo at left show how the mini-oven is built. Not shown here is heater transistor Q1, which is fastened to the back of the heatsink.



A 16-way IDC cable (see Fig.9) is used to connect the display board to the main board. Take care to ensure that the three LEDs are correctly oriented and that their bodies sit 11mm above the PC board. The 10μF capacitor must be mounted with its body flat against the PC board, as shown here.

Having lined the canister, the next step is to 'up-end' it and lower it down over the mini-oven components on the PC board. Note, however, that you may have to cut a small 'pocket' in one side of the foam liner to clear the 15pF capacitor.

Finally, a long plastic cable tie (or two shorter cable ties in series) can be threaded through the adjacent 3mm holes in the PC board and tightened to hold the canister down. The mini-oven assembly is now complete.

Installing the ICs

The next step in the assembly is to install all the ICs. If you've previously installed IC sockets, then it's just a matter of plugging the ICs in, taking care to ensure they are all correctly oriented. Be sure to use the correct device at each location.

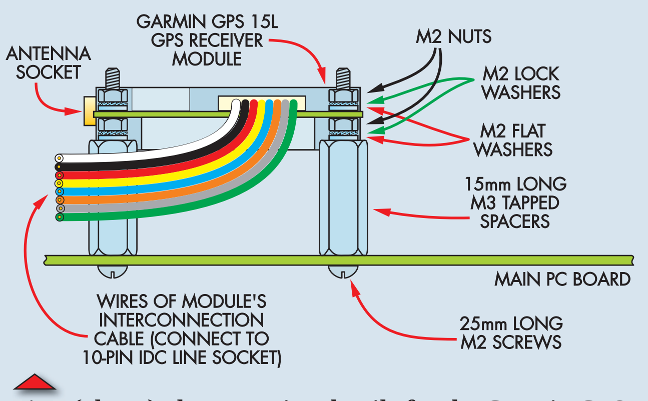
Note that most of the ICs are CMOS devices and are easily damaged by electrostatic discharge. It's really just a matter of taking a couple of precautions: (1) avoid touching the IC pins;

Table 2: Capacitor Codes

Value	μF code	EIA Code	IEC Code
100nF	0.1μF	104	100n
2.2nF	0.0022μF	222	2n2
1nF	0.001μF	102	1n0
100pF	NA	101	100p
33pF	NA	33	33p
22pF	NA	22	22p
15pF	NA	15	15p
4.7pF	NA	4.7	4p7

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	5	1MΩ	brown black green brown	brown black black yellow brown
❑	1	68kΩ	blue grey orange brown	blue grey black red brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	2	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	9	20kΩ	red black orange brown	red black black red brown
❑	10	10kΩ	brown black orange brown	brown black black red brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	2	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	1	2kΩ	red black red brown	red black black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	1	680Ω	blue grey brown brown	blue grey black black brown
❑	3	330Ω	orange orange brown brown	orange orange black black brown
❑	2	180Ω	brown grey brown brown	brown grey black black brown
❑	4	100Ω	brown black brown brown	brown black black black brown
❑	1	68Ω	blue grey black brown	blue grey black gold brown
❑	1	33Ω	orange orange black brown	orange orange black gold brown



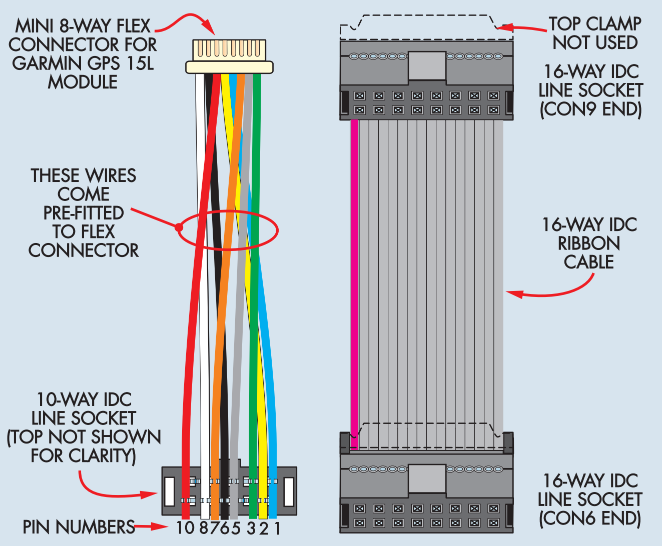


Fig.8 (above): the mounting details for the Garmin GPS 15L receiver module.

Fig.9 (right): this diagram shows how to fit the 10-way IDC line socket to the Garmin GPS 15L's cable. It also shows how to make the 16-way IDC ribbon cable.

and (2) earth yourself while you're removing them from their packaging and plugging them in (eg, by periodically touching an earthed metal object or by using a wrist strap).

Installing the GPS module

Fig.8 shows the mounting details for the Garmin GPS 15L receiver module. This mounts above the main board, behind the mini-oven assembly and above IC9, IC12, the resistors in the ladder DAC and sundry other parts.

As shown in Fig.8, the module is mounted on three M3 × 15mm tapped spacers and secured using three M2 × 25mm machine screws, together with six M2 nuts, six M2 flat washers and six M2 lockwashers.

Note that the GPS 15L module has a very small female MCX connector for the active antenna lead on one of the longer sides and an ultra-miniature 8-way SIL 'flex' connector on one end for all other connections. The module is mounted over the main PC board with its antenna connector facing towards the front and the flex connector end on the right (near CON7).

Once the receiver module has been mounted, shorten all eight wires on the special interconnecting cable supplied with it (ie, with the tiny 8-way flex connector at one end) to about 60mm long. Don't bare their ends though, because they need to be fitted to a 10-way IDC line socket to mate with CON7.

Although IDC sockets are intended for use with ribbon cable, they can also be used with separate light-duty hookup wires of the type used to make the receiver module's cable. The idea is to partly assemble the socket first and then feed the end of each wire through from one side, passing it over the teeth of its connector pin and out the other side.

Fig.9 shows where each wire goes on the connector. Once all eight wires have been fitted, the two halves of the connector are squeezed together firmly in a small vice to make the insulation displacement connections. Finally, the top part of the socket can be fitted if you wish and a small cable tie or two used to keep the wires together.

The completed cable can now be connected between the GPS module's connector and CON7.

Display board assembly

Fig.6(b) shows the display board assembly. Begin by installing the nine wire links (four under the LCD module), then install the resistors, trimpot VR2 and the transistors Q2 to Q4. Follow these with CON9, the 14-way (7 × 2) pin header for the LCD module, switches S1 to S4 and the 10μF electrolytic capacitor. **The latter must lie flat against the PC board – see photo.**

Take care when installing switches S1 to S3. Each switch must be seated all the way down on the PC board, with its flat side to the left.

The next step is to fit the three LEDs (LED1 to LED3). These must be installed with their bodies exactly 11mm above the board, so that they later protrude through matching holes in the front panel. A cardboard spacer cut to 11mm is the easiest way to do this – just push each LED down onto the spacer and solder its leads.

All that's left now is the LCD module. Fig.10 shows the mounting details. Install the four M2 x 10mm screws first and secure them using M2 nuts. That done, place an M2 flat washer on top of each nut. Then mount the LCD module in position, making sure it mates correctly with the header pins.

The module can now be secured in position using four M2 washers, four lockwashers and four M2 nuts. That done, the header pins can be carefully soldered to the pads on the top of the LCD module.

Interconnecting cable

You now need to make up a small ribbon cable assembly to connect the two PC boards together. This is made using a 95mm length of 16-way IDC ribbon cable, fitted with a 16-way IDC

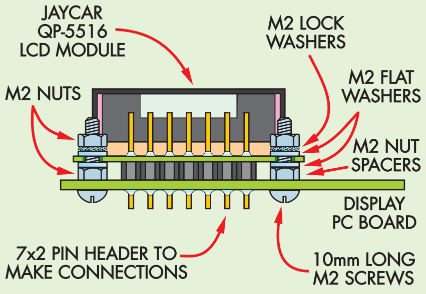


Fig.10: the LCD module is secured to the display board with M2 × 10mm screws, nuts and flat washers.

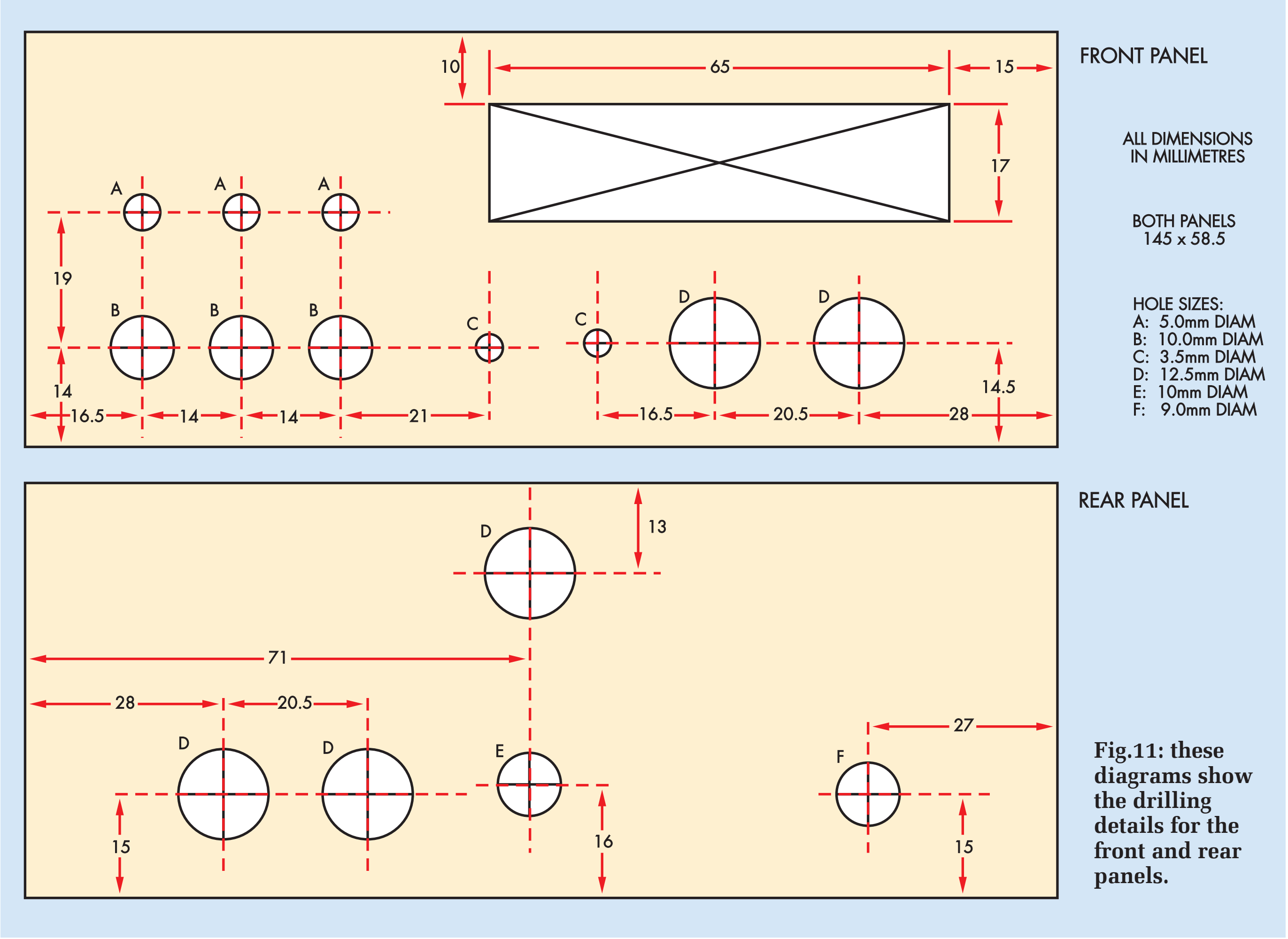


Fig.11: these diagrams show the drilling details for the front and rear panels.

line socket at each end – see Fig.9. Note that the two sockets both face in the same direction.

Note also that you cannot fit the usual top cover to the socket at the display board end, because there isn't enough space for it to clear the front panel. In fact, you may even need to file about 0.5mm from the top of the line socket to provide enough clearance.

You now need to prepare the front and rear panels of the case by drilling and cutting the various holes. These are all shown in the panel cutting diagram – see Fig.11. The 12.5mm diameter hole in the upper centre of the rear panel is used for mounting a BNC female-female panel adaptor. This is used to bring out the GPS receiver module's antenna lead.

Once the panels have been drilled, they can be dressed by attaching the front panel artworks (see Fig. 12). These artworks are attached using double-sided adhesive tape. Once attached, they can be protected by covering them with clear self-adhesive film (eg, wide sticky tape).

Case assembly

Now for the final assembly. The first step is to loosely fit the front and rear panels to the main board. That's done by removing the nuts and lockwashers from BNC connectors CON1 to CON4, then fitting the panels in place over these connectors and refitting the nuts and lockwashers.

Don't tighten the nuts at this stage – instead, leave them loose so that the panels can be adjusted.

Having attached the panels, you can now lower the entire assembly into the bottom half of the case, sliding the front and rear panels into their matching case slots as you go. Similarly, the display PC board slides into the third board slot from the front. The main board is then secured to the integral moulded support pillars using four small self-tapping screws.

The next step is to fit the cable that connects the GPS receiver module to CON7 on the main board. That done, fit the 16-way IDC cable between CON6 on the main board and CON9 on the display board.

Construction can now be completed by fitting the BNC-BNC adaptor to the rear panel and connecting the internal MCX-BNC antenna cable between this adapter and the GPS receiver module. That done, tighten the nuts on the front and rear panel BNC connectors.

Setup and adjustment

Before doing anything else, you need to install your active GPS antenna. This must be mounted outside and as high as possible, so that it gets an unobstructed 'view' of the sky. A good position should be on the top of your TV antenna mast, but you may decide on somewhere else because of the need to keep the cable length as short as possible.

The receiver end of the antenna is fitted with a BNC plug, to mate with

What the PIC firmware does

The main part of this project is the hardware circuitry which effectively locks the phase of the main 10MHz crystal oscillator to the very accurate 1Hz pulses from the GPS receiver module, as explained in the text. However, since the GPS receiver module also provides strings of useful GPS-derived data every second, along with the 1Hz pulses, we use a PIC micro to 'catch' these strings of data and allow selected data items to be viewed on the LCD.

The GPS data stream is sent in ASCII sentences at 4800bps, or 480 characters per second. The main part of the firmware program in the PIC scans front panel pushbuttons S1 to S4 and if none of the buttons are pressed, it simply waits until a character arrives from the GPS receiver and is 'caught' by the hardware USART module in the PIC.

When this happens, the PIC jumps into an interrupt servicing routine, and after making sure there weren't any errors, it reads the received character from the USART and then inspects it to see if it has any special significance – such as the start or end of a sentence. If it isn't one of these special characters, it simply saves the character in the next available address in a buffer area in its data RAM.

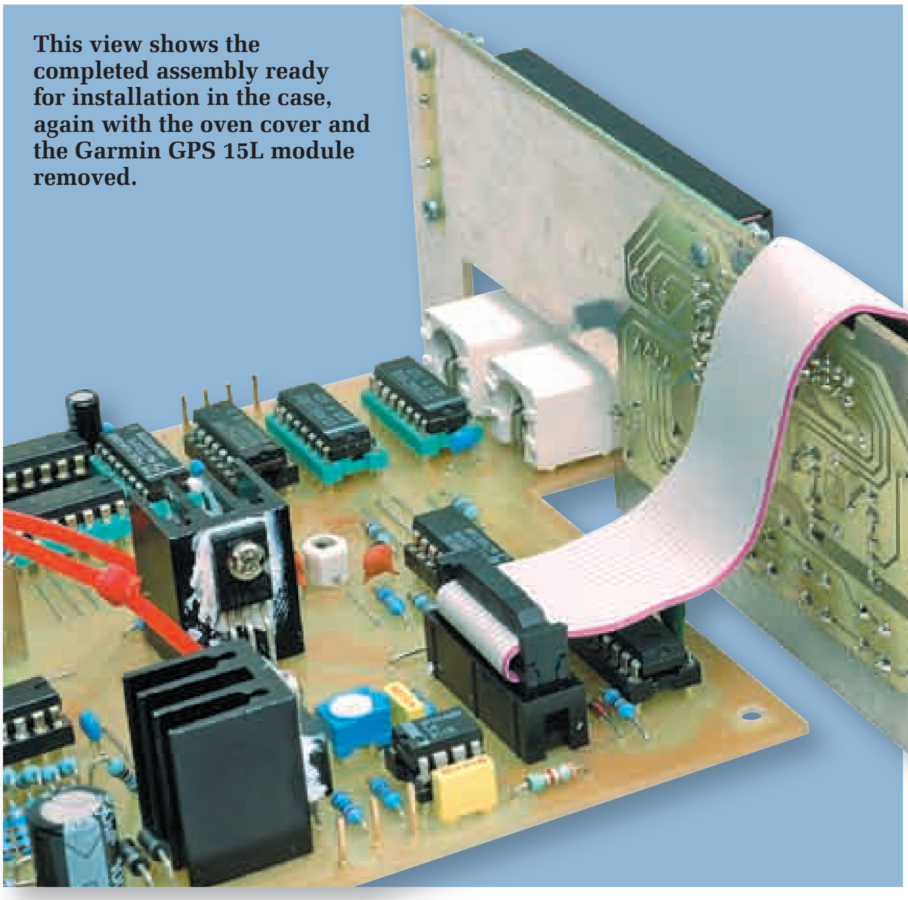
However, if the character is a 'start of sentence' character, it doesn't save it. Instead it simply resets the PIC's 'pointer' to the RAM buffer, so that following characters in the sentence will be saved from the start of the buffer.

On the other hand, if the character is an 'end of sentence' character, it jumps to a separate part of the interrupt routine which analyses or 'parses' the sentence in the RAM buffer to identify which kind of a sentence it is. It then saves the wanted data in that sentence into specific RAM addresses, where they can be displayed later.

As well as scanning the pushbuttons, the main part of the project simply displays some of this received GPS information on the LCD – ie, the UTC time and date, plus the GPX receiver's fix status and the PLL lock status.

However, if you press switch S1, S2 or S3, the program switches to one of three alternative display modes, which allow some of the other GPS information to be displayed – the latitude and longitude, the antenna height above mean sea level, the number of GPS satellites currently in view and so on. Each of these alternative display modes only lasts for about 20 seconds, after which the program switches back to the main time and date display.

Finally, press switch S4, the program displays a message to advise that it is sending initialisation commands to the GPS receiver (and does just that). It then switches back to the main display again.

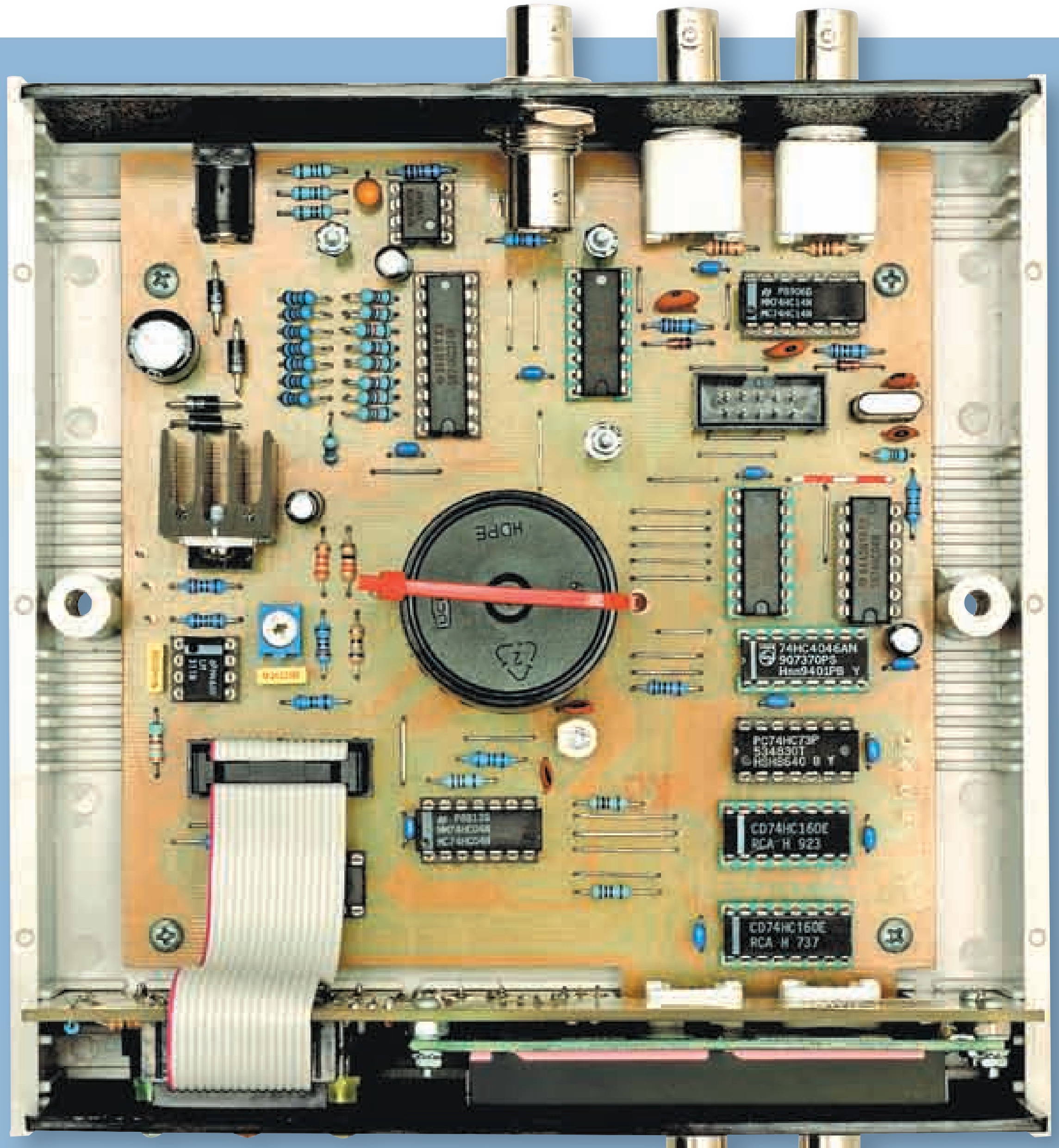


This view shows the completed assembly ready for installation in the case, again with the oven cover and the Garmin GPS 15L module removed.

the 'outside' section of the rear panel BNC adaptor. Be sure to fit this plug without introducing any short circuits, because this cable carries DC power up to the active antenna (via the GPS receiver module), as well as carrying the GPS signals down to the receiver. A short circuit could damage the GPS module.

Once the antenna is in place, apply power via the DC input socket (CON5). LED2 (PLL Lock) on the front panel should begin glowing almost immediately and you should also be able to measure +5V on the wire link just to the right of IDC header CON6 (relative to the TPG ground pin to the left of REG1). The LCD should also spring to life, although it will probably be showing mainly zeroes for the first 10 to 20 seconds.

After this time, the GPS receiver module should have found a 'fix' and the display should change to show the current UTC time and date, plus a '1' in the upper right-hand corner to show the fix status. LED3 on the front panel should also



The main PC board is secured to integral spacers on the base of the case, while the display board slides into one of the case slots. Note that the front and rear panels must be attached to the BNC sockets on the main board before mounting it in the case.

begin to blink once per second, showing the GPS 1Hz pulses, while LED1 should also begin glowing continuously to show the fix status.

LED2 may now either be off or it may begin to flash, because the PLL may not be able to lock the phase of the 10MHz crystal oscillator with the 1Hz GPS pulses as yet.

Adjusting the mini-oven

The next step is to check the status of the mini oven's temperature control. First, measure the voltage at test point TP1 relative to ground pin TPG; this should measure very close to +3.15V.

The Garmin GPS 15L receiver module is mounted on spacers attached to the main board (see Fig.8). It sits above ICs 9 and 12 and is connected to the main board via the 10-way IDC line socket.

This view shows the fully-assembled unit, with both the Garmin receiver and the oven cover in place. Note the internal antenna connection from the Garmin GPS 15L receiver's socket to the BNC-to-BNC adapter on the rear panel (see also picture on facing page).

Monitoring its performance

If you're using your frequency reference in a normal workshop/home lab environment, there's probably no need to monitor its performance any further than glancing at its front panel displays from time to time – to confirm that its GPS fix and PLL lock status are both OK. However, if you need to monitor its performance in more detail, this can be done fairly easily using the DC error voltage fed out via CON8 on the rear panel.

There is a direct relationship between this error voltage and the instantaneous phase error in the frequency reference's PLL. In fact, each 19.53mV of this error voltage corresponds to 100ns of phase error. So, if you have the PLL stabilised at an average phase error of 10µs, then the error voltage will have an average value of 1.953V. And as the phase error jitters up and down in 100ns increments, the instantaneous error voltage will similarly vary up and down in 19.53mV increments.

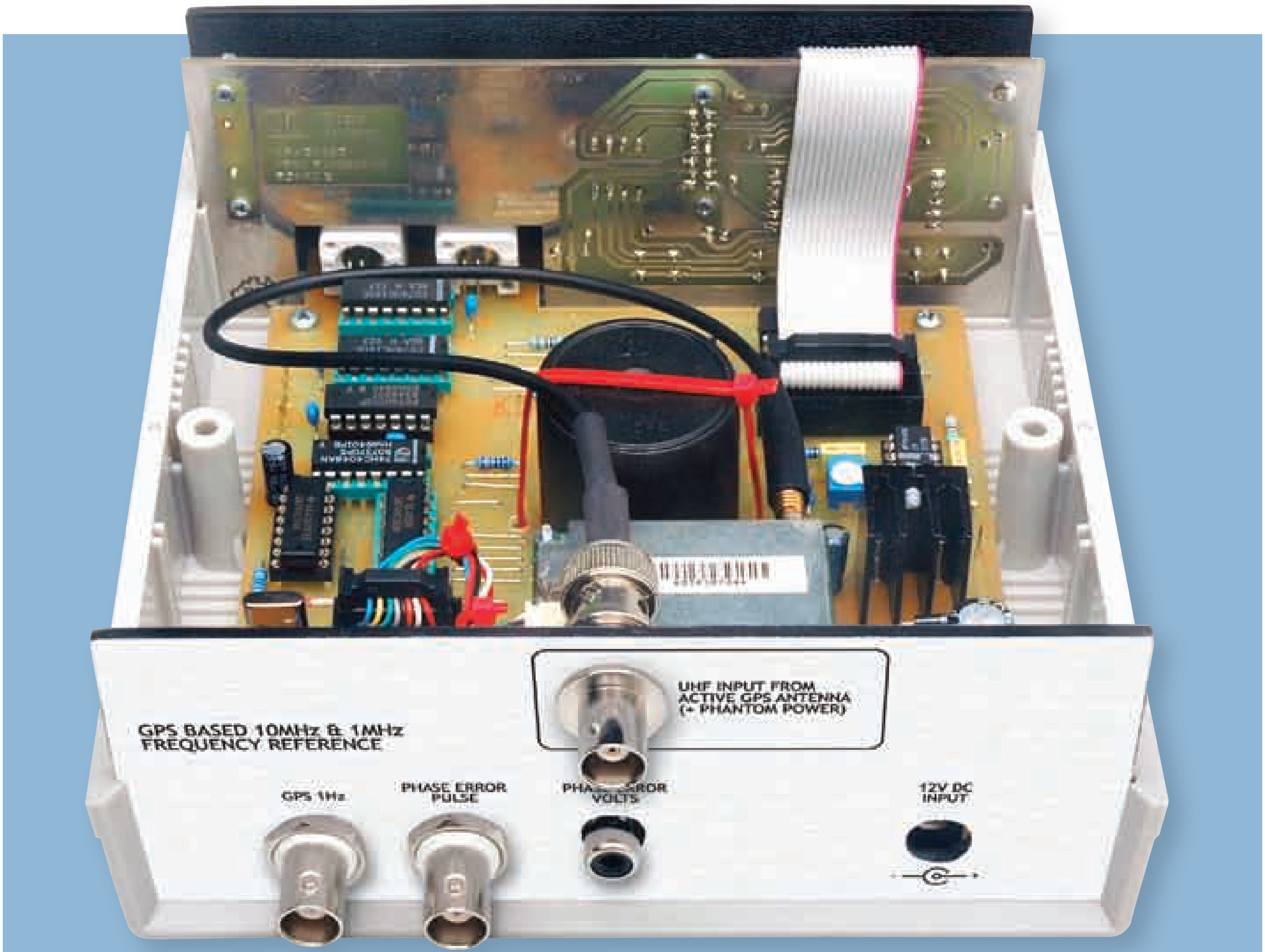
This means that if you monitor the DC error voltage continuously using a DMM and link the DMM to a PC running a data-logging program, you can record the frequency reference's PLL performance over a suitable period of time. You can then plot the mean value and standard deviation of its phase lock error. This will give you a much better idea of its medium and long-term accuracy, as well as the short-term error tolerance.

You should find a similar voltage on TP2 (within a couple of tens of millivolts). This is the voltage across temperature sensor IC10 and reflects the temperature inside the mini oven (3.15V = 315K = 42°C).

If the voltage on TP2 is outside the range 3.14V to 3.16V, try adjusting trimpot VR1 in one direction or the other until the voltage drifts back inside this range. Don't adjust the trimpot setting in large jumps though, because the temperature changes quite slowly following each adjustment.

Adjusting the PLL

When you are satisfied that the voltage at TP2 is stabilising inside the correct range, you are ready to turn your attention to setting up the 10MHz crystal oscillator and the PLL. For this, you will need to use an oscilloscope and a frequency counter.



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

The input of the scope should be connected to CON4 on the rear panel of the frequency reference, where it will be able to monitor the PLL's phase error pulses (inverted). By contrast, the counter's input should be connected to CON1 on the front panel, where it can measure the 10MHz output signal.

Before you start setting up, see what frequency reading you are getting on the counter. It should already be quite close to 10.000000MHz, although the exact reading will depend on the calibration of the counter's own timebase.

Pulse setting

Now look at the pulse waveform on the scope. What you should see is a negative-going rectangular pulse of 5V peak-to-peak, with a width somewhere between 0µs and 20µs. It may not be fixed in width, though – in fact, if the PLL isn't in lock yet, it may be cyclically varying up or down in width within the 0-20µs range.

At this stage, try adjusting trimcap VC2, which you'll find just to the front right of the mini oven. Adjust it using a small insulated alignment tool and change its setting by only a very small amount in one direction or the other. As you do, watch the pulse waveform on the scope. If it was cycling back and forth in width, this cycling will slow down if you're adjusting the trimmer capacitor in the right direction.

Conversely, if it speeds up, turn VC2 back the other way until it does slow down. If it wasn't cycling to begin with, but does so when you adjust VC2, the same applies – turn it back the other way.

The objective is to carefully adjust VC2 until the error pulse width stops cycling and remains fairly steady at a width of about 10µs. This setting corresponds to the PLL being locked close to the centre of its lock range.

By the way, don't be worried if the pulse width still varies up and down randomly in steps of 100ns (0.1µs). This is normal and is due to propagation jitter on the GPS signals, noise, dither in the PLL as a result of drift in the 'about-10MHz' clock oscillator, and so on.

Once you have achieved this stable pulse setting, check the reading on the frequency counter. It should now be reading very close to 10.000000MHz. If you get a reading very close to this, any error you see is almost certainly due to the calibration of the counter's timebase.

The only proviso here is if the counter reading is stable but very close to a frequency that's 200Hz away from 10.000000MHz (ie, 9.999800MHz or 10.000200MHz). In this case, it means that the PLL is locking quite nicely, but to one of those other frequencies.

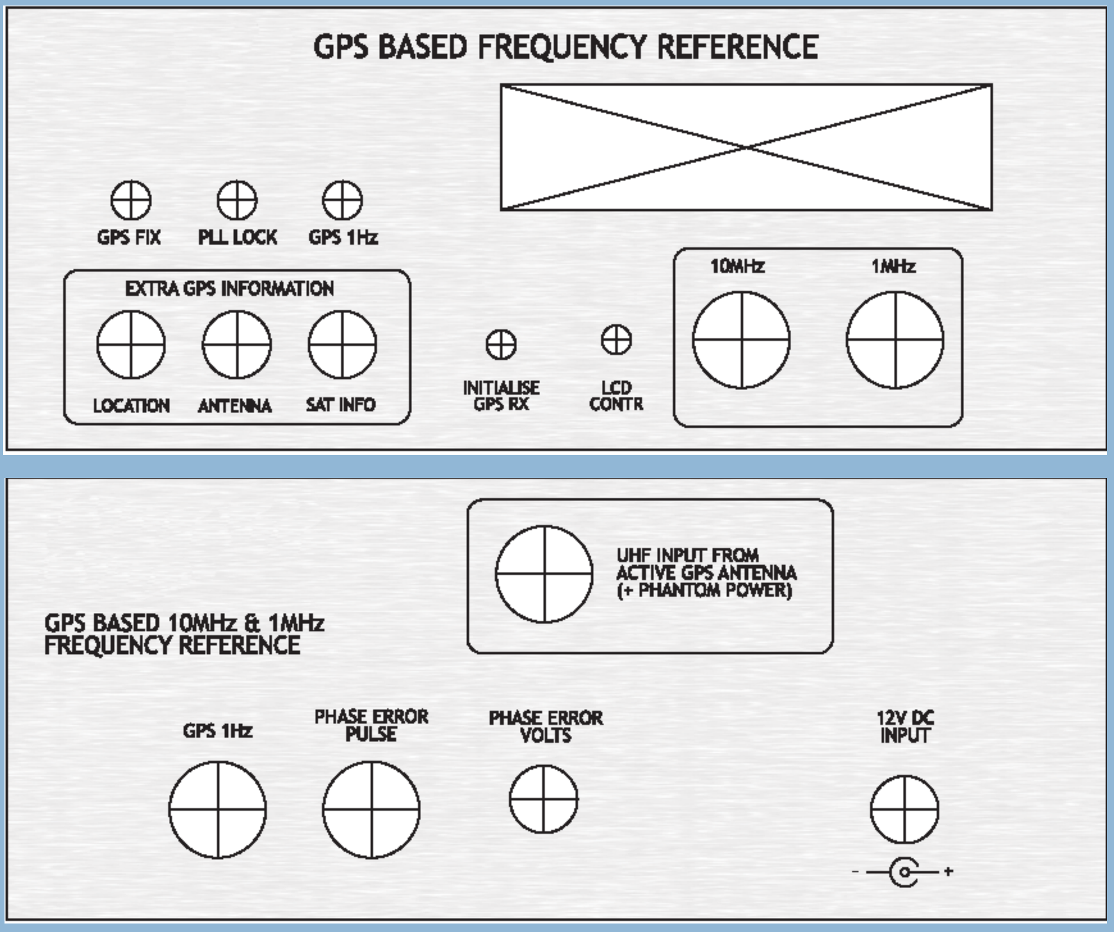


Fig.12: these full-size artworks can be copied and used to make the front and rear panels.

If you do get a reading very close to these '200Hz-away' frequencies, you'll need to try adjusting VC2 again until the PLL locks at the correct frequency.

If you can't achieve this by adjusting VC2, you will have to replace the 4.7pF NPO capacitor located just behind VC2 with a lower or higher value – depending on which frequency your PLL had been locking at. For example, if it was locking at 9.999800MHz and VC2 couldn't bring it up to 10.000000MHz, replace the 4.7pF capacitor with a 2.2pF capacitor. Alternatively, if it was locking at 10.000200MHz and VC2 couldn't bring it down to 10.000000MHz, use a 6.8pF capacitor.

When your scope shows a reasonably stable phase error pulse (with a width close to 10µs) and the counter displays a reading that's very close to 10.000000MHz, your GPS-Based Frequency Reference should be set up and ready for use. LED1 (GPS FIX) and LED2 (PLL LOCK) should now both be glowing steadily, while LED3 should continue to blink reassuringly once per second. Similarly, the LCD should normally show UTC time and GPS fix status (Fx1) on the top line and UTC date and PLL lock status (PLL: L) on the lower line.

Additional information

Additional GPS information is available on the LCD for about 20 seconds if you press one of the three front-panel buttons. For example, pressing S1 (LOCATION) will display the exact latitude and longitude of your external GPS antenna, while pressing S2 (ANTENNA) will display the antenna's height in metres above mean sea level, plus the number of GPS satellites currently in view.

Pressing S3 (SAT INFO) displays the identification number of the main four satellites in current view, plus the signal-to-noise ratio of their signals in dB – giving you a good idea of the current GPS 'fix' quality.

If your LCD readout isn't very clear, try adjusting contrast control VR2 using a small screwdriver through the hole in the lower centre of the front panel. This should give you an easy-to-read display.

Normally, you shouldn't need to initialise the GPS receiver module using switch S4 (accessible via the second small hole in the front panel). However, by all means try doing this if you are unable to set up your frequency reference as described earlier.

At the very most, this initialising should only be necessary once, because the GPS module normally saves its configuration data in non-volatile flash memory, where it's read whenever the power is applied.

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Adding a serial data port to the GPS-Based Frequency Reference

It's quite easy to add an RS-232C serial output to the GPS-Based Frequency Reference, so that the NMEA data stream from the GPS receiver module can be fed out to a PC for other purposes.

Following publication of the circuit for the GPS-Based Frequency Reference, a few readers sent emails asking how to add a serial data output port. This would enable the NMEA data stream coming from the GPS receiver module to be fed out to a PC – for synchronising real-time clocks and other purposes.

As it happens, adding such a port is very easy. All that's needed is to mount a DB9M connector on the rear panel in a suitable spot (say above CON3 and CON4) and connect it to the main board via the simple inverting buffer circuit shown in Fig.1.

As you can see, the circuit uses just two resistors and one PN100 transistor, so it could be wired on a postage-stamp sized piece of matrix board and supported on the back of the DB9M connector by the wiring. There are only three connections to be made between this serial port circuit and the main PC board: one for the ground connection, one for the +5V line and the third for the buffered RS-232C GPS receiver's data stream available from the output of IC14e (pin 10).

This last signal is also conveniently available via the wire link on the top of the main board, just to the rear of IC8 and its 100nF supply bypass capacitor (one of the two links just to the front of CON7). *EPE*

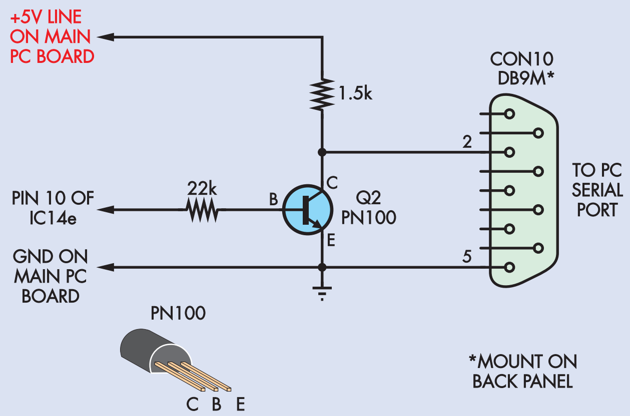


Fig.1: a serial data output port can be added to the GPS-Based Frequency Reference using this simple circuit.

Microstepping Four-Phase Unipolar Stepping Motor Driver

By MARK STUART

Achieve smoother motion by increasing the steps

STEPPING MOTORS are used in so many applications that they are becoming a common, though usually hidden, part of everyday life. They are very simple devices, which rely on their associated drive circuits to produce controlled, precise movement.

The simplest drive circuits allow movement in Full-step mode, where the motor windings are switched on and off in sequence, usually turning in 48 or 200 discrete steps per revolution. Half-step mode is achieved by switching the windings alternately singly and in pairs to achieve 96 or 400 steps per revolution. These drive modes only use on-off switching of the motor windings, and so the circuits are very basic, with just four switching transistors as output devices.

Microstepping

Microstepping achieves smoother motion with higher numbers of steps by driving the windings with variable current instead of just switching them on and off. In this way, each step can be divided by 4, 8 or even 16 parts so that a 200 step motor can give up to 3,200 steps per revolution.

The circuitry necessary to achieve this was once complicated and bulky, and reserved for expensive industrial drives. Now things are easier, and the SLA7062M stepper/driver device described here combines all of the drive and control circuits necessary to make microstepping relatively simple.

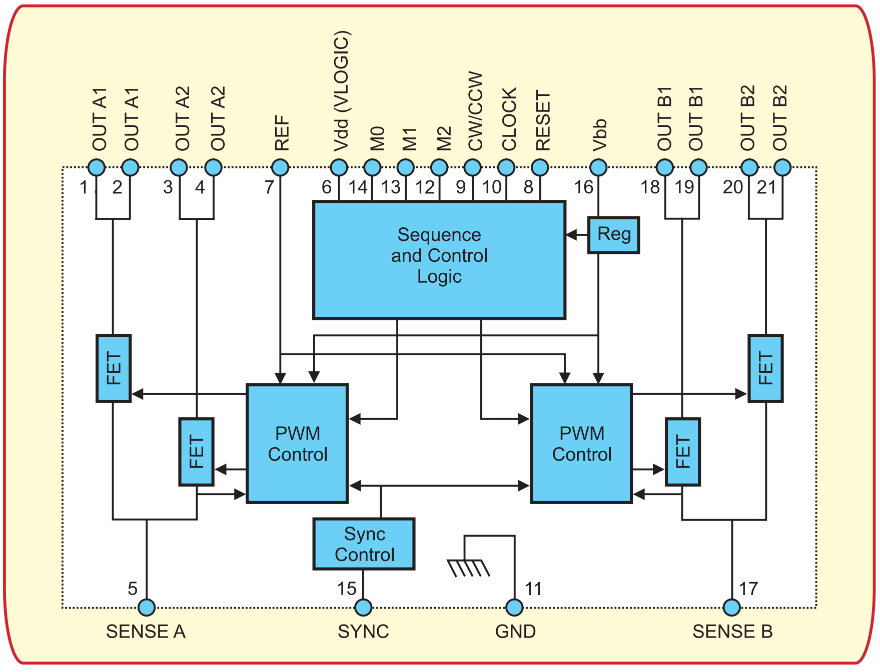


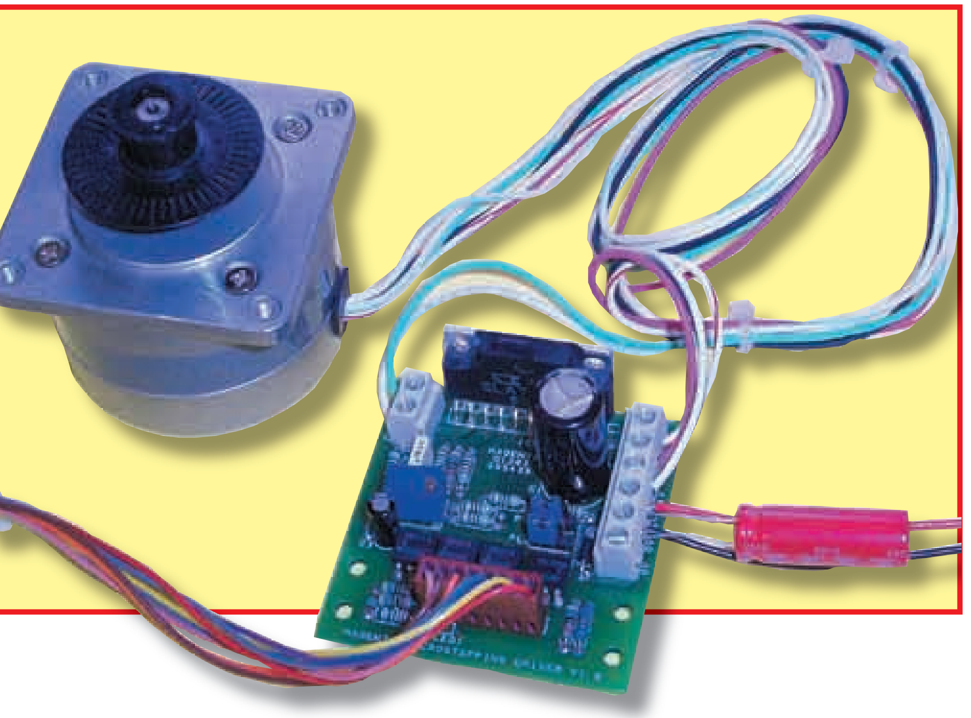
Fig.1: Simplified internal block schematic and functional diagram for the SLA7062M stepper motor translator/driver IC

Principles

The essential part of microstepping is controlling the current in the motor windings. In principle, it could be achieved by switching in a number of different resistor values. The result would be cumbersome, and very inefficient, but it would nevertheless produce microsteps.

To achieve current control efficiently, the SLA7062M uses PWM (pulse width modulation) control, applying variable width pulses to set the motor current to the required values. For sixteenth step operation, each winding current can take one of 16 different values, which are derived from a single external reference.

During a microstep, the current in each winding is sensed by the voltage drop across low value resistors in the 'ground' side of the output drivers. This is compared with the required value, and the PWM timing is adjusted accordingly.



takes place on each rising edge of the Clock input.

Reference voltages

The voltage applied to the REF pin allows the motor current to be controlled. This voltage is compared with the voltage drop across the output current-sensing resistors to control the PWM signal.

Values between 0V and 1.5V can be applied during normal operation. If this voltage is raised above 2V, then the circuit is put into Sleep mode, with the outputs turned off and most of the internal circuits shut down.

The step logic remains active though, so that the motor continues normally when Sleep mode is left. The number of microsteps can be selected by the logic level on the M1 and M2 pins, as shown in Table 2.

Special function

The Sync pin has a special function that allows the two PWM controllers to be locked together so that they run at the same frequency. This function can reduce the switching signal noise level when the motor is in certain positions, but can also reduce performance in other ways.

It is most effective when both windings are being driven at 70.7% of maximum current. At other step positions the winding current levels differ substantially and so synchronisation of the PWM signals is not recommended.

The M0 pin provides indication of when the step sequence is in a 'home' state. This is the state where two windings are driven at 70.7% of maximum current. It occurs four times during each complete step sequence. This signal can be used by the controller to give a limited amount of information about the driver.

Table 1. SLA7062M input and logic output pins

Name	Pin No.	Function	Comment
V_{BB}	16	Output driver supply	10V to 44V
REF	7	Current sense reference voltage	0V to1.5V = operate mode 2V to V_{DD} = Sleep mode
Reset	8	Reset for step logic	High = reset, Low = run
Clock	10	Step input pulse	Steps on low to high edge
CW/CCW	9	Direction input	Sets CW/CCW direction
M2	12	Step mode selector 2	Set 2, 4, 8 or 16 step mode
M1	13	Step mode selector 1	
M0	14	Home state indicator output	Logic high when in home pos.
V_{DD}	6	Logic supply	+3V to +5.5V
Sync	15	Synchronise PWM control	Locks PWM frequencies together to reduce noise

As two windings of the motor are driven at any one time, there are two independent PWM circuits. All of the current values are selected by internal logic that controls the step sequence in response to simple 'Step' and 'Direction' signal inputs.

The SLA7062M

The manufacturer's data sheet for the SLA7062M can be found at:

http://www.allegromicro.com/en/Products/Part_Numbers/97060/97060.pdf

This contains all of the necessary information about the device and some very good tables and graphs showing the stepping sequences and the different current levels used in microstepping.

A simplified internal block schematic and functional diagram of the device is shown in Fig.1.

Table 1 shows the input connections and their functions. V_{BB} is the main power supply pin for the output control circuits. It must be 10V or more to ensure adequate gate drive for the output FETs.

The logic circuits are driven by the V_{DD} supply, which can be between 3V and 5.5V. Reset is pulsed high to set the sequence logic to a known state after power up. Clock (step) and CW/CCW (direction) are the inputs to the control logic circuit. Stepping

Table 2. Step mode Control

Input M1	Input M2	Mode
H	H	Half Step
H	L	Quarter Step
L	H	Eighth Step
L	L	Sixteenth Step

Components mounted on the topside of the printed circuit board. Stepper motor driver IC5 is mounted on the PCB with its 'thermal tab' pointing away from the top edge of the board

Application circuit

The application circuit described here allows the device to be connected and used as a stepping motor driver block, requiring simple inputs from a computer port or other controller with step and direction outputs. Control is also provided to turn on the Sync function, and there is an output to monitor the M0 home position signal.

All inputs and outputs are opto- isolated so that the high currents, voltages and fast pulses in the motor control circuits are separated from the driver and control signals.

Power supply

The application circuit diagram is shown in Fig.2. Power from the main motor supply is applied directly to the motor winding centre taps, and also to the driver circuit via polarity protection diode D1. Capacitor C1 ensures the V_{BB} driver supply is free of interference and noise. The logic circuits in the driver are supplied with 5.1V from V_{BB} via resistors R7, R8, shunt regulator Zener diode ZD1 and decoupling capacitor C3.

Two resistors, R7 and R8 have been used to allow for higher power dissipation, and to make it easier to use other resistance values to accommodate different motor supply voltages. The combined resistance value should be chosen to deliver 12mA at the nominal motor supply voltage.

Reset circuit

A simple reset circuit is provided by C2 and R10. When power is applied, C2 pulls the reset pin high for a short time, setting the driver into an initial 'home state'. As C2 charges via R10 the reset pin is pulled to zero volts, putting the driver into operating mode.

In most applications it is necessary to put the motor into a known 'home'

Parts List – Microstepping Four-Phase Unipolar Stepping Motor Driver

1 PC board, code 710, size 56mm × 56mm (available from the *EPE PCB Service* or from Magenta Electronics Ltd)
4 Two-way terminal blocks, 5mm pitch snap together type (TB1 to TB4)
2 Three-way pin headers, each with one two-way shorting link (PL1, PL2)
1 Eight-way pin header, 0.1 inch pitch SIL (PL3)

Semiconductors
1 SLA7062M stepper motor driver (IC5)
4 CNY17-3 opto-isolators (IC1 to IC4)
1 BZX85, 5V1, 400mW Zener diode (ZD1)
1 1N4001 1A rectifier diode (D1)
1 surface mount LED, red low current, type 1206 (LED1)

Capacitors
1 1000µF 50V radial electrolytic, 5mm lead pitch (C1)
1 100nF 63V polyester, 5mm lead pitch (C2)
1 100µF 10V miniature radial electrolytic (C3)
1 470µF 50V (minimum) low impedance, motor decoupling, radial elect. – see text

Resistors (0.6W, 5% metal film, unless stated otherwise)
6 1Ω 2512 surface mount 1W (R1 to R6)
3 2.2kΩ (R7, R8, R23)
3 4.7kΩ (R9, R13, R14)
2 10kΩ (R10, R11)
4 470Ω (R12, R19, R20, R21)
1 1k (R15)
1 100Ω (R22)
3 47kΩ surface mount, type 1206 (R16 to R18 see text)

Potentiometer
1 5kΩ multiturn preset, 0.1 inch pitch in-line leads (VR1)

(Magenta Electronics Ltd., can supply a complete kit of parts for this project, price £18.76. A special offer (for a limited time) is available for the complete kit plus a 200 step motor type MD23 (as shown in the photographs) for £26.96. Prices include VAT, add £3.00 for UK postage.

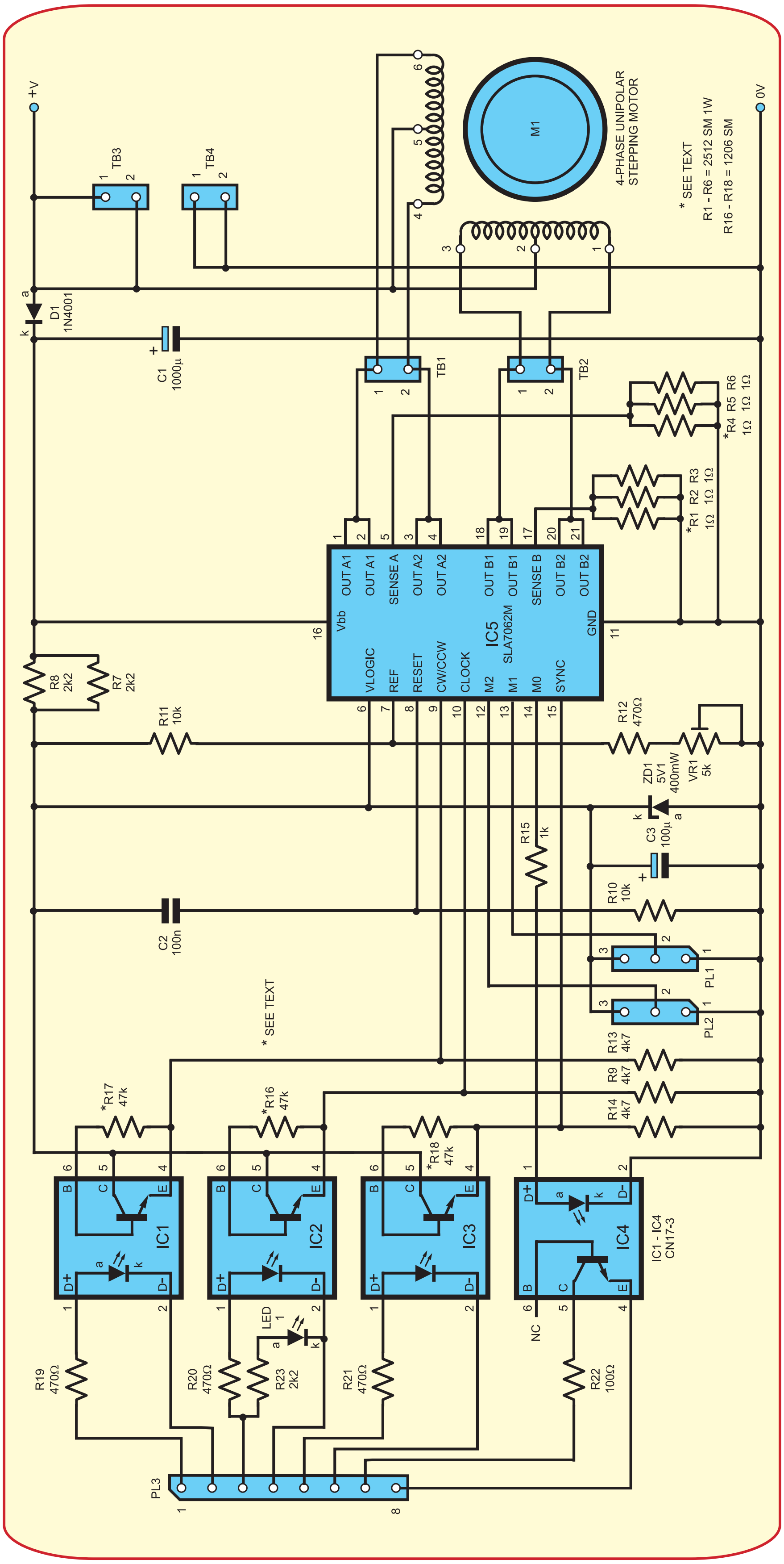


Fig.2: Full circuit diagram for the Microstepping Four-Phase Unipolar Stepping Motor Driver. LED 1, resistors R1 to R6 and R16 to R18 are surface mount types

position after switch on. This is normally achieved by driving the motor slowly until it reaches a sensor of some kind – usually a microswitch or an optical sensor, or a combination of both. All motor movement is then made from that initial reference point.

Step mode control

Two patch areas with jumper links allow the M1 and M2 pins to be linked to 5V or 0V. Table 2 shows how these select the step mode.

The output driver FETs have current-sensing resistors in their ground (source) connections. These are R1, R2, R3, and R4, R5, R6. Surface-mounted chip resistors have been chosen to minimise stray inductance and provide a good means of heatsinking straight to the circuit board copper track area.

Using three resistors in parallel allows easy setting of suitable values and higher power dissipation capability. Although surface mounted, the size of these power resistors makes them relatively easy to solder.

Current adjustment

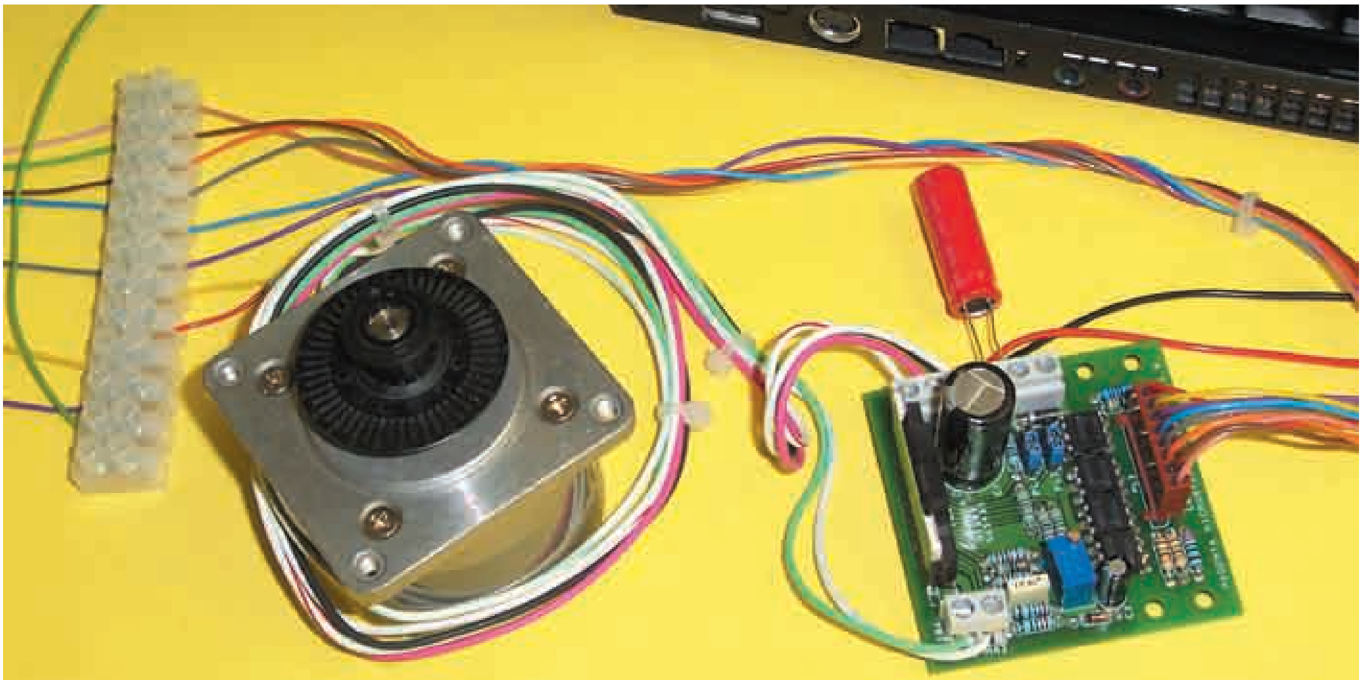
The voltage on the REF pin (V_{REF}) defines the cut off point for the current control of the output drivers. Resistors R11, R12 and preset VR1 are in a potential divider chain, which sets the REF voltage from the 5.1V logic supply.

Adjusting VR1 allows the value to vary from 0V to 1.5V. This voltage is compared with the voltage drop across the current sensing resistors. The combination of V_{REF} and R1, R2, R3 and R4, R5, R6 sets the motor current levels.

Inputs

Motor drive circuits have high current and voltage pulses, and so it is important to separate them from logic and controller devices. Using opto-isolators is a very effective means of separation, as it removes the ground connection as well as the signal inputs. It also has the advantage that input signals of either polarity can be connected just by reversing the connections to the opto-isolator LED inputs.

Three isolated inputs are provided, CW/CCW (direction), CLOCK (Step), and Sync. Resistors R13, R9,and R14 hold the driver logic circuit inputs low. Signals that turn on the opto-isolators pull the driver logic inputs high.



The completed circuit board linked to a small 200 step motor. Note the motor decoupling electrolytic capacitor wired directly between terminal blocks TB3 and TB4. It should have a *minimum* value of 470µF, see text

Resistors R16, R17 and R18 are optional base pull-down resistors that can be fitted to increase the turn-off speed of the opto-isolator phototransistors. When using sixteenth step driving, the motor needs a high input clock rate to be driven at speed, and so adding R16 may be necessary. The value depends on the type of opto-isolator fitted, but 47kΩ provides a good compromise – increasing the speed without reducing the sensitivity too much.

An LED has been added across the Clock input to give some useful indication that there is activity when fault finding. Logic outputs should be capable of driving 3mA at 4.5V. Most circuits can provide suitable levels.

As the inputs are effectively just LEDs with series resistors it is possible to connect them for negative or positive drive signals. The controller will need to provide the correct signals polarity to suit.

Output

A single isolated output via IC4 permits monitoring of the M0 home position. The output must be treated as an 'open collector' signal and needs a load resistor to produce a suitable voltage output. The resistor can be in either the emitter or collector circuit of the output phototransistor, and so can be arranged to give a positive or negative going output.

Motors

The circuit has been tested with a number of small and medium sized stepping motors. Only *unipolar motors* can be used. These normally have two centre tapped windings and are connected as shown in Fig. 2. Some motors have four separate windings which allow unipolar or bipolar operation by making appropriate connections.

Setting the required current levels is achieved by selecting the values of R1 to R6. Fitting three resistors of the same value spreads out the heat evenly for higher current levels. If lower current levels are used, only one, or two resistors need to be fitted.

Power supplies

Although C1 decouples the driver power V_{BB}, it is also important to ensure that the motor supply has a good low impedance decoupling capacitor connected close to the driver board. A minimum of 470µF connected directly between TB3 and TB4 where the power is connected to the circuit board will ensure that the PWM control runs correctly.

The motor current is controlled by the PWM circuit and not directly by the supply voltage. Using a higher voltage is important because it forces the motor current to rise more quickly and so allows higher operating speeds and better acceleration.

Medium and larger size motors, which are intended to be used with advanced driver circuits and high voltages would reach their maximum rated current if driven at only 4V or 5V from a DC source. This arrangement minimises the winding inductance and allows high current rise times, which maximise the motor's performance.

The SLA7062M has a maximum voltage rating of 44V and can handle current up to 3A, with appropriate heatsinking. The output FETs are avalanche protected so that they will handle the normal inductive switching spikes generated by the motor leakage inductance. With larger motors, adding fast clamp diodes between the end of each winding and the motor positive supply will provide additional protection.

Construction

A small double-sided circuit board with plated through holes accommodates all of the components, with terminal blocks for the motor windings and power connections and a 0.1 inch pitch pin header for the control signals. The layout has been carefully thought out to avoid ground loops by confining the motor current to large direct copper areas.

This board is available from the *EPE PCB Service*, code 710. Fig. 3. shows the board component layout and full-size top and underside copper foil tracks. Fig.4 indicates the positioning of the

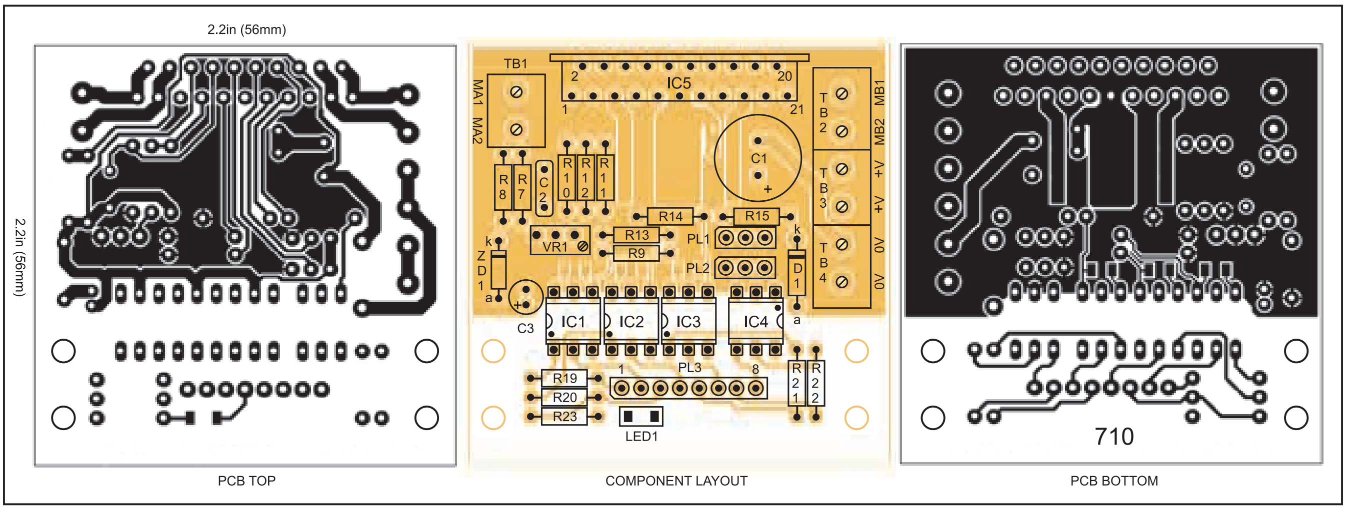


Fig.3. Stepper motor driver printed circuit board component layout and full size copper foil masters for the topside and underside of the board

surface mount resistors on the underside of the PCB. For further guidance, the photographs show the completed board.

There is provision for a small surface-mounted indicator LED1 on the top side of the board. Speed-up resistor R16 (a 1206 surface-mounted type) is necessary for high stepping rates, but R17 and R18 will not be needed in most applications.

A heatsink for IC5 will be needed in most cases. The thermal tab is connected internally to 0V, so insulation might not be necessary in systems with negative ground, but in that case make sure that a good direct connection exists between the heatsink and the circuit negative supply pin.

Testing

As with all construction, begin testing by thoroughly inspecting the circuit board assembly for misplaced components, dry joints, and solder bridges. A good flux cleaner is useful as a clean board is easier to check. Make sure that the two jumpers are in place on PL1 and PL2.

Simple tests can be carried out without a motor, using a multimeter to make sure that there is a supply on the V_{BB} pin, a 5.1V logic supply and that the voltage on the REF pin can be adjusted between 0V and approximately 1.5V. Temporarily set the REF pin to about 0.3V to provide a low current level for testing with a motor.

The inputs can be activated in turn with a battery or power supply, and the state of the corresponding pins on IC5 should be seen to change. Once the basic things are correct, a motor should be connected and the power applied through a current-limiting resistor to prevent damage if there is a fault. A temporary heatsink should be fitted to avoid

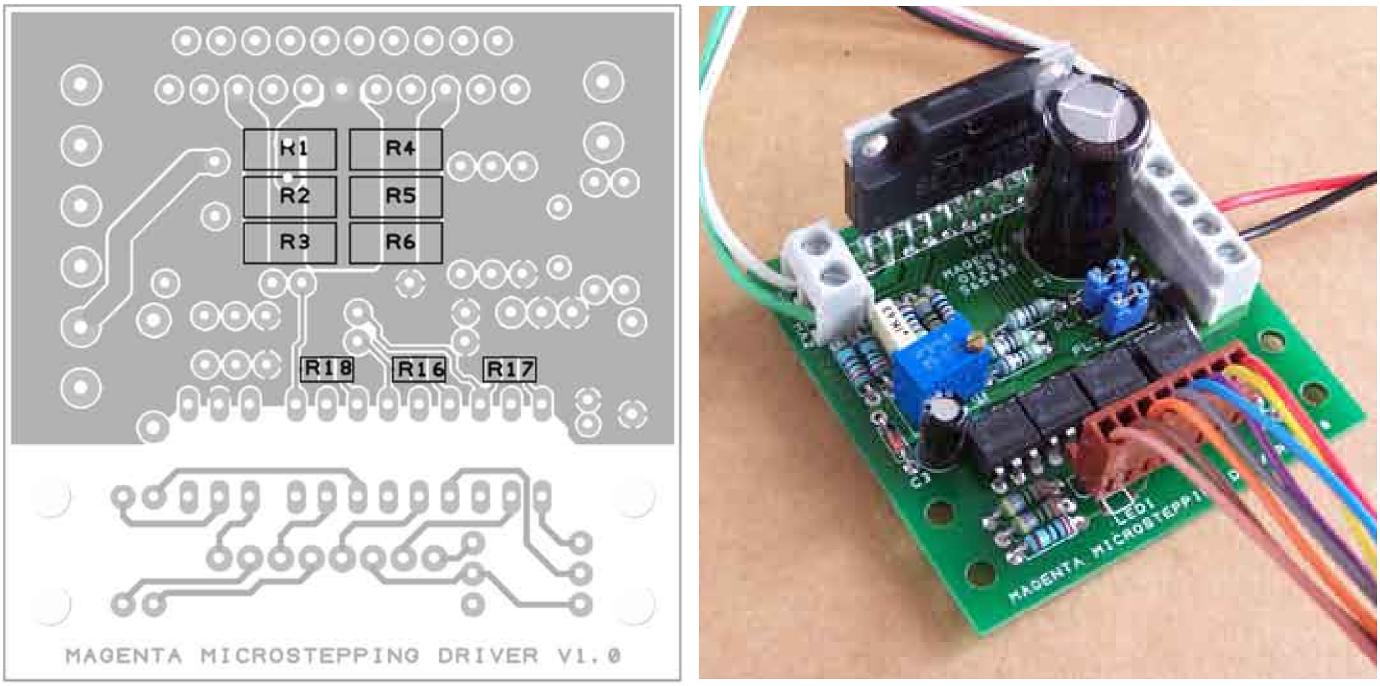
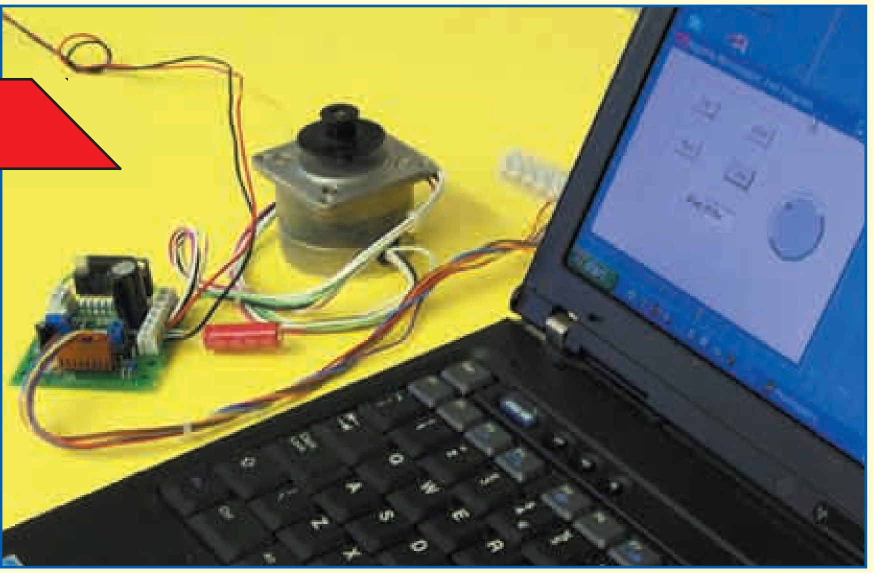


Fig.4: Underside diagram of the circuit board showing the positioning of 'surface mount' resistors. Speed-up resistor R16 is necessary for high stepping rates, but R17 and R18 will not be required in most applications. The completed Microstepping board is shown above. The 'thermal tab' of IC5 will probably need a small heatsink attached to it – see text



Computer Connections

The driver board opto-isolators are sensitive enough to be driven directly from most 'normal' computer parallel ports. A standard 'tower' system fitted with a parallel port I/O card, ran perfectly using 470Ω resistors for R19, R20, and R21.

Some computers' ports have different output driver capability, especially notebook types, and it was necessary to reduce the resistors to 150Ω to operate correctly from the built-in port of an IBM Thinkpad.

In applications demanding the highest speed, it is better not to overdrive the opto-isolators, as this will extend their turn off time, so don't fit lower value resistors than necessary.

Resistor R23 should be chosen to match LED1 (if it is fitted), but should not be less than 470Ω to avoid loading the computer too much.

Three outputs used by the driver test program are bits 0 to 2 of the computer port I/O register. A single input is used for the 'home' signal. Note that this input is Bit 3 of the port control register, which is one location above the port I/O address. The 'home' signal is connected as an open collector driver and uses the computer port pull-up resistor as a load. A valid 'home' signal is 'active low' as the driver transistor turns on and pulls down the input. These connections are shown in Table 3. Any of the computer port pins from 18 to 25 can be used as ground connections.

The pins chosen for the test program are arbitrary, any other combination of I/O pins may be used. There are sufficient I/O pins to connect more than one driver to a single port, provided software can be written to match!

Always be careful when testing the board to make sure the computer port wiring doesn't come into contact with the motor supplies. 'Flying' wires can damage an I/O port very quickly!

Table 3 Computer connections

Function	Driver PL3 Pin	Computer Pin	Computer Ref.	Computer Address
Clock	1	2	Bit 0 (Data 0)	Port Base Address
Direction	3	3	Bit 1 (Data 1)	
Sync	5	4	Bit 2 (Data 2)	
Home	7	15	Bit 3 (Error)	Base Address + 1
Ground	2,4,6,8,	18 - 25	Logic Ground	

overheating while testing. A small piece of aluminium should be sufficient.

Take care when connecting a motor that the correct winding connections are made. Be sure that the two ends of one centre-tapped winding go to TB1 and the other winding to TB2. It doesn't matter which way round the two ends of any one winding are connected, as this will only alter the direction of rotation (and it is a convenient way of doing so without altering the controller logic).

Applying a signal from a function generator to the clock input should result in motor rotation. Turning on the Direction input should reverse the rotation, and the M0 output will be seen to turn on every time the motor passes a 'home' state.

The Sync pin can be energised when the motor is in a home state and the result should be a reduction in the background noise from the motor caused by the two PWM signals beating with each other.

If all is well, the motor current can be increased and the speed raised to find the limits of performance. Note that exceeding the rated motor current can demagnetise and ruin some types of motor.

Test run software

Some basic driver software is available from the Magenta Ltd website (**www.magenta2000.co.uk**). This is only a simple program to test and run the motor at low speeds. Commercial CNC software compatible with the microstepper board is available from many sources. Magenta also supply a complete kit of parts for this project – see the Parts List. ***EPE***

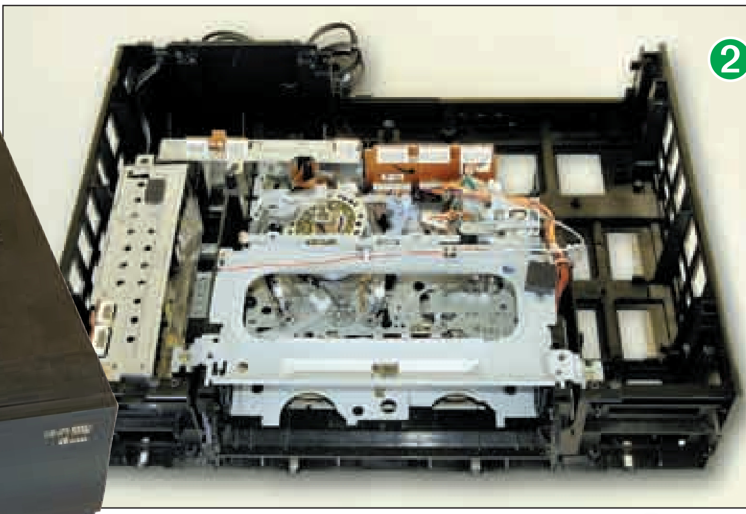
Recycle It!

BY JULIAN EDGAR

You've found a no-cost VCR – now let's salvage the good bits

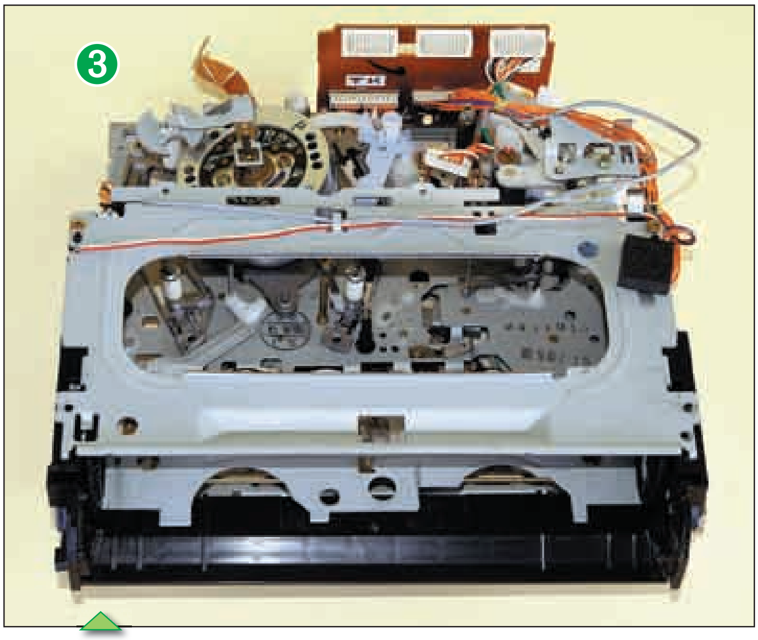
Rather than building a project, this month we're going to look at the parts that you can easily obtain from a VCR. 'Obsolete' kit like VCRs is now available for nothing or near-nothing – the one shown here was picked up at a garage sale for a few pounds – but on kerbside rubbish collection days they are free! But what good parts are inside? Contrary to what you might expect, the best bits are mechanical rather than electronic. Let's take a look.

Here's the starting point – a Goldstar hi-fi VHS machine, model number R-F903CH. But of course, the make and model don't really matter very much – what's more important is how heavy it is! Huh? Well you see, the heavier a VCR, the more likely you are to find salvageable components inside. In fact, to go to extremes, the ancient U-matic video tape machines weigh an incredible amount (some can barely be lifted) and inside you'll find some fantastic engineering, including high-quality solenoids and switches. On the other hand, a super lightweight VCR has few motors and solenoids and generally less of anything you might want. This Goldstar unit was 'middling' in weight.



It takes very little time to remove the cover (keep those screws!) and strip out the main circuit boards. In fact, it's worth stressing that disassembling a VCR is really a quick and easy process – expect to take perhaps only half an hour to do the job from start to finish.

It makes sense to do all the mechanical work in one go, coming back to the electronic parts later in the process. So, with the electronic boards placed to one side, the next step is to remove the tape transport mechanism and head. This assembly is almost always found on a sub-chassis, which is screwed to the plastic inside the case.

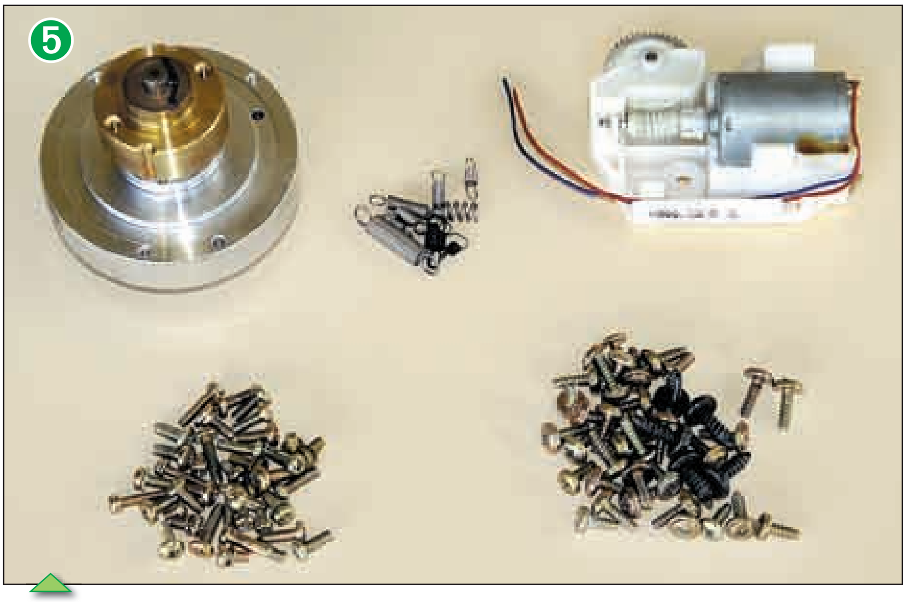


Here's the inner chassis on its own. At this stage, the contents of the VCR have already been narrowed down to just this and the PC boards. Throw the rest away as you remove it – ie, the top and bottom covers, the front cover and the inner plastic chassis.

The next steps involve pulling this piece of gear apart. You'll need a good-quality medium point Phillips head screwdriver – invariably, some of the screws are tight and once you start mangling screw heads with a second-rate screwdriver, it rapidly gets too hard. Put all the screws, springs and drive belts into plastic containers as you proceed.

And here's one of the pearls. I'm happy collecting a whole VCR just to pull this part out – that's how good I think it is. But what is it? It's the spinning drum assembly that holds the video heads that read, write and erase the tape. It's designed to rotate with great precision many millions of times during the life of the VCR, and as a result, it's beautifully made.

Specifically, its mechanicals comprise a hardened steel shaft, sealed ball bearings, brass fittings (they're either an interference fit to the shaft or are secured with Allen-head grub screws) and a diecast alloy support frame. In almost any application where you need small bearings and an axle (robotics, a wind vane, small wind generator, model car) these parts can be put to good use. What's more, they're pretty well standardised across all VHS VCRs, so if you need two axles (or four bearings, etc) just keep on collecting!



Here's what we have so far. At top left is the disassembled drum assembly. In the centre at the top are 10 springs (nine extension and one compression), while below that are 38 machine screws and 44 self-tapping screws. 'He's joking', you're saying. 'Why bother collecting the screws?' Well, you tell me which local hardware store has small, plated, Phillips head self-tappers in stock? Or a fine metric-thread Phillips head machine screw – just what you might need one day as a replacement in a piece of gear you're working on!

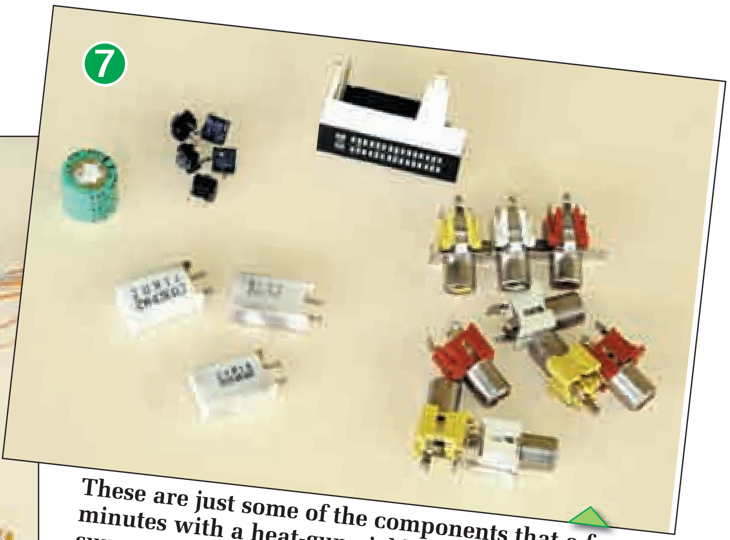
At top right is a DC brush-type permanent magnet motor, which uses a worm gear to drive an output shaft. It would make a perfect winch for a model boat, or it could be used to slowly rotate a display.

Rat It Before You Chuck It!

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

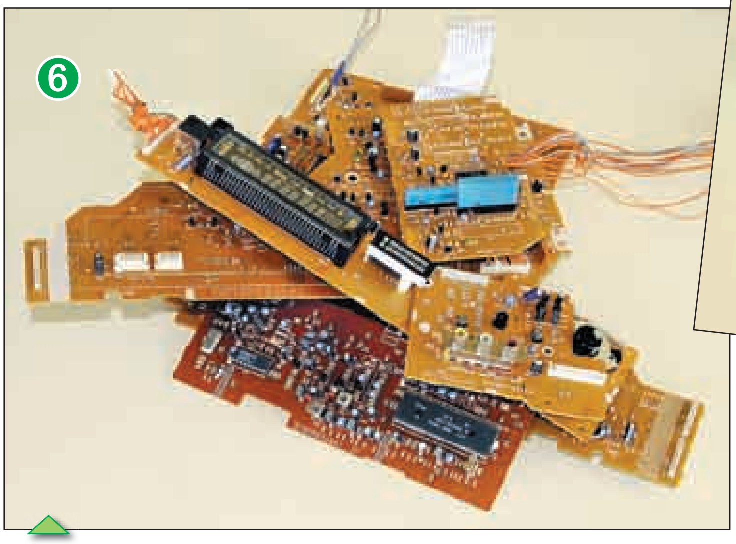
And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you salvage the high-quality bearings from VCR heads.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

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



These are just some of the components that a few minutes with a heat-gun yielded. They include a 0.22F super-capacitor (great for human-powered LED torches), five micro pushbutton switches, a 2-channel LED bargraph display, nine RCA phono sockets and three high-power resistors. Not shown are the 20 electrolytic capacitors that also took only moments to remove.

Incidentally, what you don't now do with these components is put them in a 'junk box'. If you can't readily access them when you need them (and sorting through a kilogram of assorted components is not the way to find them!), you'll never use them. Instead, invest in multi-compartment plastic trays or a small set of clear plastic component drawers to store your components and be sure to clearly label the drawers.



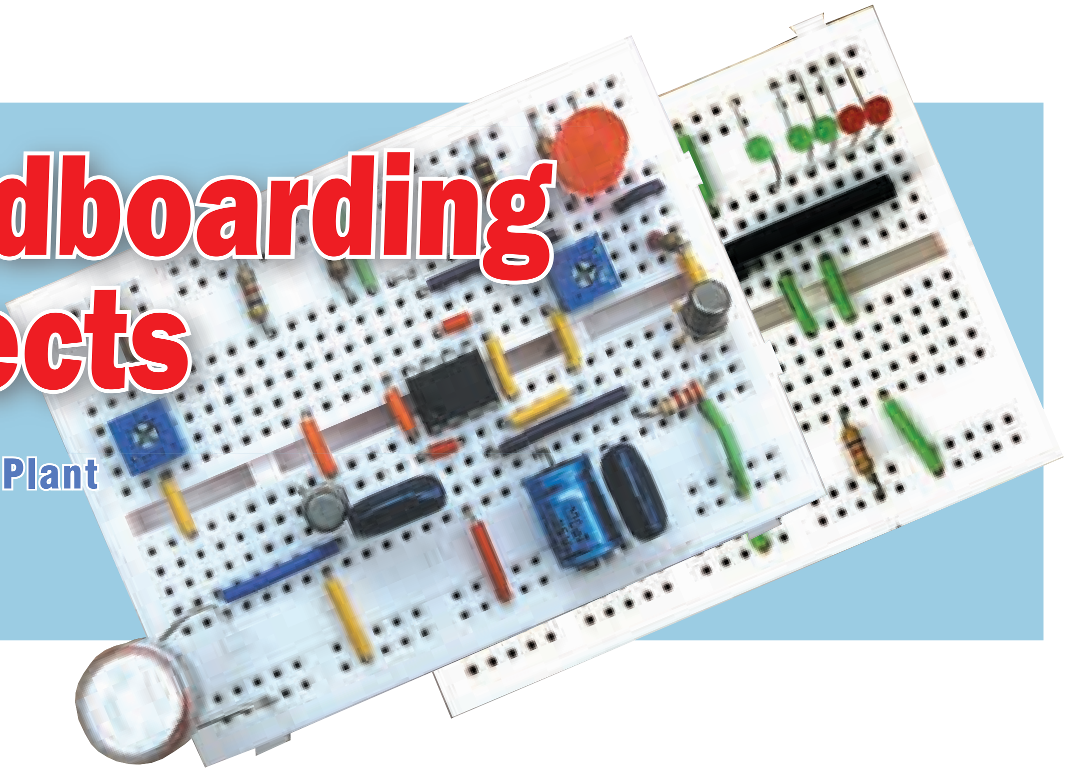
Remember the PC boards we put to one side? Well, here they are. Now, I know what you're thinking – he's going to tell us to get out the soldering iron and sucker and laboriously unsolder every one of these trivial low-cost components . . . and who'd bother wasting their day doing that?

Fair comment – and it's not me who'll be spending the time. Instead, what I do is identify the bits that I'm likely to have a use for and which cost more than just a few pence to buy – parts like the colour-coded RCA phono sockets, the high-power wirewound resistors and the high-value, small package capacitors. And forget the soldering iron. All you do is secure the PC board in a vice, aim a heat-gun at the solder side and gently pull on the component you want to remove with a pair of pliers. Using this method, it takes just a minute or so to salvage 10 or 15 components – and that's time worth spending.

Also collected was an infrared pass filter (this photo was taken through it!), a smoked plastic bezel, some high-power diodes, a drive belt and a heatsink. And there were heaps of bits I chose to throw away – the mains power cord, a metal sheet with punched ventilation holes (ie, the undercover), the rubber feet and so on.

In fact, the components that I salvaged can be cupped in two hands – and that's good! Good because it takes little room to store them and good because only the most valuable bits were kept. So the next time you see a VCR on its way to the tip, take a moment to think whether you could use any of the components inside it.

Breadboarding Projects



by Dr Malcolm Plant

A beginner's guide to simple, solder-free circuit prototyping
Part 8: Motion Detector and Moisture Monitor Mk.2

This month's breadboarding projects involve the use of a light sensor and a five LED driver chip.

Project 14:
Motion Detector

THE circuit shown in Fig.8.1 is designed to energise a relay for a preset time when light falling on the light-dependent resistor, LDR1, is interrupted by a passing object. But it works only when the interruption is rapid; a slow reduction of light intensity does not operate the switch. This effect is useful since it responds to shadows of objects moving at a moderate pace past LDR1, while slow moving shadows, eg from passing clouds, do not trigger the switch.

The circuit comprises three main building blocks. In the sensor and switch building blocks, a sudden decrease in light falling on LDR1 increases the LDR's resistance and raises the voltage on the base terminal of transistor TR1, which switches on. The sudden surge of current flowing through resistor R2 sharply lowers the voltage on the collector (c) terminal of TR1.

In the timer/monostable building block, the signal from TR1 is coupled by capacitor C1 to the trigger (pin 2) of IC1, a type 555 timer used as a monostable. The 555 is activated and provides a time delay dependent on the values of resistor R4 plus potentiometer VR2, used as a variable resistor, and capacitor C1.

In the driver building block, the output pulse from pin 3 of IC1 switches on TR2 and energises relay RLA1 and LED1 for the preset time. Variable resistor VR2 adjusts the time for which the relay is energised and VR1 affords some adjustment of the sensitivity of the circuit to light changes. If the reduction of light falling on LDR1 takes place slowly, the fall in voltage on pin 2 of IC1 takes place too slowly to trigger the monostable and the relay is not energised.

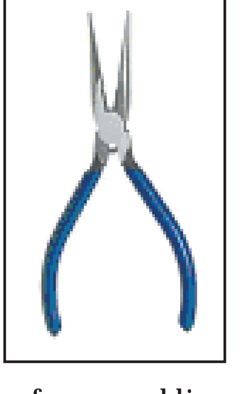
Notes

● **Never** use the relay to control power from the AC mains supply. If you want to use it for controlling mains-operated devices you must seek the help of a qualified electrician.

● For better directional sensitivity, place the LDR inside a short length of tubing.

● LED1 is included to show the state of the output signal and is not essential to the operation of the circuit.

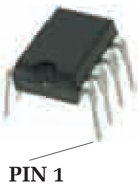
You will need...


Three basic tools for assembling Protobloc projects: screwdriver, snipe-nose pliers and wire cutter/strippers

Component Info

IC1, type 555 timer IC



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

LDR1, light-dependent resistor type ORP12.

It does not matter which way round the LDR is connected

Components needed...

Motion Detector

Integrated circuit, IC1: type 555 timer

Transistors, TR1 and TR2: both type BC108 or similar in a TO18 style package

Light-dependent resistor, LDR1: type ORP12 or similar

Light emitting diode, LED1: colour red or green

Diode, D1: type 1N4148 signal diode

Potentiometers, VR1, VR2: 100kΩ (VR1) and 500kΩ (VR2), both miniature preset types

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

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

Resistors, R1 to R7: values 4.7kΩ (R1, R2, R4); 1MΩ (R3); 330kΩ (R5); 2.2kΩ (R6); 220Ω (R7). All 0.25W 5% carbon film.

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

Battery, B1: 9V and connecting leads

Protobloc and wire links

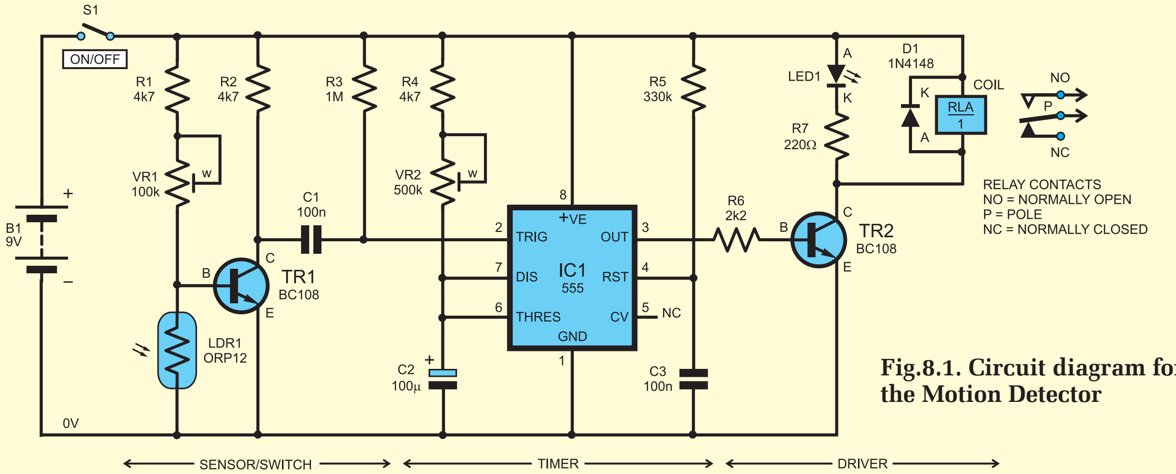
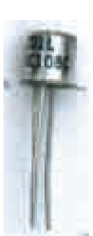
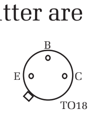


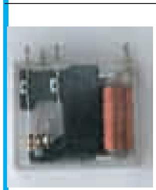
Fig.8.1. Circuit diagram for the Motion Detector

TR1 and TR2, type BC108
NPN transistor



Seen from below, the emitter lead is next to the small metal tag. Clockwise from the emitter are the base, and collector leads.





RLA, relay 6V energising voltage.

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

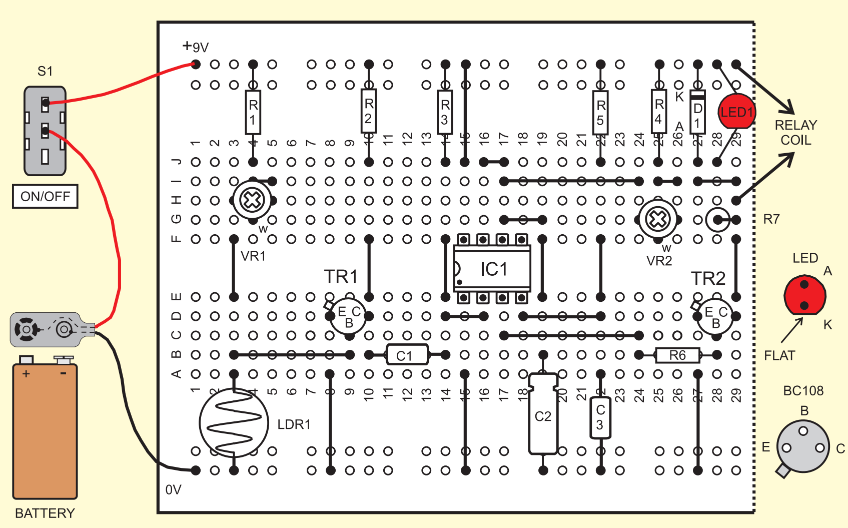


Fig.8.2. Motion Detector breadboard component layout

Project 15:

Moisture Monitor Mk.2

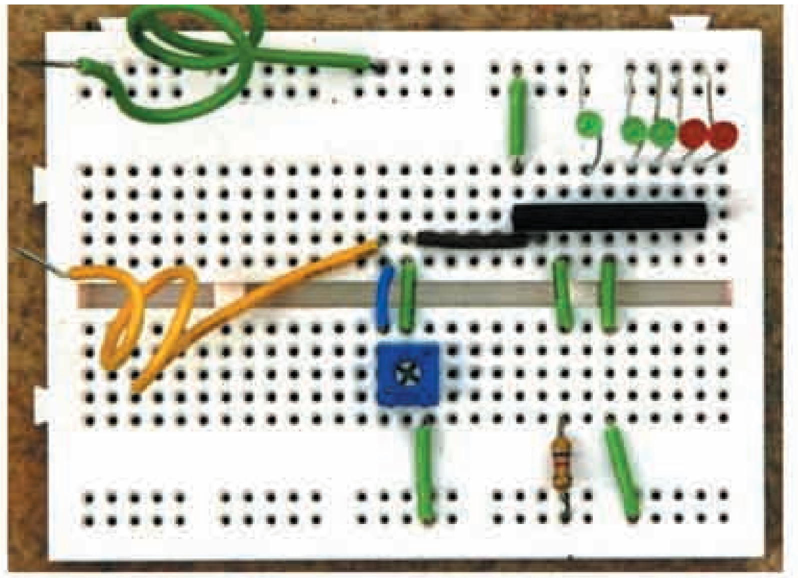
The circuit shown in Fig.8.3 is a simpler alternative to the Mk.1 design described in *EPE* November 2008. It uses fewer components and is therefore easier to assemble on Protobloc.

You do not need to select the ladder of resistors that provides the reference voltages for the four comparators in the Mk.1 design, as these are incorporated in the 'special' integrated circuit, IC1, type LB1413N LED meter. However, this does mean that you have less control over the input levels when the LEDs switch on, but for this application there is no need for fine tuning of the switching points.

Key component

Integrated circuit IC1 is the key component and it has two modes of operation, AC or DC. In this project it is used in the DC mode, but see the *Sound Sensor* project to be published in this series (July '09) for an application that uses it in the AC mode.

The DC voltage fed directly to the input of IC1 is generated by a voltage divider made up of the resistance between two probes, P1 and P2, and the adjustable resistance of preset potentiometer VR1. When the probes are in damp soil, the resistance between the probes is low and the voltage fed to IC1 is higher than when the probes are in dry soil.



Components needed...

Moisture Monitor Mk.2

Integrated circuit, IC1: type LB1413N LED level meter in a 9-pin SIL package
Light emitting diodes, LED1 to LED5: three green and two red, use 3mm dia.types
Potentiometers, VR1: 50kΩ miniature preset type
Resistors, R1, R2: values 4.7kΩ (R1), 47Ω (R2) – see text
Switch, S1 (On/Off): single-pole, single-throw (SPST)
Battery, B1: 9V and connecting leads
Probes, P1 and P2: two 50mm or 100mm long nails or similar metal rods to act as probes
Protobloc and wire links

Preset VR1 can be set to light all five LEDs. The drier the soil, the higher the resistance between the probes and the lower the voltage fed to IC1 and so fewer LEDs are lit.

If you are expecting to light the five LEDs continuously for a prolonged length of time, do not exceed the 9V supply voltage; most of the power is consumed within the IC. It is recommended that when using a higher power supply voltage, that you insert a resistor in series with the LEDs to restrain the power consumed within the IC package – see Fig.8.4.

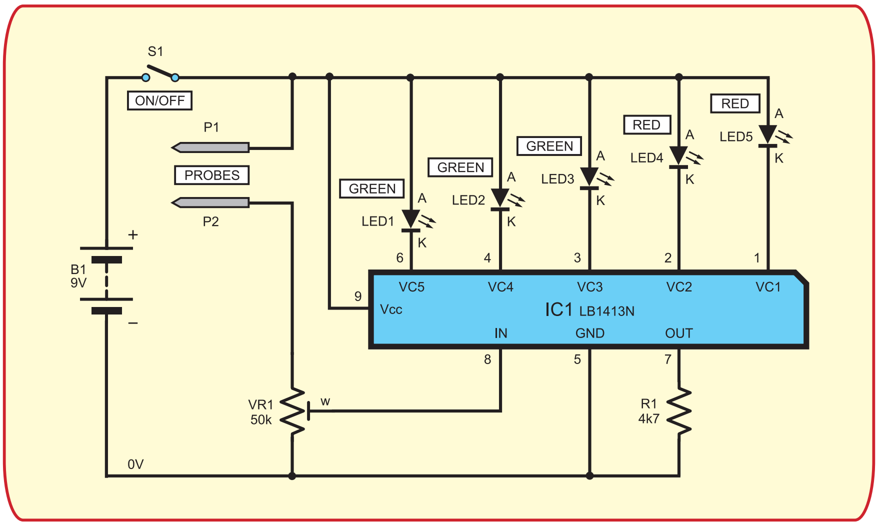


Fig. 8.3. Circuit diagram for the Moisture Monitor Mk.2

Breadboard

The Protobloc component layout for the Moisture Monitor Mk.2 circuit is shown in Fig. 8.5. The probes can be made up from a couple of 50mm to 100mm long nails or metal rods.

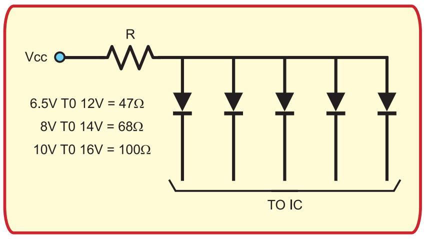
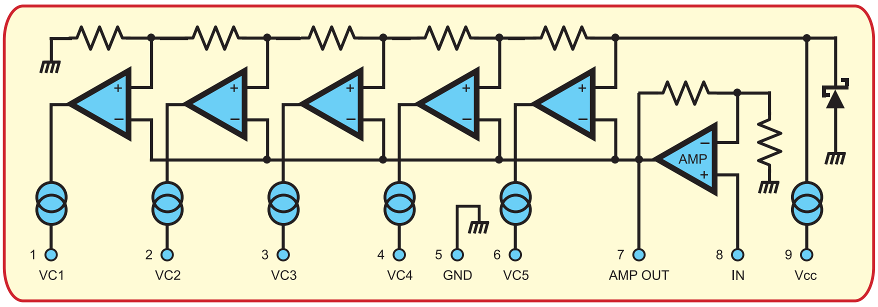


Fig. 8.4. When using a higher supply voltage, insert a resistor in series with the LEDs

Inside the Sanyo LB1413 Five LED Level Meter Driver



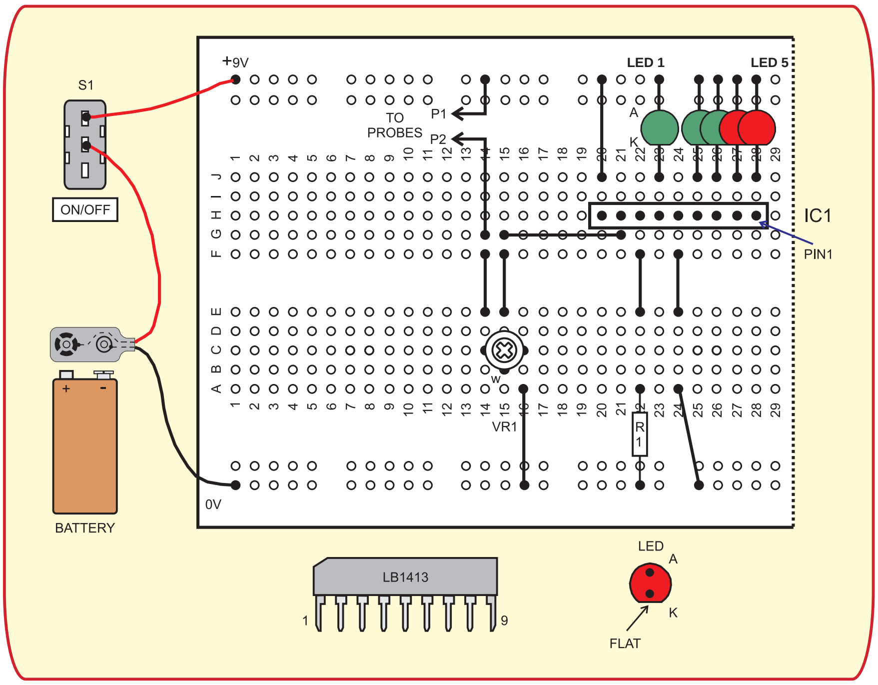


Fig. 8.5. Assembly of the Moisture Monitor Mk.2 on Protobloc

Notes

● IC1 needs to be sitting well down on the surface of the breadboard if the pins are to make good contact with the underlying clips.

● Trial and error using plant pots with three different soil conditions (dry, dampish and well watered) will quickly establish a setting of preset VR1.

Component Info

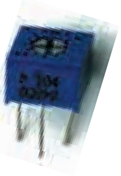
IC1, type LB1413N LED level meter

Reading from the chamfered end, the pins are numbered 1 to 9

LED1 to LED 5, 3mm green (3) and red (2) light-emitting diodes

The longer lead is the anode, the shorter lead is the cathode.

VR1, potentiometer



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

S1, single-pole changeover switch

Use the centre pole and either of the other two connections to make an on/off switch.

Next Month: Lightning Detector

Construction brief

To ensure trouble-free assembly, you should try and follow these basic guide lines

Always use single-core 0.6mm diameter plastic-sleeved wire for wire links, not thicker. The ends of the wire should be stripped of plastic for about 8mm. The use of thicker wire can permanently damage the springy sockets underneath each hole.

Never use stranded wire; it can fray and catch in the sockets, or a strand can break off and cause unwanted connections below the surface of the breadboard.

It is very important to make sure that the bared ends of link wires and component leads are straight before inserting them into the breadboard. Kinks in the wire will catch in the springy clip below the socket and damage it if you have to tug to release the wire from the holes.

Make sure that the arrangement of components and wire links is tidy, with components snugly fitting close to the surface of the Protobloc. This usually means providing more link wires than is perhaps necessary, so as to avoid having wires going every-which-way across the board.

Never connect the battery leads to the top and bottom rails of the breadboard until you have carefully checked that all the component connections correspond to those on the circuit diagram.

Some components, such as switches and relays, do not have appropriate wire leads for insertion into the Protobloc. If you have access to a soldering iron, solder short lengths of single-core 0.6mm diameter plastic-sleeved wire to the terminals of these components.

Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

THE range of connectors available from the larger electronic component suppliers just seems to keep growing. 'Golden oldies' such as jack plugs and sockets and DIN connectors are still going strong, but new applications often inspire a range of new connectors.

Finding and using the right type of connector used to be fairly straightforward, but these days things are complicated by the sheer number of different types that are available. The numerous variations on most types further complicate matters, and can make it difficult for beginners to find the right one.

It is probably fair to say that most of the connectors listed by the larger component suppliers are not the type of thing that you are likely to need for a typical *EPE* project. From time to time you might build a project that requires one of the more exotic and expensive plugs or sockets, but few designs require anything other than the more 'run of the mill' types. This slightly simplifies matters, but when buying connectors you still have to be careful to obtain the right types.

Jacks of all trades

In this digital age, the various traditional types of audio connector are still in widespread use, and might still be the most common type in *EPE* projects, because they are often pressed into service for something other than audio use. Jack plugs and sockets are probably one of the oldest types of connector, but their popularity shows no sign of waning.

Jack connectors are probably used more today than ever before. Headphones and headsets are almost invariably fitted with some form of jack plug. The original jack connector is the 6.35mm (¼in) type, which is also known as the 'standard' type.

Although standard jacks are huge in size comparison to many items of modern electronics, they are still used to a significant extent. For example, they are used with electric guitars and in the general world of electronic music, where their ruggedness is a definite advantage. However, they are clearly out of proportion to many electronic gadgets, and standard jack plugs are bigger than many MP3 players for example.

The much smaller 3.5mm version was introduced for applications where small size was required, and an even smaller 2.5mm type was introduced at about the same time. Incidentally, the size refers to the diameter of a plug's barrel. Although 6.35mm may not seem that much more than 3.5mm, the difference in overall size between the two types is much more than one might imagine (Fig.1). As pointed out previously, standard jack connects are usually very tough, but this is not true of the smaller types. High quality 2.5mm and 3.5mm jack connectors are available, but even these are nothing like as tough as a typical 6.35mm type. Some of the smaller jack connectors are a bit flimsy and unsuitable for 'knockabout' applications.

Fig.1. The standard jack plug on the right is very much larger than the 3.5mm type on the left. The standard jack plug is a stereo type having the 'ring' connection near the tip

Fig.2. An insulated jack socket (top) and an open construction stereo type (bottom). Unlike open construction sockets, the insulated type does not provide a connection to the panel via the body of the component

There are mono and stereo versions of all three sizes. The barrel of the plug is in two sections for stereo types, which are no larger than their mono equivalents. With a mono plug, the main barrel section carries the chassis or earth connection and the tip carries the signal. With a stereo plug, the main part of the barrel carries the earth connection while the smaller section (the 'ring') is used for the right-hand signal. The tip carries the signal for the left-hand channel.

This assumes that the connectors will be used for their intended purpose, but jack plugs and sockets are used in many non-audio applications such as camera remote controls and temperature sensors. It is then up to the designer to decide on the assignments of the various parts of the plug.

Jack connectors are very versatile, but they are not suitable for all applications that require a two or three-way connector. In particular, they are unsuitable for operation at high frequencies or with high currents.

Open and shut case

When buying jack connectors it is not just a matter of obtaining components of the correct size and type (stereo or mono). There are one or two additional complications to deal with. Jack sockets are available in 'open' and 'insulated' versions (Fig.2). The open type is of largely metal construction and the mounting bush connects internally to the earth tag. The insulated type usually has a plastic case and mounting bush/nut, and therefore provides no internal connection between the earth tag and the mounting bush.

The insulated type is favoured in applications where there are potential problems with 'hum' being introduced by earth loops, which in practice usually means a project associated with electronic music. There will not necessarily be any dire consequences if an open type is used when an insulated jack socket has been specified, but it is probably best to always use the specified type.

On the face of it, many jack sockets have too many tags. Only two tags are required on a mono jack socket, but open construction miniature jack sockets often have three, and mono insulated jack sockets have four tags. With some insulated sockets, the additional tags on one side of the component simply duplicate those on the opposite side. More usually though, the extra tags are needed to accommodate a built-in switch that is operated when a plug is inserted into the socket. The normal use of the switch is to turn off an internal loudspeaker when headphones are plugged into the socket.

Of course, the integral switch contacts are irrelevant in many applications and the additional tag or tags are left unused. Fig.3 (right) shows the correct method of connecting an open construction 2.5mm or 3.5mm jack socket. The two leads to the loudspeaker are omitted when the automatic switching is not required. The left-hand illustration identifies the tags of an insulated jack socket. The switch contacts are simply ignored if they are not needed.

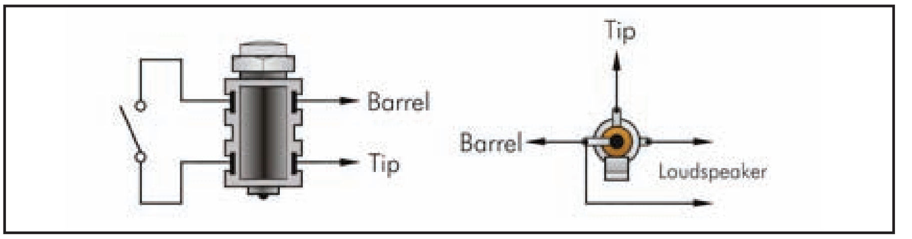


Fig.3. Connection details for an insulated jack socket (left) and an open construction miniature jack socket (right). With most projects, the extra tags for the switch contacts are left unused

All aboard

Because it is the most economic way of doing things, commercial electronic goods tend to be built with as many of the components as possible fitted onto a printed circuit board. Many projects for electronics hobbyists are built along the same lines, with the controls and sockets fitted directly onto the circuit board.

Jack sockets, together with many other types of connector, are therefore available in chassis mounting and PCM (printed circuit mounting) versions. The PCM type is fitted on the circuit board like any other component, but always at one edge of the board so that a hole at the appropriate point in the case provides access to the socket.

With PCM sockets, it is essential to obtain sockets that are physically compatible with the circuit board. The PCM sockets of a particular type will not necessarily use exactly the same pin layout. It is important to ensure that the sockets are securely fixed to the circuit board, but few types have provision for screw fixing. The printed circuits pins and the soldered joints are all that hold them in place.

This is unfortunate, since a fair amount of force might be applied to the socket each time a plug is inserted or removed. Partially detached PCM sockets are not unknown problems with commercial equipment, and will certainly occur with home-constructed equipment unless the sockets are firmly fixed in place.

The most important thing is to make sure that the socket is fitted tight against the circuit board with no discernible gap between the body of the socket and the surface of the circuit board. This is a crucial point with practically any PCM component. Use generous amounts of solder on all the pins, but especially with any large pins. Any outsize pins are designed to take the strain and act as the main means of fixing the socket in place. In some cases, they serve no other purpose.

It is often possible to superglue a PCM component in place prior to soldering. Apart from the additional support provided by the adhesive, it also ensures that the component is tight against the board when it is soldered in place. One slight drawback is that once the component has been fitted to the board it is unlikely that it could be removed without seriously damaging the board.

PCM sockets often have a mounting bush and nut so that they can be panel mounted. This makes it possible to use them as conventional sockets that are mounted on the front panel and hard-wired to the circuit board. Some work quite well in this fashion, while others have small and relatively insubstantial pins that are easily broken off.

Making the interconnections using a thin and flexible grade of connecting wire helps to minimise the risk of snapping off one of the pins. It is also possible to do things the other way around, with panel mounted controls and connectors being hard wired to solder pins fitted on the board in place of PCM controls and connectors. However, unless there is no alternative it is definitely better to use the correct type of socket rather than improvising.

DIN

Although the range of DIN connectors has steadily grown over the years, this type of connector is perhaps used somewhat less than in the past. There is a rather basic two-way type intended for loudspeaker outputs of small audio power amplifiers, but all the other DIN connectors are intended for low power applications. They are only designed for low frequency applications and are available in everything from three to eight-way versions, plus the two-way loudspeaker type.

Normal DIN connectors are approximately 12mm in diameter, but there is a relatively new range of miniature types that are roughly half that size. The miniature types are used mainly in non-audio applications, and do not seem to feature in many electronic projects.

In addition to the two different sizes, there are complications such as three versions of the five-way connector, and there are both panel-mounting and PCM types. Due care has to be taken when ordering DIN connectors. Panel-mounting DIN connectors do not have a mounting bush, but instead require a 12.5mm diameter mounting hole. Additionally, two smaller mounting holes are required to accommodate the 6BA or M3 mounting bolts.

Phono

A phono connector is a basic two-way type that was originally designed for audio applications, and there are no multi-way versions. Although designed for low frequency use, phono connectors are a standard type of connector for use with amateur video equipment, and they are also used for some other high frequency applications. Although only a monophonic connector, the phono connector has become the standard type for stereo hi-fi systems. A pair of connectors is used to accommodate the signals for the two stereo channels, and the interconnections are carried by twin (figure-of-eight style) leads.

It may be a very simple type of connector, but it is still possible to obtain phono sockets in various styles. The normal panel mounting type requires a single mounting hole of about 6.35mm in diameter, and has a large solder-tag that fits in front of the mounting nut at the rear of the component. This provides the socket's chassis (earth) connection. This type of socket tends to work loose with use, and the mounting nut must therefore be fitted as tightly as you dare.

PCM versions are available, as are the old style phono sockets that have several sockets on a plastic panel. One way of mounting these is to make a rectangular cut-out that is just large enough to accommodate all the connections at the rear of the panel. Four or six small holes are needed for the M3 mounting bolts. An easier method is to drill a hole of about 10mm in diameter for each socket, making sure that the tags at the rear of the unit do not touch the panel.

Getting connected

Many projects that have audio connectors can be used with ready-made leads, most of which are quite cheap these days. In some cases, a do-it-yourself lead will be required, and making the connections to miniature jack plugs and DIN types can be a bit awkward. In fact, it will be virtually impossible unless the plug is securely held in place. It can be fitted in a small vice or fixed to the worktop using Bostik Blu-Tack or plasticine.

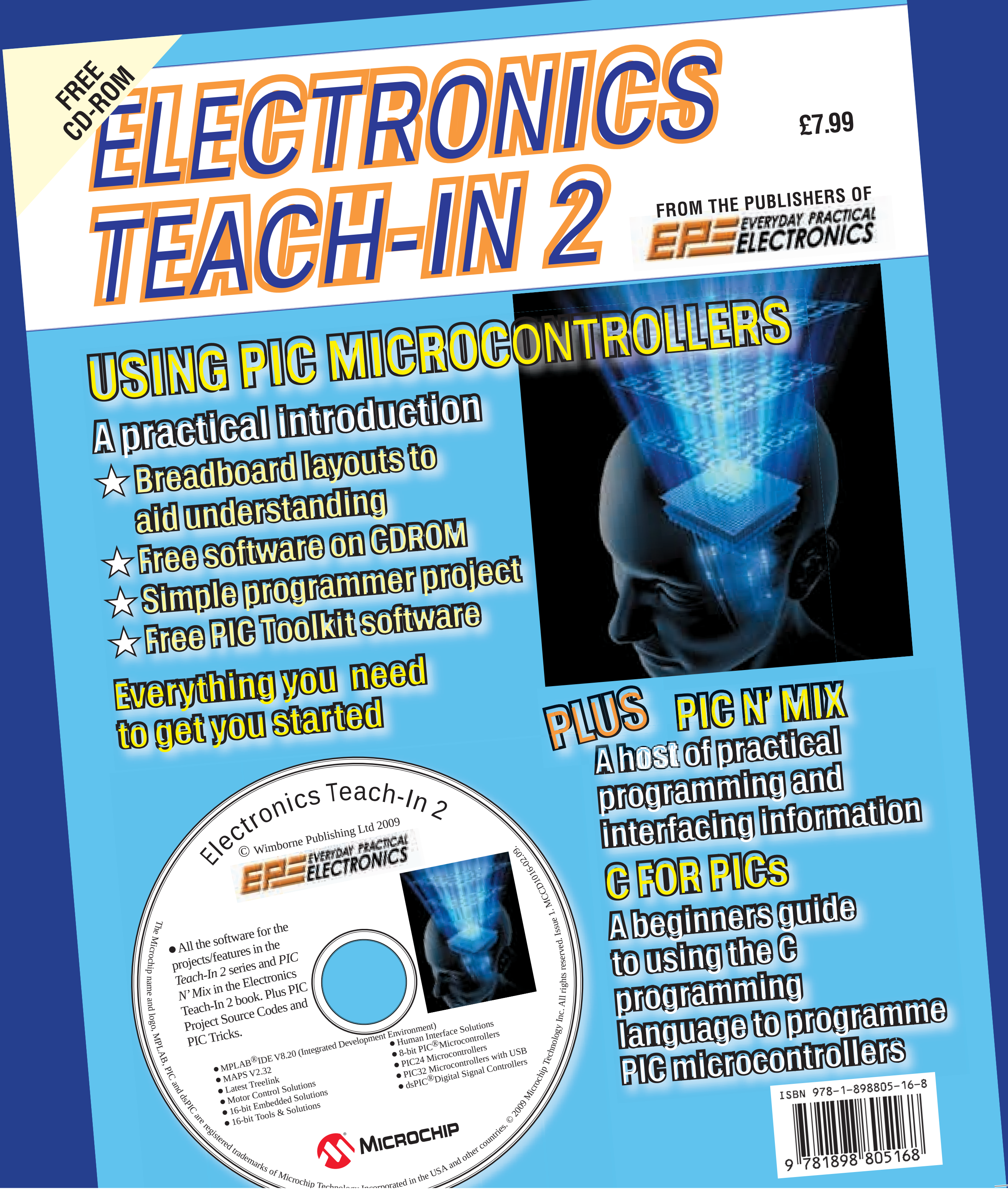
As with any form of hard-wiring, make sure that the ends of the wires and the tags of the plugs are properly tinned with solder before making the connections. If the tags or pins are dirty and will not take a coating of solder, scrape them clean with the blade of a screwdriver or the small blade of a penknife and then try again. When soldering the connections it is necessary to take due care to avoid short circuits between the tags or pins, since there is very little gap between them. Remember to fit the plastic cover onto the lead before connecting it to the plug.

Taking the strain

Audio plugs normally have a couple of metal grips (Fig.4) that can be squeezed onto the cable using a pair of pliers. This provides a simple but effective form of strain relief, and helps to prevent the connections from being broken if someone manages to kick or otherwise knock the lead. With a shielded

Fig.4. A stereo jack plug with the cover removed (top) and part of the shell of a DIN plug. Both have the all-important strain-relief grips at the rear

cable, leaving the screen exposed to the strain relief grips provides a connection between the screen and the chassis of the plug. However, it is definitely advisable to ensure that a reliable connection is obtained by using a soldered connection as well.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Measuring rotational movement and direction

Recently, *EPE Chatzone* (**chatzones.co.uk**) user **pepbox (Pepe)** posted the following question about measuring rotational movement and detecting direction:

Can anyone help me with the software to make a turns counter for a coil winder? I want to use a PIC and possibly a couple of devices using a module containing an LED and a phototransistor to detect when either a white or black strip passes the detector. I need to be able to detect forward and backwards, I hope I am able to work out the software to drive a seven-segment display myself.

Simply counting the number of times a wheel rotates is straightforward – a single photosensor arranged to switch when the wheel is in one particular position will provide pulses that can be counted by a hardware counter or PIC software. However, if we need to detect direction of movement, and count up or down as appropriate, we need a more sophisticated approach and more than one photosensor.

The same principles of direction sensing can be applied to a range of situations, such as objects passing though a sensing beam, as well as to rotating discs. A related problem is that of position sensing, where we measure the angle of a rotating part, or the position of something with linear forwards and backwards movement.

These systems have a wide range of applications, most obviously in measuring the position and movement of machinery such as robots, but also in more mundane items such as the volume controls on audio equipment. In the latter case, the analogue audio signal is not passed through a potentiometer to control volume, but the position or movement of the control is measured digitally and used to control the audio signal.

Concepts

Although Pepe was after a software solution, direction discrimination and counting can be implemented in either hardware or software. The basic concepts of what you have to do are the same and this article will consider both hardware and software approaches.

Consider a rotating disc marked with black and white sections, above which we have placed an optical sensor (see Fig.1). In the figure, the gray bar represents the fixed sensor mounting and the red dot indicates the location of the sensor. The disc is free to rotate past the sensor.

Assume that light is shining onto the disc so that when the sensor is above a white area we get a relatively large signal compared to when it is above a black area and that this signal is passed through a suitable comparator circuit so that we obtain a clean digital signal with a '0' representing a black area and '1' a white area.

As the disc rotates we will get an alternating 1 and 0, with the frequency of this signal indicating the speed of rotation. If we have one white region on the whole disc (as in Fig.1a), it is a simple matter of counting pulses to count the number of revolutions.

However, this may mean that we do not 'see' any signal most of the time. More frequent updates that movement is occurring may be useful in some cases; this is easily achieved using more black and white regions (as in Fig.1b), and we then need to divide the pulse count to get a rotation count.

We are not restricted to rotary motion with this technique – we can pattern a linear bar and measure movement in a similar way. We can also use holes or slots in the disc or bar to switch the level of light falling on the sensor as movement occurs. It is also possible to use magnetic sensing in a similar way using Hall-effect sensors, particularly for metallic objects with a regularly varying physical structure (eg, gear wheels).

Code patterns

We can achieve detailed measurement of movement by using more complex patterns on the disc and multiple sensors. If we use several sensors and arrange the black and white areas appropriately, we can provide a binary coded output that indicates the position (angle of rotation) of the disc. Fig.2 shows an example of this using a 3-bit number, giving an angular resolution of 45 degrees.

This seems fine, but actually it is not a sensible way of patterning the disc. The

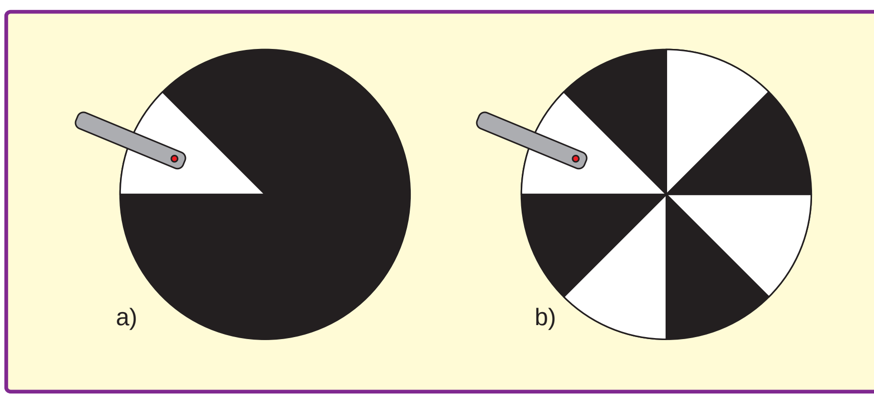

Fig.1. Optical sensing of motion

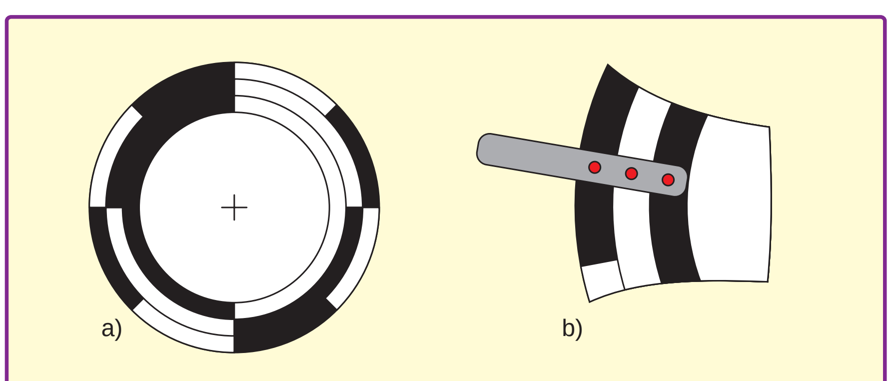

Fig.2. (a) Disc patterned with binary code, (b) arrangement of sensors

problem is that unless the sensors are perfectly aligned as we move from one segment to the next, the bits which change may not do so at the same instant, leading to unwanted ‘intermediate’ codes.

In our example, the worse case for this is the change from 000 to 111 or vice versa, where any 3-bit number (or even a sequence of two numbers) could appear as an intermediate code.

The solution is to pattern the disc so that only one bit changes as we move from one segment to the next, as shown in Fig.3. This type of binary code is called a *Gray code*; we can use a logic circuit, or software lookup table, to convert it to standard binary numbers.

Using code-patterned discs is useful where the disc position is simply an angle, but if the movement of the disc over multiple revolutions must be measured it is less useful. Furthermore, if high resolution is required, then the printing of the disc becomes complex and difficult and potentially large numbers of sensors are required (one per bit).

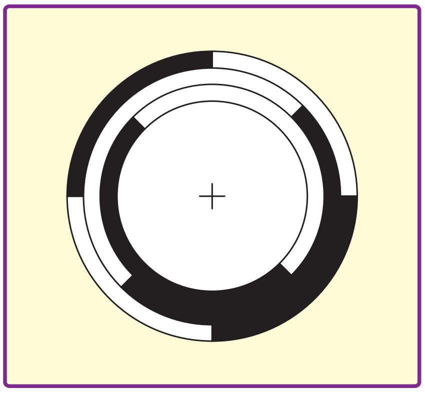

Fig.3. Gray-coded disc

The incremental encoder disc pattern and sensor locations are shown in Fig.4. The quadrature signal is obtained from sensors A and B and the reference (index) signal from sensor I. The spacing of the alternate black and white zones determines the resolution with which location can be measured. The separation distance between sensors A and B is half the length of the black and white sections.

If we are only interested in whole revolutions then a single white region (or slot) could be used. The disc would be all black except for a single white region like that shown in Fig.4b. The index sensor would not be required but the other two sensors would be positioned in the same way. A wider white region (half the circle, with sensors at 90 degrees) would give more slowly changing input signals, which may be helpful.

The waveforms obtained from the sensors in Fig.4a with constant speed rotation are shown in Fig.5. If a single small white region is used for once per revolution detection, then the zero (ie AB=00) regions of the waveform will be stretched in comparison with Fig.5, but the sequences of 1s and 0s on AB will still be the same. Indeed, it is the sequence of digital ‘codes’ from sensors A and B that is critical to direction detection.

For clockwise movement we get the sequence AB = 00, 10, 11, 01, 00,.. and for anticlockwise movement we get the sequence AB = 00, 01, 11, 10, 00,... Note that these sequences are Gray codes in that only one bit changes as we move one step to the next.

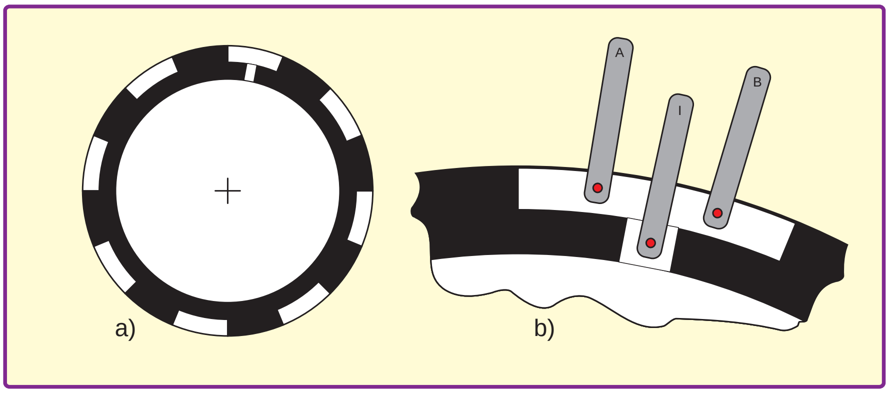

Fig.4. Incremental encoder for motion sensing (a) disc pattern, (b) sensor locations

Incremental encoder

An alternative approach, called an *incremental encoder*, uses two sensors that generate a quadrature signal – that is two waveforms offset by a 90° phase shift. Movement is indicated by the output of either sensor switching and direction is indicated by the relative phase (±90°) of the signals. These signals can be used to control a counter to obtain a binary representation of position. As this approach, unlike the Gray code disc, does not directly indicate absolute location, a third sensor may be used to provide an index or reference point.

Direction indicating

It should be obvious that all combinations of values for A and B occur in both these sequences, so a combinational logic circuit cannot be used to indicate the direction. A direction indicating circuit must have memory, so it must use flip-flops. Similarly, a software implementation must remember the previous code and compare it with the current one.

There are a couple of simple approaches to determine the direction of movement from the A and B signals (in Fig.5). One way is to look at the level of (say) B when there is a positive edge on A. This is easily

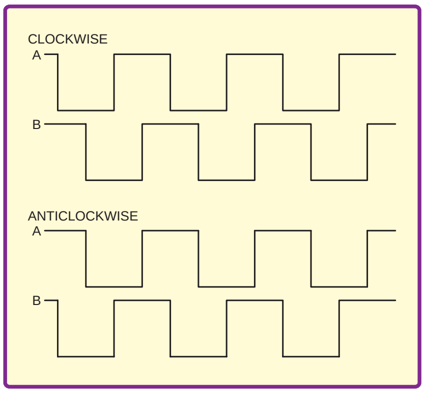

Fig.5. Quadrature signals from the incremental encoder shown in Fig.4a, starting from sensor positions shown in Fig.4b (With logic 0 for black and logic 1 for white)

achieved by connecting B to the D input of a D-type flip-flop and A to the clock (CLK). Checking Fig.5 will show that a 0 indicates clockwise and a 1 indicates anticlockwise. In our arrangement, we can check the direction at any of the edges (positive or negative) of the two waveforms (A and B) in a similar way.

Each edge also represents a definite indication of movement and can be used to increment or decrement a counter circuit depending on the direction. We can update the count and direction on every positive edge of A, every change of A, or every change of either A or B. This gives four different resolutions to a position measurement.

Some circuits allow switching between resolutions (x1, x2 and x4). The binary value in the counter will then represent the relative movement of the disc since the counter was last set to a particular value (eg, reset by the signal from the index sensor (I in Fig.4b)).

Another simple direction detection idea uses the fact that we can get the direction if we XOR the previous value of A with the current value of B (or vice versa). For the clockwise sequence AB = 00, 10, 11, 01, 00 we get Direction = X, 0, 0, 0, 0, and for the anticlockwise sequence AB = 00, 01, 11, 10, 00 we get Direction = X, 1, 1, 1, 1. The X simply indicates that we cannot tell the direction from the first step because there is no ‘previous’ value to use.

Software implementation

This leads to a quite simple software approach, assuming we repeatedly read the value of A and B on digital ports of a PIC or similar microcontroller, we can use the following repeated steps to find the direction:

1. Read A and B sensors values (CurrentA and CurrentB) on a digital input port.

2. Compare current values of A and B with their previous values.

3. If A or B has changed find the direction using Direction = PreviousA XOR CurrentB, otherwise do not update the direction. If counting movement, increment or decrement the count value depending on the direction just calculated.

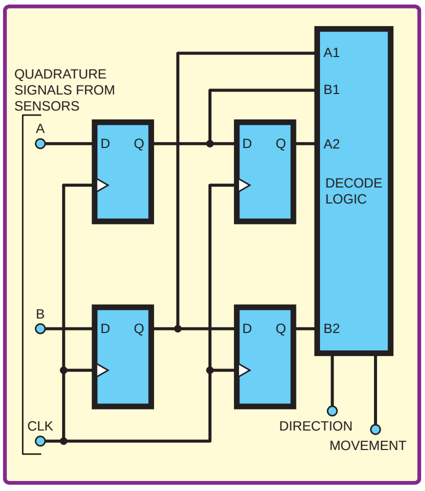

Fig.6. Quadrature decode circuit to determine direction of movement

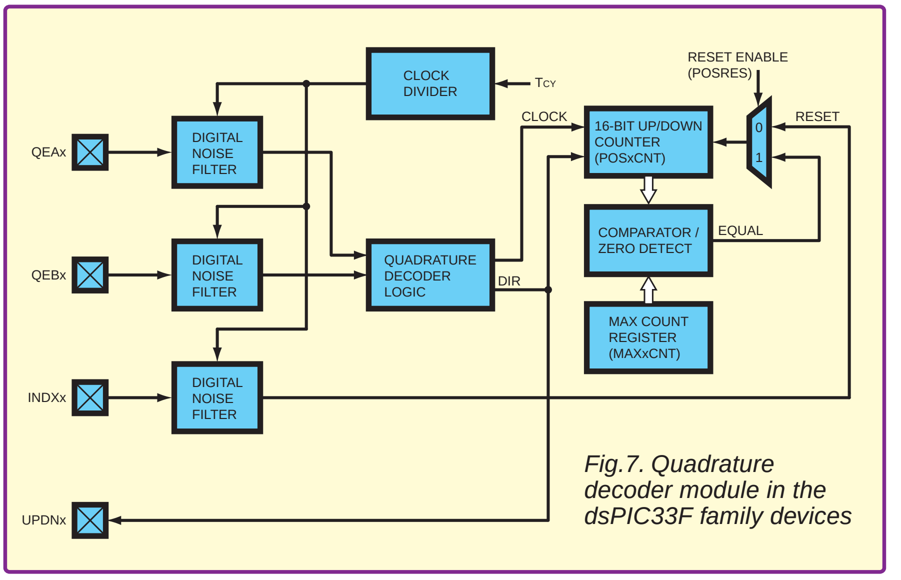

Fig.7. Quadrature decoder module in the dsPIC33F family devices

4. Update the values of PreviousA and PreviousB with CurrentA and CurrentB respectively.

It is important to realise that this approach is sampling the sensor values and that this sampling must be faster than the changes on the sensor signals, otherwise errors will occur. There must be at least two samples (Port reads) of the sensor values between changes in A and B to guarantee correct operation. For a given mechanical set-up, it should be possible to calculate or measure the shortest interval between changes of A and B knowing the fastest speed at which the mechanical system can move.

Hardware implementation

A similar process can be implemented in hardware – for example, as shown in Fig.6. Here both sensor inputs are sampled by flip-flops under the control of a regular clock. These flip-flops store the current values (A1 and B1) and at the same time pass their previous values (A2 and B2) to two other flip-flops in the manner of a shift register. The four values can be processed by a logic circuit to determine the direction and whether or not any movement has occurred in the current clock cycle. These signals can then be used to control an up/down counter.

The logic design can be a little tricky due to the need to prevent races between the direction discrimination and movement signals – the direction signal must be stable before an up/down counter controlled by this signal is clocked.

It is also possible to design a state machine to perform quadrature decoding. A synchronous state machine uses a clock to sample the sensor inputs, but an asynchronous state machine can be triggered directly by the sensor inputs and not require a clock. Both the state machine approach and the circuit in Fig.6 can be made to indicate movement at different resolutions, as mentioned above, and may even be designed with switchable resolution.

Vibration detection

There is often a need to distinguish between definite movement in a particular direction and vibration about a basically fixed point, which continuously switches one of the sensors, particularly as most mechanical systems are prone to some vibration. This problem prevents us from using the simple solution of connecting (say) sensor A to the clock of an up/down counter and sensor B to the up/down control. Vibration on A would cause a continuous count, rather than the required repeated up-down or static response.

Some microcontrollers have built-in quadrature decoder and counter circuits, for example the dsPIC33F family devices – digital signal processing PICs from Microchip (**microchip.com**) – have one or more built-in Quadrature Encoder Interface (QEI) modules (see Fig.7).

Specialised incremental position sensor decoder ICs are also available, for example the HCTL-2032 from Avago Technologies (**avagotech.com**). Like the dsPICs, these chips also include simple digital filters to remove glitches from the input waveforms. A simplified block diagram for this family of devices is shown in Fig.8 (actually taken from an earlier incarnation, but still showing the basic features of the current device).

A good method of measuring movement and position with direction indication is to arrange two sensors to provide a quadrature signal. This signal can be decoded using custom logic, a quadrature decoder IC, a software routine on a microcontroller, or you can use a microcontroller with a built-in quadrature decoder.

Further Information

Avago Technologies quadrature decoder ICs:

www.avagotech.com/pages/en/motion_control_solutions/integrated_circuits/decoder/hctl-2032-sc/ (click on PDF link for datasheet)

Quadrature Encoder Interface information from dsPIC33F Family Reference Manual:

ww1.microchip.com/downloads/en/DeviceDoc/70208A.pdf.

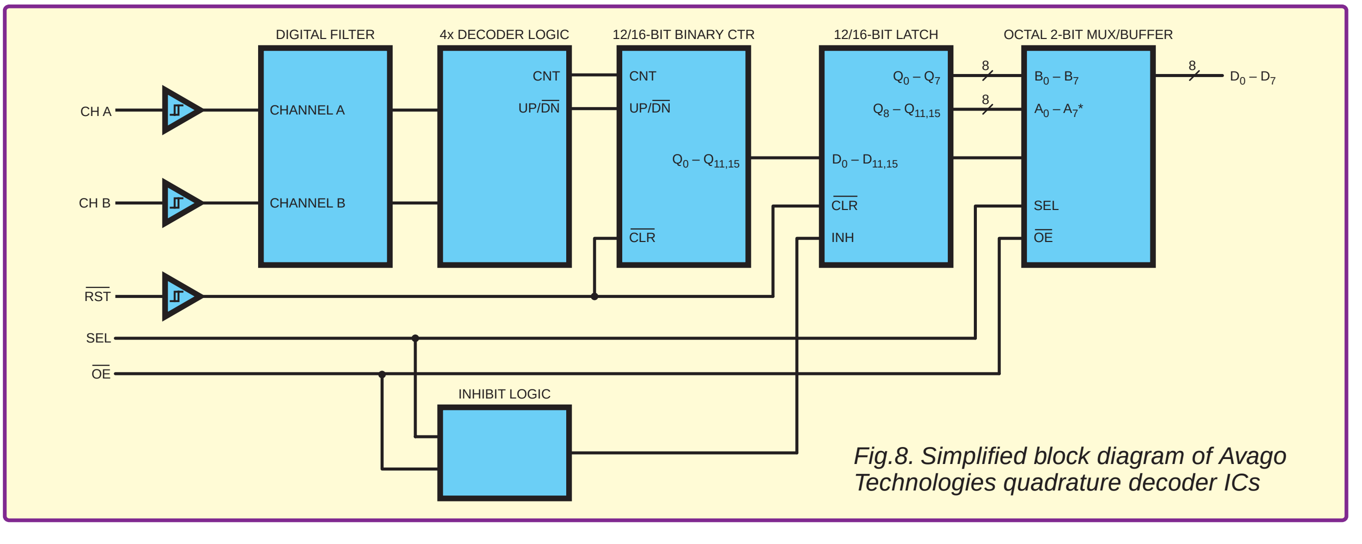

Fig.8. Simplified block diagram of Avago Technologies quadrature decoder ICs

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Video from a PIC – Part 2

We suggested last month that developing the hardware and software for video would be an interesting journey, and it certainly has been. We've had some interesting evenings since last month's article.

PIC24 microcontroller

As we would like to develop a system that is easy to program, we have taken the unusual step to not only take on a new subject – video generation – but also leap to a new processor: the PIC24. This is a 16-bit processor that runs at up to 80MHz, giving 40 million instructions per second. So although it is a bit risky trying out a new processor, the PIC24 has the extra processing power to help overcome any limitations in the efficiency of our design. That way, we can create something that works, and optimise it later on. We will trust in Microchip that moving from the PIC18 to the PIC24 will not be a major challenge – it's only a month till the next article!

As this is the first time we have covered the PIC24, and our project will be developed in C, you will probably want to download the free C compiler from Microchip (**www.microchip.com**. It's a 41MB file, so if you are on a slow dial-up link, we suggest you ask a friend to download it for you. You will of course need MPLAB to be pre-installed, but if you follow this column you probably have it installed already.

A bit of background on the PIC24 processor is called for now. The PIC24 is special: unlike other Microchip processors, it is actually a 'cut down' variant of another processor family, the dsPIC30F. The PIC24 is simply a dsPIC30 without the digital signal processing engine. While this is all very well – not everyone is interested in digital signal processing – it has introduced a source of great confusion. The PIC24 C compiler is based on the dsPIC30 compiler, and shares many common features, including its name. Picking through the PIC30 references can take a bit of getting used to, but we have already done that so you don't need to worry about it.

So, to download the C compiler for use with this month's article, go to the Microchip website. Under 'development tools' click on 'MPLAB C compilers', then 'MPLAB C Compiler for PIC24 MCUs', then 'MPLAB C Compiler for PIC24 Evaluation' version. The current release is v3.12, but this changes all the time. The evaluation version is fully functional; it just does not provide full code generation optimisation when translating from C to assembly language. So don't be put off by the 'evaluation' title; if the extra code it generates causes a problem you can always pay a pound more and get a larger memory device.

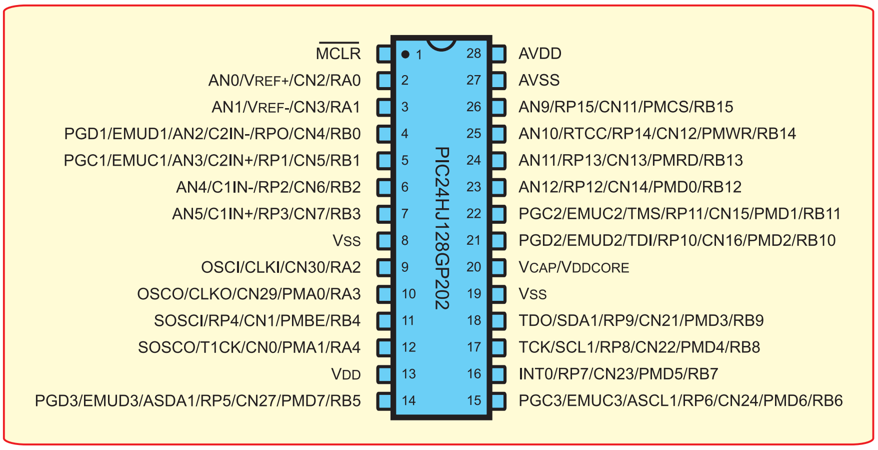

Fig.1. PIC24HJ128GP202 pinout

You will need to log into the Microchip website to download the compiler. Creating an account on their website is no more complicated than providing your email address, and takes just a few minutes; well worth the effort.

The compiler integrates itself into MPLAB automatically, and once downloaded you should be able to open the workspace file that accompanies this article and simply build the project.

If you want to make the most of this article, you should download the project files from the *EPE* website (via **www.epemag.wimborne.co.uk**) (found under 'library', 'project code library', '2009 Projects', '05-2009') and view the source files contained in the *PicNMix* zip file. To try out the code you will need to build the circuit, have access to a PIC programmer such as the PICKIT2, and of course have a PAL television with phono video input to hand. We will look at hooking up to a SCART interface, and also driving a standard LCD monitor in a later article.

Designing the hardware

We listed the requirements for the software and hardware in last month's article, but let's recap:

- Simple to build
- Simple to program
- Generate a 4.7μs sync pulse every 64μs
- Generate pre, post and vertical sync pulses to delineate a frame
- Generate a video signal for each line

All of these signals have to be very accurately timed relative to each other, as the television is expecting them to appear at precise times. This means that wherever possible we will use the peripheral hardware of our microcontroller to generate the signals, and keep software out of the process as much as possible. Any timing-critical signals generated by software would become corrupted by interrupts; it's much better to leave signal generation to hardware.

We are going to focus on black and white video output rather than colour. Colour encoding in PAL is *very* complex – and extremely difficult to generate on a PIC without additional hardware. Also, we are not going to provide support for gray scale, just white and black. When we know how well the circuit performs, we will investigate improved features. But don't worry, even this basic level of video output can provide considerable entertainment.

The processor we are using this month is the PIC24HJ128GP202, in a 28-pin dual-in-line package that will be familiar to many readers. It comes with an impressive 128KB flash, and a high clock speed – 80MHz, giving 40 million instructions per second. That extra processing power will come in handy later on.

The pin out of the processor is shown in Fig.1. It's a curious device; while superficially it looks similar to other high performance PICs, the PIC24 is rather different. For a start it's a 16-bit device, which means it processes 16 bits of data at a time – twice the processing power of an 8-bit processor at the same instruction rate.

The second and more interesting feature of this PIC is that the peripheral hardware inside it is not directly connected to any single set of pins. Instead, in software, you can map them to any of the 16 RP port

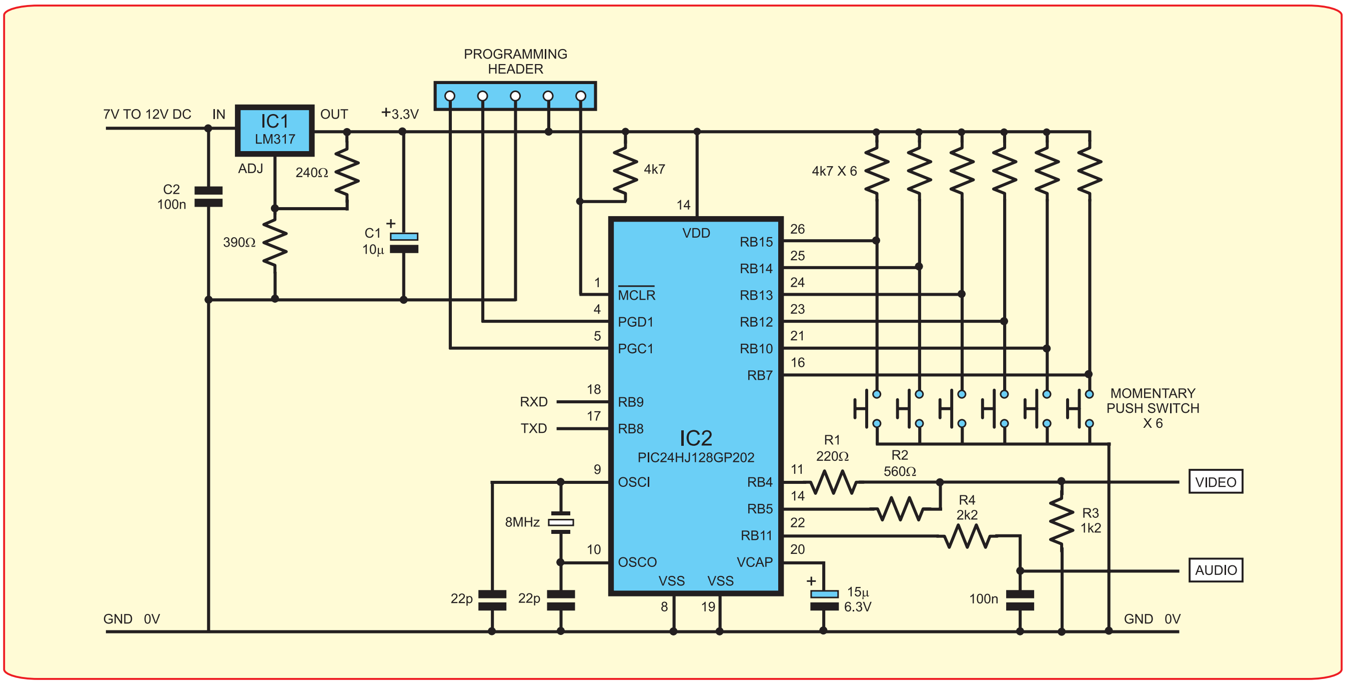

Fig.2. Video generation circuit diagram

pins you wish. While it's not a particularly useful feature for us – ours is a very simple design that can be laid out on stripboard – it's great for those more complex designs where PCB layout requirements call for short or conveniently routed tracks.

Circuit diagram

The circuit diagram is shown in Fig.2. As our requirements are simple, so is the circuit. IC1 is a standard regulator to provide 3.3V for the processor (you can use any 3.3V regulator; there is nothing critical in this design). A programming header is included with a PicKit2 interface to simplify programming and debugging. Six momentary push switches and associated pull-up resistors have been added to support the example program we have produced to demonstrate the video library software. They allow for two, three-button 'controllers' to be hooked up to the board, but are not required by the library code itself – so feel free to implement your own interface hardware if you wish.

Pins 18 and 19 of IC2 are shown as connected to the RXD and TXD signals. These are for RS232 support, which is currently not used. We will use these pins for a serial link in a later article.

The video generation circuit is based around components R1, R2 and R3. It is probably the simplest and cheapest interface possible, as any type of resistor will do. In conjunction with the 75Ω input impedance of a television's phono video input they allow the PIC to generate 0V, 300mV and 1V levels on the video signal. Simply connect this and a ground line to your television via a single core screened cable, such as used for hooking up microphones, and a phono plug.

The component values were derived through a combination of an Excel spreadsheet and trial and error. In use, the peak voltage output does not quite reach 1V (which indicates maximum intensity) but this was not found to be a problem. The component values had to be chosen carefully, because unlike other Microchip processors, the PIC24 has a limited output drive capability of just a few milliamps.

A simple audio output capability has been added, implemented by components R4 and a 100nF capacitor. The PIC will generate a square wave output signal at audio frequencies, and the two components form a single-pole low-pass filter with a fairly aggressive cut off frequency to give a close approximation to a sinewave. It's not going to play music, but the effect is quite good. The output level is sufficient to directly drive a television's audio input through another phono plug.

Modern televisions come equipped with several external video input connectors. Phono and SCART are the veteran ones, with digital connectors becoming more common. We have chosen to use the phono input simply because the connector is easy to purchase; next month we will show how to connect through a SCART connector. The signals are the same, so there will be no changes to the electronics required. Digital video inputs have a completely different electrical connection, incompatible with our design and so will not be considered. Most televisions support both analogue and digital inputs, however.

It's a remarkably simple circuit, and yet as we will see, the results are surprisingly good.

Software

The starting point for software development is with the basic sync pulse; can we generate a 4.7µs pulse every 64µs, all without any software intervention? The solution to this lies with the 'Output Compare' peripheral within the PIC. It's an odd name, which doesn't really help to explain what the feature actually does – which is to produce user-defined pulse sequences on a pin. Once configured, it will continue to output the user-defined pulse signal without any further software control. Perfect, if we can generate the very specific timings that we require.

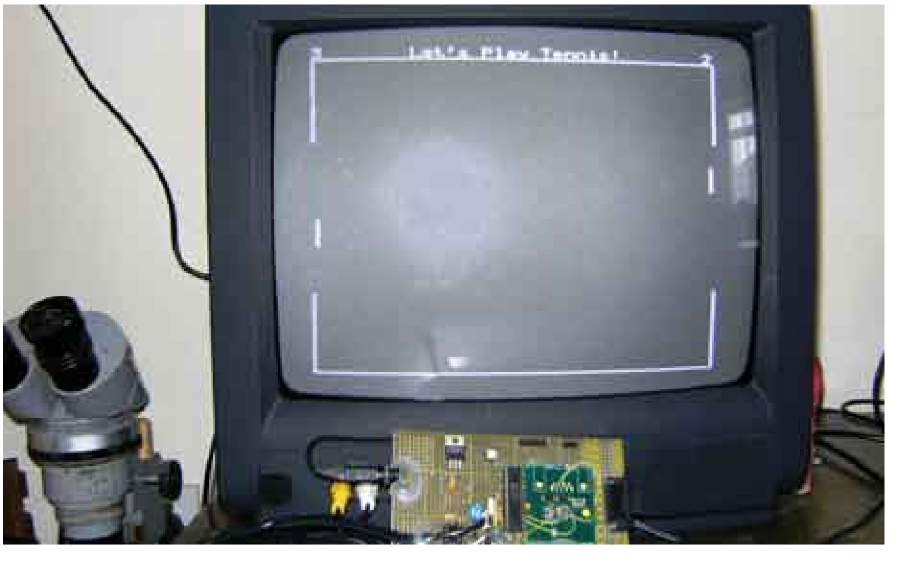

Fig.3. Example of TV display using the circuit in Fig.2.

The module works in conjunction with a timer, Timer2 in our case, which provides a basic 'count'. Two registers within the peripheral, OC3RS and OC3R, define at what value of the timer the port pin will toggle. So to get the timings we require – a 4.7μs pulse every 62μs – we are going to need 100ns resolution.

Timer2 is a 16-bit timer that can run directly from the internal instruction timer clock, Fcy. This is 40MHz, which gives a basic count rate of one increment every 25ns. Although this is perfect for our 4.7μs interval (a value of exactly 188 is required) we need to check that the period of 64μs is within the resolution of the 16-bit timer. A quick bit of maths gives a count value of 2560, which is easily within the timer's resolution. Clearly, this part of the design is easy.

Sync pulse generation

Our sync pulse generation scheme is not so straightforward, however. If you refer back to Fig.3 in last month's article you will see that there are some complicated pre- and post-equalisation sync pulses, which are twice as fast as normal sync pulses, plus some vertical interval pulses which appear inverted. How will we handle these?

Actually, very easily, using the trick of 'piggy backing' an interrupt off the pulse train signal. As Timer2 is acting as the timing source for the Output Compare module, we can write an interrupt routine which occurs whenever the output pin goes low, which signals the start of the pulse. When our interrupt occurs we can then write to the Output Compare registers to tell it when to go high. The Timer2 register continues to count at the rate of the oscillator clock, so our interrupt routine can take its time and write the registers at its leisure. The shortest sync period is 2μs, which equates to 80 instructions. Even using the C programming language we can easily service an interrupt in this time.

Within our interrupt routine (called _T2Interrupt in the **pic24video.c** file) we use a programming technique called a *State Machine* to count lines in each of the different 'states' that the program is in. These states are:

0 : Setup for 6 short sync pulses
1 : Output sync pulses
2 : Setup for 5 long pulses
3 : Output sync pulses
4 : Setup for 6 short sync pulses
5 : Output sync pulses
6 : Setup for normal line output
7 : Output lines

The program will loop round these states continuously, and very efficiently too.

Running a basic state machine within the Timer2 interrupt and observing the sync output on RB5, the data appears to be good. There was no point trying to observe the signal on a television at this point, as we have not started adding any video data to the signal, and so the display would remain blank.

Accurate and stable

At this point during development we were rather anxious to see if the video sync generation was accurate and stable, so we made a quick hack into the interrupt routine's state machine. Within state 7, which gets invoked for every line on the display, we hacked in a 20μs delay and then toggled the video pin RB4 high then quickly low. With a great deal of anticipation we hooked the composite video output line from the circuit to the television, and switched channel to Aux In.

Eureka! A solid, stable vertical bar appeared on the screen. We spent the rest of the evening hacking various random dots and checker board patterns, just enjoying watching a simple PIC processor and a few pennies worth of components controlling a television screen.

This initial success demonstrated two things: the Output Compare sync generation method worked, but also that generating video data could be done with timings that were relative to an interrupt. Any jitter caused by the microcontroller delaying its response to a request to process the interrupt was not visible. This latter point will simplify how we generate the actual video content, as we shall see shortly.

Within state 7 of the interrupt routine we have to perform one extra piece of logic at this stage: not all of the display lines are actually visible, top and bottom. Experimenting with the lines our vertical bar was displayed on indicated that the first 35 and the last 20 lines cannot be seen, so the state machine has a simple 'if' statement to take no action when these lines are being processed. This results in 240 visible lines in our application, which will help save on video memory (no point using RAM for pixels that cannot be seen) and also increasing the amount of processing time available to your application.

Now it's time to think about how we will transfer the pixel data from RAM to our video output pin. To start, we pick an approximate number of pixels that we would like to see on each display line – say 208. Referring to the display line timings from last month's Fig.2, we have 52μs in which to display those 208 pixels. That means 250ns per pixel. With 25ns per instruction, that only gives us 10 instructions with which to fetch the data, mask out the bit we are interested in and set the output pin accordingly – tricky.

SPI Output

Fortunately, there is another peripheral that can help us out, the SPI interface. If you have not come across this before, it's a synchronous serial port that can run at very high speeds. Being synchronous means that the rate at which data bits come in and go out are in time with a clock signal, and so are very accurate. Also, unlike asynchronous serial interfaces, there are no start or stop bits. The data you write into the transmit buffer is exactly what comes out. We can make use of this feature to produce a continuous bit stream containing only our data. As pixels are single bits that are either '1' for on or '0' for off, this interface is ideal for our purposes. So long as we can keep the SPI transmit buffer filled with data we should see no gaps on our display.

If you examine the source code of state 7 in the _T2Interrupt routine within **pic24Video.c**, you will see how we make 13 writes to the SPI buffer, which is 16 bits long, to generate our 208 pixel output. Apart from this code all that is required is to set up the SPI peripheral with a clock speed of 250ns, or 4MHz. Unfortunately, this isn't possible; the closest we can get to it is 5MHz, which means that our 208 pixels will only fill 80% of the screen width. But that is good enough for now, and we can improve on the situation later.

Next month, we will complete the description of the video library and describe a simple demonstration application. Until then, the full source code for the video library and demonstration application can be found on the *EPE* website. Fig.1 shows what you can expect – we hope you try it out, it's a fun trip down memory lane!

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ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS


Logic Probe testing

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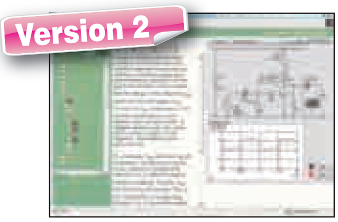
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0



Circuit simulation screen

Electronics Circuits & Components V2.0 provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals***: units and multiples, electricity, electric circuits, alternating circuits. ***Passive Components***: resistors, capacitors, inductors, transformers. ***Semiconductors***: diodes, transistors, op amps, logic gates. ***Passive Circuits. Active Circuits***. *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.

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

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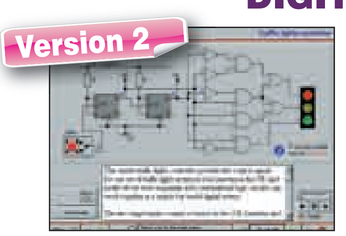
DIGITAL ELECTRONICS V2.0



Virtual laboratory - Traffic Lights

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

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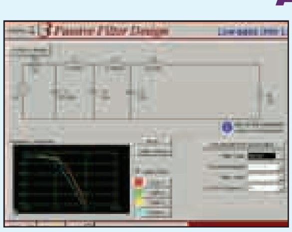
ANALOGUE FILTERS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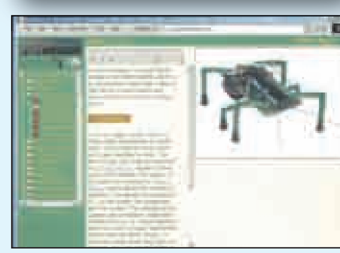
ROBOTICS & MECHATRONICS


Case study of the Milford Instruments Spider

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

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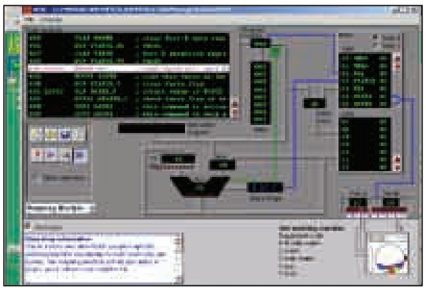

'C' FOR 16 Series PICmicro Version 4

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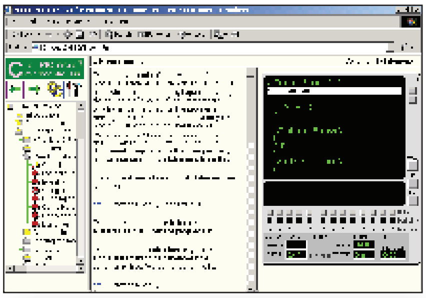

Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space. Flowcode will run on XP or later operating systems

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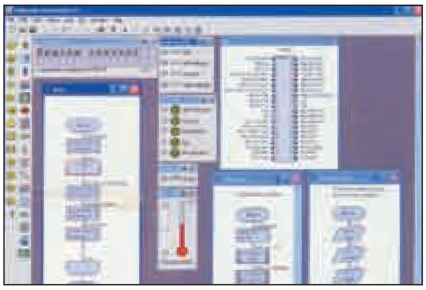

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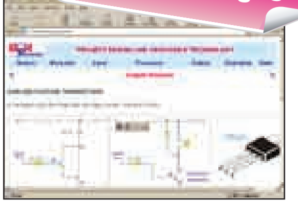

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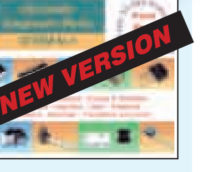

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READOUT

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 ★

A true diehard

Dear EPE

As a long-term reader and a recent subscriber, I note with interest the issues people have brought up regarding running their older DOS or early-version software on later operating systems, especially XP and Vista. Since many of these programmes are/were expensive, or users prefer the earlier versions, many of us like to stick with familiar software until we are forced to upgrade. But, we don't have to – nor do we have to spend a lot of money to resolve this issue.

My interest in electronics was first seeded by *EE* magazines (and to a slightly lesser extent by *Practical Electronics*) back in the 70s. That interest led me to my current position as the owner/director of a computer service company. Many of my clients use older 'green-screen' software to run anything from accounts to CNC machines and, for whatever reason, wish to continue using it.

As their machines 'die' and need to be replaced, they are also virtually forced to upgrade their operating system to keep up with other relevant technologies. How we get around the problem is by using Microsoft Virtual PC. This software, once quite expensive, is now freeware and can be downloaded directly from Microsoft (link below).

It is then a small step to dig out our Windows 95/98/ME disks from the drawer and install that version of Windows onto the Virtual Machine (VM). If you don't have these disks, they can be picked up cheaply from many second-hand software dealers or well-known auction sites for a nominal charge.

Briefly, a virtual machine is a separate operating system that runs 'inside' an existing system. You double-click an icon to start the virtual machine, then, when the VM system has 'booted', you can run your software of choice on that version of Windows, rather than your incompatible XP/Vista setup.

It is easy to set up, works like a dream, requires only a small amount of your hard drive space for the VM system's virtual hard drive, and older operating systems tend to run very quickly on modern hardware. Access to printers and other peripherals is done via the host machine's hardware layer, so compatibility is maintained for 'new' hardware.

While it may all seem complicated, a typical *EPE* reader should have no trouble installing and configuring MSVPC on their XP or Vista machines. If help is needed, our old friend Google has all the answers.

http://www.microsoft.com/windows/downloads/virtualpc/default.mspx (Virtual PC download)

http://www.ehow.com/how_2060126_install-operating-system-microsoft-virtual.html (External, non-affiliated 'how to install Virtual PC' link)

Dave Thompson, Christchurch NZ, by email

Excellent advice Dave – I took this route one stage further. I used to draw circuit diagrams for EPE *using an early 90s version of CorelDraw running on Windows 98 in Virtual PC – on Mac OSX! It worked seamlessly, which was quite a tribute to the quality of VPC.*

Netcam

Dear EPE

Is there any way to monitor a remote place using a camera via the internet without subscribing to a DHCP server.

Sam Zack, Canada, by email

Panasonic has a range of IP CCTV cameras that includes free access to **viewnetcam.com***, which provides you with a personal secure web address to manage the camera.*

http://panasonic.net/pcc/support/netwkcam/technic/viewnetcam_info.html

Some Panasonic cameras have Wi-Fi capability, so it talks to the router wirelessly. However, I have really struggled to get this running and it still doesn't log in properly. I suspect issues with broadband supplier messing up IP addresses.

http://www.networkwebcams.co.uk/index.php?cPath=32

Alan Winstanley

Soldering no-go

Dear EPE

In the April *Readout* you asked for further comment on tinned leads in 13A plugs.

Dave Reeves is quite right; in a former existence ten years ago (before retirement) I used to safety assess electronic equipment for BSI to EN60950.

A mains lead in a screwed terminal block (plug or equipment) that was pre-consolidated by solder was considered a failure. To be honest, I can't remember about secondary voltages.

Incidentally, a screw into the copper was a failure as well. The terminal blocks come in two types. Some blocks just have the screw bearing straight into the wire (fail) and others have a small flat springy strip between the wire and the screw (pass).

Things may have changed in the last ten years, but I doubt it.

Roger Warrington, by email

Dear EPE

With reference to Dave Reeves letter (April '09), having served time in product safety I can confirm that tinning multi-stranded mains conductors to neaten up the ends is a no-no. As far as I can recall, it would not get past the approvals authority for CE marking.

Bare copper provides a springy resilience that presses back against a screw terminal or the like, and thus keeps the contact tight. If solder is introduced into the equation, it squashes under the pressure of the terminal and gradually creeps out of the way over a period of time, so that a screw terminal becomes loose. You may have seen this in old mains plugs and wondered why.

Need I go on? A loose contact is a point of high resistance, and apart from the mechanical stability and potential for arcing, if the contact is carrying any appreciable current it will lead to local heating and a fire risk.

Don't do it. If you come across any mains plugs that have been made up in this way, cut off the ends of the wires and reassemble with untinned ends.

Ken Wood, by email

Sound advice Roger and Ken – I must confess that this is an error I have made, but it's never too late to learn, especially where mains and safety are involved.

Net Work

Alan Winstanley

Welcome to this month's *Net Work* column, our regular feature for Internet users. Be sure to head over to our website at *EPE* Online at **www.epemag.com**, where you will find more bonus material to complement my column. Reader ***John Porter*** wrote to say:

Hi Alan, love your articles! I was wondering how you connected your laptop to the Internet through your mobile phone, as mentioned last month. I have free Internet access via Orange and would like to take advantage of it in non-wifi supported space! I, like you, prefer a PDA and have an O2 XDA II phone.

On the *EPE* Online *Net Work* web page I have added a new article on using a mobile phone as a modem, starting with a legacy Nokia GSM phone, and using a Windows Mobile smartphone via USB and Bluetooth. I highlighted a Belkin USB Bluetooth dongle which is perfect for non-Bluetooth laptops. I had very passable results using GPRS and Bluetooth.

My online article mentions 0845 (UK only) subscription-free Internet access – dial-up networking (DUN) in other words. If broadband goes down then the often-overlooked 56k DUN is an alternative to bear in mind, especially if your laptop has a built-in modem. For details of suitable 0845 numbers go to **www.epemag.com** and click the *Net Work* link at the top.

A prim and proper registry

My thanks go to reader ***Mel Daniels,*** who emailed me:

Hi Alan, I am a regular reader of your Net Work *articles. My computer has slowed right down and someone has suggested a registry cleaner. How about writing an article on them?*

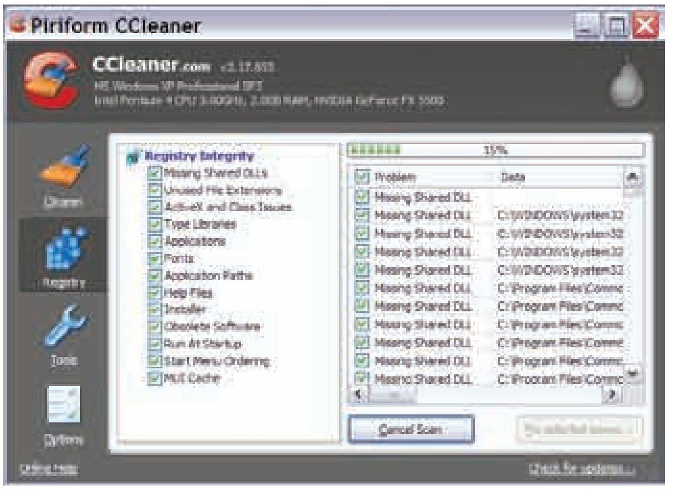
Although *Net Work* is mainly an Internet column rather than being computer-orientated, Mel's query coincided with a possible registry-related problem on one of my machines.

The Registry is the critical core in Windows, containing the configuration details of installed software, hardware, multiple users and more. Sometimes, rogue or poorly-written software can damage the registry, creating odd Windows annoyances or even preventing programs from operating altogether.

My PC started throwing up error messages whenever Windows Explorer opened: 'Error Loading Resource DLL'. My best guess was that Windows Explorer was looking for a 'shell extension' program that no longer existed, but which had not cleaned up after itself properly. I also noted that whenever I opened a JPEG image file, the machine crashed immediately (a vital clue!). In-depth anti-virus scans turned up a blank.

I found Windows Registry Repair Pro from 3B Software (**www.3bsoftware.com**), cost $19.99, but after a time-consuming scan the problem still remained, and a further test with trusted Malwarebytes revealed no malware either.

Soon I was googling for registry cleaner programs. One port of call was Trend Micro Housecall (**http://housecall.trendmicro.com**), a free online scanner (requires Java) from a reputable supplier – but allow plenty of time for scanning. This found nothing either, and the hours drifted by…



CCleaner from London-based Piriform is a reputable Registry Cleaner worth trying – best of all, it's free

Screaming marketing

Following more Google links for registry programs, I found many sales methodologies to be highly disagreeable. When you're making a 'distress purchase' such as a registry repair product, it's worth being cynical and on your guard! Google's sponsored results muddy the waters with 'registry cleaner comparison' sites. A casual surfer has no way of knowing if they are genuine links, phoney reviews or just money-spinning affiliate links, which can detract from the very product they are trying to sell.

The first paid-for Google link I tried clicked through to an aggressively written landing page at **http://preview.tinyurl.com/d63oby** (20 screen-fulls of screaming marketing) that recommended RegCure software (or buy direct from **www.regcure.com**). One 'free' download later, RegCure highlighted 1,991 supposed errors. To fix them, all I had to do was 'register'. A convenient link to a popup still did not give the game away – a website launched with no sign of price. Eventually, you get to the very, very end to read the bottom line: it costs $39.95 but a special discount 'expiring at midnight' offers a $10 reduction.

When uninstalling RegCure, it made a last-gasp attempt at a sale by offering itself for 'free' – the handy link sends you to a TrialPay page and RegCure remains firmly embedded until you go back to uninstall it properly. Does RegCure work? I'm afraid I will never know. It seemed attractive-enough for novices, but in my book anything that is not transparent and up-front about costs is immediately uninstalled, leaving behind, I hope, no registry errors of its own.

RegCure had a passing resemblance to RegDefense (**www.regdefense.com**) that was $44.95 reduced to $29.95. It claimed to find 2,500 errors and counting – once launched, it could not be cancelled, and it installed a nagging 'register' system tray icon that could not be removed.

Turning to another download, Uniblue Registry Booster 2009 (**www.liutilities.com**), I was somewhat miffed to see the very last thing during 'registration' (purchase) that its so-called 'Active Protection' was in fact an annual subscription!

Overall, I came away very dismayed by this online marketing whirlwind. To answer the reader's enquiry, I suggest starting closer to home with London-based Piriform's CCleaner freeware from **www.ccleaner.com** and be sure to install **ccsetup217.exe**.

You could gamble on a download and it might work, or it may be $30 or $40 (a year) wasted. For paid-for software, in the past I suggested PC Tools (**www.pctools.com**), which is now backed by the armour-plated brand of Symantec. A trial of their Registry Mechanic is available. Or try WinOptimiser 6 from **Ashampoo.com**.

In general, try to find more clues about the registry problem and think of the time when symptoms were first noticed. Had a program recently been uninstalled? Try re-installing it: in my case, I found that Corel Paint Shop Pro, which handles my JPEGs, simply needed re-installing.

On my monthly blog I'll continue this theme with plenty of screenshots and hyperlinks, so be sure to head over to **www.epemag.com** and click the *Net Work* link at the top. You can Email me at **alan@epemag.demon.co.uk**

DIRECT BOOK SERVICE

Electronics Teach-In + FREE CD-ROM

Mike Tooley

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

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

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

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CIRCUITS AND DESIGN

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

142 pages **Order code BP332** **£5.45**

PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.

Bridges the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias – tedious and higher mathematics have been avoided where possible and many tables have been included.

The book is divided into six basic sections: Units and Constants, Direct-Current Circuits, Passive Components, Alternating-Current Circuits, Networks and Theorems, Measurements.

256 pages **Order code BP53** **£5.49**

MICROCONTROLLER COOKBOOK
Mike James

The practical solutions to real problems shown in this cookbook provide the basis to make PIC and 8051 devices really work. Capabilities of the variants are examined, and ways to enhance these are shown. A survey of common interface devices, and a description of programming models, lead on to a section on development techniques. The cookbook offers an introduction that will allow any user, novice or experienced, to make the most of microcontrollers.

240 pages **Order code NE26** **£25.99**

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

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2

EASY PC CASE MODDING
R.A Penfold

Why not turn that anonymous grey tower, that is the heart of your computer system, into a source of visual wonderment and fascination. To start, you need to change the case or some case panels for ones that are transparent. This will then allow the inside of your computer and it's working parts to be clearly visible.

There are now numerous accessories that are relatively inexpensive and freely available, for those wishing to customise their PC with added colour and light. Cables and fans can be made to glow, interior lights can be added, and it can all be seen to good effect through the transparent case. Exterior lighting and many other attractive accessories may also be fitted.

This, in essence, is case modding or PC Customising as it is sometimes called and this book provides all the practical details you need for using the main types of case modding components including:- Electro luminescent (EL) 'go-faster' stripes: Internal lighting units: Fancy EL panels: Data cables with built-in lighting: Data cables that glow with the aid of 'black' light from an ultraviolet (UV) tube: Digital display panels: LED case and heatsink fans: Coloured power supply covers.

192 pages + CD-ROM **Order code BP542** **£8.99**

COMPUTING AND ROBOTICS

WINDOWS XP EXPLAINED
N. Kantaris and P. R. M. Oliver

If you want to know what to do next when confronted with Microsoft's Windows XP screen, then this book is for you. It applies to both the Professional and home editions.

The book was written with the non-expert, busy person in mind. it explains what hardware requirements you need in order to run Windows XP successfully, and gives an overview of the Windows XP environment.

The book explains: How to manipulate Windows, and how to use the Control Panel to add or change your printer, and control your display; How to control information using WordPad, notepad and paint, and how to use the Clipboard facility to transfer information between Windows applications; How to be in control of your filing system using Windows Explorer and My Computer; How to control printers, fonts, characters, multimedia and images, and how to add hardware and software to your system; How to configure your system to communicate with the outside world, and use Outlook Express for all your email requirements; how to use the Windows Media Player 8 to play your CDs, burn CDs with your favourite tracks, use the Radio Tuner, transfer your videos to your PC, and how to use the Sound Recorder and Movie Maker; How to use the System Tools to restore your system to a previously working state, using Microsoft's Website to update your Windows set-up, how to clean up, defragment and scan your hard disk, and how to backup and restore your data; How to successfully transfer text from those old but cherished MS-DOS programs.

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Robert Penfold

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

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MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision command system

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

298 pages **Order code BP902** **£14.99**

THE PIC MICROCONTROLLER YOUR PERSONAL INTRODUCTORY COURSE – THIRD EDITION John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised third edition covers the popular reprogrammable Flash PICs: 16F54/16F84 as well as the 12F508 and 12F675.

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The book's companion website at http://books.elsevier.com/companions/9780750665568 contains: downloadable files of all the programs and subroutines; program listings for the Quester and the Gantry robots that are too long to be included in the book.

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THEORY AND REFERENCE

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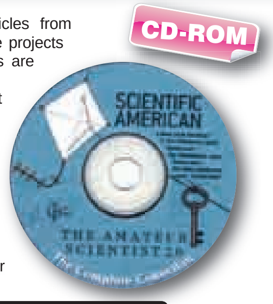

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The contents include a description of the basic oscillscope; Advanced real-time oscilloscope; Accessories; Using oscilloscopes; Sampling oscilloscopes; Digital storage oscilloscopes; Oscilloscopes for special purposes; How oscillocopes work (1): the CRT; How oscilloscopes work (2): circuitry; How oscilloscopes work (3): storage CRTs; plus a listing of Oscilloscope manufacturers and suppliers.

288 pages **Order code NE37** **£25.99**

ELECTRONIC TEST EQUIPMENT HANDBOOK
Steve Money

In most applications of electronics, test instruments are essential for checking the performance of a system or for diagnosing faults in operation, and so it is important for engineers, technicians, students and hobbyists to understand how the basic test instruments work and how they can be used.

The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of these instruments are also examined.

206 pages **Order code PC109** **£9.95**

UNDERSTANDING ELECTRONIC CONTROL SYSTEMS
Owen Bishop

Owen Bishop has produced a concise, readable text to introduce a wide range of students, technicians and professionals to an important area of electronics. Control is a highly mathematical subject, but here maths is kept to a minimum, with flow charts to illustrate principles and techniques instead of equations.

Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.

The text is supported by questions under the headings Keeping Up and Test Your Knowledge so that the reader can develop a sound understanding and the ability to apply the techniques they are learning.

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NEW FULL COLOUR COMPUTING BOOKS

HOW TO FIX YOUR PC PROBLEMS — R.A. Penfold

What do you do when your laptop or desktop stops working properly. Do you panic, try to find the answer on the page of fault finding tips you may find at the back of the manufacturers manual. Or do you spend hours trying to get through to a telephone helpline or waste even more time waiting for an email reply from a helpdesk.

Well help is now at hand! This book will assist you in identifying the type of problem, whether it's hardware, software or a peripheral that is playing up? Once the fault has been identified, the book will then show you how to go about fixing it. This book uses plain English and avoids technical jargon wherever possible. It is also written in a practical and friendly manner and is logically arranged for easy reference.

The book is divided into four main sections and among the many topics covered are: Common problems with Windows Vista operating system not covered in other chapters. Also covers to a lesser extent Windows XP problems. Sorting out problems with ports, peripherals and leads. Also covers device drivers software and using monitoring software. Common problems with hard disc drives including partitioning and formatting a new drive. Using system restore and recovering files. Also covers CD-ROM and Flash drives. Common problems with sound and video, including getting a multi-speaker system set up correctly.

An extremely useful addition to the library of all computer users, as you never know when a fault may occur!

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AN INTRODUCTION TO WINDOWS VISTA — P.R.M. Oliver and N. Kantarris

If you have recently bought a new desktop or laptop it will almost certainly have Windows as its operating system. Windows Vista manages the available resource of a computer and also 'controls' the programs that run on it.

To get the most from your computer, it is important that you have a good understanding of Vista. This book will help you acheive just that. It is written in a friendly and practical way and is suitable for all age groups from youngsters to the older generation. It has been assumed that Vista is installed and running on your computer.

Among the numerous topics explained are: The Vista environment with its many windows. How to organise your files, folders and photos. How to use Internet Explorer for your web browsing. How to use Microsoft Mail for your emails. How to control your PC and keep it healthy. How to use Vista's Accessibility features if you have poor eye sight or difficulty in using the keyboard or mouse. And much more besides....

With the help of this book you will easily and enjoyably gain a better understanding of Microsoft's amazing Windows Vista operating system.

Printed in full colour on high quality non-refective paper

120 pages **Order code BP703** **£8.49**

COMPUTING WITH A LAPTOP FOR THE OLDER GENERATION — R.A. Penfold

Laptop computers have rapidly fallen in price, increased in specification and performance and become much lighter in weight. They can be used practically anywhere, then stored away out of sight. It is therefore, not surprising that laptop sales now far exceed those of desktop machines and that they are increasingly becoming the machine of choice for the older generation.

You may want to use your laptop as your main computer or as an extra machine. You may want to use your laptop on the move, at home, at work or on holiday. Whatever your specific requirements are, the friendly and practical approach of this book will help you to understand and get the most from your laptop PC in an easy and enjoyable way. It is written in plain English and wherever possible avoids technical jargon.

Among the many topics covered are: Choosing a laptop that suits your particular needs. Getting your new computer set up properly. Customising your computer so that it is optimised for your particular needs. Setting up and dealing with user accounts. Using the Windows 'Ease of Access Center'. Optimising the life and condition of your battery. Keeping the operating system and other software fully up-to-date. Troubleshooting common problems. Keeping your computer and data safe and secure. And much more besides...

Even though this book is written for the older generation, it is also suitable for anyone of any age who has a laptop or is thinking of buying one. It is written for computers that use Windows Vista as their operating system but much will still apply to Windows XP machines. Printed in full colour on high quality non-refective paper

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The practical and friendly approach of this book will help newcomers to easily learn and understand the basics of spreadsheets. This book is based on Microsoft's Excel 2007 spreadsheet, but much of the book will still apply to earlier versions of Excel. The book is written in plain English, avoiding technical and mathematical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.

Among the many topics explained are how to: Install the software. Use the exciting new features of Excel 2007. Create and use a spreadsheet. Enter, edit and format text, numbers and formulae. Insert and delete columns and rows. Save and print a spreadsheet. Present the information on a spreadsheet as a graph or chart. Manage and safeguard Excel files on disc. Use Excel as a simple database for names and addresses.

This book will help you to quickly gain confidence and get to grips with using spreadsheets. In fact, you will wonder how you ever managed without them.

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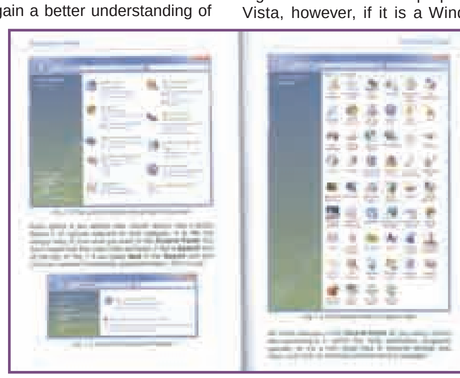
AN INTRODUCTION TO DIGITAL PHOTOGRAPHY WITH VISTA — R.A. Penfold

The friendly and practical approach of this book will help newcomers to digital photography and computing to easily learn the basics they will need when using a digital camera with a laptop or desktop PC. It is assumed that your PC uses Windows Vista, however, if it is a Windows XP machine the vast majority of this book will still apply. The book is written in plain English, avoiding technical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.



Among the many topics explained are how to: Understand the basic features of a digital camera. Transfer photographs from your digital camera to your computer. View your photographs. Save, sort and file your photographs. Manipulate, crop and carry out simple corrections to your photographs. Copy your photographs on to CD or DVD. Print your photographs. Share images with family and friends anywhere in the world by email or with an online album.

This book will help you quickly get to grips with, gain confidence and expand your horizons in the fascinating hobby of digital photography.

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PROJECT BUILDING

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different.
The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

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BUILDING VALVE AMPLIFIERS
Morgan Jones

The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.
A unique hands-on guide for anyone working with valve (tube in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.
Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

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GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.
In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

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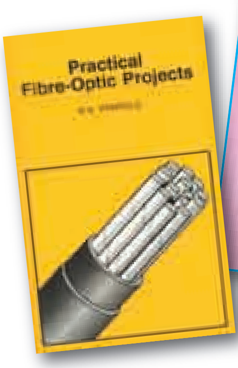
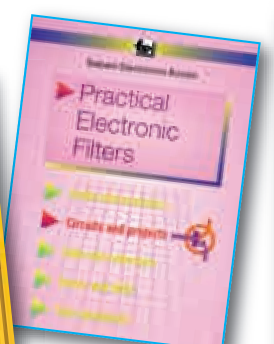
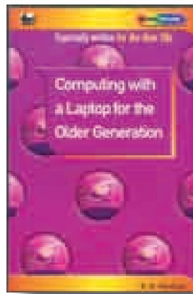


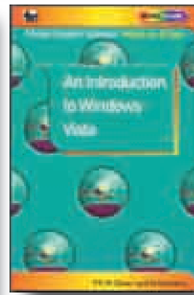


PRACTICAL ELECTRONIC FILTERS
Owen Bishop

This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.
The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.
Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

188 pages **Order code BP299** £5.45





PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.
The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.
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STARTING ELECTRONICS, THIRD EDITION
Keith Brindley

A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.
A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.
Breadboarding layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages **Order code NE42** £12.99

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.
There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.
Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

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NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photocopies of articles are available if required – see the Back Issues page for details. WE DO NOT SUPPLY KITS OR COMPONENTS FOR OUR PROJECTS.

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Boards can only be supplied on a payment with order basis.

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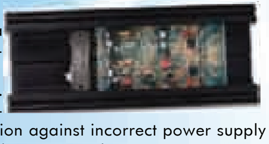

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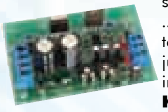

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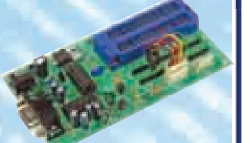

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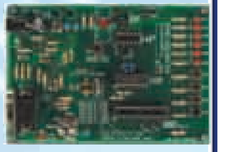

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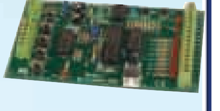

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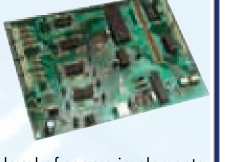

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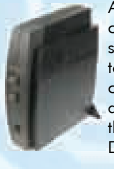

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