THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EVERYDAY PRACTICAL ELECTRONICS

Vol.32 No.1

CAN $6.99/US $4.95

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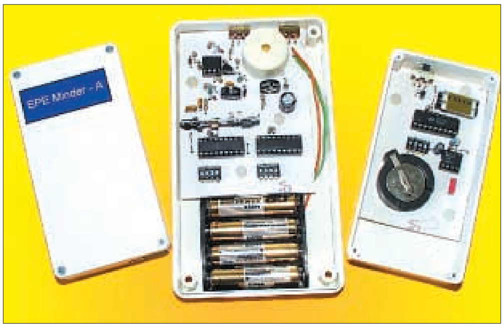
WIND SPEED METER
An ultrasonic anemometer

EPE MINDER
Versatile RF protection



FM FREQUENCY SURFER
88 to 125MHz Receiver

PLUS

PICAXE LIGHT CHASER PROJECTS

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COMMENTS . . . POPULAR FEATURES . . .

VOL. 32. No. 1 JANUARY 2003
Cover illustration by jgr22

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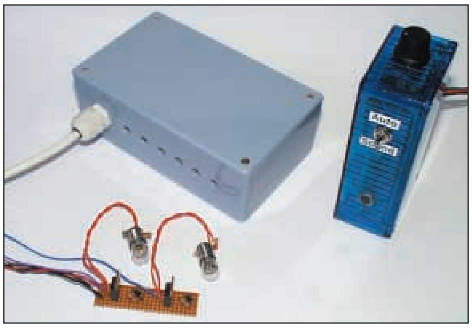

Projects and Circuits

Series and Features

Regulars and Services

Our February 2003 issue will be published on Thursday, 10 January 2003. See page 3 for details

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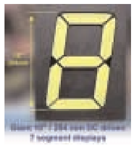
THIS MONTH'S SELECTION FROM OUR VAST EVER CHANGING STOCKS

GIANT 10" 7-SEGMENT DISPLAYS



A bulk purchase enables us to bring to you these GIANT 7-segment digital displays at a **now affordable** price!! The **10" character size** gives exceptional readability at long distances and enables a host of applications including, score boards, **digital clocks, counters, event timers** etc. As the units are a simple electro-mechanical device and operate from 12V DC, simple switching via switches, relays, PIC or PC may be used to control single or multiple digits. Units feature integral 'Zero Power' memory which greatly simplifies desgn. For an **excellent DIY practical article**, see the May issue of **'Everyday Practical Electronics' magazine. Ideal School / College construction project**. Supplied in good RFE condition, complete with data sheet.

Less than 30% of makers price — **Only £29.95**(B) **or 4 / £99.00**(D)
Order RW44 — Order PH26

THE AMAZING TELEBOX

TV SOUND & VIDEO TUNER
CABLE COMPATIBLE *

Converts your colour monitor into a QUALITY COLOUR TV!!

The **TELEBOX** is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors or AV equipment which are fitted with a composite video or SCART input. The composite video output will also plug directly into most video recorders, allowing reception of **TV channels not normally receivable on most television receivers*** (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television channels. **TELEBOX MB** covers virtually all television frequencies VHF and UHF **including the HYPERBAND as used by most cable TV operators.** Ideal for **desktop computer video systems** & PIP (picture in picture) setups. For complete compatibility – even for monitors without sound – an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard. Brand new – fully guaranteed.

TELEBOX ST for composite video input type monitors	**£36.95**
TELEBOX STL as ST but fitted with integral speaker	**£39.50**
TELEBOX MB Multiband VHF/UHF/Cable/Hyperband tuner	**£69.95**

For overseas PAL versions state 5.5 or 6 mHz sound specification.
*For cable / hyperband signal reception Telebox MB should be connected to a cable type service. Shipping on all Telebox's, code (B)

NEW State of the art PAL (UK spec) **UHF TV tuner module** with **composite** 1V pp video & **NICAM** hi fi stereo sound outputs. **Micro electronics** all on one small PCB only 73 x 160 x 52 mm enable full tuning control via a **simple 3 wire link** to an IBM pc type computer. Supplied complete with **simple working program** and documentation. Requires +12V & + 5V DC to operate.
BRAND NEW - Order as MY00. Only £39.95 code (B)
See www.distel.co.uk/data_my00.htm for picture + full details

HARD DISK DRIVES 2½" - 14"

2½" **TOSHIBA** MK1002MAV 1.1Gb laptop(12.5 mm H)	***New***	**£59.95**
2½" **TOSHIBA** MK4313MAT 4.3Gb laptop (8.2 mm H)	***New***	**£105.00**
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2½" **TOSHIBA** MK1614GAV 18 Gb laptop (12 mm H)	***New***	**£149.95**
2½" to 3½" conversion kit for Pc's, complete with connectors		**£15.95**
3½" **COMPAQ** 313706-B21 (IBM) 9 gb ULT/SCSI3	***New***	**£199.00**
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5¼" **HP C3010** 2 Gbyte SCSI ***differential*** RFE tested		**£195.00**
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8" **FUJITSU** M2322K 160Mb SMD I/F RFE tested		**£195.00**
8" **FUJITSU** M2392K 2 Gb SMD I/F RFE tested		**£345.00**

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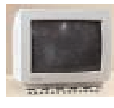
CGA, EGA, VGA, SVGA



Mitsubishi FA3415ETKL 14" SVGA **Multisync** colour monitor with fine 0.28 dot pitch tube and resolution of 1024 x 768. A variety of inputs allows connection to a host of computers including **IBM PC's** in **CGA, EGA, VGA & SVGA** modes, **BBC, COMMODORE** (including Amiga 1200), **ARCHIMEDES** and **APPLE.** Many features: Etched faceplate, text switching and **LOW RADIATION MPR** specification. Fully guaranteed, in EXCELLENT little used condition. **Tilt & Swivel Base £4.75**

VGA cable for IBM PC included. **Only £129** (E) **Order as CG73**

External cables for other types of computers available - CALL

Generic LOW COST SVGA Monitors

We choose the make, which includes Compaq, Mitsubishi, IBM, etc. Supplied ready to run with all cables, Standard RTB 90 day guarantee.

14"	15"	17"
£59.00	**£69.00**	**£79.00**

Supplied in good used condition. Shipping code (D)

VIDEO MONITORS

PHILIPS HCS35 (same style as CM8833) attractively styled 14" colour monitor with **both RGB and standard composite 15.625 Khz video inputs** via **SCART socket** and separate phono jacks. Integral audio **power amp and speaker** for **all audio visual uses.** Will connect direct to **Amiga and Atari** BBC computers. Ideal for all **video monitoring / security** applications with **direct connection to most colour cameras.** High quality with many features such as front concealed flap controls, VCR correction button etc. Good used condition - fully tested - guaranteed
Dimensions: W14" x H12¾" x 15½" D. **Only £99.00** (E)

PHILIPS HCS31 Ultra compact 9" colour video monitor with **standard composite 15.625 Khz video** input via SCART socket. Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13½" D. 240 V AC mains powered. **Only £79.00** (D)

INDUSTRIAL COMPUTERS

Tiny shoebox sized industrial 40 Mhz 386 PC system measuring only (mm) 266 w X 88 h X 272 d. Ideal for dedicated control applications running DOS, Linux or even Windows ! Steel case contains 85 to 265 V AC 50 / 60 hz 70 Watt PSU, a 3 slot ISA passive backplane and a Rocky 318 (PC104) standard, single board computer with 8 MByte NON VOLATILE solid state 'Disk On Chip' RAMDISK. System comprises: Rocky 318 (PC104) SBC ISA card with 40MHz ALi 386SX CPU, 72 pin SIMM slot with 16 Mbyte SIMM, AMI BIOS, battery backed up real time clock. 2 x 9 pin D 16550 serial ports. EPP/ECP printer port, mini DIN keyboard connector, floppy port, IDE port for hard drives up to 528 MByte capacity, watchdog timer and PC/104 bus socket. The 8 MByte solid state 'disk on a chip' has its own BIOS, and can be fdisked, formatted & booted. Supplied BRAND NEW fully tested and guaranteed. For full data see featured item on website. Order as QG36.

100's of applications inc: firewall, routers, robotics etc **Only £99.00** (D)

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Made by **Eurocraft Enclosures** Ltd to the **highest possible spec,** rack features **all steel construction** with removable side, front and back doors. Front and back doors are **hinged for easy access** and all lockable with five **secure 5 lever barrel locks.** The front door is constructed of double walled steel with a **'designer style'** smoked acrylic front panel to enable status indicators to be seen through the panel, yet remain unobtrusive. Internally the rack features fully slotted reinforced vertical fixing members to **take the heaviest of 19" rack equipment.** The two movable vertical fixing struts (extras available) are pre punched for standard 'cage nuts'. A **mains distribution panel** internally mounted to the bottom rear, provides 8 x IEC 3 pin Euro sockets and 1 x 13 amp 3 pin **switched utility socket.** Overall ventilation is provided by fully louvered back door and double skinned top section with top and side louvres. The top panel may be removed for fitting of **integral fans** to the sub plate etc. Other features include: fitted castors and floor levelers, prepunched utility panel at lower rear for cable / connector access etc. Supplied in **excellent,** slightly used condition with keys. Colour Royal blue. some grey available – CALL – Can be supplied in many other configurations.

33U	42U	47U
Order as BC44	**Order as DT20**	**Order as RV36**
External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)	External dimensions mm=2019H x 635D x 603 W. (79.5" H x 25" D x 23¾" W)	External dimensions mm=2019H x 635D x 603 W. (88" H x 25" D x 23¾" W)
Only £245	**Only £345**	**Only £410**

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BIG £ SAVER

Undoubtedly a **miracle of modern technology** & our special buying power ! A **quality product** featuring a fully cased **COLOUR** CCD camera at a give away price ! Unit features full autolight sensing for use in **low light & high light applications.**

A 10 mm fixed focus wide angle lens gives **excellent focus and resolution** from close up to long range. The **composite video** output will connect to any composite monitor or TV (via SCART socket) and most video recorders. Unit **runs from 12V DC** so ideal for security & **portable applications** where mains power not available. Overall dimensions 66 mm wide x 117 deep x 43 high. Supplied BRAND NEW & fully guaranteed with user data, 100's of applications including Security, Home Video, Web TV, Web Cams etc, etc.

Order as LK33 ***ONLY £79.00 or 2 for £149.00*** ***(B)***

SOFTWARE SPECIALS

NT4 WorkStation, complete with service pack 3 and licence - OEM packaged. ***ONLY £89.00*** ***(B)***

ENCARTA 95 - CDROM, Not the latest - but at this price !	**£7.95**
DOS 5.0 on 3½" disks with concise books c/w QBasic .	**£14.95**
Windows for Workgroups 3.11+ Dos 6.22 on 3.5" disks	**£55.00**
Windows 95 CDROM Only - No Licence -	**£19.95**
Wordperfect 6 for DOS supplied on 3½" disks with manual	**£24.95**

SOLID STATE LASERS

Visible red, 670nm laser diode assembly. Unit runs from 5 V DC at approx 50 mA. Orginally made for continuous use in industrial bar-code scanners, the laser is mounted in a removable solid aluminium block, which functions as a heatsink and rigid optical mount. Dims of block are 50 w x 50 d x 15 h mm. Integral features include over temperature shutdown, current control, laser OK ouput, and gated TTL ON / OFF. Many uses for experimental optics, comms & lightshows etc. Supplied complete with data sheet.

Order as TD91 ***ONLY £24.95*** ***(A)***

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TEST EQUIPMENT & SPECIAL INTEREST ITEMS

Unless marked NEW, items in this section are pre owned.

MITSUBISHI FA3445ETKL 14" Ind. spec SVGA monitors	**£245**
FARNELL 0-60V DC @ 50 Amps, bench Power Supplies	**£995**
FARNELL AP3080 0-30V DC @ 80 Amps, bench Suppy	**£1850**
KINGSHILL CZ403/1 0-50V @ DC 200 Amps - NEW	**£3950**
1kW to 400 kW - 400 Hz 3 phase power sources - ex stock	**£POA**
IBM 8230 Type 1, Token ring base unit driver	**£760**
Wayne Kerr RA200 Audio frequency response analyser	**£2500**
INFODEC 1U, 24 port, RJ45 network patchpanels. #TH93	**£49**
3COM 16670 12 Port Ethernet hub - RJ45 connectors #LD97	**£69**
3COM 16671 24 Port Ethernet hub - RJ45 connectors	**£89**
3COM 16700 8 Port Ethernet hub - RJ45 connectors NEW	**£39**
IBM 53F5501 Token Ring ICS 20 port lobe modules	**£POA**
IBM MAU Token ring distribution panel 8228-23-5050N	**£45**
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE I/O	**£550**
ALLGON 8360.11805-1880 MHz hybrid power combiners	**£250**
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	**£POA**
Marconi 6310 Programmable 2 to 22 GHz sweep generator	**£4500**
Marconi 2022C 10KHz-1GHz RF signal generator	**£1550**
HP1650B Logic Analyser	**£3750**
HP3781A Pattern generator & **HP3782A** Error Detector	**£POA**
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	**£1800**
HP6264 Rack mount variable 0-20V @ 20A metered PSU	**£475**
HP54121A DC to 22 GHz four channel test set	**£POA**
HP8130A opt 020 300 MHz pulse generator, GPIB etc	**£7900**
HP A1, A0 8 pen HPGL high speed drum plotters - from	**£550**
HP DRAFTMASTER 1 8 pen high speed plotter	**£750**
EG+G Brookdeal 95035C Precision lock in amp	**£1800**
Keithley 590 CV capacitor / voltage analyser	**£POA**
Racal ICR40 dual 40 channel voice recorder system	**£3750**
Fiskers 45KVA 3 ph On Line UPS – New batteries	**£4500**
Emerson AP130 2.5KVA industrial spec.UPS	**£1499**
Mann Tally MT645 High speed line printer	**£2200**
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	**£945**
HP6030A 0-200V DC @ 17 Amps bench power supply	**£1950**
Intel SBC 486/125C08 Enhanced Multibus (MSA) **New**	**£1150**
Nikon HFX-11 (Ephiphot) exposure control unit	**£1450**
PHILIPS PM5518 pro. TV signal generator	**£1250**
Motorola VME Bus Boards & Components List. SAE / CALL	**£POA**
Trio 0-18 vdc linear, metered 30 amp bench PSU. **New**	**£550**
Fujitsu M3041R 600 LPM high speed band printer	**£1950**
Fujitsu M3041D 600 LPM printer with network interface	**£1250**
Siemens K4400 64Kb to 140Mb demux analyser	**£2950**
Perkin Elmer 299B Infrared spectrophotometer	**£500**
Perkin Elmer 597 Infrared spectrophotometer	**£3500**
VG Electronics 1035 TELETEXT Decoding Margin Meter	**£3250**
LightBand 60 output high spec 2u rack mount Video VDA's	**£495**
Sekonic SD 150H 18 channel digital Hybrid chart recorder	**£1995**
B&K 2633 Microphone pre amp	**£300**
Taylor Hobson Tallysurf amplifier / recorder	**£750**
ADC SS200 Carbon dioxide gas detector / monitor	**£1450**
BBC AM20/3 PPM Meter (Ernest Turner) + drive electronics	**£75**
ANRITSU 9654A Optical DC-2.5G/b waveform monitor	**£5650**
ANRITSU ML93A optical power meter	**£990**
ANRITSU Fibre optic characteristic test set	**£POA**
R&S FTDZ Dual sound unit	**£650**
R&S SBUF-E1 Vision modulator	**£775**
WILTRON 6630B 12.4 / 20GHz RF sweep generator	**£5750**
TEK 2445 150 MHz 4 trace oscilloscope	**£1250**
TEK 2465 300 MHz 300 MHz oscilloscope rack mount	**£1955**
TEK TDS380 400Mhz digital realtime + disk drive, FFT etc	**£2900**
TEK TDS524A 500Mhz digital realtime + colour display etc	**£5100**
HP3585A Opt 907 20Hz to 40 Mhz spectrum analyser	**£3950**
PHILIPS PW1730/10 60KV XRAY generator & accessories	**£POA**
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CLAUDE LYONS 12A 240V single phase auto. volt. regs	**£325**

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NEXT MONTH

WIND TUNNEL

This design can be used to investigate the effect of air flow on small objects under controlled conditions, demonstrating, for example, how aircraft or bird wings create lift.

It is intended for use with the Wind Speed Meter *in this January issue, but can also be used on its own. It has an easily constructed long rectangular wooden frame with clear perspex panels that enclose a fan at one end whose rotation rate is controlled electronically by a potentiometer. Air flow rate is variable from less than 1mph to around 8mph, although the range can be raised or lowered depending on the motor used and the tunnel's chosen dimensions.*

An optically coupled sensor responds to a light beam being broken by the fan blades and a PIC microcontroller determines the fan's revolutions per second in relation to the number of fan blades. The result is shown on an alphanumeric liquid crystal display.

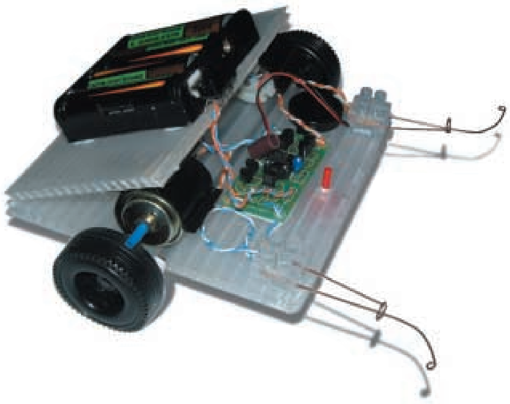
The fan has an induction motor rated at 230V a.c. 26 watts. It is powered from a 12V car battery via a step-up frequency controlled inverter.

BRAINIBOT

Get into robotics with this intriguing project.

At first glance this is a simple two wheeled buggy, but its responses to signals from its three sensors make it appear to be surprisingly intelligent. The mechanical design described has been kept as simple as possible so that basic components can be used, but other hardware can be adapted to run from the same circuits – providing plenty of room for experiments.

To keep the assembly simple, the electronic control board has been designed to use the bare minimum of components, and the smallest PIC microcontroller that will provide sufficient inputs and outputs. The final design uses an eight-pin microcontroller, demonstrates some interesting PIC programming and hardware techniques, and has a performance that would be expected from something much more complicated.



TESLA TRANSFORMER

Tesla invented his famous high frequency, high voltage transformer in 1891. This small version is much safer to operate and adjust than the larger versions and all the materials and parts required are readily available. It will, however, give a sizzling demonstration of Tesla's best known discovery with an impressive, vicious, hissing discharge.

NEW SERIES

BACK TO BASICS – simple, easy to build projects

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FEBRUARY 2003 ISSUE ON SALE THURSDAY, JANUARY 10

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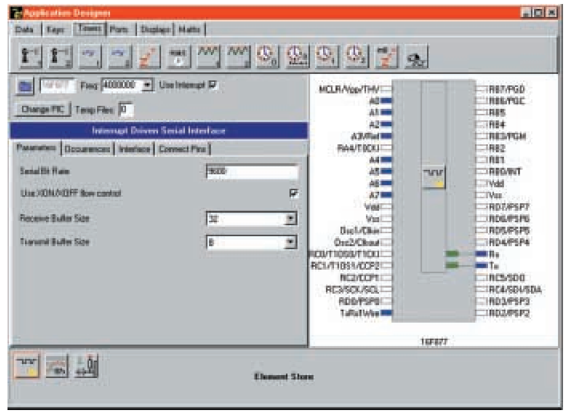
New from FED – 18 Flash series support and chips

18F452 now supported in our C Compiler, WIZ-C, WIZ-ASM Development board and programmer

WIZ-C Compiler including support for 18F452 and 16F877

What is the WIZ-C Rapid Application Environment?



- Our PIC C compiler including a new front end
- An application designer for the FED PIC C Compiler
- Drag a software component onto your design & set up the parameters using check boxes, drop down boxes and edit boxes (see shot right)
- Connect the component to the PIC pins using the mouse
- Select your own C function to be triggered when events occur (e.g. Byte received, timer overflow etc.)
- Generate the base application automatically and then add your own functional code in C or assembler
- Simulate, Trace at up to 10x the speed of MPLAB
- Supports 14/16 bit core PICS
- **16F87x, 16C55x, 16C6x, 16F8x, 16C7xx, 18Cxx, 18Fxx etc.**
- C Compiler designed to ANSI C Standards

Professional Version Enhancements to our C Compiler and WIZ-C Rapid Application Environment

- Manage and simulate multiple projects together
- Connect PIC pins across projects to allow simulated devices to communicate
- Handle assembler and C projects
- View and inspect variables in native C format
- Inspect all local variables and their values in native C format
- Maintain a history within simulation to back track and determine the past leading up to an event

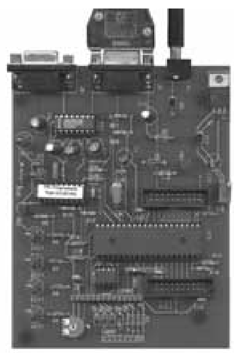
Prices
WIZ – C Standard – **£70.00**, Professional **£100.00**. Upgrade for existing WIZ-C owners **£30.00**
PIC C Compiler Standard – **£60.00**, Professional **£90.00**. Upgrade for existing Compiler owners **£30.00**
Other upgrade options are available together with reduced price bundled packages – see our web site for details

Other products supporting 18F452 and 16F877

Development Board

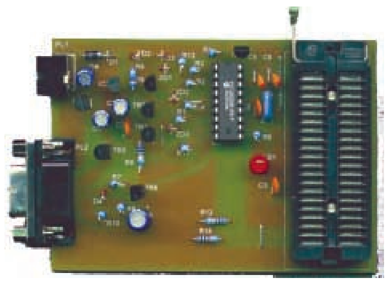
- Handles 40 pin PIC devices including 18F452 and 16F877
- Includes on board Programmer – no separate programmer required
- 4 LED's on board, Analogue on trimpot, 2 duplex serial ports
- 1A 5V regulator
- 20MHz crystal
- Interfaces for LCD, hex keypad, 32 I/O pins on IDC connectors
- Will run FED PIC BASIC (included on CD)
- I2C EEPROM socket

Price – **£45.00** Built and Tested. 16F877-20P **£6.00**, 18F452 **£8.00**, CD with BASIC & Programmer Applications **£5.00**

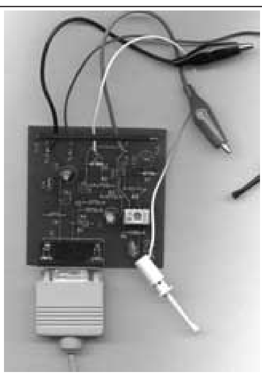


PIC Programmer including 18Cxxx and 18F8xxx

Handles serially programmed PIC devices in a 40 pin multi-width ZIF socket. 16C55X, 16C6X, 116F62x, 6C7X, 16C8x, 16F8X, 12C50x, 12C67x, 16C72X, PIC14000, 16F87X, 18Cxxx, 18Fxxx etc



Also In-Circuit programming. Operates on PC serial port.
Price : £45/Kit £50/Built & Tested



In Circuit Debugger

In Circuit Debugging is a technique where a monitor program runs on the PIC in the application circuit. The ICD board connects to the PIC and to the PC. From any of our applications it is then possible to set breakpoints on the PIC, run code, single step, examine registers on the real device and change their values. The ICD makes debugging real time applications faster, easier and more accurate than simulation tools available for the PIC.

- Only **£30.00**, requires a copy of WIZASM, WIZ-C or our C Compiler applications. Operates with 16F87x to emulate most 14 bit core chips, 18F support coming soon !

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EVERYDAY PRACTICAL ELECTRONICS

THE No. 1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

VOL. 32 No. 1 JANUARY 2003

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MINDER

Our focus in *EPE* is often on security and electronics can be helpful in this respect – it can also help the criminals, but more of that later. In this issue we present the *EPE Minder*, a fairly simple radio alarm system that can tell you if your possessions or even your children/pets etc. stray away from you. The system has a multitude of uses and we hope it can help to prevent crime as well as providing a reminder to pick up your briefcase or coat.

Just one word or warning, this system is not fail-safe or foolproof and, whilst it should normally operate correctly, please do not *rely* on it for the safety of your family or valuables. It is an excellent back-up for the normal, sensible security precautions that everyone should be aware of in this day and age.

CARD SECURITY

Whilst electronics is a wonderful thing and modern society simply could not operate without it, it does sometimes help criminals to secure goods or services fraudulently and, I guess along with many other companies, we have suffered from this problem. It is all too easy for anyone to use someone else's credit card number to obtain goods illegally or of course to use stolen cards. Fortunately the major credit card companies are continually improving security to prevent this crime.

Why am I telling you what you probably already know? Well the information we will need from you if you order by credit card in future has now increased. In addition to the usual card number and card expiry date we will now also need a Card Security Code – this code appears on or just below the signature strip on credit cards, it is the last three digits of the number shown there. In general the full number is the card number plus the three digit security code, or the last four digits of the card number plus the security code. What we will need are those last three digits.

As an additional check our terminal will also now verify the postcode and house number of the card holder, so security will be further enhanced. It's good news for all law abiding customers and hopefully bad news for those who think it is OK to steal from others. Unfortunately certain individuals tend to take advantage at this busy time of the year.

GREETINGS

Finally the season's greeting to all our readers, a happy, peaceful and prosperous new year from everyone at Wimborne Publishing Ltd.

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PROJECTS AND CIRCUITS

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.

A number of projects and circuits published in *EPE* employ voltages than can be lethal. **You should not build, test, modify or renovate any item of mains powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.**

COMPONENT SUPPLIES

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

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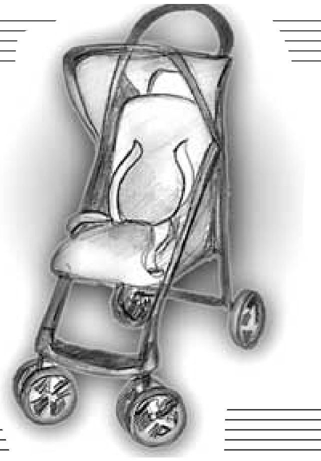
The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

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

Constructional Project

EPE MINDER



TERRY de VAUX-BALBIRNIE

Looks after your personal belongings – maybe even your children!

THE *EPE* Minder consists of two type-approved transmitter units and a receiver. If either transmitter becomes separated from the receiver, a buzzer in the latter part will sound. The receiver is fitted with a switch to allow the use of only one transmitter if required.

MIND HOW YOU GO

This system was originally designed as a two-channel child alarm (to protect either a single child or two children at the same time) but many other applications spring to mind. For example, one transmitter could be placed inside a briefcase and another in a coat pocket. If the user forgot to pick up either of these items and walked away, the buzzer would sound in the receiver.

The receiver must be carried on the person in a way that would make it practically impossible to lose it. This could be done using a belt clip, for example. Note that it will not be possible to use this system if either the transmitter or receiver were placed inside metal containers or if there were substantial metallic "screening" objects between them.

OPERATING RANGE

The operating range may be adjusted according to the intended purpose. However, it does depend on conditions. Adjustment is carried out by means of "aerial link wires" on the circuit panels.

With all these in place, the range of the prototype exceeds 12 metres in open air. It will also work throughout several rooms indoors if required.

If the battery voltage in either transmitter or receiver falls below a certain value, or if a transmitter is switched off, a buzzer will sound. The specified batteries in the transmitters should provide several hundred hours of operation. Those in the receiver should provide around 100 hours.

PERSONAL CODE

The *EPE* Minder uses a system of digitally encoded low-power radio signals, which pass from the transmitters to the receiver. The code is different for each transmitter so that the receiver is able to distinguish one from the other.

Type-approved, pre-aligned transmitter and receiver modules that operate at 433MHz. are used. No traditional "radio" skills are needed and no licence is needed for their use in the UK.

SIDE ISSUE

The manufacturer of the transmitter modules can find no published data on the effect on humans of radio waves at a power of less than 10mW. It is claimed that there is more r.f. energy released from the average TV or PC and that the 433MHz frequency band has been used for "wireless" remote controls for more than 10 years with no known adverse effects.

It would appear that the use of this system to protect children is safe in view of the very small power involved. Teenagers use mobile phones for long periods and these operate at a higher frequency and power level. Also, the source is placed close to the brain. However, cautious constructors may choose to avoid this application.

TRANSMITTER CIRCUIT

The circuit diagram for a single transmitter unit is shown in Fig.1. Current is supplied to the circuit from a 3V "coin" cell, B1, via on-off switch S2 and diode D1. The diode provides reverse-polarity protection.

It is best to use the specified Schottky device which introduces a smaller forward voltage drop, and therefore less loss, than a conventional silicon diode (0·2V rather than 0·7V approximately). Capacitor C2 provides a small reserve of energy and prevents the supply voltage from fluctuating. This stabilises operation.

A low power 7555 timer, IC1, is set up in a standard astable (pulse generator) configuration. While switched on, this produces a continuous train of on-off pulses at its output, pin 3.

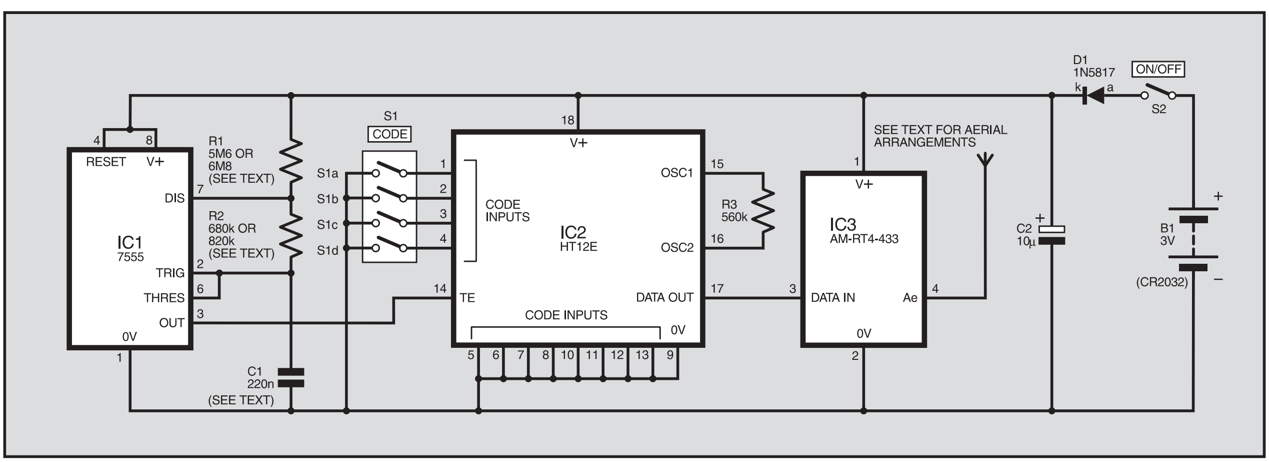


Fig.1. Completed circuit diagram for the 433MHz Transmitter.

The choice of resistors R1, R2 and capacitor C1 provide one pulse per second for one of the transmitters (Unit A) and one pulse every 1·2 seconds for the other one (Unit B). In fact, the timings are slightly longer but it helps to consider them as above.

Also, the *on* times are much longer than the *off* ones in each case. The purpose of this will be explained presently.

CODED MESSAGE

The section of the transmitter circuit associated with producing the digital code is based on encoder device, IC2. The code comprises a 12-bit "word" (a string of twelve on-off pulses). Its composition is determined by the logic states of pins 1 to 8 and pins 10 to 13 (labelled "Code Inputs"). A high state (positive supply voltage) applied here (or leaving the pin unconnected) produces a logic "1" while a low state (0V) gives a logic "0".

A 4-way d.i.l. switch S1 (S1a to S1d), applies a set of pre-arranged logic states to pin 1 to pin 4 respectively (that is, the first four bits of the code) – closing a switch connects that pin to 0V and provides logical "0" while leaving it open gives a "1".

There are, therefore, 16 possible codes and, since this is ample, the rest of the code pins are connected to 0V (giving zeros). An example of a code is:

1 0 11 0 0 0 0 0 0 0 0

The resulting information (code) is sent serially from IC2 pin 17 (Data Out) but only when pin 14 (transmit enable or TE) is made low. This will happen on each short "off" state of IC1 output, pin 3. In the time available, the data can be transmitted several times. If the pulse is interrupted in the middle of the stream, the word finishes before it stops.

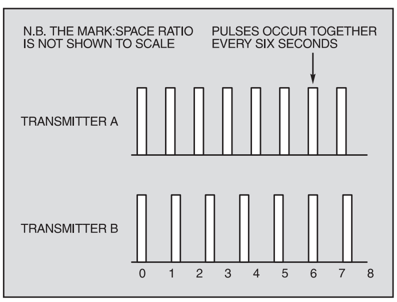


Fig.2. Timing pulses for the two transmitters, A and B.

Each transmitter therefore provides short pulses of data. If the signals were to be transmitted from the two units continuously, the receiver would gather garbled data and would probably not respond to either.

However, by sending the data in short bursts, most of the time there will be a clear gap between that sent by each transmitter. It also greatly reduces the average current requirement and extends battery life.

TIME PERIODS

The time periods of the two transmitters A and B have been made significantly different (approximately 1 sec. and 1·2 secs. respectively) by using different values for R1 and R2. The reason for this will become apparent by referring to Fig.2.

EPE Minder Receiver (top) and two Transmitter units. These models incorporate type-approved, pre-aligned, 433MHz transmitter and receiver modules. No operating licence is required in the UK.

Note that this system must be regarded as providing secondary protection only. It does not reduce the user's obligation to exercise care and vigilance in looking after his or her children, pets, property etc.

It will be seen that the two sets of data will only be given simultaneously every six seconds. Only during this time will the receiver pick up conflicting information. However, this has been designed to "hold off" operation for some three seconds so any conflicts have no effect. If the time periods of the two transmitters were made nominally the same, there could be long periods of overlapping data before the pulses fell out of step again. Because of the "hold-off", the buzzer will take a short time to respond but this is usually of no consequence.

Returning to the transmitter circuit Fig.1, encoder IC2 pin 15 and pin 16 (OSC1 and OSC2) need a resistor (R3) connected between them. This controls the frequency of the on-chip oscillator and this, in turn, determines the rate at which information is processed.

SUPPLY VOLTAGE

The specified transmitter module, IC3, requires a supply voltage of between 2V and 14V applied to pin 1. Pin 2 is connected to "earth" (0V). Data arriving from IC2 pin 17 is fed to pin 3 (Data In) and pin 4 (Ae) is connected to an external aerial (if this is needed).

The transmitter module draws only a negligible current except while data is being given whereupon it rises to some 4mA. Since the data stream is very short with long spaces between, the *average* current is only about 400µA. The current needed for IC1 and IC2 amounts to some 100µA, giving a total of around 500µA for the entire unit.

COMPONENTS

TRANSMITTER
(two sets required)

Resistors

R1	5M6 for A; 6M8 for B (see text)
R2	680k for A; 820k for B (see text)
R3	560k

All 0·25W 5% carbon film.

See SHOP TALK page 71

Capacitors

C1	220n ceramic
C2	10µ radial elect. 25V

Semiconductors

D1	1N5817 Schottky diode
IC1	7555 low power timer
IC2	HT12E encoder
IC3	AM-RT4-433 a.m. transmitter module

Miscellaneous

S1	4-way d.i.l. switch
S2	sub-min. right-angled slide switch, p.c.b. mounting
B1	3V 2032 lithium "coin" cell (20mm dia. × 220mAh capacity)

Printed circuit board available from the *EPE PCB Service*, code 378; plastic case, size 111mm × 57mm × 22mm approx; 8-pin i.c. socket; 18-pin i.c. socket; s.i.l. socket or pieces of d.i.l. socket for IC3 (see text); holder for coin cell (B1); small nylon fixings; solder etc.

Approx. Cost Guidance Only **£18.00** *excl. case & batt.*

CONSTRUCTION – TRANSMITTER

It is advisable to use the specified transmitter module. This needs no special setting up. Some types require considerable skill to achieve resonance.

Construction of this section is based on a single-sided printed circuit board (p.c.b.) which covers a single Transmitter and needs to be repeated for the second unit. The Transmitter topside component layout and full-size underside copper foil track master are shown in Fig. 3. This board is available from the EPE PCB Service, code 378 (Trans.). Two of these are required for two transmitters.

As described, everything is mounted on the p.c.b. Switch S2 (On-Off) could be placed off-board and hard wired to the corresponding points on the p.c.b. if this is more convenient.

Begin construction by drilling the fixing holes. Solder the link wires in position (leave just a little slack in the "Aerial link" to allow it to be cut later to reduce the range if this is found to be necessary). Add the battery holder and i.c. sockets.

Use an i.c. socket for the transmitter module rather than soldering it directly to the board. Pieces cut from a dual in-line socket were used in the prototype unit. Follow with the 4-way d.i.l. switch S1 and On-Off slide switch S2.

Solder all resistors and the capacitors in position, taking care over the polarity of electrolytic capacitor C2. Note particularly the different values for resistors R1 and R2 depending on the transmitter unit (A or B). Identify the p.c.b.s by pencilling "A" in a free place on one of them and "B" on the other.

Add diode D1 taking care over the orientation. D1 may be replaced with a piece of wire if it is impossible to insert the battery in the wrong sense. Decide on settings for d.i.l. switches S1a to S1d in each unit. It does not matter what the codes are as long as they are *different*.

PRECAUTIONS

Insert IC1, IC2 and transmitter module IC3 into their sockets taking care over their orientation. The (top view) pin-out details of IC3 are shown inset in Fig.3.

Follow the usual anti-static precautions when handling all the i.c.s to avoid possible damage. This is because they are CMOS devices which could be ruined by electrostatic charge on the body. It will be sufficient to touch something which is earthed, for example, a metal water tap before touching the pins. Do not insert the battery cells in their holder at this stage.

MPT 1340

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RECEIVER CIRCUIT

The complete circuit diagram for the Receiver section is shown in Fig.4. This draws approximately 3mA, so a more substantial battery pack is needed than for a transmitter. While the buzzer WD1 is sounding, the current rises to some 6mA.

The battery pack used in the prototype consists of four AAA size alkaline cells. If AA size cells could be accommodated inside the case, these would provide a doubling of operating time.

ON THE RANGE

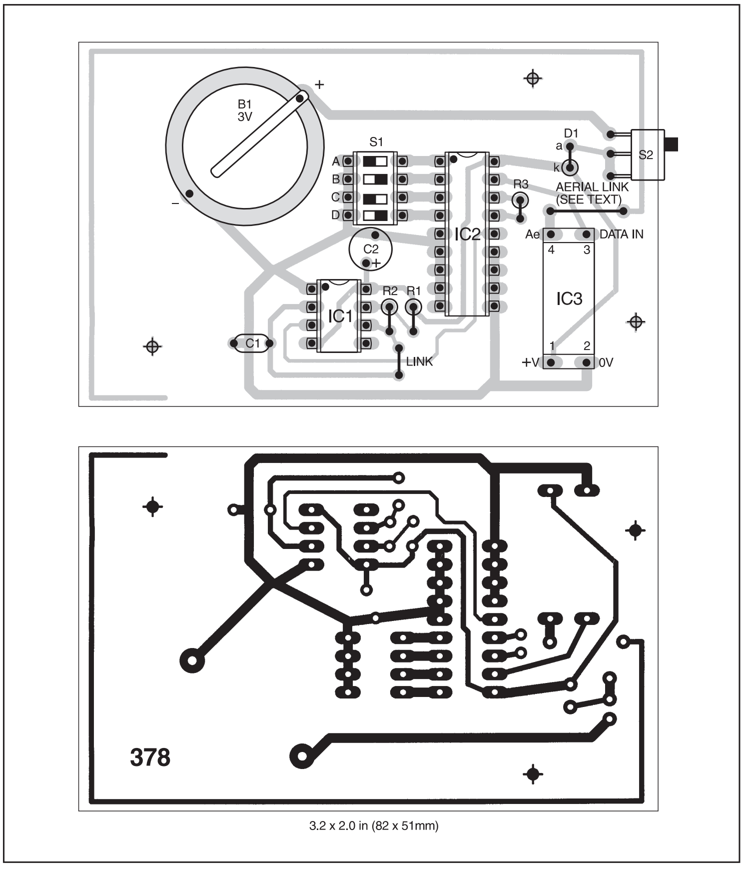
Receiver module, IC1, requires a supply of between 4·5V and 5·5V. The 6V nominal battery pack, B1, is brought within range by the forward drop of diode D5 (0·7V approx.) This diode also provides reverse-polarity protection.

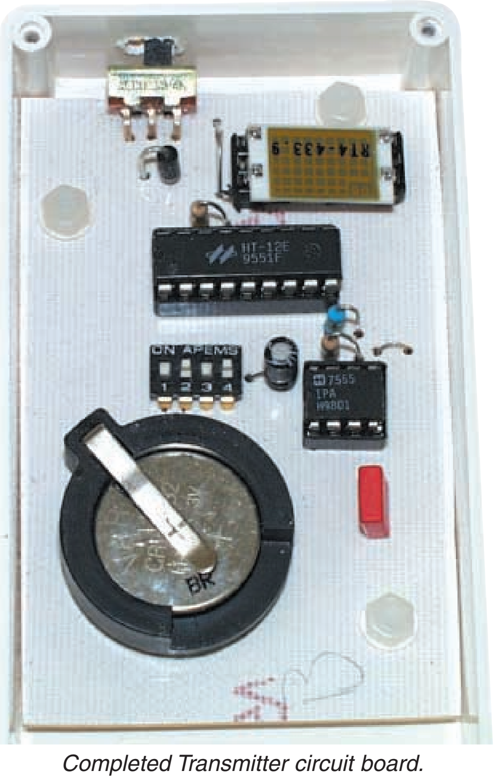
Capacitor C4 charges up and provides a small reserve of energy. This will be useful when the battery is nearing the end of its operating life.

When the supply voltage falls below some 4V, the receiver stops working and the buzzer will sound. Below around 3V, the buzzer itself will not operate so it is important to check operation each time the units are used.

Receiver IC1 should be of the a.m. (amplitude modulation) type as specified in the components list. As such, it will respond to the on-off pulses provided by the transmitter. The inexpensive *super*

TRANSMITTER CONSTRUCTION





Completed Transmitter circuit board.

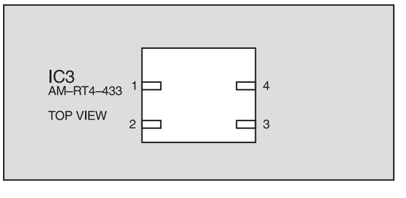


Fig.3. Printed circuit board component layout and underside copper foil master pattern for a single Transmitter (two are required). The pinouts for the AM-RT4-433 a.m. transmitter module are shown above right.

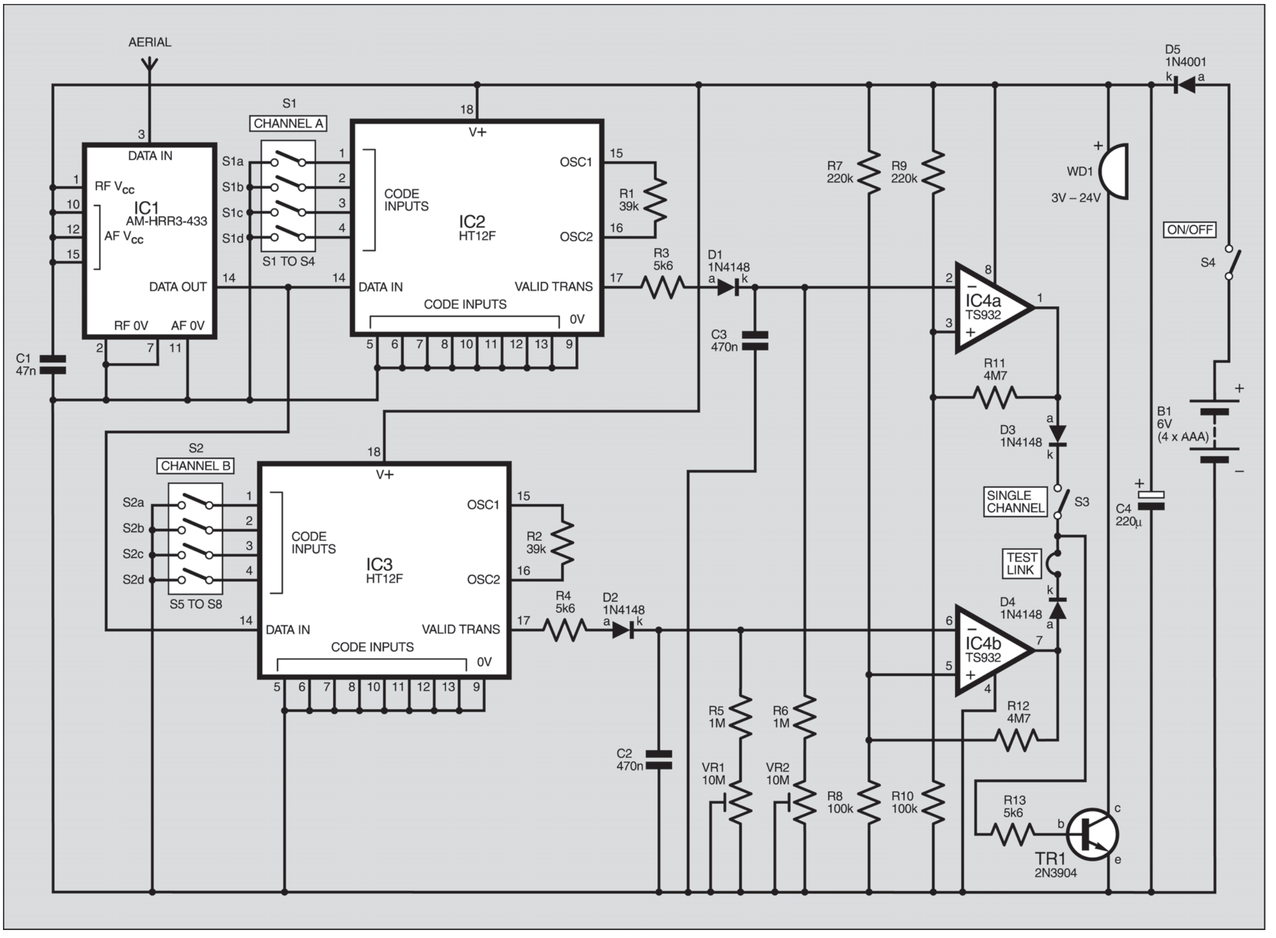


Fig.4. Full circuit diagram for the Receiver. This circuit draws about 3mA, so a four-cell battery pack is needed.

regenerative (rather than superhet) variety will be perfectly adequate.

The low-power variants of these receivers have not been tested. Although for battery operation they would appear to be ideal, the standard type is more readily available.

The receiver may be considered as having separate r.f. (radio frequency) and a.f. (audio frequency) sections. These have individual supply inputs (pins 1, 10, 12 and 15 with some being duplicated). These are all connected together and decoupled using capacitor C1.

CODE BREAKING

When information is detected by the receiver module (IC1), it is amplified and provided serially at pin 14 (Data Out). It is then applied to pin 14 (Data Input) of the pair of decoders IC2 and IC3.

These decoders are set to respond to the same codes as those used in the transmitters by making IC2/IC3 pins 1 to 8 and pins 10 to 13 either high or low in the same way. Each decoder will then be responsible for one transmitter – IC2 for Unit (Channel) A and IC3 for Unit (Channel) B.

As with the transmitter, IC2/IC3 pins 1 to 4 are set to either logical 1 or 0 using d.i.l. switches S1a to S1d (for IC2) and S2a to S2d (for IC3). All other code inputs are connected to 0V.

As before, OSC1 and OSC2 (pin 15 and pin 16) require resistors (R1 and R2 respectively) to be connected between them to control the frequencies of the internal oscillators. These are set to some 50 times that used in the transmitters.

Incoming data is validated by IC2 and IC3 by checking it three times. If this is successful, pin 17 (Valid Transmission), goes high. Thus, IC2 pin 17 will provide short "on" bursts every one second in response to Transmitter A and IC3 pin 17 will act similarly every 1·2 seconds for Transmitter B.

HOLD-OFF

Any warning signal must not be given during the "off" periods of IC2/IC3 pin 17. That is, it must not "think" that a transmitter has gone out of range because no signal is received during this time.

It must also "smooth over" any sets of conflicting data arriving every six seconds or thereabouts. It is therefore necessary to provide some means of holding off operation for a short time, say, three seconds.

Only the action of IC2 will be considered for the moment because IC3 behaves in exactly the same way. While IC2 pin 17 is high, current flows through resistor R3 and diode D1 to charge capacitor C3. This reaches virtually supply voltage almost instantaneously.

While pin 17 is low, diode D1 is reverse-biased and capacitor C3 cannot discharge back into the decoder i.c. However, it is given a controlled discharge path through fixed resistor R6 and preset VR2. The repeated on states keep C3 topped up.

When conflicting data is received, C3 misses a "topping up" pulse and the voltage across it falls. Preset VR2 is adjusted so that it does not drop below one-third of supply voltage (nominally 2V) when this happens. When data is missing for a sufficiently long time (due to the transmitter being out of range or switched off) the voltage across capacitor C3 falls below the 2V point.

VOLTAGE LEVELS

The voltage across C3 is applied to the inverting input of one section of dual op.amp IC4 (IC4a pin 2). The corresponding non-inverting input (pin 3) is held at approximately one-third of supply voltage (nominally 2V) by the potential divider action of fixed resistors R9 and R10.

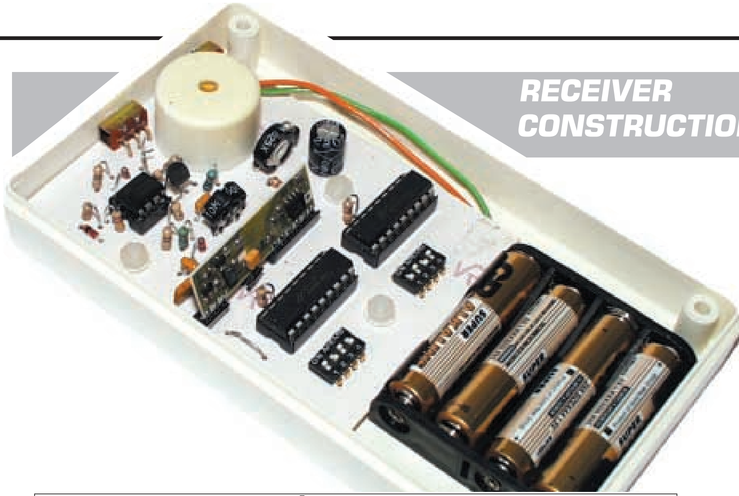
Thus, the voltage at IC4a pin 2 will normally exceed that at pin 3 and IC4a output (pin 1) will be *low*. When the transmitter is out of range, the voltage at pin 2 soon falls below that at pin 3 so the op.amp will switch on with output pin 1 going *high*. Positive feedback applied through resistor R11 sharpens this switching action.

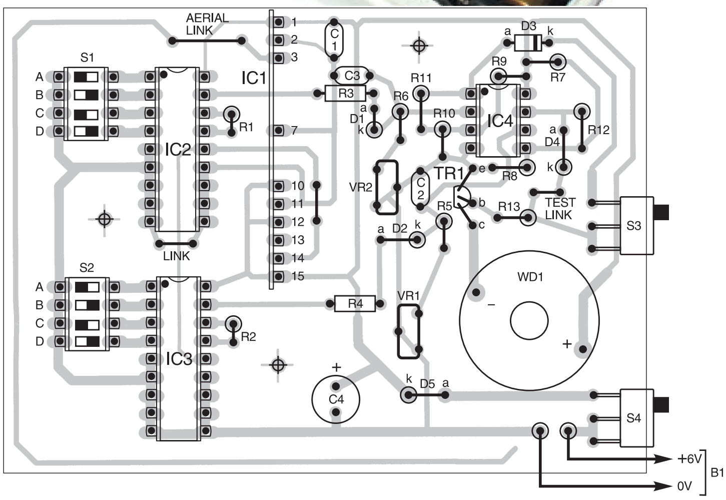
Providing the Single Channel switch S3 is closed, current will enter transistor TR1 base (b) though diode D3 and resistor R13. Buzzer WD1 in its collector circuit then sounds.

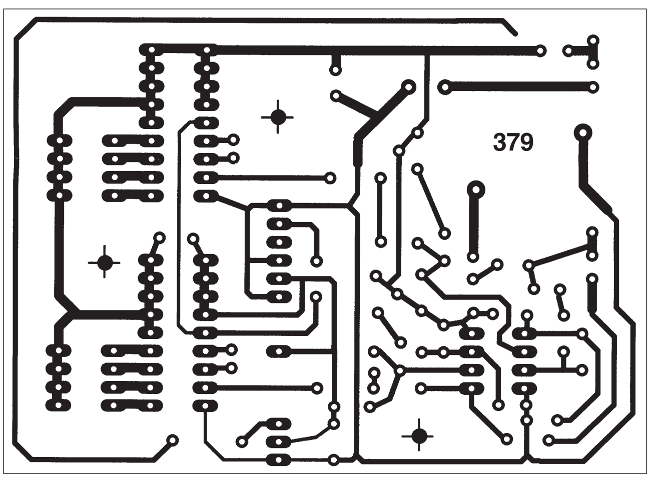
MISSING LINK

The same situation arises with decoder IC3 and the other section of dual op.amp IC4 (IC4b) in response to Transmitter B. Providing the "Test link" is in place, transistor TR1 will turn on with current entering the base via diode D4 and resistor R13. The result is that *either* transmitter signal failing (or both failing) will cause buzzer WD1 to sound.

RECEIVER CONSTRUCTION

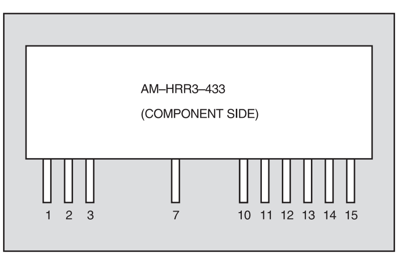






3.6 x 2.6 in (90 x 65mm)

Fig.5. Receiver printed circuit board component layout and full-size copper foil master. The AM-HRR3-433 a.m. receiver module pinout details are shown below.



COMPONENTS

RECEIVER

See SHOP TALK page 71

Resistors

R1, R2	39k (2 off)
R3, R4, R13	5k6 (3 off)
R5, R6	1M (2off)
R7, R9	220k (2 off)
R8, R10	100k (2 off)
R11, R12	4M7 (2 off)

All 0·25W 5% carbon film.

Potentiometers

VR1, VR2	10M min. carbon preset, vertical (2 off)

Capacitors

C1	47n ceramic
C2, C3	470n ceramic (2 off)
C4	220µ radial elect. 16 V

Semiconductors

D1 to D4	1N4148 signal diode (4 off)
D5	1N4001 50V 1A rect. diode
TR1	2N3904 *npn* transistor
IC1	AM-HRR3-433 a.m. receiver or similar 433MHz receiver module
IC2, IC3	HT12F decoder (2 off)
IC4	TS932 micropower dual op.amp

Miscellaneous

S1, S2	4-way d.i.l. switch (2 off)
WD1	3V to 24V d.c. solid-state buzzer, operation 10mA maximum
B1	1·5V AAA alkaline cells (4 off), with holder and connector (see text)
S3, S4	sub-min. right-angled slide switch, p.c.b. mounting (2 off)

Printed circuit board available from the *EPE PCB Service*, code 379 (Rec); plastic case, size 143mm × 82mm × 30mm approx. (external); s.i.l. socket (or pieces of d.i.l. socket (see text); 18-pin d.i.l. holder (2 off); 8-pin d.i.l. socket; small nylon fixings; solder etc.

Approx. Cost Guidance Only **£28.00** *excl. case & batts.*

Table 1: Receiver Pinout Functions

Pin No		*Pin No*	
1	R.F. supply +V	9	non-existent
2	R.F. 0V	10	AF supply +V
3	Data In (Aerial)	11	A.F. 0V
4	non-existent	12	AF supply +V
5	non-existent	13	Test point (not used)
6	non-existent	14	Data Out
7	R.F. 0V	15	AF supply +V
8	non-existent		

If the Single Channel switch S3 is open, the signal from IC4a output is interrupted and the circuit will work only in response to Transmitter B. The Test Link allows each circuit section to be operated independently so that they may be tested and adjusted separately.

CONSTRUCTION – RECEIVER

Construction of the Receiver unit is also based on a single-sided printed circuit board (p.c.b.). The topside component layout and full-size underside copper foil track master are shown in Fig. 5. This board is available from the *EPE PCB Service*, code 379 (Rec.).

Begin construction by soldering the link wires (4 off) in place. In the case of the Aerial link, leave a little slack for it to be cut later if necessary. For the Test link, use two short pieces of bare wire, which may be twisted together to make the connection later.

Follow with the sockets for IC1 to IC4. Receiver module IC1 has its pins arranged in s.i.l. (single in-line) format. This is shown inset in Fig.5. Use pieces of i.c. socket for this rather than soldering it directly to the p.c.b.

The functions of the various pins in the Receiver module used in the prototype are shown in Table 1. Referring again to the pinout details in Fig.5, it will be seen that spaces are left on the i.c. where non-existent pins could be.

If using a different receiver to that specified, you are likely to find that the pin-out follows the same standard. However, this point should be checked before purchasing. In some units, further pins are missing but this should not matter because several of them are duplicated.

CODE SWITCHES

Solder the two banks of 4-way d.i.l. switches (S1a to S1d and S2a to S2d) in position also switches S3 (Single Channel) and S4 (On-Off) (unless these are to be mounted off-board). Next, solder in position the resistors and capacitors. Note that C4 is an electrolytic capacitor and must be connected with the correct polarity.

Add the four diodes and transistor TR1, again taking care with their orientation. Solder the battery connector or leads in place depending on the type of battery holder used.

Insert IC2, IC3 and IC4 in their sockets making sure that they are placed the correct way round. Insert Receiver module IC1 taking care because the pins are easily bent. Note that its component side is towards IC2/IC3. *All these devices are static-sensitive, so observe the precautions mentioned earlier*.

Set S1a to S1d to the code used in Transmitter A and S2a to S2d to that used in Transmitter B.

TESTING

Having completed the Receiver board, we can now commence testing all three boards. It helps to minimise the Receiver "hold-off" time by adjusting preset VR1 fully anti-clockwise (as viewed from the left-hand side of the p.c.b.) and preset VR2 fully clockwise (as viewed from the right-hand side of the p.c.b.). Check that the Test link has been left unconnected to prevent IC4b signal from passing to transistor TR1's base.

Switch on Single Channel switch S3 so that Channel A is enabled. With On-Off switch S4 off, insert the batteries. Switch on. After a short delay, the buzzer WD1 should sound.

Now place Transmitter A approximately three metres away from the Receiver, insert the battery and switch on. The buzzer should begin to bleep every second.

The same procedure is now repeated for Transmitter B. To do this, switch S3 off to disable Channel A and firmly twist together the ends of the Test link wires. It is not advisable to solder this connection unless the i.c.s are removed first. The buzzer should bleep at a slightly slower rate than for Transmitter A.

It is unlikely that the time periods of the two transmitters will be the same (due to overlapping component tolerances). However, if they are, one of them will need to be changed. Choose slightly higher values for resistors R1 and R2 to slow it down and vice versa. *Remove the i.c.s before making any modifications*.

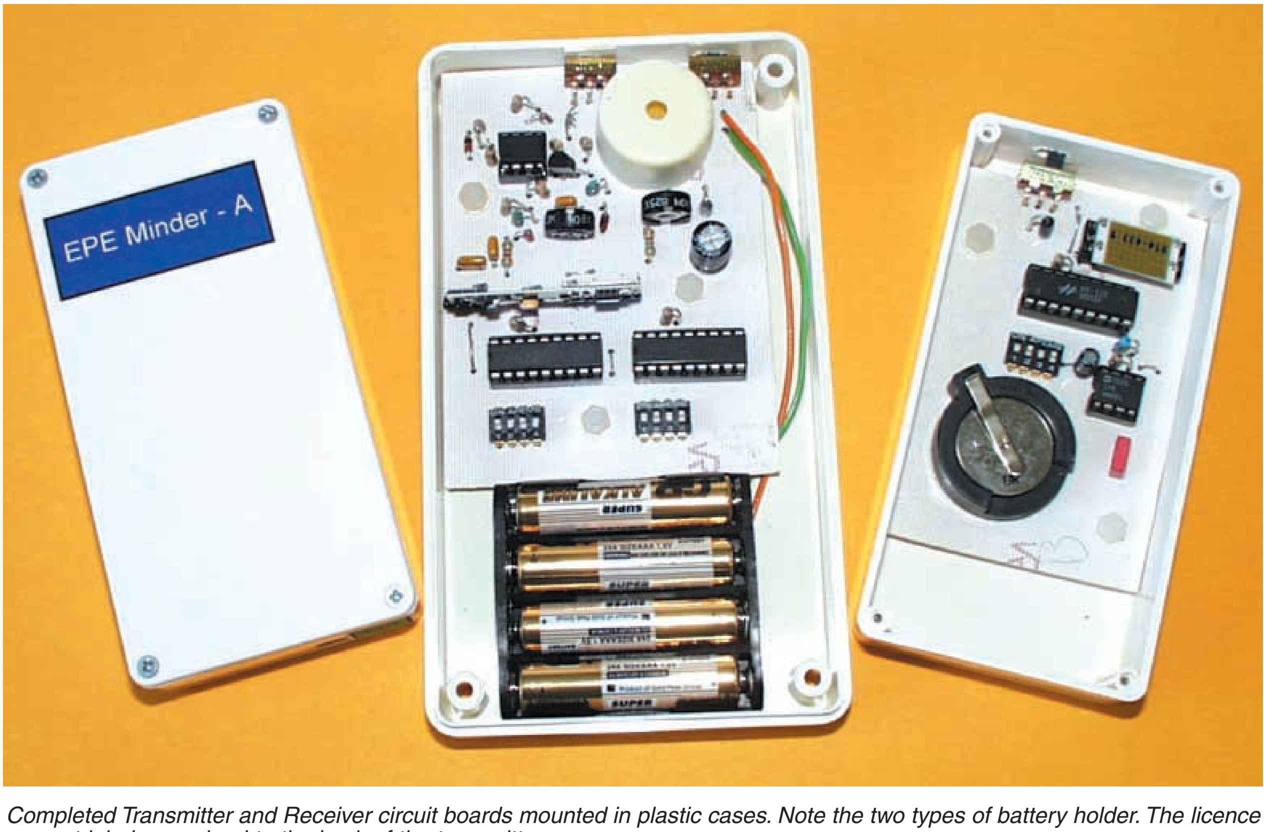
HOLD-OFF TIME

When both transmitters have been tested, switch S3 on to enable both channels. presets VR1 and VR2 should now be adjusted to approximately mid-track position. This should provide a sufficient "hold off" time plus a small margin.

The buzzer should now remain off and only sound when one of the transmitters is switched off or moved out of range. Leave them operating for several minutes. If the occasional spurious bleep is heard, increase the settings of VR1/VR2 to prevent this happening.

OPERATING RANGE

This is the best time to decide on an appropriate operating range. Cut the receiver and/or the transmitter Aerial links and separate the ends to reduce the range if necessary. *If you change your mind and need to re-solder an aerial link, remove all the i.c.s from that unit first*.



Completed Transmitter and Receiver circuit boards mounted in plastic cases. Note the two types of battery holder. The licence exempt labels are glued to the back of the transmitter cases.

Table 2: Operating Range

Transmitter Link	*Receiver Link*	*Range (metres)*
Closed	Closed	12
Closed	Open	8
Open	Closed	2

Completed Transmitter with "licence exempt" label glued to the case.

There is plenty of room for experiment with the existing, and other, aerial arrangements. Remember, however, that any transmitter aerial *must* be placed internally in its case. To fulfil regulations, *it must not be connected through an external feeder.*

The operating range results obtained with the prototype models, in an open space, are shown in Table 2.

There is some hysteresis in operation (the *on* and *off* distances are not the same). With the transmitter aerial link cut, this is particularly evident and the Transmitter must be brought close to the Receiver for the warning to stop. This could be useful for certain purposes.

CASE FOR THE TRANSMITTER

Choose a *plastic* box (two required, one for each unit) that is large enough to accommodate the Transmitter p.c.b. Hold the p.c.b. a little above the base of the box and mark the position of the hole needed for the operting tab (toggle) for the on-off slider-type switch. Cut this out then, with the p.c.b. in position, mark its fixing holes.

Remove the p.c.b. and drill the fixing holes. Mount the p.c.b. using nylon washers and/or stand-off insulators and nylon fixings to give the required clearance for the switch.

In order to comply with UK regulations, attach a permanent label to the outside of each transmitter unit. This must display the following wording: **MPT1340 W.T. Licence Exempt**. The minimum size of the label is 10mm × 15mm and the height of the lettering must not be less than 2mm (see photograph above).

CASE FOR THE RECEIVER

Choose a *plastic* box that is large enough to accommodate the Receiver p.c.b. and battery holder (see photographs). If a belt clip needs to be fitted, do this now.

Follow the same procedure described earlier for mounting the transmitter p.c.b. and producing the cutout slots in the case side panel for the two slide switches. Make sure the switches operate smoothly once the p.c.b. is in position.

Secure the battery holder in the case. Measure the position of the buzzer and drill a hole in the lid to allow the sound to pass through.

Make some tests with the units under real working conditions. Make any further adjustments to the aerial arrangements and adjust presets VR1/VR2 if this is found to be necessary. □

News . . .

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

DATAPLAY WON'T

DataPlay have dropped out of the mini-disk scene. Barry Fox reports.

ALTHOUGH Philips says it is "just coincidence", the first showing of SFFO (Small Form Factor Optical system – see the item on the next page) preceded the corporate shutdown of DataPlay in Colorado – just as the company was launching its own miniature disk format.

The DataPlay concept was unveiled in Las Vegas at the *Consumer Electronics Show* in January 2001. The 32mm double-sided disk is coated with phase change recording material and stores 250MB on each side.

Although phase change coating allows erasure, DataPlay never implemented the function and the only disks were write-once. The FAQ on Imation's web-site says "Imation DataPlay Digital Media is write-once. Future DataPlay offerings may be rewritable." Toshiba said two years ago that there was no erase button in order to keep recorders simple. Trade customers say they were originally told the disk would be rewritable and were astonished when they found it had been changed.

DataPlay has raised $119 million since founding in 1999 through backing of Eastman Kodak, Imation, Samsung, Intel, musician David Crosby, Toshiba, Universal Music Group and others. BMG and EMI pledged to release music along with UMG. Toshiba told record companies they could sell disks with pre-recorded music on one side, and the second side blank for downloading.

Pricing Difficulties

But Toshiba lost interest because of the difficulty of making the technology work reliably at reasonable price. In the US, the cheapest DataPlay recorder comes from China and costs $319. Samsung is now part of the Blu-ray blue laser consortium.

Imation (the 3M spin-off) launched the new "Mini Optical Media" at the *Stuff Live 2002* toys-for-boys show at Earls Court in early October just as the parent company admitted it could not raise the $50 million needed to keep going and sent its 120 workers home on unpaid "furlough" leave. Imation had sent out large cardboard boxes filled with air bags, to emphasise the small size of the DataPlay disk trapped in the middle, and promised recorders from companies called MediaEnabling and iRiver. Imation had been ramping up manufacture of blank disks on a single line in the USA which also produces CD-RW disks and diskettes.

Another 120 DataPlay workers lost their jobs in July. Said Marcus Heap, European Business Development Manager:

"Imation is an investor in the DataPlay company, and a business partner. We continue to fully support the DataPlay format. The company in the US has sent employees home, they call it furlough, while financial restructuring goes on. Other companies are involved in the decision. We expect more information within two weeks. Of course this needs resolving but as far as we are concerned it is business as usual – we do not expect this in any way to mean the demise of the DataPlay format."

Numerous Patents

DataPlay has now closed operations and put the company up for sale. The patent records show that Dataplay has a folio of at least 85 international filings.

The most recent (WO 02/077980 and 983) tell how the laser is moved across the disk and kept in focus. Whereas CD and DVD players mount the laser optics on a sled and move it linearly, Dataplay puts the optics on a pivoted arm, like a miniature gramophone pickup. The arm is flexible and the laser beam is kept tightly focussed on the disk surface by tilting the arm slightly up and down. This arrangement, says Dataplay, uses less power than a linear sled so lets battery-portables run longer; tilt focussing can react more quickly to compensate for jogs.

Another patent WO 01/93009 tells how a series of recordings, made at different times, can be added to the non-erasable disk and its non-erasable electronic table of contents. A new electronic index is added to a list of indexes on the disk every time a new recording is made. The playback laser always looks for and reads the last index on the list

There has only been one other case of a format being killed on launch day. That was in the mid-eighties when the Japanese companies backing the MSX computer system pulled the plug on the day the Consumer Electronics Show opened in Las Vegas in January 1985. The MSX Pavilion was stripped of exhibits overnight and glossy magazines which had prepared MSX Special issues were left with egg all over their faces.

EASY CURRENT MONITORING

LEM has introduced the DF series of current transducers for accurate measurement of low d.c. currents from 10mA to 500mA without breaking the primary cable.

The new series provides a two per cent measurement accuracy and has galvanic isolation between the primary and secondary circuit of up to 5kV. Outputs are adapted for many types of control board (microcontrollers, PCs etc.) using fingersafe terminals. The supply voltage is ±12V d.c., allowing bi-directional measurement.

For more information contact LEME HEME Ltd., Dept EPE, 1 Penketh Place, West Pimbo, Skelmersdale, Lancs WN8 9QX. Tel: 01695 720777. Email: kwi@lem.com.

NEW NRPB BULLETIN

The National Radiological Protection Board (NRPB) has integrated the *Radiological Protection Bulletin* into its web site at **www.nrpb.org**. The first edition of the *nrpb eBulletin* contains an editorial on Chernobyl, various news items and articles on magnetic fields, nuclear power, depleted uranium and protecting against the dangers of ultraviolet light.

In the NRPB's Annual Report 2001/2002 recently received, it was interesting to note that the web site is also said to be "a good teaching resource and learning tool for children as well as the wider audience".

Earls Court Expo Postponed

Undoubtedly some of you will have been looking forward to the next Electronics World Expo that was due to take place at Earls Court, London, in February. This "Design to Manufacture" event for the electronics industries has now been postponed and is likely to be rescheduled for the autumn of 2003. Visit **www.ewex.co.uk** for the latest information.

SFFO MINI-DISK LAUNCH

Barry Fox reports.

Philips of the Netherlands has for two years been working secretly on the SFFO, Small Form Factor Optical system project at a research centre in Southampton, England. SFFO was first mentioned in a lab research report written earlier this year. In early October Philips gave the first semi-public showing of SFFO at a Japanese electronics exhibition to convince doubters that it really is possible to store 4GB on a 3cm disk, and build an optical drive as small as a plug-in memory card.

SFFO has spun off from the work done by Philips on Blu-ray, the standard for using 405nm blue lasers on DVD-sized disks already agreed by Hitachi, LG, Matsushita/Panasonic, Pioneer, Philips, Samsung, Sharp, Sony and Thomson.

The 3cm disk will be the same thickness as a DVD, but spin-coated with a much thinner layer of phase change recording material – 0.1mm for SFFO compared to 0.6mm for DVD. Because the SFFO laser only has to "see" through this very thin layer, there is little risk of beam distortion if the disk tilts when the device is jogged.

The glass photo-polymer lens has a light transmitting pupil of only 1.3mm, one third the size of the lens in a DVD recorder. This reduces its mass to one tenth and gives immunity to mechanical jogs. The drive shown in Japan is 0.7cm thick, 5.6cm long and 3.4cm wide. The lab has now reduced thickness to 0.5cm. The target is a drive thin enough to slot into a standard memory card socket.

The disk will initially store 1GB on each side, but dual layer coating as already used for DVD will double the capacity again, to a 4GB total. The disk comes in a protective caddy, but users can take out the disk and use it bare. But this will not be a good idea, warns Philips, if people put SFFOs in their pocket along with loose change.

Wayne Fletcher, SFFO Program Manager at Southampton, says it can be ready for sale in two years, if there is industry agreement. Chris Buma, who heads Philips' optical division in Eindhoven, says disks can be made for "a few cents".

"I don't think a $5 drive will ever be possible," says Fletcher. "But whereas the memory card makers can put slots in a portable device for next to nothing, and charge $100 for a card, we could charge $100 for a drive with the promise of very inexpensive disks".

ULTRA-MINI METER

A 3½ digit l.e.d. voltage meter with 9mm digit height in a compact d.i.l. package has been added to Lascar Electronics range of low-cost, ultra-miniature panel instruments.

Features of the OEM 1B-LED module include selectable decimal points, auto-polarity, auto-zero and 200mV full scale reading with on-board calibration. Prices start at £15.50, and volume discounts are available.

For more information contact Lascar Electronics Ltd., Dept EPE, Module House, Whiteparish, Salisbury, Wilts SP5 2SJ. Tel: 01794 884567. Fax: 01794 884616.

Email: lascar@netcomuk.co.uk.
Web: ww/lascarelectronics.com.

EOCS RISING

The Electronic Organ Constructor's Society (EOCS) is a Society which has reported that it is has been experiencing a rise in the number of members who are pleased to write articles for its *Electronic Organ Magazine*, the latest copy of which, number 183, has recently been received at *EPE*.

Don Bray, Editor of the magazine, comments though that there is still room for more. If you have something to say about electronic organs – be it new technology or traditional craftsmanship, a long article or idea snippet, or even an interesting photograph – he would be pleased to hear from you.

Of course, Ron Coates, the Membership Secretary and Hon. Treasurer, will also be delighted to hear from any *EPE* reader who wishes to join the EOCS. If you live in London, Essex or the South of England you will not only receive the regular magazine, but you will also be able to meet with like-minded organ enthusiasts at one of the periodic meetings. You have missed the London Symposium at the end of October, but there will be another in April next year, and there are other local meetings to attend as well.

For more information about the EOCS, contact Ron Coates, Membership Secretary, Dept EPE, 2 Boxhill Nurseries, Boxhill Road, Tadworth, Surrey KT20 7JF. Email: treasurer@eocs.org.uk.

FML CAT

The 2003 catalogue for FML Electronics has been received. Whilst six pages of A4 may not at first sound enticing – get a copy and be prepared for a surprise at the sheer quantities of device types that are listed, especially in the semiconductors category, which probably lists several hundred types.

Other categories for which a respectable selection of component types is listed include capacitors, crystals, optoelectronics, resistors, potentiometers and thermistors.

For more information contact FML Electronics, Dept EPE, Freepost NEA 3627, Bedale, N.Yorks DL8 2BR. Tel: 01677 425840. Email: fml.electronics@breathemail.net.

Sherwood Cat

Sherwood Electronics have sent us their 2003 catalogue. It costs £1 but this is likely to be soon recouped through using the vouchers that are included with it.

The catalogue comprises around 100 A5 pages which offer the convenience of having ready access to a wide variety of basic electronic components that any electronics enthusiast is likely require in pursuit of their hobby. Included are bulk-purchase packs of selected useful items, and each priced at only £1.

For more information contact Sherwood Electronics, Dept EPE, 7 Williamson Street, Mansfield, Notts NG19 6TD.

SQUIRES 2003 CAT

Wondering what to buy *yourself* for Christmas? Squires Model and Crafts Catalogue 2003 holds all sorts of fascinating items that any dedicated hobbyist in any constructional field will find desirable!

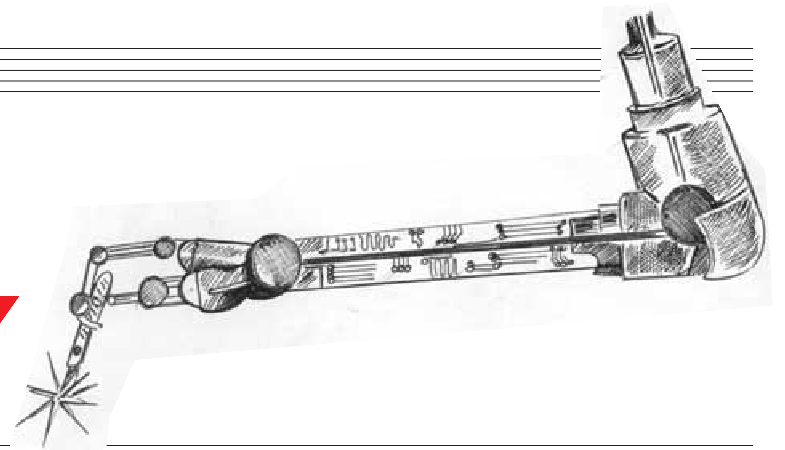
The catalogue is the ninth issue produced in the ten years since Squires commenced trading. Its range of contents seems to include everything except the proverbial kitchen sink – screwdrivers, spanners, anvils, drills, chisels, pyrography tools, scenic materials, capacitors, connectors, knobs, relays, resistors, semiconductors, speakers – just a few random selections from the extensive list, catered for by over 600 pages in A5 format.

We've said before, and confirm it again – this catalogue is the key to an Aladin's cave of goodies, and a worthwhile reference book for the workshop.

Squires say they offer "an excellent and friendly service" which includes: free catalogue to any UK address, same day despatch for orders placed before 4pm, P&P free of charge, payment accepted by cheque, credit or debit card.

For your copy of this bumper catalogue, contact Squires Model and Craft Tools, Dept EPE, 100 London Road, Bognor Regis, W. Sussex PO21 1DD. Tel: 01243 842424. Fax: 01243 842525.

Regular Clinic



CIRCUIT SURGERY

ALAN WINSTANLEY and IAN BELL

This month we look at the construction and applications of power MOSFETs.

All About MOSFETs

Our thanks to reader ***Dave Larner*** who emailed us on the subject of power MOSFETS:

"Looking through past issues of EPE *very few projects use power MOSFETs and I wonder why? I suspect static may be a problem but this seems to be outweighed by the low on-resistance and need for very little heatsinking and the large current handling capabilities.*

I have obtained MOSFET data sheets for IRF530, BUZ11 and PHB50N06LT. I see the gate voltage needs to be as high as 4V for some types, I also note that some types have low gate voltage for direct driving from 5V logic. One of the problems is that there seem to be many different types and methods of construction."

We can't really say why power MOSFETS are not seen in *EPE* as often as Dave would expect; the projects represent the efforts of many different authors with different approaches and experience and we at *CS* are not privy to all their design decisions.

However, we can have a go at explaining the various power MOSFET structures, which may help those who do find it a little confusing. Dave also asked about drive circuits (e.g. to drive power MOSFETS from logic devices) and we will be looking at this in another instalment of *Circuit Surgery*.

As Dave points out there is a variety of types of power MOSFET with different constructions, and different names, with some of the names being trademarks of particular manufacturers. These names include DMOS (Double Diffused MOS) and VMOS (Vertical MOS), which are often used generically, but were originally developed commercially by Siliconix in the 1970s. Then there is HEXFET from International Rectifier, TMOS from Motorola, TrenchFET from Vishay/Siliconix, PowerTrench from Fairchild, and that's by no means an exhaustive list.

The power MOSFET market can probably be divided into the "heavy duty" area – dealing with very high voltages and currents, and the "high efficiency" area at low voltages and moderate currents, where devices are typically targeted at applications such as the switch mode power supplies in portable systems like laptops. For heavy duty use, MOSFETS capable of handling 1000V drain-source voltage or drain-source currents of over 150A are available.

How They Work

To understand the meaning of the many MOSFET names and the need for these various structures that go with them, we need to know a little bit about how MOSFETS are constructed and operate. Conduction between source (s) and drain (d) in an ordinary MOSFET takes place in a narrow channel region under the gate (g) (see Fig. 1). The term *lateral* MOSFET is used to describe this structure of the standard low power MOSFET as the current flows entirely through a horizontal plane.

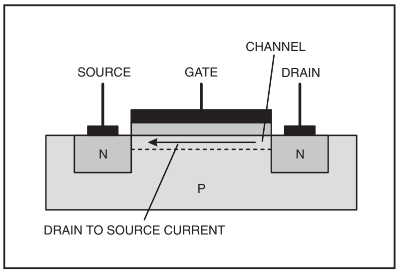


Fig.1. Lateral MOSFET used for low power applications.

The basic operation of the *n*-channel MOSFET (as shown in Fig. 1) is as follows: if we apply zero, low or negative gate-source voltage, the device is off because the *n-p-n* regions act as two back-to-back diodes. Only a very small leakage current can therefore flow from drain to source (or vice versa). Here, "*n*" and "*p*" refer to the type of chemical used to "dope" pure silicon to create interesting semiconductor behaviour.

In the case of *n*-type silicon it has more electrons free to take place in conduction than in pure silicon. Whereas, *p*-type has fewer electrons, but these gaps can be regarded as mobile "holes" which act like positively charged versions of the electrons in the *n*-region. Thus, both *p* and *n*-type silicon conduct to some extent. Placing an *n*-region next to a *p*-region creates a *pn* junction, also known as a "diode junction", through which current will usually flow in only one direction.

Getting back to the MOSFET, if we apply a positive gate-source voltage the electrostatic attraction of this gate voltage will pull (negatively charged) electrons from the nearby silicon to the *p*-type region just under the gate. If sufficient electrons accumulate here there will eventually be an excess of electrons so the area just under the gate will *behave* as if it is *n*-type silicon.

At this point it will have a created an *n*-type *channel* connecting the *n*-type drain and source regions, thus we have an *n-n-n* path from source to drain, rather than the *n-p-n* back-to-back diodes previously described. Conduction can now take place from source to drain. The transistor is on and the gate-source voltage at which this occurs is called the *threshold voltage*.

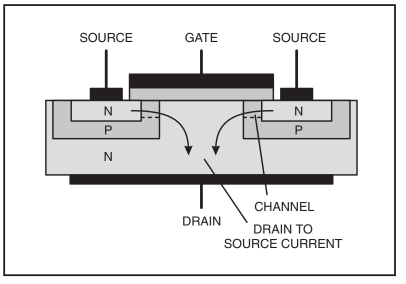


Fig.2. Simplified DMOS power MOSFET structure.

The approach to the physical structure of the MOSFET device shown in Fig. 1 cannot readily be extended to produce high power devices – the cross sectional area of the conducting region simply cannot be made big enough (to make R_{ON} small) without using an unreasonably large area of silicon. Furthermore, the large gate area would make such a device very slow due to the capacitance of a very large gate.

The structure of a DMOS power MOSFET is shown in Fig. 2. The channel is still horizontal under the gate, but it is much shorter than in the conventional MOSFET, and the current flow between channel and drain is vertical. The short channel means a low on resistance, a property required by power devices. The T-shape current flow is probably the source of the name TMOS.

HEXFET Structure

The vertical nature of power MOSFETs means that the transistors can readily be repeated in a parallel structure to increase current handling capacity. A variety of shapes can be used for these repeated structures such as squares, triangles or, as illustrated in Fig. 3, hexagons (hence HEXFET).

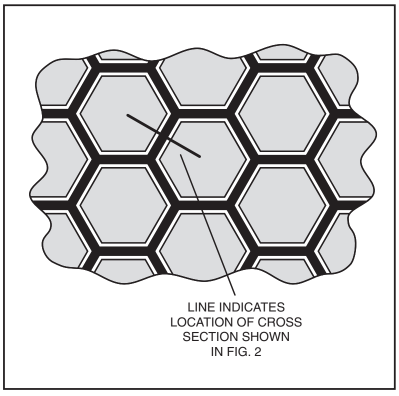


Fig.3. Top view of the MOSFET using hexagonal repeated cells to form parallel transistors. The grey areas form the source and black areas are the gates.

Some power devices have over 20,000 parallel transistor cells. Note that MOSFETs work happily in parallel because they do not suffer from current hogging and thermal runaway like bipolar transistors (a topic previously discussed in *Circuit Surgery*).

Another power MOSFET structure is shown in Fig. 4 in which the gate is placed in a U-shaped groove or trench (hence the word "trench" appearing in various power MOSFET product names). Also, V-shaped grooves are used. Such devices have a completely vertical drain-source current flow, allowing even greater density in cellular structures. However, these structures are also used in strips rather than the array of cells shown in Fig. 3.

The actual structures of real power MOSFETS are more complex than those shown in the diagrams here (for example the *n*-type area connected to the drain has different regions with different doping levels).

Choosing A Device

In terms of choosing a device to use, if you understand that the various names relate to each company's promotion of their technology and that all the devices are basically power MOSFETS, then perhaps things will seem a little easier. Identify your key need – high efficiency, high speed, high voltage, high current, etc. and then select a device optimised for this that meets all your other requirements in terms of voltages, currents, power and speed.

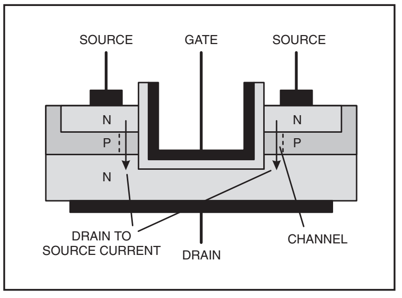


Fig.4. Simplified UMOS structure, named after the U-shaped gate "groove" cross section, V-shaped groove devices are also available.

Power MOSFETS have a number of advantages over bipolar transistors in high power applications:

- MOSFETS are **voltage-controlled** devices, so the drive circuit does not have to supply a continuous current to hold the MOSFET in the *on* state (current is required to charge the gate capacitance at switch-on, however).

- They have better switching efficiency. That is, the power wastage that occurs due to the process of switching is lower in MOSFETS than in bipolar devices.
  This is particularly important in applications where the power device is continuously switched at relatively high frequencies – switched mode power supplies being a key application where this advantage is exploited.

- As we have already mentioned, MOSFETS can be used in parallel much more easily than bipolar transistors.

One disadvantage is that MOFETS are not as good as bipolar transistors for very high voltage use. A consequence of building a power MOSFET that can block high voltages is increased on-resistance and hence higher power dissipation when the device is switched on.

However, the other advantages of MOSFETS have led to them being combined with bipolar devices for high voltage applications to form ***insulated gate bipolar transistors*** (IGBTs). As you might expect there is also on-going research to produce very high voltage MOSFETS which overcome the problems with the basic devices.

As Dave mentioned in his question, threshold voltages are typically 4V, but in order to fully turn on many of these devices for use at their full current rating, 10V or more may be needed.

We will return to this and other issues relating to driving power MOFETS in the next instalment of *Circuit Surgery. IMB.*

Constructional Project

F.M. FREQUENCY SURFER

TOM MERRYFIELD

Riding the airwaves at 88MHz to 125MHz will trawl-in many unusual and unexpected contacts

As a variation on Amateur Radio, the idea for this project came about after operating a commercial v.h.f. (very high frequency) receiver which unfortunately was "deaf" to narrowband transceiver signals beyond 100MHz.

Adding a long aerial, an impedance matcher and a wideband aerial amplifier offered a marginal improvement, but it soon became clear an improved detector stage and better low-pass filtering was required. Although built from scratch, the result is a circuit based on the Philips IDA7000 f.m. processor i.c., incorporating phase-locked loop detection, mixer and necessary oscillator stages.

Strictly speaking, the project is really a v.h.f. receiver providing a nominal coverage from 88MHz to 125MHz but in use it covers a variety of signals. (The range can also be extended to a top limit of approximately 146MHz. See later.) This includes wideband f.m. broadcasts, aeronautical communications, fixed and private mobile radio, amateur bands activity on the lower frequency channels and the occasional shortwave transmission via satellite.

With a little care and a few precautions, this project can be easily built and set up using a long aerial as opposed to a co-axial cable and feeder system. The cost of a slow-motion drive (these can be difficult to obtain) is also avoided since accurate tuning can be achieved using ordinary tuning capacitors.

F.M. IN CONTEXT

As most readers will recall, the mediumwave and longwave bands pertain to amplitude modulation (a.m.), the audio information being impressed upon a carrier of constant frequency by varying its amplitude. At the receiver end a simple diode detector can be used to retrieve the audio from the carrier.

In some cases only a small portion of the modulated waveform may be transmitted as in single side-band (s.s.b) transmission used, for example, in Amateur Radio transceiver activity.

A frequency modulated (f.m.) signal however, is where the carrier frequency is made to deviate from the central carrier frequency. Clearly, this implies the need for an f.m. detector as opposed to an a.m. type, the desired output being a voltage proportional to the amplitude of the modulating signal (or audio) relative to the degree of frequency deviation.

PLL DETECTION

Whereas a simple ratio detector could be used to detect wideband f.m. signals, a more sophisticated form – namely, Phase-Locked Loop detection (PLL) – is required to adequately demodulate narrowband transceiver signals intercepted by the aerial system.

As incorporated in the TDA7000 f.m. processor (IC1 – see Fig.1), the PLL loop includes a phase detector comprising two inputs; that is, a signal from the reference oscillator and that generated by the Voltage Controlled Oscillator (VCO). Due to the existing phase difference or error, the output from the phase detector is fed into a low-pass filter which removes unwanted harmonics and noise whilst blocking all a.c. components of the waveform.

Hence, only the d.c. component, referred to as the control or error voltage, is inputted to the VCO (pin 6 of IC1). This in turn modifies the VCO frequency so the phase offset is compensated for with the VCO "locked" on to the incoming reception frequency.

The advantage here is that narrowband signals can be similarly processed – even at frequencies of some several hundred megahertz! Also, since the VCO is linked directly to the tuned circuit (Fig.2), sharper tuning is more easily accomplished so long as a high *Q* is maintained over the relevant band of frequencies.

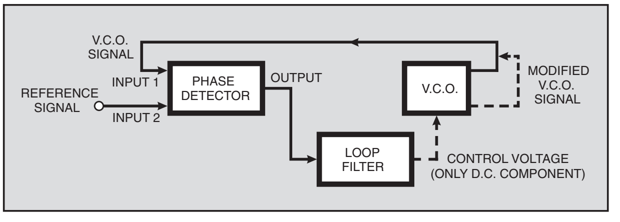


Fig.1. Simplified block diagram for the PLL

CIRCUIT OPERATION

The full circuit diagram for the F.M. Frequency Surfer is shown in Fig.3. Although the circuit may seem relatively complex, it can be easily broken into stages as shown in the block diagram of Fig.2.

Furthermore, coils L1, L2, L5 and L6 are home-wound and easy to construct, with coils L3, L4 and L7 being ordinary widely available inductors. These, however, are not the suppression type which tend to be more expensive but don't actually work very well in the circuit!

In order to employ the long aerial effectively and reduce losses, the twin coil L1/L2 provides some impedance matching whilst also forming a part of the aerial filter circuit. As shown in Fig.3, the signal is proportionately tapped off via two tappings on L1 and the finish winding of L2 as switched inputs to the filter circuit.

Since even very expensive scanning equipment can be hampered by poor front-end filtering, the latter plays an important role by aiding front-end selectivity, reducing interference and bypassing out of band

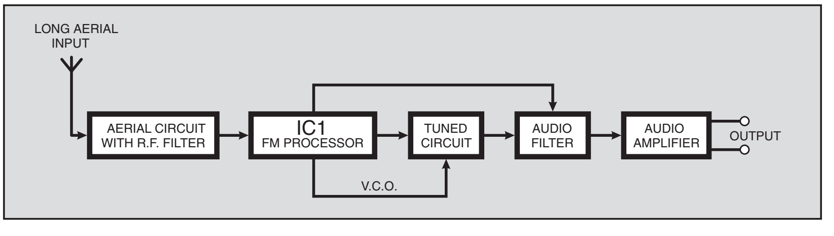


Fig.2. Block schematic diagram for the F. M. Frequency Surfer

signals to ground. This also avoids using tuned circuits in the aerial circuit with capacitors C1 to C8 offering stepped-up attenuation via the 12-way single-pole rotary switch S1.

In terms of high frequency signal processing, most of the work is carried out by IC1. Apart from PLL detection (discussed earlier), other necessary stages include an r.f. input and mixer to convert the reception frequency to a much lower intermediate frequency, in this case 10·7kHz.

Despite employing quite a few external capacitors mostly for decoupling purposes the actual connections for IC1 are straight forward. The signal is inputted to pin 13 via the aerial circuit with pin 2 as the output terminal coupled to the audio filter via capacitor C22. Note the tuned circuit is connected only via pin 6 of IC1.

Resistor R1, with bypass capacitor C23, set the nominal output voltage. If using an external power supply (mains adaptor), it must not exceed 10V d.c., this being the maximum permissable supply voltage for IC1.

VCO

No separate tuned circuit is needed to resonate the VCO since the VC1/VC2 network caters for both this and selecting the reception frequency. The sharp tuning capability required to adequately tune in narrowband transceiver activity is assisted by this network, including capacitors C25 and C26, in maintaining a high *Q* over the fairly broad tuning range.

For instance, without capacitor C24 and coil L6 the frequency response beyond 115MHz becomes flatter, thus reducing the selectivity. Further, since the margin of error becomes more critical with narrowband signals, VC1 (trimmer) and VC2 (variable) capacitors therefore have to he adjusted very carefully (see In Use).

In comparison, s.s.b. signals, can be missed altogether since only a part of the modulation envelope is transmitted making the signal extremely narrowband.

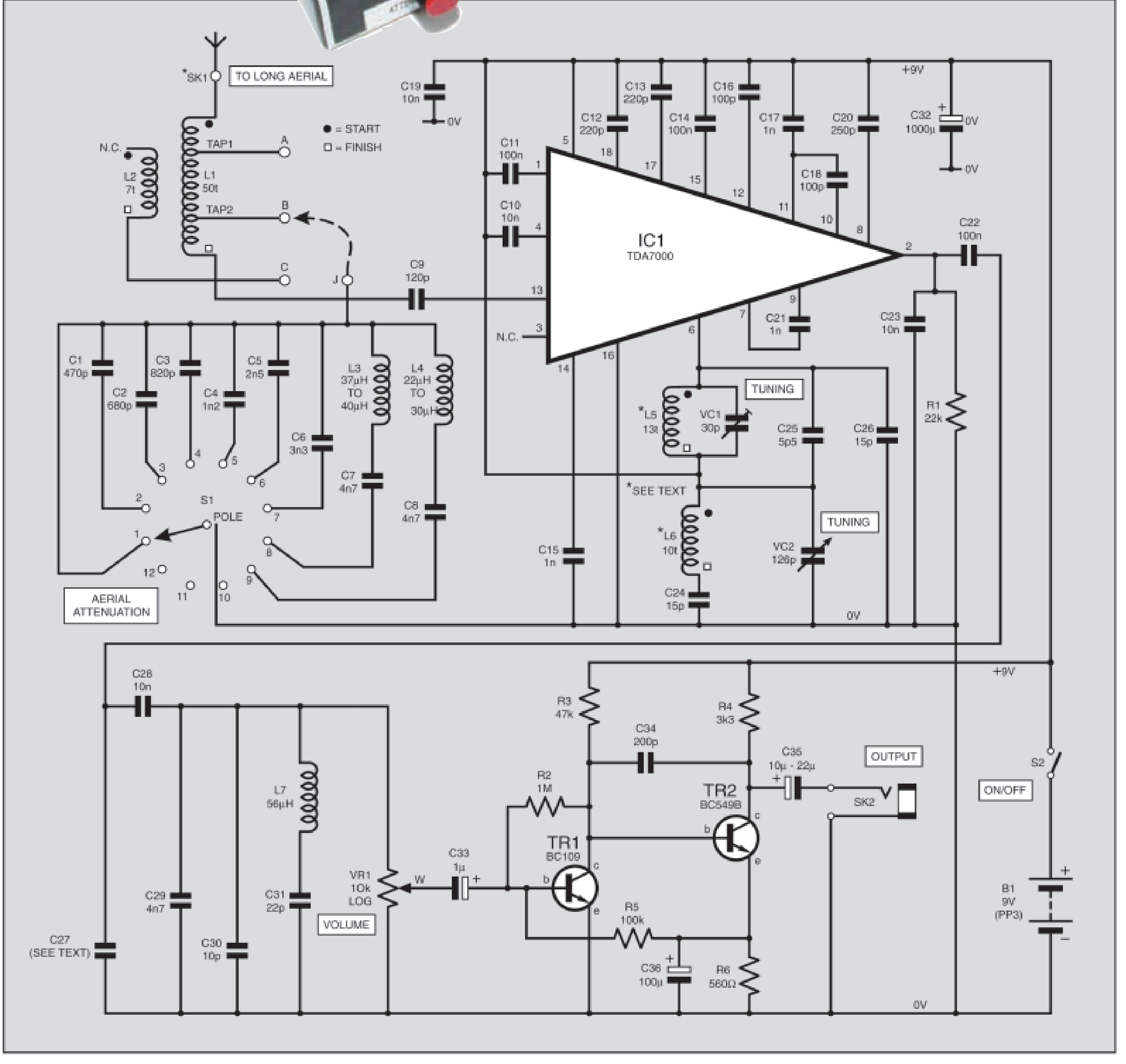


Fig.3. Full circuit diagram for the F. M. Frequency Surfer. The audio output is fed into a crystal earpiece or high impedance headphones.

Table 1: Broad Classification of Frequencies

Frequency	*Type*	*Predominant Usage*
0·3MHz to 3MHz	Medium Frequency	A.M. – Domestic Radio, including longwave and medium wave
3MHz to 30MHz	High Frequency	A.M. / S.S.B. – Shortwave Radio, Amateur Bands, Maritime etc.
30MHz to 300MHz	Very High Frequency	F.M. – Commercial wideband f.m. (88MHz to 108MHz) and narrow band transceiver activity, s.s.b. also used

AUDIO FILTER

Capacitors C27 to C31 and inductor L7 comprise a simple audio filter network prior to the audio amplifier. They also reduce the noise component of the demodulated signal whilst bypassing stray r.f. to ground, which could otherwise distort the audio output.

Note that C27 is a home-made capacitor constructed from two short off-cuts of p.v.c. covered wire twisted with a couple of turns and soldered in place. The free ends however, are not wired but instead kept "loose" to avoid introducing a short.

The filtered audio signal is now coupled to a simple audio amplifier through variable potentiometer VR1 and electrolytic capacitor C33.

AUDIO AMPLIFIER

Transistors TR1 and TR2 form a high gain audio amplifier stage, with resisitors R3, R4 and R6 providing local biasing. Resistor R5 and capacitor C34 are needed for stability at high frequencies with C35 decoupling the stage from the audio output.

Note that whereas capacitor C32 caters for any voltage surges, C19 is required for bypassing any a.c. signals present in the supply line and as such, is placed strategically next to the processor stage.

Due to the output impedance being relatively high, a crystal earpiece or high impedance type headphones are needed to hear the output.

TUNING MECHANISM

Since using the wrong type of tuning capacitor can significantly reduce the performance of high frequency circuits, it is worth mentioning that VC2 is a 126pF device with a built-in f.m. section that is usually sold as being for use with i.c. radio chips. If a 6-lug type is obtained the middle and side lugs will have to be correctly identified with the middle lug wired to 0V.

Due to VC1 playing a critical role in making precise adjustments, a modern film type trimmer is not really suited for this sort of application. A 30pF differential type trimmer was used in the prototype, this being a bulky, airspaced device of the metal vane variety.

It should be pointed out that obtaining the exact type is not crucial; other single turn air-spaced devices of 30pF – perhaps bought second hand and in good condition – will perform well. The main advantage is that minute adjustments can be made easily. A 25pF device will also work, but the value of capacitor C25 will have to be increased to around 10pF with coil L5 wound with two extra turns.

COIL CONSTRUCTION

Constructing the coils is a simple process so long as it is not hurried and the coil wire handled very carefully.

To be effective, the twin coil L1/L2 is wound on a 10mm diameter former with irregular gaps left between most windings. Coil L1 is constructed from 30s.w.g. wire. Initially wind 20 turns then make a small loop of about 15mm to 20mm secured by a couple of twists to form the first tapping.

After winding another 15 turns, the second tapping is similarly made. Complete the coil with a further 15 turns and seal over the end sections only using insulation tape so it keeps from unwinding. The start

COMPONENTS

Resistors

R1	22k
R2	1M
R3	47k
R4	3k3
R5	100k
R6	560Ω

See SHOP TALK page 71

All 0·25W 5% carbon film.

Potentiometers

VR1	10k rotary carbon, log.

Capacitors

C1	470p polystyrene
C2	680p polystyrene
C3	820p polystyrene
C4	1n2 polystyrene
C5	2n5 polystyrene
C6	3n3 polyester
C7, C8, C29	4n7 polyester (3 off)
C9	120p polyestyrene
C10, C19, C23, C28	10n ceramic disc (4 off)
C11, C14, C22	100n ceramic disc (3 off)
C12, C13,	220p polystyrene (2 off)
C15, C17 C21	1n ceramic disc (3 off)
C16, C18	100p polystyrene (2 off)
C20	250p polystyrene
C24, C26	15p ceramic, low K
C25	5p5 ceramic, low K
C27	homemade (two pieces of p.v.c. covered wire – see text)
C30	10p ceramic, low K
C31	22p ceramic, low K
C32	1000µ radial elect. 25V
C33	1µ radial elect. 25V
C34	200p polystyrene
C35	10µ to 22µ radial elect. 25V
C36	100µ radial elect. 25V
VC1	30p differential single turn air-spaced trimmer or similar – see text
VC2	126p min. a.m./f.m. tuning capacitor (ZN414/6 radio i.c. type)

Semiconductors

TR1	BC109 *npn* low power transistor (no suffix)
TR2	BC549B *npn* low power transistor
IC1	TDA7000 f.m. processor

Coils and Inductors

L1/L2	50 turns (L1) and 7 turns (L2) 30s.w.g. enamel coated copper wire – see text
L3	37µH to 40µH axial inductor (non-suppression)
L4	22µH to 30µH axial inductor (non-suppression)
L5	13 turns 24s.w.g. enamel coated copper wire – see text
L6	10 turns 26s.w.g. enamel coated copper wire – see text
L7	56µH to 60µH axial inductor (non-suppression)

Miscellaneous

S1	1-pole 12-way rotary switch
S2	s.p.s.t. on-off toggle switch
SK1	phono socket, single hole fixing chassis mounting
SK2	3·5mm mono jack socket, with matching plug
B1	9V battery (PP3 type), with connectors

Stripboard, size 27 holes × 14 copper strips (Aerial), 44 holes × 17 strips (R.F.), 31 holes × 17 strips (Audio), and 0·1in matrix copper pad (single or tri-pad) board 15 × 15 holes (Tuner); plastic case, size approx. 200mm (W) × 110mm (D) × 62mm (H); potting box, 75mm (L); 18-pin d.i.l. socket; 20-pin d.i.l. socket; 10 metres plastic coated wire for long aerial (optional); plastic knobs, with skirts (3 off); connecting wire; M4/M3 nuts, bolts and spacers; circuit board stand-off pillars; self-adhesive pads; rubber grommets; solder pins; solder etc. Crystal earpiece or high impedance headphones.

Approx. Cost Guidance Only **£30** *excl. case, batt. and headphones* of the winding is indicated on the circuit diagram with a ●, and the end with a □.

The coupling coil L2 is simply seven turns of 30s.w.g. wire wound over the length of L1 with turns kept in the same direction as for L1. Note that the start of this winding is not actually connected up once in-circuit.

Once the enamel insulation has been scraped off from the "ends" using sandpaper, plastic-covered, flexible (multistrand) leads should be soldered to the tappings; including the start lead of L1, which will be used for the long aerial connection.

TUNING COILS

The tuning coil, L5, is wound from 24s.w.g. wire at exactly 13 turns on a 6·5mm dia. former. Conveniently, a pencil of similar diameter can be used to wind the coil on then slid out with most turns having a gap of about 1mm.

As with the preceding coils, L6 is also air-cored but constructed from 26s.w.g. wire at 10 turns on a 10mm dia. former. Reserve a gap of 2mm to 3mm approx. between most turns.

Coils L3, L4 and L7 are commercial inductors and should be easily obtainable. Typical ratings (micro Henries) are shown on the circuit diagram Fig.3.

ALIGNMENT AND SCREENING

Unfortunately, simply "slapping the coils on" the circuit boards can distort their effectiveness at v.h.f. frequencies unless properly aligned. For instance, once soldered in place, L5 and L6 stand away from the board as opposed to resting on it.

Positioning of the circuit boards and L1/L2 inside the case. The Tuning board is mounted inside its own potting box. Note the small "screening" partition by L1/L2.

As a stringent check, L5 should take up no more than 16mm to 17mm in length to ensure the correct distribution of turns. If the length seems shorter, gently push the relevant turns a part a fraction so the offset fills out, taking care not to scrape away any of the protective coating.

Although coil L6 is shown parallel to L5 in Fig.3 it should actually be positioned perpendicular to L5 as in Fig.5. Therefore, keep the start and end windings approx. 40mm long so the coil can be rotated easily into position after soldering it in.

Since both coils form a section of the tuned circuit, this is kept separate as a whole from the rest of the project. See "Casing Up" section later.

CONSTRUCTION

The circuit board component layouts, details of underside copper track breaks/links and interwiring, are shown in Fig.4 to Fig.7.

The constructor may be surprised to see several circuits boards being used in this project but this helps to build the circuit in

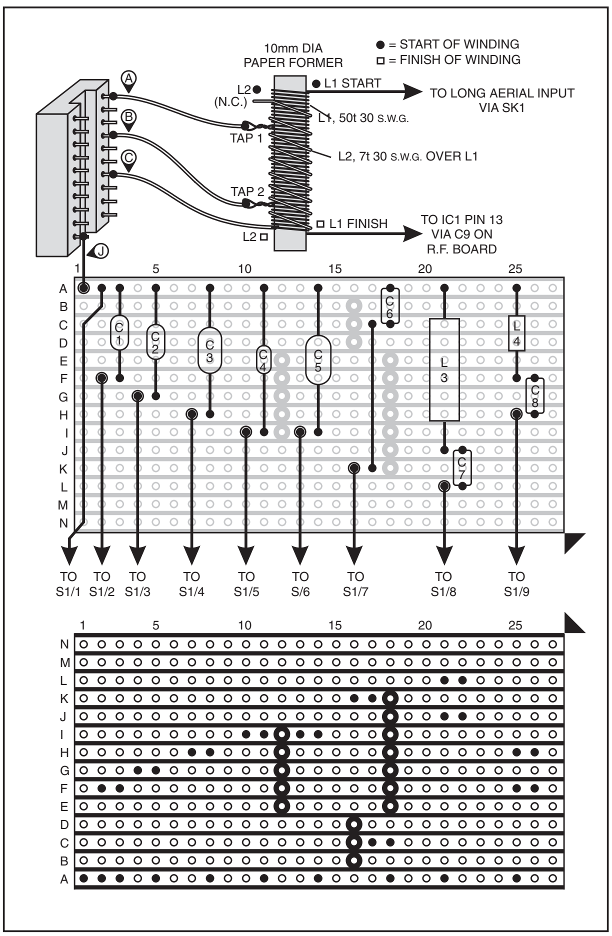


Fig.4. Attenuator board component layout, wiring and underside copper break details.

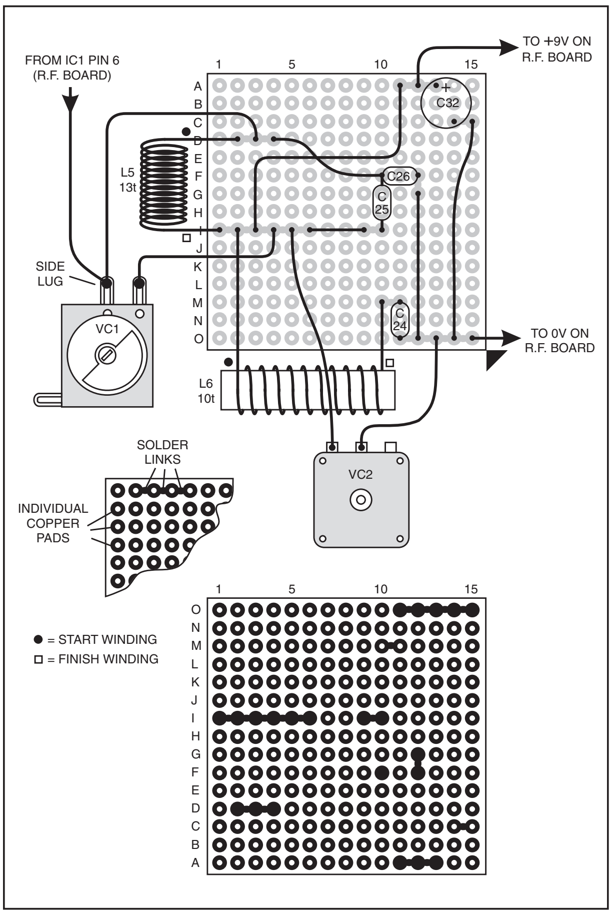


Fig.5. Tuning "pad" board component layout, underside "linking" and interwiring.

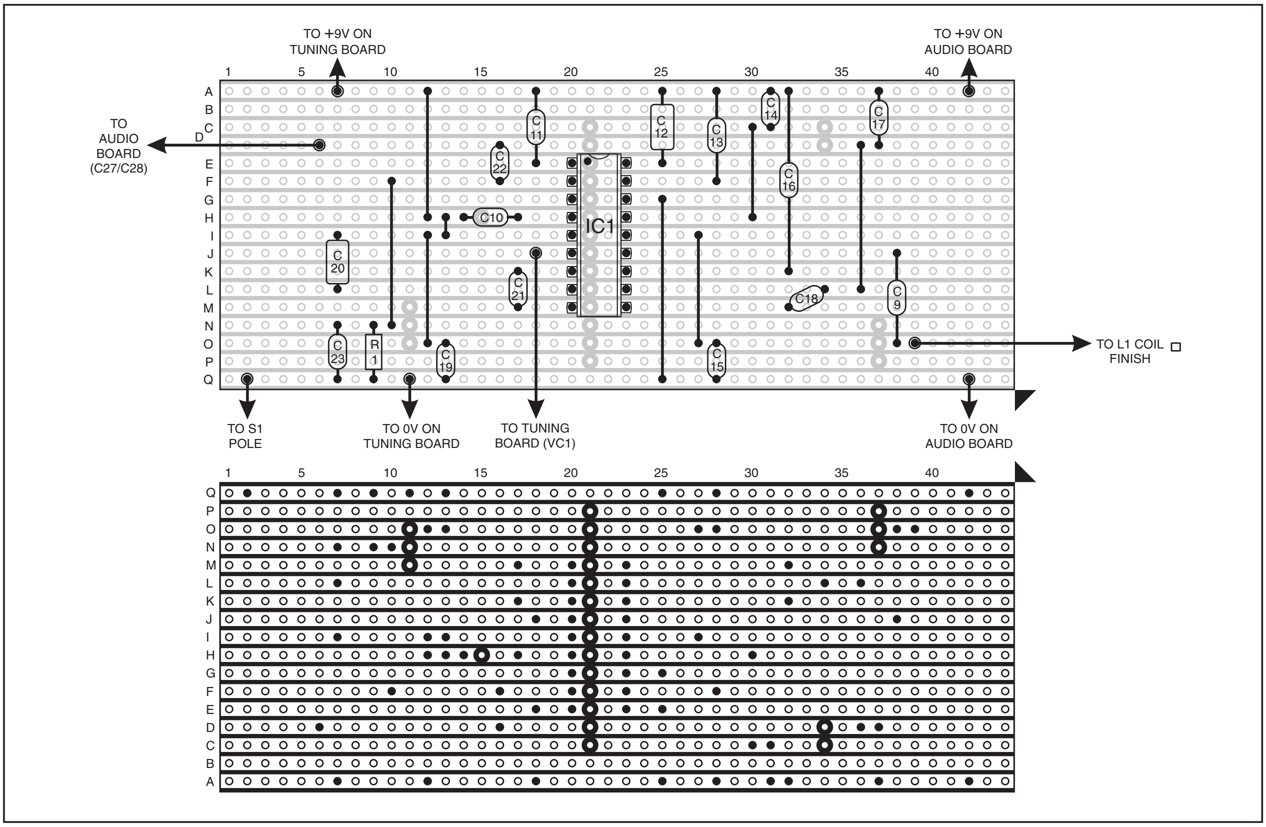


Fig.6. R.F. Tuning board component layout, underside copper strip breaks and lead-off wiring details.

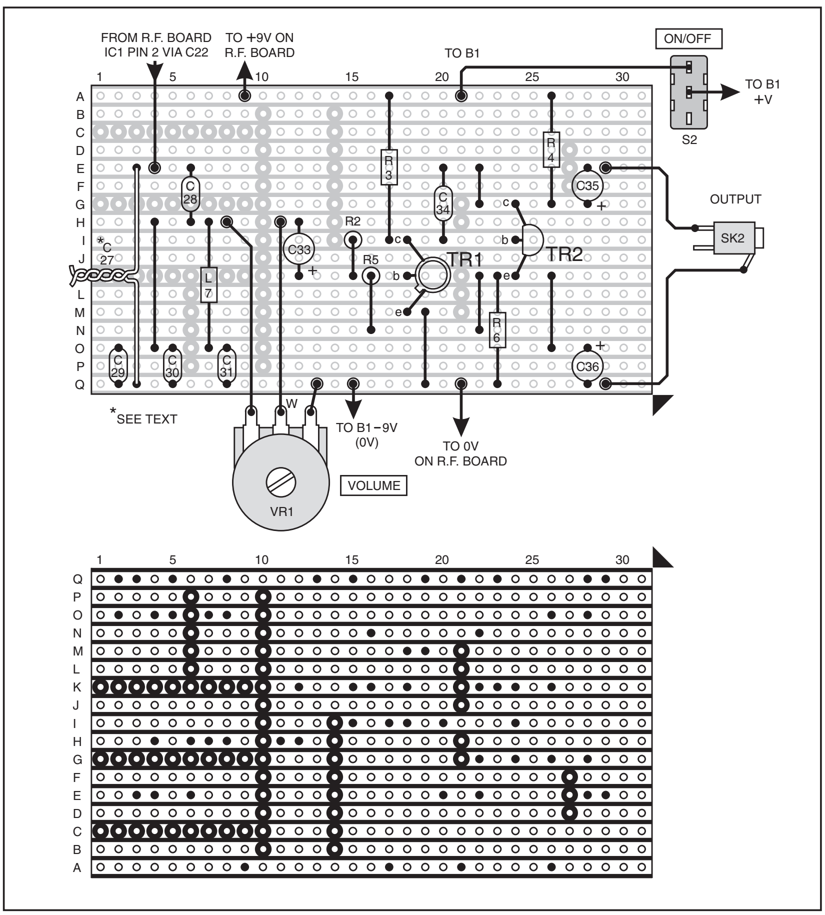


Fig.7. Audio/Filter circuit board component layout, interwiring to off-board components and details of breaks required in the copper tracks.

stages and assists fault-finding; there is, however, a more fundamental reason.

Taking into account the very high frequencies involved, despite building the project without error and confirming correct d.c. voltages using a multimeter, there can still be serious problems with spurious feedback and ineffective decoupling having a detrimental effect on the performance. Hence the need to physically isolate the aerial circuit, IC1 processor and tuner/audio stages.

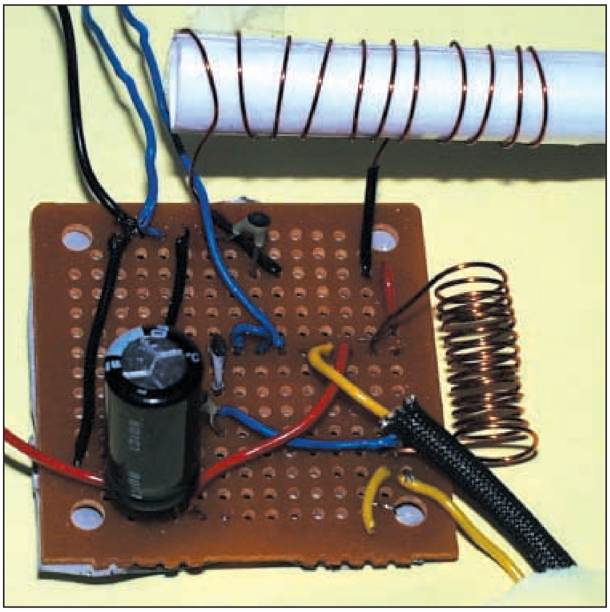
Because the VCO tuning can also be dogged with oscillation problems, the tuned circuit was soldered on to a "pad" or "tri-pad" type board to limit stray capacitances. (Note this type has small, circular pads for soldering connections as opposed to copper tracks running parallel.) The links for this section are made with single core p.v.c. covered wire.

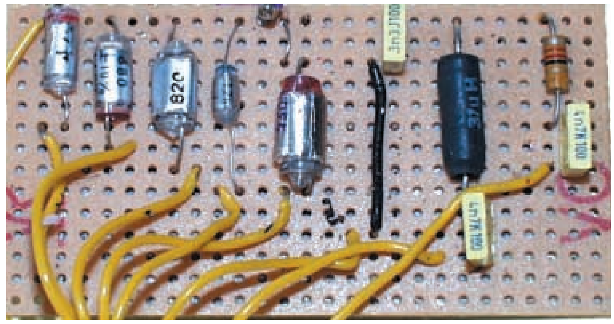
Another measure is to insulate the copper section for each circuit board using p.v.c. or "gaffa" tape once the project has been tested and is ready to be encased. The size of each stripboard required can simply be determined by counting the number of rows and columns in each case and then trimmed from a larger board.

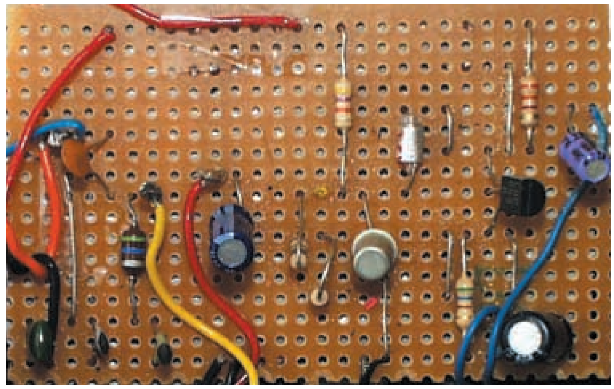
SELECTIVITY

As an auxilliary circuit aiding front end selectivity at higher frequencies, the aerial filter network (lead J) at the junction of C1 to C6 and L3, L4 can be switched in-circuit by wiring it to any one of the three inputs. That is, the first and second tappings and the "finish" lead of coil L2 of the twin coil labelled A, B and C respectively in Fig.3 and Fig.4.

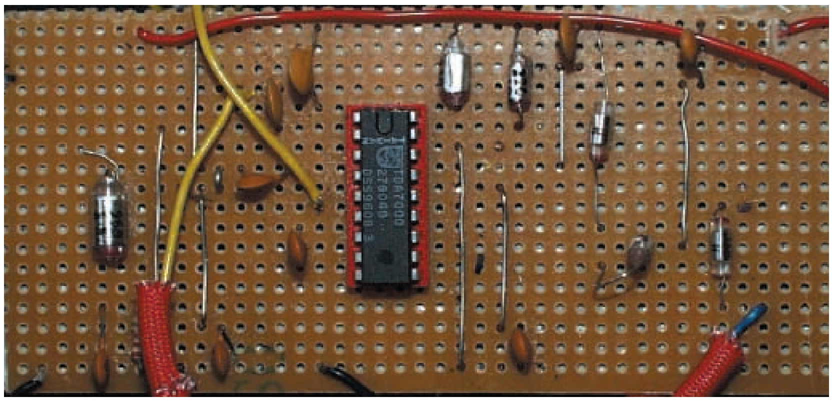
Rather than using a second rotary switch, an easier solution is to employ a d.i.l. socket as shown in Fig.4. At the very







Prototype circuit boards (left to right, top to bottom): Tuning board; Attenuator board; Audio board and R.F. board.



least this should be a 14-pin holder so the inputs are not soldered in close proximity.

Also, the relevant holes will have to be drilled at the side of the casing to accommodate the socket before soldering connections are made. The front or insert side of the socket then makes it possible to "plug in" a jump lead from the filter circuit to coil points A, B or C.

TESTING AND FAULTFINDING

Apart from incorrect wiring and wrongly mounted components, each circuit board should be inspected carefully for short circuits caused by solder splashes bridging over adjacent copper tracks.

Indeed, for the less experienced constructor, it is advisable to practice stripboard soldering before building the project, the rule being not to use excessive solder. You must contain each soldered joint within it's own track area.

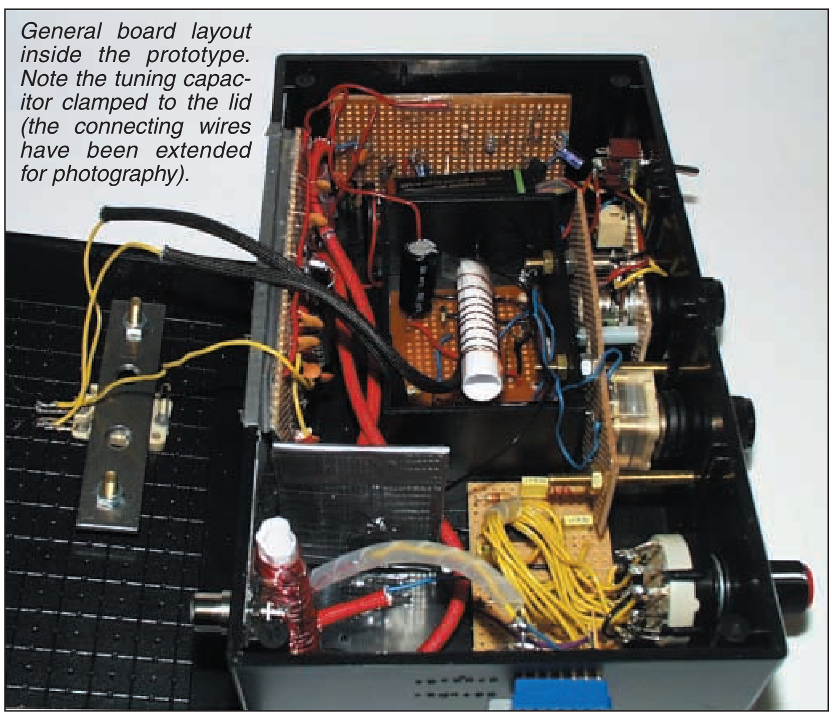
The pinout details for IC1, transistors TR1 and TR2 should, of course, be correctly identified and inserted correctly into the stripboard.

Generally speaking, if the output is silent this indicates a short circuit and/or a wrong connection. For the latter, external wiring and supply lines should also be checked to see if the voltages are correct.

If only static is heard in the output despite VR1 being advanced to full adjustment, this tends to point to a loose connection and/or dry joint. Assuming a 9V supply and no signal conditions, (i.e. the aerial is left disconnected), key voltages can be easily confirmed using a multimeter switched to the 0V to 10V d.c. range. The key voltages are set out in Table 2.

CASING UP

The project can be housed in a large-sized case of approximately 200mm by 110mm. Whereas the processor board (IC1) is situated facing the control panel, the audio stage is placed well out of the way towards the far side of the panel.



General board layout inside the prototype. Note the tuning capacitor clamped to the lid (the connecting wires have been extended for photography).

The aerial coil is screened from IC1 by an insulated section of matrix board positioned vertically. The external connection pertaining to the aerial input (start of L1) is made via a phono socket SK1 fitted to the side or back panelling (see Fig. 10).

As mentioned before, the tuned circuit (including L5 and L6) is kept separate as a whole by housing it in a large sized potting box kept in place via the front panel fixtures – see Fig.8. Incidently, a suggested method for mounting the controls to the front panel is also depicted, with additional supports needed for VC2 and VR1 in order to even out the load-bearing.

Since VC1 is adjustable, via a small pitch screwdriver or trim tool, it is fitted to the top surface or lid of the enclosure. This enables easy access to the adjustment slot, whilst giving the project a more intriguing look!

During trials, it was discovered that the wiring for VC1/VC2 and to pin 6 of IC1 should not exceed more than 80mm. This, however, is assisted by the strategic placing of the tuned circuit in close proximity to the controls and IC1.

IN USE

Any thin, p.v.c. insulated wire can be used as the long aerial, whether single-cored or multistrand. About 10 metres will suffice, the aerial being kept well away from electrical cables and not doubled over on itself.

It should be remembered that strong signals can easily overload the unit, in which case the aerial should be loosely coupled to the aerial input. That is, the flex is simply twisted around the aerial input socket (phono socket) without the exposed strands making electrical contact. Otherwise, the connection is more directly made using a phono plug.

Note also that VC2 is adjusted relative to VC1 to maintain the required "offset". For instance, VC1 is carefully tuned near continuous pulses and/or on-off tone bursts which either precede or indicate transceiver activity. Variable capacitor VC2 is then adjusted for the best signal.

As discussed earlier, the aerial filter can be switched in-circuit via coil L1/L2 tapping inputs A, B or C to reduce interference and improve poor-quality signals beyond 112MHz by applying attenuation a step at a time.

However, due to lower frequency signals being impeded it is advisable to keep the filter circuit disconnected when initially operating the Surfer. Once the output has been gauged, the filter can be switched in-circuit noting any difference in signal quality.

Table 2: Key Circuit Voltages

Test Point		*Voltage*
IC1	Pin 5	9V
IC1	Pin 13	1·8V
IC1	Pin 6	9V
IC1	Pin 2	0·9V
TR1	Collector	1·4V
TR2	Collector	4·8V
TR2	Emitter	0·7V

No Signal Conditions; Vs = 9V
Average current consumption
= 9·8mA approx.

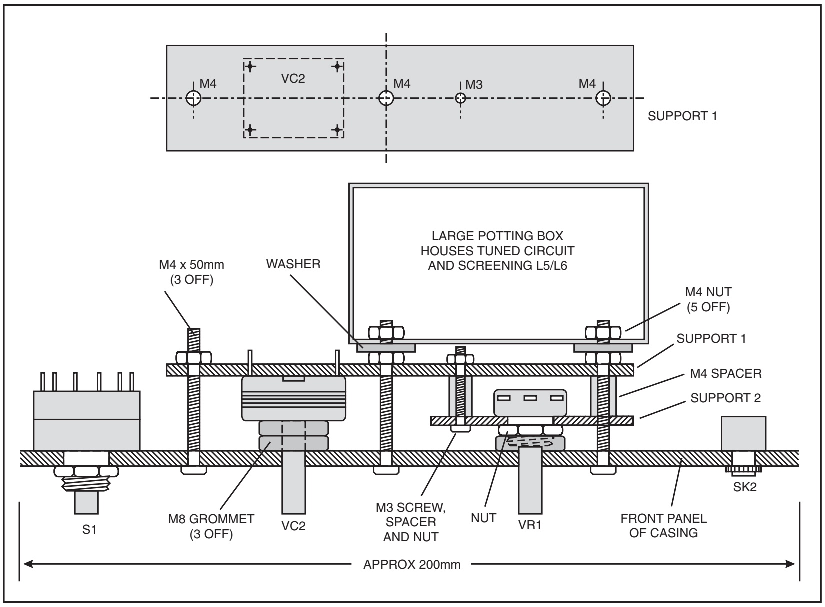


Fig.8. (above) Front panel component mounting details.

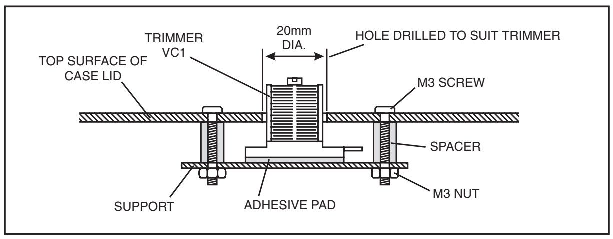


Fig.9. (right) Mounting trimmer capacitor VC1 on the case lid.

TUNING-IN

Although practice is needed to operate the unit confidently, the following procedure can be used as a convenient start point.

1 – Set VC2 at a third of its tuning range.
2 – Adjust VC1 incrementally until a signal is approached.
3 – Re-adjust VC2 to fine-tune.
4 – If using attenuation, repeat 1 to 3 for each step-up value.

RESULTS

Despite being a simple circuit (and therefore less prohibitive to build), the prototype picked up a range of transceiver signals on the f.m./v.h.f. bands including fixed/mobile communications and paging systems at around 86·5MHz and 110MHz. In some instances as VC1 is advanced slowly, normal free-floating f.m. static is abruptly interrupted by so called "channel static" indicating a communications line being open.

Apart from aeronautical radio-navigation tone bursts (110MHz, upwards), nearby aircraft signals (117·5 MHz) were also detected though very little may be understood unless the operator is familiar with coded abbreviations!

More accessible is Amateur Bands activity heard frequently on the lower frequency channels with one or both sides of the conversation received clearly.

With a little trial and error, the nominal range can be extended (86MHz to 146MHz) by experimenting with attenuation and, primarily, inputs A, B and C in turn.

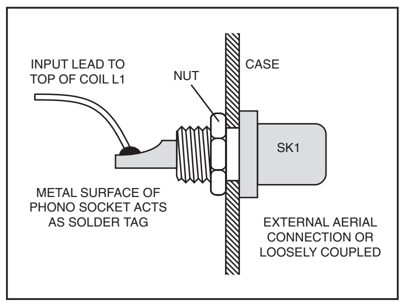


Fig.10. Using a phono socket for the external long aerial connection.

Ending on a precautionary note, it should be remembered to loosely couple the aerial where overloading occurs. Secondly, keep the wiring for VC1 and to IC1 pin 6 as *short* as possible – otherwise the reception of transceiver signals may be much reduced. □

New Technology Update

Semiconductors based on indium phosphide challenge those made from silicon and gallium arsenide. Ian Poole reports.

SINCE semiconductor devices were first introduced a variety of materials have been used as the basic semiconductor material. Germanium was the first that gained widespread acceptance, and the first transistors that were widely used in the 1950s and early 1960s were made from this. With developments in refining techniques, it then became possible to use silicon. This was much cheaper to use than germanium and its performance was superior in most areas. As a result silicon gained its place of dominance in the market in the early 1960s and it has remained in this position since.

In the late 1980s a third technology arose. This was based on compound materials from groups III and V of the periodic table of elements. From this development many gallium arsenide devices hit the market, exploiting the higher electron mobility of these semiconductors and enabling much higher speeds and frequencies to be achieved. Although more difficult to manipulate and hence more costly, gallium arsenide managed to pick its place in the market, offering far superior performance to that of silicon.

Indium Phosphide

Now devices based on a new compound are beginning to emerge from the development laboratories. Based on indium phosphide (InP) these devices offer very significant advantages over all other technologies and they are finding many applications in the areas of fibre optics and millimetre wave radio.

Development is not a fast process. In this year's *Appleton Lecture* at the IEE in London, Professor Midwinter cited examples of developments in photonics taking decades to reach fruition in view of their far reaching nature. However, developments in indium phosphide have not taken nearly as long and there are many real applications to which they can be applied.

For example, they provide the only technology that allows photodetectors and lasers to be integrated onto the same substrate as other analogue and mixed signal circuits. Not only does this force down costs, but more importantly it enables many performance parameters to be met.

They can also be used in the wireless industry. Although cost is far more of an issue in this area, indium phosphide products show a significant improvement both in basic performance and in a lower power consumption – a factor that is particularly important for cellular telephone handsets where battery life is a major consideration. It is also found that indium phosphide devices can be manufactured relatively easily to outperform gallium arsenide and silicon devices.

New Processes

One of the key enabling elements in the development of indium phosphide has been the emergence of low cost processes to grow indium phosphide crystals suitable for semiconductor device manufacture.

Throughout the 1990s there was a relatively high level of investment into the development of low cost wafers for i.c. applications. For these applications large wafers are required, coupled with exacting requirements for surface finish and flatness.

Further difficulties with processing indium phosphide are encountered, as it is very volatile around its melting point. To overcome this the growth of the crystals requires very high pressures. This means that specialised equipment is needed for the crystals to be grown satisfactorily. Until recently there has been a lack of commercially manufactured equipment to enable the indium phosphide crystals to be grown, especially in a form suitable for making large wafers.

To overcome this problem work has been undertaken by the University of New York to refine the work at the Hanscom Research Site and develop a design that enables high pressure synthesis and crystal growth. The design provides the facility to synthesise the indium phosphide by the direct injection of phosphorus and then grow the crystals under high pressure. This provides a method of being able to economically produce high quality wafers.

Improved Yield

In another initiative, a small business named GT Equipment Technologies based in Nashua, New Hampshire and part funded by a programme from the US government, improved the crystal growth hardware. It took the output from some modelling simulations and actual experiments they had performed and applied them to the equipment. The new system enabled indium phophide wafer costs to be reduced by around 50% whilst improving their quality. In turn this has reflected in the improved yield and performance of the resulting devices.

Work is now under way in a variety of establishments to produce four and six inch diameter wafers. With the increasing levels of integration, the industry is using these large wafers to reduce the production costs and increase the yield. However, uniform crystals of this size are not as easy to produce as the smaller ones, requiring larger equipment and more controlled growth. Once perfected the larger wafers enable the financial returns to be gained, and the costs to be reduced in this very competitive and cost conscious business.

Feature Sizes

Silicon technology has progressed a long way in recent years. Feature sizes on silicon have fallen dramatically and now 0·13 micron technologies are commonplace. Iindium phosphide technology is well behind this but is still able to provide performance results that are well ahead of that of silicon. Now much development activity is being placed into moving forwards with indium phosphide photolithography. With feature sizes on indium phosphide still about ten times those used on silicon it is possible to imagine the possibilities indium phosphide is likely to offer in the future.

To illustrate this, results for an indium phosphide high electron mobility transistor (HEMT) have been published detailing its performance at 220GHz. These results are from devices fabricated in the laboratory and not production items. These will take a number of years to catch up, but it shows the way in which technology is moving. Accordingly it is likely to be some time before these devices are commercially available. However, with technology moving towards higher frequencies as the lower ones become more congested, the new indium phosphide technology is likely to be used far more widely.

Dual Technology

Whilst indium phosphide brings significant performance and cost benefits in many areas, it is still considerably more expensive to produce than silicon CMOS that is very well established and is recognised as a very cheap-to-produce technology. As a result of this a number of companies that focus on indium phosphide technology are looking carefully at ways in which the benefits of both technologies can be used to their best.

One of the most obvious and cost effective is to partition the design of a chipset carefully so that all the very high speed areas are contained within an indium phosphide chip and the slower areas are contained within a CMOS chip. This relatively straightforward approach normally involves two companies as the ones that specialise in indium phosphide normally do not have the capability to fabricate chips using other processes. This has resulted in a number of companies that focus on indium phosphide teaming up with CMOS houses.

Summary

The future for indium phosphide looks to be very bright. Whilst it is still more expensive than some processes, it is still able to provide some real cost savings when used for high performance circuit areas. For the future its use is predicted to rise and this will result in costs falling and its use becoming even more widespread.

Further details about radio and electronics technology can be found at www.radio-electronics.com.

PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

Even if commercial cases are used for every project it is still necessary to do some finishing off yourself in order to get some really neat looking results. This is an area where things have changed in recent years, with traditional transfers and panel making techniques being largely replaced by computer based methods and labellers.

One recurring problem is the decline in the commercial use of traditional labelling materials, which has resulted in a reduced range of products being produced. They are also more difficult to track down.

On the other hand, more modern techniques offer the same advantages to the amateur that they do to the professionals. Panel overlays and labels can be produced with greater precision than is possible by hand.

Using computer based techniques it is also possible to produce fancy designs that can only be handled by highly skilled professionals when traditional techniques are used. Resorting to a computer perhaps deskills the process to some extent, but it certainly opens up a range of new possibilities.

Right Materials

With traditional methods it is possible to produce overlays using any sheet material that is reasonably durable. The choice is more restricted if the panels are to be produced on a computer, because the material used has to be compatible with the printer. Large computer stores and specialist suppliers have stationery that is specifically designed for use with laser and (or) inkjet printers. One approach is to print onto good quality paper and then cover the panel with a self-adhesive transparent material to protect the lettering.

Another method is to print a mirror image of the design onto transparent film, which is available as overhead transparency film for both laser and inkjet printers. The film is then glued to the front panel using something like Scotch Spray Mount. This permits the film to be repositioned if you do not get it right the first time, and it does not give a blotchy effect under the film.

The point of this method is that the lettering is on the rear side of the film where it is well protected. It is because the overlay is effectively used back to front that the printout has to be a mirror image.

Obviously this method only works well with panels that are in good condition, because the transparent film will let any imperfections show through. If the panel is scratched or marked it is better to fix the film onto a sheet of card or paper and then fix the paper to the case.

Actually, it seems to be easier to get the overlay to stick reliably to the case using this method. Coloured panels can be produced by using card or paper of the required colour.

Free Software

One obvious problem of computer methods is that suitable software is needed. The best types of software for this application are CAD (computer aided design) and illustration programs. CAD software is the better when conventional panels will be produced, and illustration programs are better if you wish to get creative and do your own thing.

Both types of software will do the job well though. Paint programs and photo editing software might be usable, but they are less well suited to the task.

CAD and illustration software can be quite expensive, and mostly cost hundreds or even thousands of pounds. On the other hand, a very basic application such as this does not require the latest up-market software. Older versions of these programs are often given away with computer magazines, or sold off cheaply.

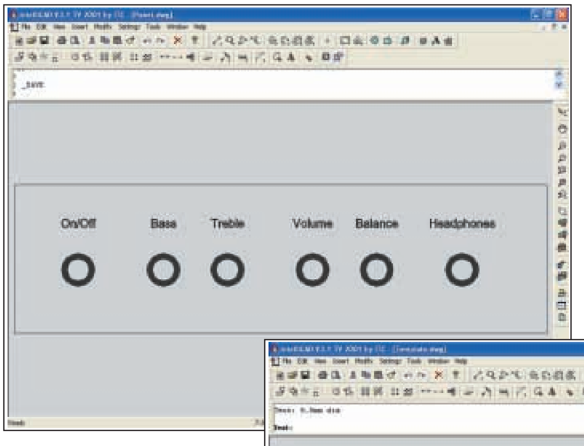


Fig.1. (above). A simple panel design, created using IntelliCAD, ready to be printed out.

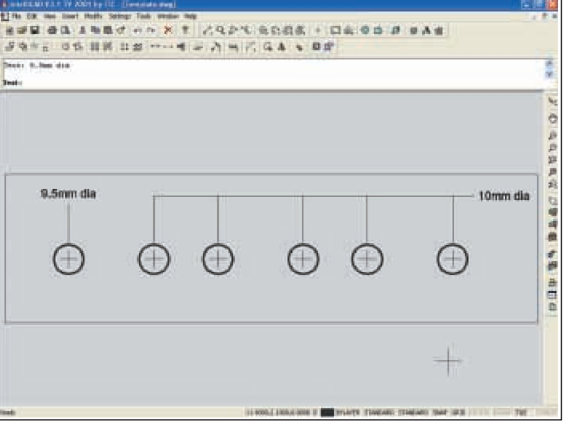


Fig.2. (right). Template for the design of Fig.1. The text command permits notes to be added.

There should be little difficulty in finding suitable software on the Internet for free. For example, a working demonstration version of IntelliCAD is available (try **www.intellicadms.com**). The opening screen of this program has the usual Windows style menus and toolbars.

Snap To It

Before starting on a design it is necessary to get the screen set up correctly. The page size might be preset at the default printer's paper size but it is sometimes necessary to set suitable drawing limits yourself.

A grid of dots can be provided on the screen to aid the accurate positioning of objects. When working in metric units a grid at five or 10 millimetre intervals is about right, depending on panel size.

The snap grid usually works separately, so the cursor will not snap to the grid points unless this feature is activated. Most programs permit the snap grid to be set independently of the visual grid, so it can be set at a smaller interval such as one or two millimetres. This enables objects to be drawn and placed with good resolution, but avoids having so many grid dots that the drawing is obscured.

If necessary, you can zoom in on a small part of the drawing and set an even finer snap grid so that greater precision can be obtained. The snap grid can be switched off if you would prefer to draw or place objects "by eye".

Making Your Mark

A bewildering array of drawing tools are included with CAD and illustration programs, but for panel layouts the line, circle, and text commands will suffice. There will probably be a choice of line types, often called Line and Polyline. The Line command usually draws single line segments whereas the Polyline instruction can be used to produce lines having multiple segments.

Polylines are often more versatile, offering various widths, complex curves, and neater results when closed to produced shapes. Where the choice is available it is best to use the more complex line command so that your options are left open.

Start by drawing a rectangle to represent the outline of the panel – see Fig.1 and Fig.2. In addition to the visual grid there should be a co-ordinate display and (or) onscreen rulers, so it is easy to get the dimensions correct. Next add circles or "donuts" of the appropriate sizes to represent the mounting holes for the controls, sockets, etc. Any rectangular cut-outs can then be added.

Next the legends are added, and a range of fonts are available from a standard Windows installation. Plenty of add-on fonts are available on the Internet and elsewhere. A full range of sizes are available as well, so there should be no difficulty in getting the lettering exactly as required. Many of the standard fonts look rather "heavy" when used for panel legends, but there are sometimes "light" versions available that are better suited to this application.

Spaced Out

Remember to make sure that sufficient space is left to accommodate the control knobs. The easy way to do this is to temporarily add a circle to represent the outline of the knob. It should then be easy to position the label where it will look neat and will not be obscured by the control knob. When you get more proficient with the drawing program it is possible to take things a stage further and produce more realistic representations of the control knobs, switches, or whatever.

The author has often advocated designing panel layouts by placing control knobs on the actual panel, together with fixing nuts to represent toggle switches, and this sort of thing. Drawing programs offer an interesting alternative, and it is easy to move objects around the design in order to get things just right. In fact you can save several versions of the layout and then pick the one that looks best.

However, always check that the selected layout is a practical one. Sometimes part of the component behind the mounting panel will be larger than the part, or the control knob, in front of the panel. Do some careful measuring to ensure that everything will fit into place properly.

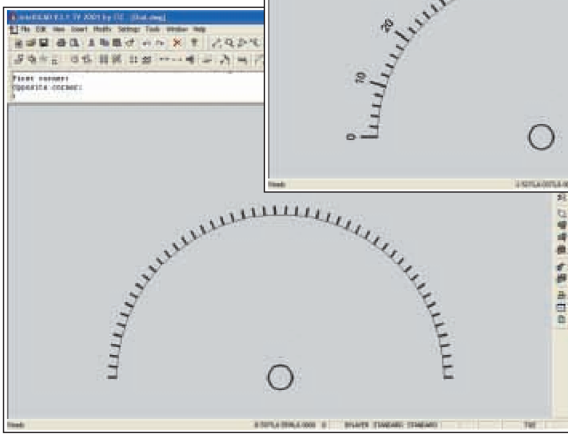
Most CAD programs have some 3D capability, and many can render line drawings to produce quite realistic results. Producing 3D representations is much more difficult and time consuming than drawing up two-dimensional plans, and it is certainly not the place to start. However, it is something that is worth investigating once you get to grips with the drawing program.

Template

One way of handling the drilling and cutting of the panel is to design the layout using the computer, and then draw the design onto the actual panel. This has to be regarded as doing things the hard way though, and in general it is easier if the design is printed out on paper and then glued to the front panel. It then acts as a template that indicates the drilling centres, etc.

The paper also provides the panel with a certain amount of protection while it is being drilled. It is advisable to fix the template in place with a water soluble adhesive so that the paper and glue are easily removed once the panel has been completed.

Fig.3. (below). The beginnings of the dial. The ticks were added using the Polar Array command.



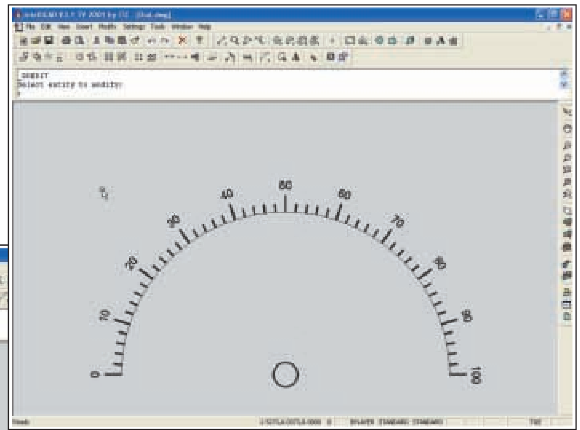


Fig.4. (above). The finished dial, complete with labels. The division label legends are added using another Polar Array command.

You can use the same drawing for the panel and for the template, but it is probably better to produce the panel overlay first. With the panel drawing safely saved on disk, save it under another name and edit this version to produce the template. Add crossed lines to indicate drill centres, add dimensions, notes, or any information that will be useful when working on the front panel.

Provided the drilling and cutting are accurate, the overlay and the panel should be a perfect match. A simple overlay design and the matching template are shown in Fig.1 and Fig.2 respectively.

Dial-A-Dial

Producing neat dials using conventional materials can be very difficult even for those with the necessary skills. Using most drawing programs it is quite easy once you know how.

The example dial (see Fig.3 and Fig.4) covers 180 degrees, has 50 minor divisions, and 10 main ones, with only the main ones being labelled. The dial after the initial steps is shown in Fig.3. A circle has been added at the centre of the dial and a 180 degree arc was then added.

Drawing the 51 "ticks" around the arc to produce the 50 minor divisions would be very difficult since the ends of the lines do not conveniently fall on grid points. The easy way around this is to first draw one of the lines at the end of the arc, which can utilise the snap grid. Next the Polar Array command is used to produce all the others in one operation.

This is just a matter of selecting the object to be cloned (the first tick mark), indicating the centre point, specifying the number of objects in the array, and the angle to be covered. The original object counts as one of the objects in the array, so 51 and not 50 objects must specified.

Drawing programs usually operate using a mathematic co-ordinate system and not a geographic type. The angle therefore has to have a negative figure to copy in a clockwise direction, and a positive one to copy in a counter clockwise direction.

You are normally given the choice of having the objects rotated as they are copied or left with the original orientation. In this case rotation must be used or the lines will all be horizontal.

The finished dial design is shown in Fig.4. The major ticks were produced in much the same way as the minor ones. The initial tick mark was stretched to double its previous length, after which it was used as the basis of another polar array. This time 11 objects spread across 180 degrees are used.

The division labels are added using another polar array, with the "0" being added first using a rotation value of 90 degrees. The others are then copied from this using the Polar Array command.

Finally, the copies are edited to the correct values. If you prefer to have all the labels the right way up it is probably best to add them anywhere and then move then into position "by eye" with the snap grid switched off.

Summing Up

Even using the basic techniques described here it is possible to produce some very professional looking results. It takes a while to become reasonably proficient at using a drawing program and the Help system is likely to put in plenty of overtime initially.

However, just about anything is possible once the main drawing and editing commands have been mastered. It is possible to produce results that rival professional equipment, and provided you already have a PC and a printer the cost is very low.

UWB – Wireless on Steroids

The fastest wireless technology yet, beating Wi-Fi, Bluetooth and infrared by miles. That's what advocates claim for ultra wideband modulation or UWB. Others, however, wonder whether this miracle wireless technology will cause more grief than good.

A rather apt buzzword of the moment is "untethered". It sums up neatly the way many people now expect 100 per cent connectivity for mobile phones, laptops and other devices wherever they are – in the home, at work or out and about. And it's wire-free solutions that make this possible, using some kind of radio link or infrared beam.

Speed is not the strong point of these systems, however; none of them can match the data rate of a hard-wired broadband connection for instance. That's why the quest is still on for an alternative that delivers more content, faster and at lower cost.

The exponents of ultra wideband radio claim the search is over. With UWB they are offering a technique that is almost 10 times as fast as current alternatives and uses less power than either Bluetooth or Wi-Fi. What's more, it can co-exist with existing radio users and requires no dedicated wireless spectrum.

Sounds too good to be true? You bet. The concept's logic is indisputable, but truly viable only in a radio environment redesigned entirely to eliminate the vulnerability of traditional transmissions.

BROAD BASICS

So what is UWB, how does it work and what are the qualifications that could hold back its deployment?

In concept UWB differs fundamentally from nearly all other approaches to radio communication. Whereas most transmission modes occupy an intentionally narrow slice of spectrum to conserve power and to make space for other occupants of the band, UWB does the opposite. But then whilst most conventional radio systems transmit at robust power levels to ensure adequate signal strength at the receiver, UWB once more does the opposite. Again, most normal radio systems radiate a continuous signal – but not UWB.

The unique feature of ultra wideband is that it uses extremely low power radio pulses (around 50 millionths of a watt) that extend across a large portion of the spectrum, for example from 1GHz to 4GHz. To any receiver tuned to a specific frequency these UWB transmissions will appear as mere background noise and will be ignored (so long as they don't interfere with reception of other signals). Because UWB sends pulsed transmissions at such low power across a broad frequency range using very short pulses (half a billionth of a second), the risk of interference is indeed low – at least in theory.

In February 2002 the Federal Communications Commission in America gave conditional approval to companies seeking to market products employing UWB technology, whilst its British counterpart, the Radiocommunications Agency, in July sponsored a colloquium on UWB, its applications and the regulation issues. Articles are appearing on the subject everywhere and for many interested parties the question is purely when, not whether.

DREAM COME TRUE

The most pressing attraction of UWB transmission right now is its vastly expanded capabilities in crowded airwaves. In a world obsessed with broadband connectivity and untethered mobility, UWB holds open the promise of any-place, any-time broadband delivery.

Many applications are suggested, ranging from audio and video distribution in the home to high-precision location and tracking systems and sophisticated radar systems. It has the potential for worldwide open-spectrum use, with lower power consumption and implementation costs (in the r.f. chain) than rival technologies.

Unlike the other radio technologies, which send dense, narrow signals within a particular portion of the spectrum reserved exclusively for themselves, UWB does the opposite. Instead it transmits tiny bursts of information very rapidly over a vast swathe of frequencies (hence the name ultra wideband) for extremely short periods of time at low power. The scattergun technique ensures receivers pick up enough signal, whilst the low average density of signal means UWB signals can share radio spectrum with other existing services.

PRACTICAL MATTERS

As well as opportunities, UWB presents several challenges, for which solutions are also proposed. Frequency sharing with existing users of the airwaves is the most obvious and interference to other classes of user could be a major problem. Some services, such as satellite location systems and radio astronomy research, could be very hard hit.

As well as being a source of interference to other users, UWB is also vulnerable to interference from other services. Because, in order to gain regulatory approval, the system is designed to work on extremely low signal strengths it will be very susceptible to interference, particularly when interfering devices are at very close range (such as mobile phones).

UWB is not a long-range system any more than Wi-Fi or Bluetooth are. Power levels will be extremely low in radio bands below 3GHz, which may also decrease the attraction of UWB. The technology too is at an early stage of development and standardisation is incomplete (not that this ever deterred early adopters!).

Assuming the claims made for UWB are all substantiated, maximum advantage from the technology would be gained by starting from scratch to redesign radio communications entirely. This of course is not an option and means that the brave new world of UWB may find coexistence with exponents of existing r.f. techniques very uneasy.

The real task, most observers agree, is to recognise the difference between interference and harmful interference. Appearing to support this view, the FCC has stated, "With appropriate technical standards, UWB devices can operate using spectrum occupied by existing radio services without causing interference, thereby permitting scarce spectrum resources to be used more efficiently."

WORLD-CHANGING?

Will UWB change the world? That's a difficult question to answer. Optimism is widespread, although American technology guru Robert X. Cringely injects more than a touch of reality when he likens UWB to the proverbial 100 mile-per-gallon carburettor, the gadget that every car owner wants (and every oil company doesn't).

He is convinced that UWB will create a thorny business problem for existing communication businesses as it comes to offer a cheaper, better alternative to almost every means of getting in touch. Local phone companies, cable TV operators, mobile phone outfits and Internet Service Providers all look vulnerable to Cringely. Even if they adopt UWB in order to compete, he asserts, the value of their old infrastructure will drop to zero.

Time will tell if he is right but there's little doubt over the basic capabilities of UWB; it is a promising technology that is likely to deliver the required performance. Small size, low cost and low power consumption are all believed to be achievable, whilst interference issues have potential solutions. Best of all, the potential market is extremely sizeable.

APPLICATIONS

Ultra-wideband could:

- Help cars avoid collisions by sensing the location and speed of oncoming vehicles.
- Allow police to detect the movements of a hostage-taker through a wall.
- Spawn wireless home networks, linking cable set-top boxes or computers. UWB goes a step beyond Bluetooth and other current short-range wireless systems by transmitting video and other high-bandwidth content. It can wirelessly download video from a camcorder to a TV.
- Track the precise location of retail products in stores or keep track of military equipment.
- Provide low-cost security systems that distinguish between a pet and an intruder.

WHO REALLY INVENTED THE TRANSISTOR?

ANDY EMMERSON

Conflicting claims and some revisionist history.

BEFORE the fall of the Soviet Union the state educators of the old USSR were kept busy rewriting history, either deleting from the roll of honour all reference to heroes of the people now fallen from grace or ascribing the credit for every modern miracle to obscure communist pioneers.

This time, however, it's the Americans under fire for falsifying history and the subject is the invention of the transistor. The received wisdom is that William Shockley, John Bardeen, and Walter Brattain invented this device in 1947 and of that there can surely be no doubt. But there is, and the colourful claims and counterclaims make some fascinating reading.

One fact is not in dispute, that the achievement of Shockley, Bardeen and Brattain was responsible for kick-starting the solid-state electronics revolution and the age of computerised informatics. To decry their role in transforming electronics would be both churlish and crazy, but the claim that they pioneered solid-state amplification has no substance at all.

RECEIVED VERSION

Before we go back to the dark ages, let's examine the standard version of transistor history, courtesy of Andrew Wylie, who has set up an excellent website (see later) devoted to early transistor devices. He states:

"The transistor was invented at Bell Laboratories in December 1947 (not in 1948 as is often stated) by John Bardeen and Walter Brattain. 'Discovered' would be a better word, for although they were seeking a solid-state equivalent to the vacuum tube, it was found accidentally during the investigation of the surface states around a diode point-contact. The first transistors were therefore of the point-contact type. William Shockley, the theorist who was leading the research, knew at once that this was not what he was seeking: at the time he was trying to create a solid-state device similar to what we now call a junction field-effect transistor.

Bell Labs kept their discovery quiet until June 1948 (hence the confusion about the date of discovery). They then announced it in a fanfare of publicity, but few people realised its significance, and it did not even make the front page of the newspapers. Shockley basically ignored the point-contact transistor, and continued his research in other directions. He modified his original ideas and developed the theory of the junction transistor. In July 1951, Bell announced the creation of such a device. In September 1951 Bell held a transistor symposium, and licensed their technology for both types of transistor to anyone who paid the required fee of $25,000. This was the start of the transistor industry that has changed the way that we live, in the Western world at least."

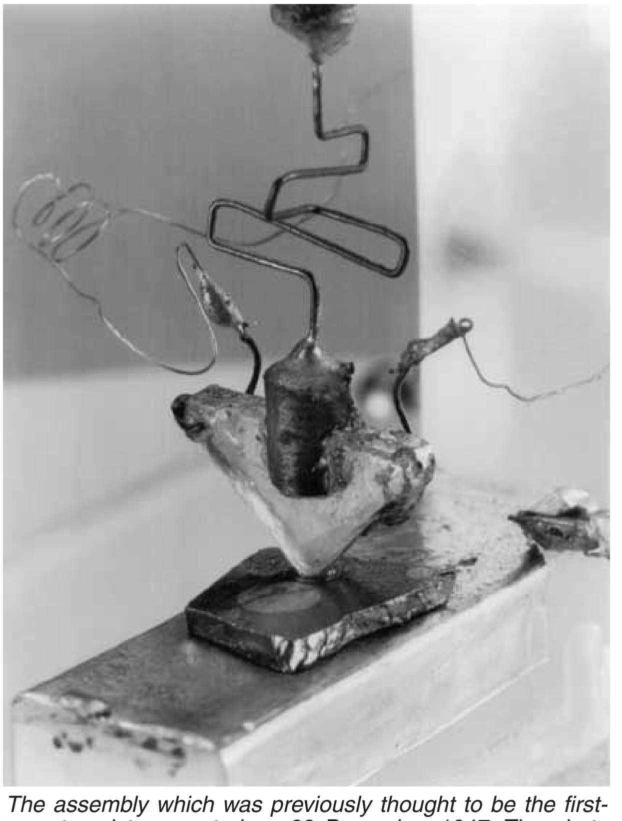
ALIEN EFFORTS

However, an entirely different origin has been proposed by Jack Shulman, president of the American Computer Company. Frankly, his theory is pretty fantastic but it makes a rattling good read if nothing else. Here's what he says . . .

"I grew up in the household of the head of Bell Labs, so I knew that there was something strange about the transistor because I knew Bill Shockley, and Bill Shockley was something of a witless buffoon. There's no way he could have invented the transistor.

The symbol for the transistor is made up of three pieces: positive, positive and negative; or negative, negative and positive...silicon dioxide doped with arsenic and boron, in 1947. Now, in 1947, doping things with boron was not easy. It required the sort of equipment that even Bell Labs in 1946 did not possess. They had this type of equipment at Lawrence Berkeley Laboratories, but it would have taken thousands and thousands and thousands of man-hours to invent the transistor.

If you look back at it historically, what AT&T was claiming was that one day this 'genius', William Shockley, was working with a rectifier; he looked at it and he noticed it had unusual propensities, and there, bingo, he invented the transistor! He figured it out right there!



The assembly which was previously thought to be the first-ever transistor, created on 23 December 1947. The photo scale is approx. twice life size. Courtesy of Bell Laboratories/Lucent Technologies.

Anybody believe that story? Me neither. And I knew, because the administrative head of the transistor project was Jack Morton – the man at whose house I was staying to go to school and whose sons I was friends with. He often commented on the fact that it was really a shame that those three idiots got responsibility for the transistor and he didn't."

Mr Shulman goes on to claim that the transistor's real origin lies in technology recovered by the US Air Force from an alien spacecraft recovered at Roswell, New Mexico in 1947. It's extremely controversial stuff and contrary to all received wisdom – but quite amusing of you don't take it too seriously. Let's move on rapidly, back down to earth and to minerals in particular.

START OF SILICON

It was in 1906 that the G. W. Pickard of Amesbury, Massachusetts perfected the crystal detector and in November of that year took out a patent for the use of silicon in detectors (see Fig. 1). Arguably this was the start of the silicon revolution and it did not take long before experimenters achieved amplification using crystal devices, long before the term transistor was devised.

Solid-state electronics were born even earlier, when Ferdinand Braun invented a solid-state rectifier using a point contact based on lead sulphide in 1874. But it's to Pickard that the credit goes for discovering that the point contact between a fine metallic wire (the so-called "cat's whisker") and the surface of certain crystalline materials (notably silicon) could rectify and demodulate high-frequency alternating currents, such as those produced by radio waves in a receiving antenna (what Pickard called a "wave-interceptor"). His crystal detector (point-contact rectifier) was the basis of countless crystal set radio receivers, a form of radio receiver that was popular until the crystal detector was superseded by the thermionic triode valve.

By its nature the crystal rectifier was a passive device, with no signal gain. But radio historian Lawrence A. Pizzella WR6K notes anecdotal stories of shipboard wireless operators in the second decade of the 20th century achieving amplification using a silicon carbide (carborundum) crystal and *two* cat's whiskers. He cites a taped interview made in 1975 with Russell Ohl at his home in Vista, California in which claims of signal gain were made. This is an excerpt from Ohl's testimony:

"He gave me a copy that he had of . . . I think it was The Electrician. *It was a British magazine, one of these big-paged things, you know. In it was a translation from a Russian paper in which they had used carborundum with two contacts and a battery supplying one of the contacts and had gotten a power gain of ten times. And this was way back in the 1910s, so the fact that you could get a power gain had been known, but it was never put on a controlled basis. I knew about it because an operator of the Signal Corps back in 1919 had told me that some of the operators used carborundum as oscillators for receiving. When I had seen this article that Curtis gave me, I was not astounded because I had known about this before I ever saw the article. I had heard about it.*

I knew a former first sergeant in the Signal Corps who had lived in the boarding house that I lived and he was an expert radio operator. He told me a great deal about the use of crystal detectors on ships. He told me that professional operators carried two crystal detectors with them. One of them was made of carborundum and one of them was something like galena or something of that sort. He said the carborundum was used for two purposes. They used it in the harbour when they were close to a transmitter to prevent burnout. They also used it at long distances with two points. One point was excited with a battery and they were able to get long wave oscillations out of it and in that we were able to be in long wave telegraph stations."

Ohl, it should be noted, was the man who invented the silicon solar cell in 1941 and discovered during World War II that semiconductors could be doped with small amounts of impurities to create useful new properties. Born in 1889, he was bitten by the radio bug at the age of 16 and devoted much of his life to making simple radio receivers employing semiconductors. His accidental discovery of the *pn* barrier in his work at Bell Telephone Laboratories led to the development of solar cells.

OSCILLATING CRYSTALS

A fascinating letter to *Wireless World* in May 1981 under this title came from Dr Harry E. Stockman of Sercolab (Arlington, Mass.). Then 76 years old, he had lived through the era under discussion and provided a valuable summary of "prior art" preceding the re-invention of the transistor. His letter had been triggered by a *Sixty Years Ago* item in the same periodical recalling an article by W. T. Ditcham on crystal oscillation in its May 1920 issue.

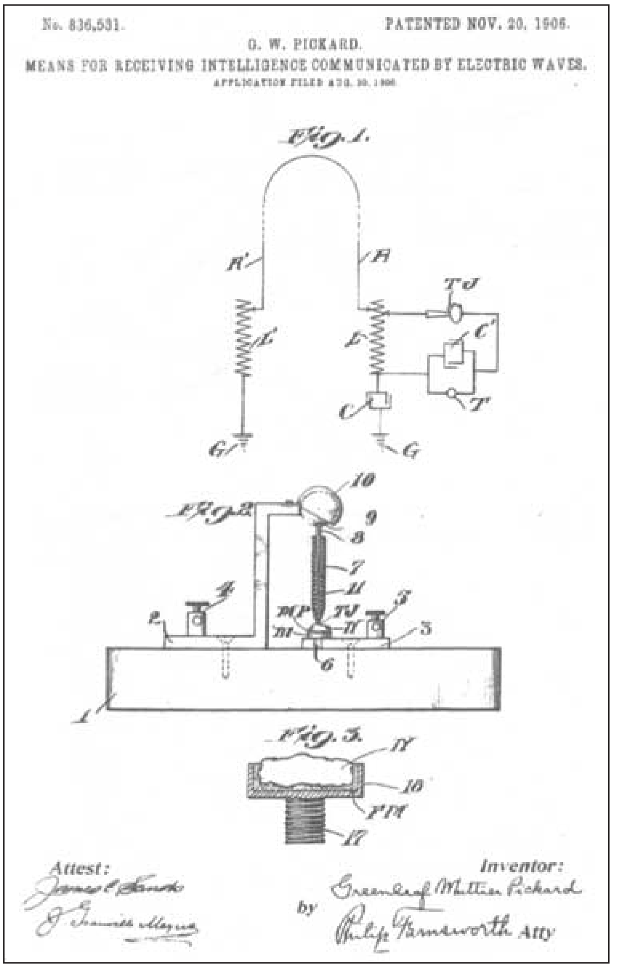


Fig.1. Pickard's patented crystal detector of 1906 kick-started the silicon revolution.

This effect, he stated, was discovered by Dr. W. H. Eccles in 1910, and remarked:

"It is hard to realize that it took about ten years for practical active crystal-diode circuits to appear, in spite of Ditcham's reminder – circuits that included both r.f. and a.f. amplification. The last one, at the time, was totally unknown to most 'affectionados', one of them being the author of this letter. Most of the credit for creating practical devices (of this kind) goes to O. V. Lossev of Russia, whether or not he knew of Eccles' pioneer work a decade earlier. He should have known about it; one has the right to expect that he as a qualified scientist was familiar with the world's scientific literature."

Clarification comes from Lawrence Pizzella, who explains how these experimenters created successful amplification techniques using mineral crystal devices. Lossev, he says, used zincite and a steel cat's whisker with bias to make an oscillator and even a low-power transmitter in the early 1920s. This was reported in considerable detail in the September 1924 issue of *Radio News* and in the October 1 and October 8 1924 issues of *Wireless World*. Hugo Gernsback, the editor of *Radio News*, named this the "Crystodyne" and predicted that crystals would someday replace valves in electronics. All details needed to duplicate these circuits to make a tunnel diode oscillator are in these articles. A German book by Eugen Nesper described an oscillating detector circuit in 1925 too, using zincite and a bias voltage of 8 to 14 volts.

With so much information in print it's inconceivable that the Bell Labs team were unaware of these techniques. But in any case Pizzella says Russell Ohl showed William Shockley his radio using crystal amplifiers several years before the transistor's alleged invention in 1947. Shockley is also quoted (in *Crystal Fire* by Riordan and Hoddeson) as saying that seeing Ohl's radio convinced him that an amplifying crystal could be made.

FIRST FET

Another experimenter of this era who deserves far greater credit is Dr Julius Lilienfeld of Germany, who in 1926 patented the concept of a field effect transistor (f.e.t.). He believed that applying a voltage to a poorly conducting material would change its conductivity and thereby achieve amplification. Lilienfeld is rightly noted for his work on the electrolytic capacitor but according to Stockman should be recognised also for his pioneering work on semiconductors.

Says Stockman, himself a distinguished author of many books and papers on semiconductor physics:

"He created his non-tube device around 1923, with one foot in Canada and the other in the USA, and the date of his Canadian patent application was October 1925. Later American patents followed, which should have been well known to the Bell Labs patent office. Lilienfeld demonstrated his remarkable tubeless radio receiver on many occasions, but God help a fellow who at that time threatened the reign of the tube."

David Topham GM3WKB adds that Lilienfeld followed his 1925 (Canadian) and 1926 (American) patent applications for a *Method and Apparatus for controlling Electric Currents* with another granted in 1933. Says David:

"US patent 1,900,018 clearly describes the field effect transistor, constructing it using thin film deposition techniques and using dimensions that became normal when the metal oxide FET was indeed manufactured in quantity well over 30 years later. The patent (and subsequent ones) describes the advantages of the device over 'cumbersome vacuum tubes'."

MORE PRIOR ART

The website of Dr Robert G. Adams states that he designed a crystal amplifier at the age of thirteen years, when he lived at Hastings, New Zealand. A photograph of his set-up along with the diagram (Fig. 2) are reproduced here from his website (see later).

Connections to the two crystals made use of the then-available vertical cantilever type cat's whisker holders, providing stable connections to the central junction and input and output points.

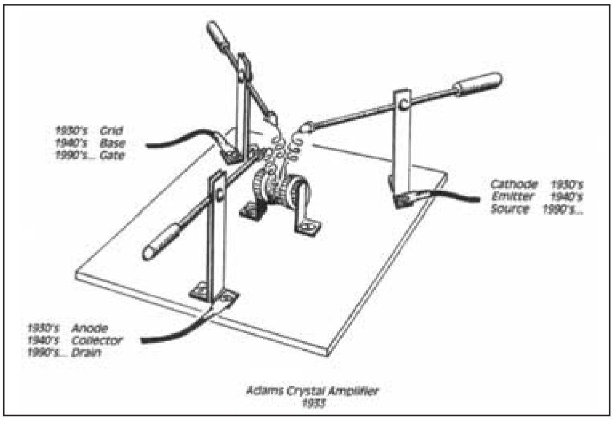
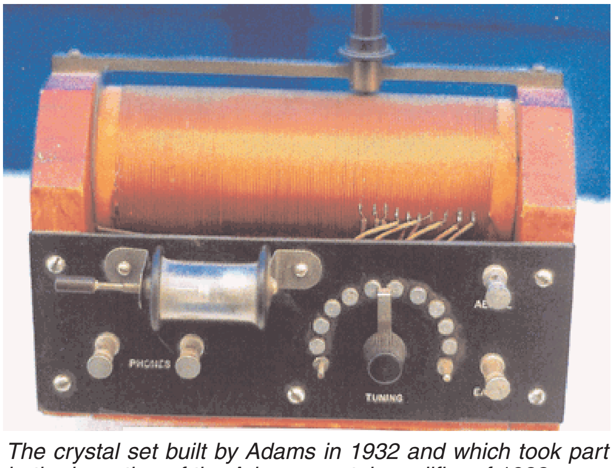


Fig.2. The crystal amplifier devised by New Zealander Dr Robert Adams in 1933, showing how terminology has changed over the years.



The crystal set built by Adams in 1932 and which took part in the invention of the Adams crystal amplifier of 1933.

Two different methods of interconnection between the two crystals gave no apparent difference in performance. Adams stresses that it never occurred to him to pursue any patent action simply because the invention was already in the public domain. In his view it was obviously unpatentable by anybody (Bell Labs notwithstanding).

Someone who built a similar amplifier of this kind is Canadian radio amateur Larry Kayser (VA3LK/WA3ZIA), who spotted a circuit for a "novel" crystal radio circuit that exhibited "amplification" published in Gernsback's magazine *Radio* during the 1932-1934 period. This, he recalls, used two cat's whisker probes on a lead-mounted galena (PbS) detector. He says he was able to duplicate this action in the early 1950s as a young hobbyist and whilst the degree of amplification was nothing like that of the first commercial transistors, it was at least in the order of 3dB or a bit more.

HISTORY REPEATED

That was then but this is now. American radio amateur Nyle Steiner K7NS was determined to prove or disprove these claims for himself – and has succeeded in spectacular fashion. On his website he posts technical results, photographs and curve traces of several experiments in which he has demonstrably achieved oscillation with iron pyrites and even transmitted his voice over the air (a circuit for a broadcast band iron pyrites negative resistance oscillator is given there).

"Success with this experiment has been a very exciting experience for me as it represents the ability to build a simple homemade active semiconductor device. It is almost like making your own homemade transistor. This is an actual realisation of some very old, and esoteric 1920s experiments by Eccles, Pickard and Lossev, that were so vaguely reported in a few articles that I have often wondered if in fact it had actually been done. Even so, I have always had an extreme fascination with those reports of being able to produce a continuous wave r.f. signal from a crude semiconductor material back in the very early days of radio."

Other experiments of his show an oscillator based on zinc ferrite and an *n*-type negative resistance device, similar to a tunnel diode, created by touching a piece of galvanized steel wire against a piece of aluminium. As Nyle says,

"This project may not be very practical but I find it to be a very exciting experience."

HISTORIC CONCLUSION

The more you study the history of invention, the fewer examples you find of entirely new devices conceived and perfected by one individual in isolation. History loves heroes and people prefer simple stories, regardless of inconvenient facts.

It's perfectly clear that Bell Labs didn't invent the transistor, they re-invented it. The fact that they totally failed to acknowledge the pioneer work done by others can be explained by human nature – pride, arrogance, ignorance or plain self-interest. It's perfectly true that the world wasn't ready for previous incarnations of the transistor but that was no reason for denying that Lilienfeld patented the original solid-state triode oscillator/amplifier well before others claimed all the credit. But that's life; it was not the first time and doubtless not the last.

FURTHER READING

Michael Riordan and Lillian Hoddeson, *Crystal Fire* (1998)

William Brinkman, Douglas Haggan and William Troutman, *A History of the Invention of the Transistor and Where It Will Lead Us, IEEE Journal of Solid-State Circuits*, Vol. 32, No. 12, December 1997 (and on **www.sscs.org/AdCom/transistorhistory.pdf**)

Julius Nesper, *Wie baue ich einen einfachen Detektorempfänger?* (1925)

Ronald Ives, *Transistors in 1923, CQ magazine* (USA), Jan. '59

RESOURCES ON THE WEB

Andrew Wylie's history of the transistor **http://ourworld.compuserve.com/homepages/Andrew_Wylie/history.htm**

Lyle Steiner's amazing experiments:
http://home.earthlink.net/~lenyr/iposc.htm

Jack Shulman's supernatural claims:
http://www.imaginationinternet.com/

. . . and some rebuttals
http://www.aethmogen.com/wri/radams/tenigma1/05tru/01txt.shtml (from which Fig. 2 and its accompanying photo were retrieved).

www.geocities.com/CapeCanaveral/Hangar/9587/

Fringe science?
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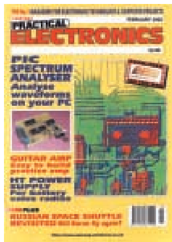

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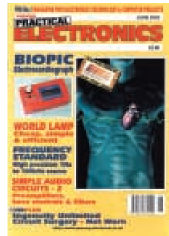

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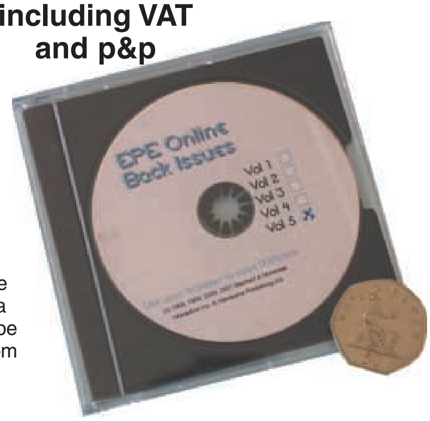

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Constructional Project

WIND SPEED METER

JOHN BECKER

Using ultrasonic techniques, this solid-state design has no moving parts and does not need calibrating

THIS wind speed meter (anemometer) is intended for use in a variety of sports-type activities, such as track events, sailing, hang-gliding, kite and model aircraft flying, to name but a few. It can even be used to monitor the conditions in your garden.

A probe is pointed in the direction from which the wind is blowing and a screen displays the rate at which the wind is moving between two ultrasonic sensors. The readout is shown on an alphanumeric liquid crystal display (l.c.d.), with readings in metres per second, feet per second, kilometres per hour and miles per hour. The resolution is to the nearest tenth of a metre per second, from zero up to around 50mph, and possibly higher.

The design is one of two spin-offs from the author's wish to design a totally solid-state (no moving parts) Weather Centre in which several environmental criteria are monitored and logged, wind speed and direction, humidity, barometric pressure, temperature, rainfall, light and UV intensities, air humidity and soil moisture content. The design will be published in a few months time.

LET THE WIND BLOW FREE!

Having designed the Weather Centre, it became necessary to prove that the ultrasonic wind speed sensing technique (more on this presently) was indeed viable. The obvious method was to mount it on a car and compare the car's speedometer with the Weather Centre's l.c.d. readout. However, it was felt that the Centre's size was too great for this and could well prove the undesirable proximity of flashing blue lights and *ee-aw* sirens behind the car!

Consequently, the wind speed sensing circuit was constructed on its own, mounted in a small enclosure which was then unobtrusively positioned outside the car's window and comparative readings taken (spouses come in very handy for such things!).

The system was accurate up to about 25mph, and then began to fall off rapidly. It was concluded that the aerodynamics of the car began to take effect above this speed and it was decided to construct the second spin-off design – a wind tunnel.

An assembly comprising a cardboard tube and an electrically controlled fan was built. The fan had a known rate of air flow per minute, the tube had a known cross-sectional area and thus the airflow rate across the ultrasonic sensors was calculated and compared against the monitor's readings. By providing the fan with a speed control, its revolutions per minute were varied, and again comparative calculations and readings were made.

PRECISION CHECKING

It all seemed fine, although there was a bit of uncertainty about whether the fan's rotational rate linearly changed the air flow rate. Then, unexpectedly, two professional wind speed monitors were made available to the author.

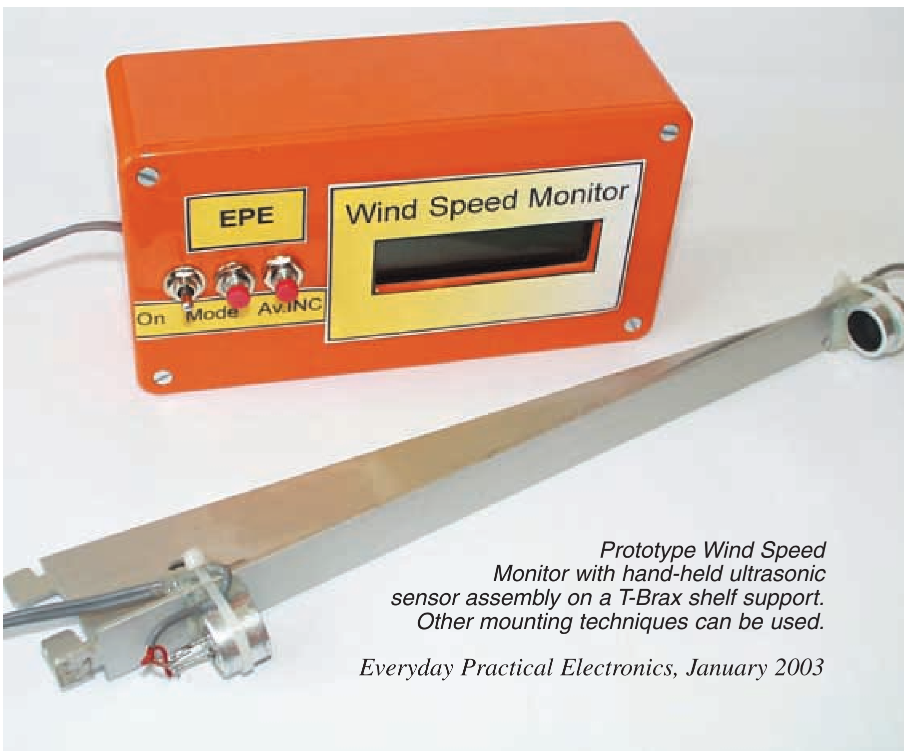
First, *EPE* contributor and schematic artist Andy Flind lent the author a hot wire/thermistor (thermal) anemometer which he had bought second-hand and uses in kite flying competitions.

Also, Mike Tooley, author and editor of *EPE*'s sister publication the *Electronics Service Manual*, arranged for the author to test his and Andy's anemometers in the wind tunnel at Brooklands College, Surrey, where Mike is a senior tutor in electronics. That wind tunnel is used by the College's aeronautical department. The readings on all three units corresponded.

Using Andy's meter as a reference, the author's anemometer and wind tunnel were further developed.

WIND SPEED SENSING

Several techniques for measuring wind speed exist. The mechanical rotating assemblies with three cups are probably the most familiar. These are frequently seen along the verges of roads, used for localised meteorological monitoring. The technique is also used in commercial weather centres on general sale to the public. It has featured in previous weather centres designed by the author and others (*Teach-In 2002*, Part 7, May '02, was the



Prototype Wind Speed Monitor with hand-held ultrasonic sensor assembly on a T-Brax shelf support. Other mounting techniques can be used.

Commercial thermal anemometer lent to the author by Andy Flind.

last time it was demonstrated, thanks to Ian Bell and Dave Chesmore).

S-shaped rotational mechanisms are frequently seen as well, rotating at speeds relative to wind movement. They are typically used in an advertising capacity outside petrol filling stations. The author used the technique in his *Met Office* design of about eight years ago.

In the thermal technique just mentioned, a component (typically a thin wire) is heated and the amount of heat loss caused by air moving across it is sensed and compared with the heat generated by an enclosed reference source. Andy's meter appeared to use a tiny and delicate thermistor arrangement in its directional probe (see photo). Such sensors are likely to be priced well above the pockets of most readers.

Pressure sensing techniques are used in high speed air flow applications, such as in aircraft. With the Provost jet trainer in the Brooklands College workshops, a rigid tube is mounted in the leading edge of one wing, running back inside the wing to a pressure sensor mounted in the fuselage. A second sensor compares the air flow pressure with atmospheric pressure monitored in a wind-tight enclosure.

This arrangement provides data about the aircraft's speed through the air, but not in relation to the ground, for which other techniques are required, such as radar and GPS (Global Positioning Satellite) systems.

PROPELLOR UNITS

There are neat little (but quite expensive) handheld units in which a propellor is rotated by the wind. The rate at which the propellor rotates is metered to display the equivalent wind speed. The propellor is mounted on precision low-friction bearings to allow very slow wind speeds to be sensed. Typically, internal blades mounted as extensions to the propellor shaft break a light beam aimed at an optical sensor, and the number of pulses generated is counted across fixed periods of time.

Some small d.c. motors can have propellors mounted on them, and the wind-activated rotations cause an output voltage to be generated. The voltage peaks are monitored and the resulting meter readout shows the equivalent wind speed. Generally speaking, such systems have too much friction to respond to slow wind speeds.

The author has not experimented with thermal sensing, but he has previously tried various pressure sensing techniques to monitor wind speed. Regrettably, the pressure sensing transducers inexpensively available on the hobbyist market proved to be too insensitive to slow wind speeds.

BI-MORPHS

It did look for a while as though bimorph elements might be usable. These are a type of strain gauge, made from thin piezo-electric rod which generates a voltage across two output wires when subjected to bending. The voltage generated *during* the bending depends on the rate at which the stress of bending changes. Attaching a scope probe to one in the workshop, voltages in excess of 50V were generated when just minor finger pressure was applied, much to author's astonishment, having expected just a few millivolts!

Bi-morphs, though, proved to be too uncontrollable for a wind speed sensing application. They are also fragile, which would have made their mounting difficult.

ULTRASONIC SENSING

For some years the author has been determined to find a way in which a solid-state wind speed sensor could be designed. Having eliminated the techniques just discussed, either because they are mechanical, too insensitive or too fragile, his attention turned to the use of sound. You are probably aware that sound travels through dry air at a speed of 750 miles per hour, 331·4 metres per second, at standard temperature and pressure (STP), effectively 15°C at sea level with an atmospheric pressure of 1013·2 millibars.

If the air is moving, the rate at which sound reaches a listener from its source varies with the direction in which the air mass is flowing – faster if the wind is coming from the same direction as the sound, slower in the opposite direction.

The time it takes for a sound to travel between a source and a receiver can be easily measured. Knowing the basic speed of sound under specified conditions, the rate at which the air mass is moving can be calculated from the measured timing. When using a single source and receiver, for the answer to be meaningful, of course, the wind must be moving directly in line with them. In practice, it does not matter whether the wind flows towards or away from the source, electronic techniques can compensate accordingly.

As will be demonstrated in the forthcoming *Weather Centre*, if several sound sources and receivers are used at different angles to each other in a fixed location, the direction of the wind can also be calculated as well as its speed.

PRACTICAL SOUNDINGS

The use of an *audio* sound source and receiver would not be practical since such a system would be subject to interference from many extraneous sounds. Ultrasonic methods, though, are much less susceptible to interference. Having searched the Web, the author found that there are indeed commercial wind speed and direction sensors that use ultrasonic techniques. One such is shown in the photograph below. It operates at 200kHz.

CAT1/2 solid-state ultrasonic wind speed and direction sensor. Photo Courtesy **www.apptech.com/cati2.htm**, Applied Technologies, Inc.

The wind's directional sensing will be discussed in the *Weather Centre*, but the speed assessment is easy to understand. Imagine two ultrasonic transducers facing each other across a known distance. One shoots a pulse at the other and the time it takes for the signal to cross between the two is measured. Using a sufficiently fast timer, times can be measured in microseconds.

Ensuring that the transducers are in line with the wind direction, the wind's speed can be readily calculated from the timing value. However, the answer only holds true if the air conditions are those specified at STP. The answers will differ if the conditions differ.

There is very simple technique that essentially allows the changes in air condition to be nullified. A signal is shot from transducer 1 to transducer 2 and a timing measured. Immediately, the roles of the transducers are reversed – now transducer 2 shoots the signal and transducer 1 receives it, and again a timing is recorded.

Two methods can then be used to establish the wind speed. In the first, an average is taken between the two timings. This provides the current speed of sound existing in that location under those conditions. Knowing the current speed of sound and the distance between the transducers,

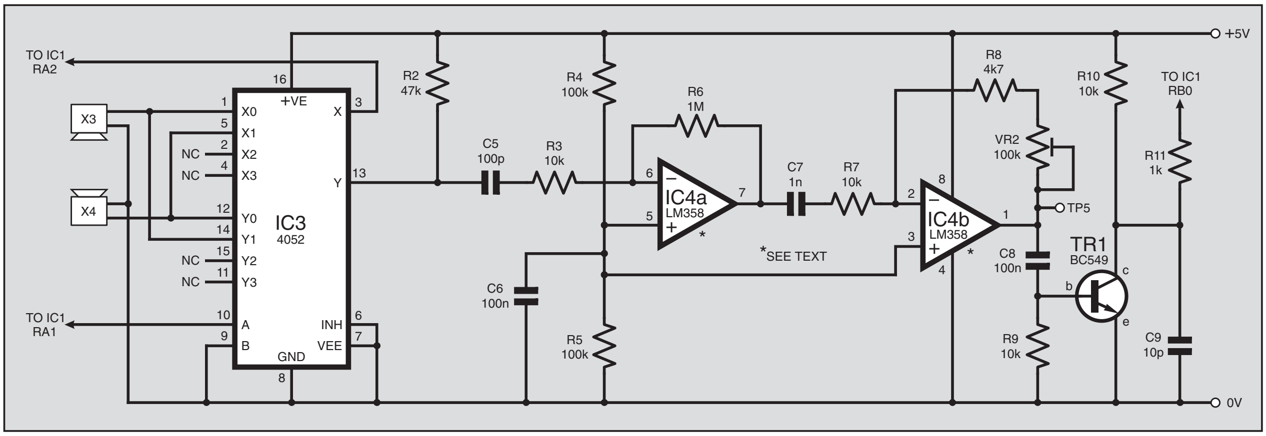


Fig.1. Ultrasonic transmission and reception circuit diagram for the Wind Speed Meter.

either of the two individual timings can be used to calculate the rate of air flow between the transducers. At a stroke, temperature, density and pressure as specific values become irrelevant.

It is worth noting that temperature is the main factor that causes a change in the speed of sound. One source states that if the speed of sound is 332m/s at 0°C, it will be 344m/s at 20°C and 386m/s at 100°C. Thus there is a change of only 3·5 per cent across a temperature range of 20°C. The effects of humidity and barometric pressure are insignificantly small by comparison.

The other technique, which for most practical situations is just as good, is to simply take the difference between the two timings and from this the equivalent wind speed can be calculated, each unit of difference representing a given value of speed change.

Both techniques are easy to implement with an accurately controlled ultrasonic pulse source and timer. It is also facilitated by the fact that even low cost ultrasonic transducers can be interchangeably used as transmitters and receivers. Although they are specifically designated as being a transmitter, or a receiver, under pulsed conditions and using a suitable circuit they can be used as either.

Indeed, in some echo sounding applications, where the time between the transmission and reception is comparatively long, only one transducer is needed, acting as both transmitter and receiver.

It is ultrasonics and the second calculation technique that are used in this design.

ULTRASONIC CIRCUIT

The circuit diagram for the ultrasonic transmission and reception functions is shown in Fig.1. The two transducers are shown as X3 and X4. As just said, they are both used interchangeably as transmitter and receiver. Analogue multiplexer IC3 selects the mode in which the transducers are used.

The transducers operate at the usual ultrasonic frequency of 40kHz. The transmission pulses are generated by a PIC microcontroller, which is described presently in relation to Fig.2. The route that the pulses take through IC3 is selected by the logic level applied to its pin 10, also controlled by the PIC.

When pin 10 is held low, the pulses are routed from IC3 pin 3 to pin 1, and out to transducer X3. This transducer transmits the pulses across a gap of several centimetres to the second transducer, X4, which receives the pulses and routes them to IC3 pin 12. The pulses, which are much attenuated by their journey, pass through IC3 to pin 13 and to the analogue amplification circuit formed around op.amps IC4a and IC4b. A MAX412 op.amp was used in the final circuit, but an LM358 was also found to be satisfactory.

When IC3 pin 10 is held high, the pulses are routed from IC3 pin 3 to pin 5, and this time out to transducer X4. Now transducer X3 receives them and they pass via pin 14 to pin 13 and so out to the amplifier.

From IC3 pin 13, the received pulses are a.c. coupled via capacitor C5 to the first amplifier, IC4a. A gain of about 100 is provided by this stage, as set by the values of resistors R3 and R6. The signal is then a.c. coupled by C7 to the stage around IC4b. Here the gain can be varied between about ×0·5 and ×10, as controlled by preset VR2. The potential divider formed by R4 and R5 applies mid-rail bias to the non-inverting inputs of the two op.amps (pins 5 and 3 respectively).

The final gain stage is provided by transistor TR1. Its base (b) is biased normally low by resistor R9, so holding it in a turned-off condition. The output from IC4b is a.c. coupled to TR1 by capacitor C8. Any positive-going pulses from C8 which exceed about 0·6V turn on TR1, causing a full line-level negative-going pulse at its collector (c). This pulse is coupled via resistor R11 back to the PIC.

For reasons unknown, the PIC16F628 microcontroller used in this design would not respond correctly when R11 was replaced by a direct link wire. A 10pF capacitor (C9) was also found necessary between the collector and the 0V line. This was discovered by accident when using an oscilloscope probe, which itself has a circuit capacitance of about 10pF.

CONTROL CIRCUIT

As shown in the control circuit diagram of Fig.2, the PIC16F628 microcontroller (IC1) is responsible for generating and sending pulses to the ultrasonic transducers, and for timing the return of the received signal. The results of its calculations are output to the 2-line 16-character alphanumeric l.c.d., X2. This is operated in 4-bit control mode, with its screen contrast adjustable by preset VR1.

The PIC is operated at 20MHz as set by crystal X1 in conjunction with capacitors C3 and C4. It can be programmed *in situ* via connector TB1, whose pins are in the author's standard order suited to

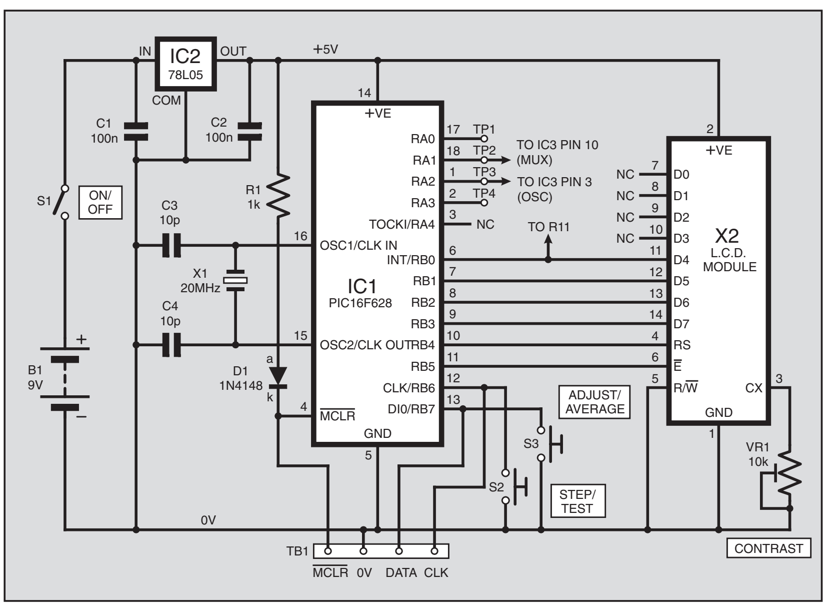


Fig.2. Circuit diagram for the control and display functions.

programming by *Toolkit TK3*. Note, however, the comment later about programming brand new PIC16F628 devices.

POWER SUPPLY

It is intended that a 9V PP3 battery should be used to power this design, although any d.c. supply between 7V and about 15V could be used. The input voltage is regulated down to 5V by regulator IC2.

Capacitors C1 and C2 encourage stability in the power lines. Current consumption in the prototype is about 14·5mA.

TRANSMISSION

In the transmission routine (SONICTX) the PIC sends a quantity of pulses whose cycle period is the equivalent to a 40kHz pulse train. The quantity to be sent is stored in the PIC's data EEPROM and can be adjusted by the user (see later). The prototype requires just two pulses to activate the transmission transducer.

Immediately prior to transmission, multiplexer IC3 is set to route the transducers to become transmitter and receiver in the order required. The PIC's Timer 1 is then stopped, reset and restarted. The pulses are then sent.

There follows a brief "masking" pause before the PIC starts expecting the return signal. This allows the amplifier circuit to stabilise in the event of any capacitively induced "ringing" which can be triggered during the transmission. The masking period value is stored in the PIC's data EEPROM and is set at 80 loop cycles in the prototype, but can be adjusted if required (see later).

Following the masking period, the PIC's interrupt function is activated and the program enters a holding loop from which it will only exit if an interrupt signal is generated, or the timer overflows.

The received and amplified signal from transistor TR1 is fed via resistor R11 to the PIC's pin RB0. This is set as an input and a signal change on it causes an RB0 interrupt to be generated. Using a modification of one of Malcolm Wiles' interrupt processing routines published in the Mar-Apr '02 issues (*Using PIC Interrupts*), the interrupt causes the Timer 1 counter to stop, the interrupt function to be turned off, and an exit made from the holding loop.

The timer value is now read and stored into one of two memory locations, depending on which transducer is doing the receiving.

ROLE SWAPPING

The roles of the transducers are then swapped through IC3, and the same transmission/reception routine is repeated. Having received the second timing, a correction value is added or subtracted according to another value which is stored in the data EEPROM, and which can also be adjusted by the user (again see later).

The difference between the two timings is then found by subtraction, inverting the result if a negative value is created. A check is then made to see if the answer is within a reasonable maximum range. If it is not, the result is limited to an increase of 16 above the previous value received. This helps to damp the effect of any extraneous sounds within the 40kHz range that might be picked up by the receiving transducer.

The answer is stored into one of 16 double-byte memory locations accessed cyclically and from which an average value is calculated from all 16 values stored. This result is then stored into a second memory block, from which a further average can be calculated if the user requests it via panel-mounted pushswitch S3.

Following storage of each final result, calculations of wind speed are made and displayed on the l.c.d. There follows a brief pause, after which the next pair of transmissions and receptions is triggered and processed. The overall sampling rate is about 3Hz.

A screen dump image of the waveforms created by this design is shown in Fig.3a. It was captured using the author's *PIC Dual Channel Scope* of Oct. '01.

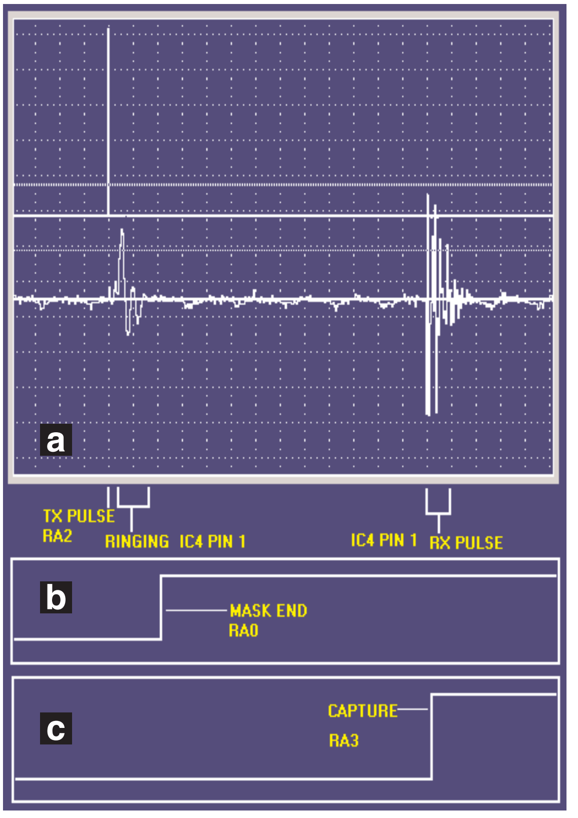


Fig.3. Waveforms associated with the ultrasonic transmission and reception functions.

The vertical line in the upper trace shows the transmission (TX) pulse. The second trace shows the "ringing" generated through IC4 by the pulse, followed by a delay as the pulse crosses to the receiving transducer. Then occurs the output waveform at IC4b, caused by the amplification of the received (RX) pulse. Again note the "ringing" generated.

In Fig.3b and Fig.3c, the schematic graphs show the relative points during the screen trace at which the masking period ends (monitored at IC1 pin RA0), and at which the interrupt routine captures the amplified pulse (monitored at IC1 pin RA3).

SOFTWARE

The PIC program software is available for free download from the *EPE* ftp site. It is also available from the Editorial office on 3·5in disk, for which a small handling charge applies. Details of obtaining the software, and preprogrammed PICs, are given in this month's *Shoptalk* column.

There are three software files, suffixed ASM (TASM grammar), HEX (MPASM) and OBJ (TASM). The MPASM hex file has configuration and data EEPROM values embedded in it. If the OBJ file is used, the PIC has to be configured separately (crystal HS, WDT off, POR on) and the data EEPROM values set manually during the value correction process that will be described shortly. Note that the unit may respond unpredictably until the values have been installed following OBJ programming.

The values are decimal 2, 80 and 0, to be stored at EEPROM locations 0, 1 and 2, respectively.

TRANSDUCER ASSEMBLY

The ultrasonic probe assembly is shown in the first photograph. This is only a suggested arrangement and other mounting techniques could be used instead. The author used a 10-inch T-Brax shelf support. This was found to be shaped so that it felt comfortable in the hand. It also allowed the transducers to be secured using cable ties and holt-melt glue (see photo below), delivered from an inexpensive "gun" available from d.i.y. centres. A handle could be fitted if preferred.

The distance between the transducer faces in the prototype was set to about 7·3ins (18·5cms) but the distance is not critical and a fraction either way does not matter.

The transducers used in the prototype were the standard front-facing open-mesh type, available from many component suppliers. Fully enclosed waterproof types were tried but it was found that they were not satisfactory in this application.

Transducer secured to probe mount using a cable tie and hot-melt glue.

Investigation showed that their transmission/reception surfaces can cause significant "ringing" in the response, disrupting the pulse shaping.

No attempt was made to waterproof the open-mesh transducers. It might be possible, though, to cover them using the end section of a finger from a thin latex glove or similar. Perhaps even cling-film might be usable.

It does not matter in which order the transducers are mounted and connected. Although supplied as a pair comprising one transmitter and one receiver, as explained earlier, they are used interchangeably in both capacities.

COMPONENTS

See SHOP TALK page 71

Resistors

R1, R11	1k (2 off)
R2	47k
R3, R7, R9, R10	10k (4 off)
R4, R5	100k (2 off)
R6	1M
R8	4k7

Potentiometers

VR1	10k min. preset, round
VR2	100k min. preset, round

Capacitors

C1, C2, C6, C8	100n ceramic, 5mm pitch (4 off)
C3, C4, C9	10p ceramic, 5mm pitch (3 off)
C5	100p ceramic, 5mm pitch
C7	1n ceramic, 5mm pitch

Semiconductors

D1	1N4148 signal diode
IC1	PIC16F628–20 microcontroller, pre-programmed (see text), 20MHz
IC2	78L05 +5V 100mA voltage regulator
IC3	4052 2-pole 4-way analogue multiplexer
IC4	MAX412 or LM358 dual op.amp. (see text)
TR1	BC549 or similar *npn* transistor

Miscellaneous

S1	min. s.p.s.t. (or s.p.d.t.) toggle switch
S2, S3	min. s.p. push-to-make switch (2 off)
X1	20MHz crystal
X2	2-line 16-character (per line) alphanumeric l.c.d. module
X3, X4	40kHz ultrasonic transducer (2 off, matched transmitter/receiver pair)

Printed circuit board, available from the *EPE PCB Service*, code 380; 8-pin d.i.l. socket; 16-pin d.i.l. socket; 18-pin d.i.l. socket; 1mm terminal pins or pin header strip; 9V PP3 battery and clip; p.c.b. supports (4 off); plastic case, 150mm x 80mm x 50mm; metal support for transducers, about 260mm (see text); cable ties; nuts and bolts to suit l.c.d. module; connecting wire; solder, etc.

Approx. Cost Guidance Only **£30** *excl. batt.*

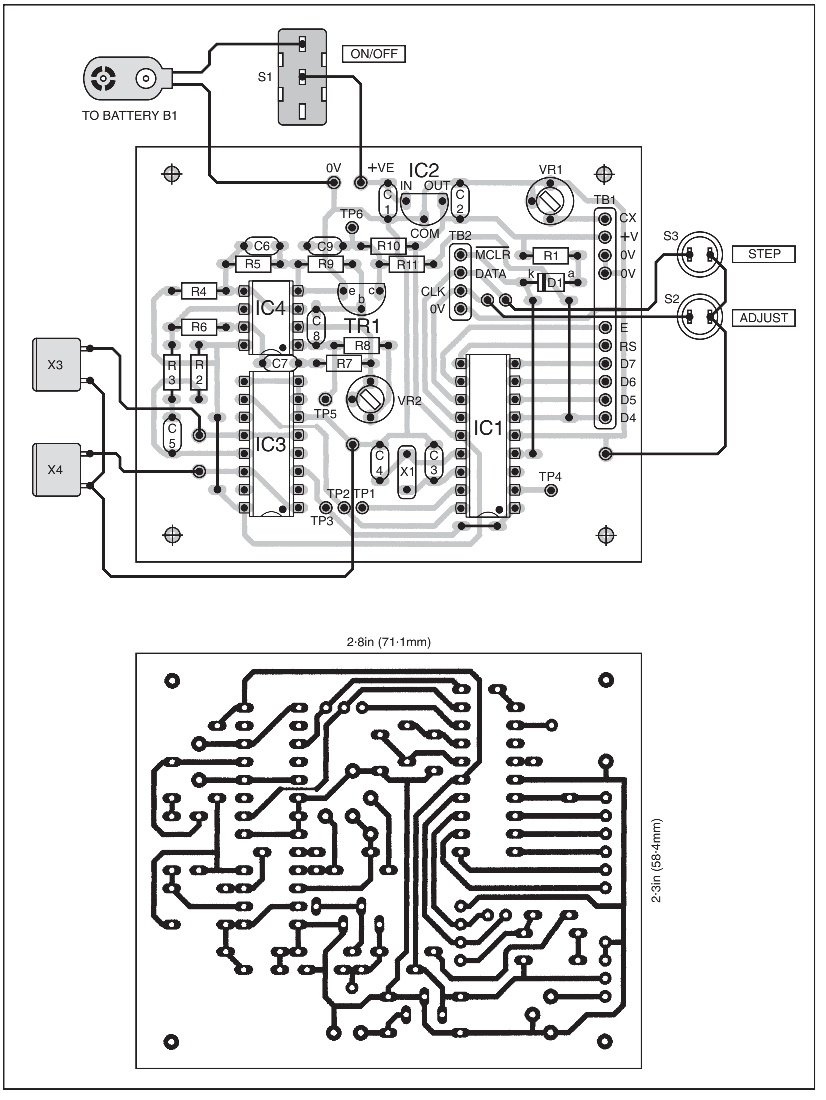


Fig.4. Printed circuit board component layout and full-size copper foil master track pattern for the Wind Speed Meter.

Screened stereo cable was used for the transducer connections back to the board, simply because it was to hand. It is thought that the screen is unnecessary and that any type of 4-way cable could be used. If the common 0V connections are made between the transducers on the probe assembly, 3-way cable could probably be used. However, these two alternative wiring techniques have not been tested.

At the unit end, the cables were passed through a hole in the box and soldered to the p.c.b. Plug and socket connections were tried, but were found to be unreliable, frequently causing signal disruption.

CIRCUIT CONSTRUCTION

Component and track layout details for the Wind Speed Meter are shown in Fig.4. This board is available from the *EPE PCB Service*, code 380. Assemble in any order you prefer, but it is suggested that you do so in order of ascending component size. Don't overlook the four link wires.

Use sockets for the dual-in-line (d.i.l.) i.c.s but do not insert these i.c.s until you have made sure that the power supply is functioning correctly. Ensure that polarity conscious components, i.e. D1, TR1 and IC2, are inserted the correct way round.

Insert 1mm terminal pins or pin-headers for the off-board connection points. Note that the TB1 and TB2 pins are in the author's standard order. The l.c.d. is connected to the pins for TB1, and typical pin arrangements for the l.c.d. itself are shown in Fig.5. Do not connect the l.c.d. until you have checked the power supply. Connection of the ultrasonic transducers can be made now, but may be left until later if preferred.

Having assembled the board and thoroughly checked the correctness of the component positions, their orientation where

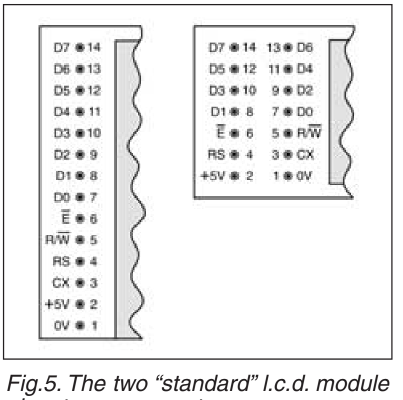
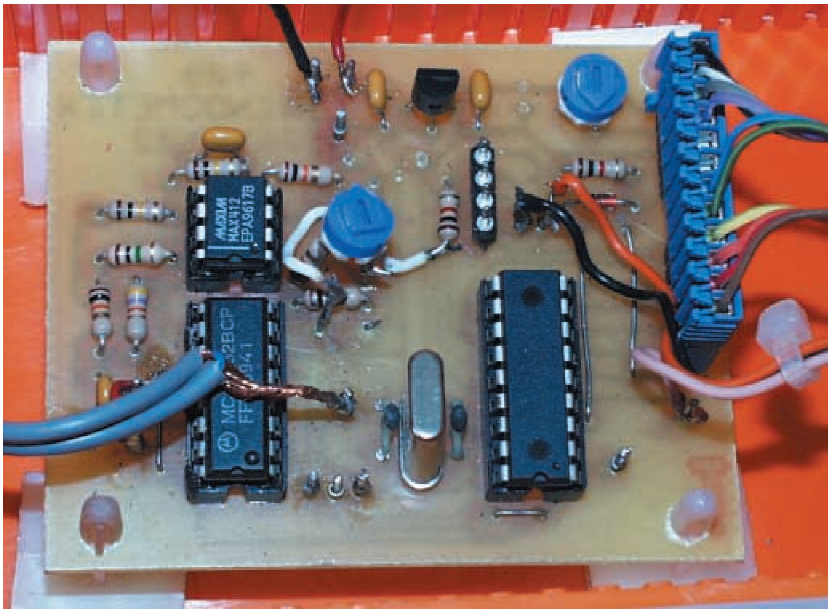


Fig.5. The two "standard" l.c.d. module pinout arrangements.



Prototype p.c.b. assembly. The changes visible have been incorporated on the final p.c.b.

appropriate, and the quality of your soldering, switch on the battery. Immediately check that +5V (within a few percent) is present at the output of voltage regulator IC2. If not, immediately switch off and correct any assembly error. Always switch off the power before making any changes on the board.

Then insert the remaining i.c.s, ensuring that they are the correct way round, and connect the l.c.d. module. The l.c.d., IC1 and IC3 are CMOS devices and the usual handling precautions should be observed, touching a grounded item of equipment before handling them, to discharge static electricity from your body.

The PIC microcontroller, IC1, should have been preprogrammed, either purchased as such, or via a suitable programmer.

Although PIC programming connections have been provided on the p.c.b., it was found that any previously unused (brand new) PIC16F628 device could not be programmed in situ due to it being connected to other components. These PICs, it seems, need to have their first programming carried out using a normal PIC programmer, such as *Toolkit TK3*.

It was found that previously used PIC16F628 devices are capable of being programmed *in situ*, and the development of this design was carried out in this fashion.

Switch on power again, and once more check the power supply output at IC2. Adjust the l.c.d. contrast setting using preset VR1 until a screen display is seen clearly. Ignore the immediate details at present.

DISPLAY VALUES

When you know that all is well, and if you have not already done so, connect the transducers. Support the probe assembly so that nothing obscures the direct path between the

Example of main monitoring display, during a slight breeze.

transducers. The room in which the testing is to be done *must* be free of draughts, so that the unit just responds in still air.

Switch on the power. Four sets of values will be seen on the l.c.d., possibly changing a bit erratically at present (see above photo).

On the top line are shown the monitored wind speed values in metres and feet per second, both having two decimal places to the nearest 0·01 value. The maximum integer value that can be shown is 99.

The lower line shows the speed in kph and mph, to one decimal place, with a maximum integer value of 999 – good luck if you ever see that shown! In fact, it is not actually known how high a wind speed the unit will correctly respond to, but it should be at least 50mph (80kph) and likely to be much higher.

The unknown factor is whether or not at really high wind speeds the transducer grills, or other aspects of the probe assembly, might cause interference by generating ultrasonics that could affect the amplifier response, a bit like wind whistling in telegraph wires, only higher pitched.

Pressing switch S3 sets the unit into full averaging mode, signified by the letters Av being shown at the far right of l.c.d. line 2. In this mode, the second block of 16 values previously mentioned is averaged and the calculations use that result instead of the immediate value that is shown when averaging is off, and Av replaced by two blanks on screen. Repeated pressing of S3 toggles between the two modes.

Pressing switch S2 selects the Test mode, replacing the top line values with the actual timing values detected during each pair of transmission cycles. These are the actual values read from the PIC's Timer 1 register. To their right is shown the absolute difference between them (without + or – signs).

Example display when in Test mode.

It is normal for the values to fluctuate slightly. In the prototype they typically hover at around 3400, but this value depends on the exact distance between the transducers.

The first two values shown were used by the author during software development, but otherwise have no practical purpose. The right hand value is used during the unit's alignment, in the unlikely event that this should be found necessary.

Pressing S2 again once more causes the metres per second (m/s) and feet per second (f/s) speeds to be shown.

ALIGNMENT

The proof of whether or not corrective alignment is needed depends on the value shown at the right of the top line in still air conditions, having pressed switch S2 to display the test values. First adjust preset VR1 until the received pulses are being adequately amplified, i.e. the displayed values are pretty consistent.

If the right hand value hovers around 0 to 1, preferably nearer to 0, no correction is needed. If it is any greater, though, adjustment can easily be carried out as described in the third of the following three correction options:

Switch off the power and wait for the screen display to go blank (supply line voltage has dropped to 0V). Hold the Averaging switch S3 pressed down, switch on the power, wait a moment and then release S3.

Screen line 2 will be blank and line 1 should show the message WIND PULSE 2. This states the number of pulses that the PIC transmits during each detection cycle. Do not adjust this value unless you have an oscilloscope to monitor the waveforms generated by the PIC.

Correction mode screen 1.

Correction mode screen 2.

Correction mode screen 3, showing confirmation that the value has been saved.

Press switch S2 (but not S3). Line 1 then shows WIND MASK 80. Again this value should only be changed if you have an oscilloscope. It is improbable, though, that either of the foregoing values will need changing.

Press switch S2 again (without pressing S3), to display CORRECTION –0 (or 0). This is the third correction mode, which you might need to use.

The data EEPROM holds the correction factor as a value between 0 and 15. Any values below 8 are subtracted from 8, and the answer is then subtracted from the sample values. For example, if the value is 7, it is subtracted from 8 and the answer of 1 is subtracted from the samples.

Conversely, values of 8 and above are ANDed with 7 (binary 111) and the result is then added to the sample values. Thus if the data EEPROM value is 9, this is ANDed with 7 to produce a value of 1, which is then added to the samples.

The ANDing process is invisible to the user, who only sees the result on screen, expressed with or without a polarity sign (+ or –) as appropriate. Zero may be returned with either sign (or without), depending how it has been reached.

To change the value, press switch S3. The value will decrement (downwards) in steps of one, from –1 to –7 for each press of S3. It will then show 0, followed by an increment (upwards), again in steps of 1 for each press of S3, from +1 to +7. After 7, it again shows 0 and decrements to –7, etc.

Having set the value, press S2 and the word SAVED will be shown on line 2. This confirms that the PIC has stored the new value back to the data EEPROM.

The SAVED message will also appear if switch S3 has been pressed with the first two correction modes. It is then necessary to press S2 to step to the next mode.

That completes the correction cycle. The next press of S2 returns the screen to show the wind speed values.

Note that pressing the switches may seem to have a lethargic response. This is due to the software continuing to take samples between each occasion it looks to see if a switch has been pressed. The switch must be released before the response occurs.

Should you need to reinstate (or install for the first time) the author's values to the EEPROM via the switches, they are Wind Pulse = 8, Wind Mask = 80, Correction = 0.

THIRD CORRECTION MODE

The third correction mode just described can be used if the sampling difference value at the right of line 1 is not fairly consistently showing zero in still air conditions. The difference is due to the two transducers not responding identically when used in receiving mode.

Note the value and then set the correction value to cancel it. For example, if the difference value consistently shows 5 then it needs to be corrected by 5.

However, the difference value is not accompanied by a polarity sign. Consequently it may not be immediately clear whether 5 needs to added or subtracted. Try setting first for one polarity, i.e. –5, and if that makes matters worse, use +5. The object is get the difference value as consistently close to zero as possible.

There will always be a bit of value-changing seen, due to the simple nature of the transducers and the amplifier. Remember that it is an analogue system being used for pulse transmission and reception amplification. The digital aspect, as shaped by transistor TR1 and read by the PIC through its interrupt function, may not necessarily respond each time to precisely the same analogue voltage level of the waveform output from op.amp IC4b.

ADVANCED SETTING

As said previously, it is highly improbable the Mask and Pulse values will need changing. However, readers who have a dual-trace oscilloscope might be interested to experiment with these two values.

Several test points have been included on the p.c.b., as follows:

TP1. Connected to PIC pin RA0, which goes high following the masking period and the PIC starting to "listen".

TP2. Connected to PIC pin RA1 and multiplexer IC3 pin 10 (the pin that controls the signal routing to and from the transducers).

TP3. Connected to PIC pin RA2 and IC3 pin 3, carrying the 40kHz output signal pulses.

TP4. Connected to PIC pin RA3, which goes high on receipt of signal capture by the interrupt routine.

TP5. Connected to the output (pin 1) of op.amp IC4b, allowing the fully amplified signal to be monitored prior to being pulse-shaped by transistor TR1.

TP6. Connected to the collector of TR1, at which the pulse-shaped signal appears.

Raw transducer signals can also be monitored at the p.c.b. points to which their leads are connected.

The most useful scope monitoring that can be done is to first connect scope Channel 1 to TP3, and set the scope to synchronise to positive-going pulses on this channel. The 5V transmission pulses being sent to multiplexer IC2 will be observed. Keep this probe connected to TP3.

Connect Channel 2 to the active pin of each transducer in turn and observe how only alternate transmission pulses are seen on this channel. With a sufficiently good scope set to a high gain setting for Channel 2, you might just also see the received signal being generated on the transducers between transmission pulses.

Monitoring TP2 with Channel 2, the multiplex path selection logic pulses will be seen. With Channel 2 on TP4, the relationship between the occurrence of the transmission pulses and the point at which the PIC's masking period ends can be observed. The software triggers TP4 at the end of the masking period, and just prior to the PIC starting to "listen".

Monitoring TP5 with Channel 2, observe the shape of the received and amplified pulse. With sync still on Channel 1, view Channel 2 on its own. At the start of the waveform, the sympathetic reaction of the amplifier to the transmission signal will be seen as a brief pulse, of about 2V peak-to-peak, depending on the setting of preset VR2.

The masking delay allows this pulse to be ignored before the PIC starts waiting for the true received pulse. This pulse's occurrence will be seen a little to the right of the first pulse, following a "quiet" gap. Note how the received pulse is considerably lengthened compared to the length of the transmission pulse. This clearly illustrates the "ringing" of the receiving transducer in response to it being hit by the transmission pulse. If you expand the scope trace, you will probably see that the ringing is at 40kHz, the frequency to which the transducer is most responsive.

Monitoring TP6 with Channel 2 shows how the op.amp output pulse train triggers the transistor into full saturation pulses. It is the first of these to which the PIC's RB0 interrupt responds. Adjust VR1 back and forth and see how the gain set for IC4b affects the transistor's reaction.

EXPERIMENTING

If you want to experiment with the values for the transmission pulses and masking, the trick is to ensure that the masking period does not end too early or too late. Secondly, the transmission pulses must cause an adequately strong response of both transmission and reception transducers, yet not cause either to "ring" for too long.

It is just possible, although unlikely, that a single transmission pulse will be adequate. Probably up to five or so will keep the "ringing" within bounds. Two pulses, though, were found to be best with several transducer units, some from different manufacturers.

The pulse count range is 1 to 9, followed by a rollover to 1. The masking value range is 1 to 255, followed by a rollover to 1. The values are changeable in the correction mode by using switch S3.

If you have PIC programming facilities, you can also confirm that the transmitted frequency is indeed roughly 40kHz. There is a command line in the SONICTX routine which has been REMmed (commented) out with a semicolon, saying GOTO BEAMITW. If you reinstate this line, reassemble and download to the PIC, the frequency output at TP1 can be monitored on a frequency counter. It is a permanent loop until the PIC is reprogrammed without the additional line.

Unless you are familiar with PIC program writing, do not attempt to change the software's transmission frequency loop values.

To reinstate the software's pulse transmission, REM-out the GOTO BEAMITW line again, and reprogram.

To temporarily speed the rate at which pulses are transmitted, switch off the power, wait briefly, then, with switch S2 pressed, switch the power back on. Release S2 a moment or two after the power has been switched on. In this mode, the PIC's Timer 0 rate is increased, so shortening the delay between sending pulses. Normal working is resumed next time the unit is switched on.

IN USE

To use the Wind Speed Meter, point the transducer assembly in the direction from which the wind is blowing. To avoid the possibility that your body may disrupt the wind flow, hold the probe somewhat away from your body.

To observe peak wind speeds, the Av message on line 2 should be absent. To obtain average wind speeds, press switch S3 so that Av is shown. The speeds shown are the average taken over 16 transmission cycles, but updated on each cycle.

Be aware, as you will soon find, that wind is not just the uniform flow of a mass of air past a given point. It is full of turbulence and the eddies within it swirl at different rates. Turbulence is even more prevalent near to fences, buildings, trees, and even other people. Where possible, take readings while well out in the open. Even then, turbulence will still be there. The transducers themselves will actually cause a bit of turbulence, but not enough to radically affect the validity of the readings.

The best you can hope for with any wind speed sensor is to show the speed that exists at a given moment in time. The wind speed indications given on the weather forecasts, for example, represent an average in relation to several hours of observation or calculation.

The calculations that relate to long-term forecasts will probably be based on barometric pressure readings, taken at strategic points across the countryside and providing information on the tightness and depth of the isobar ridges. You no doubt know that the tighter the isobar spacings, the stronger the winds that prevail.

It is also worth appreciating that wind speeds vary with height. Wind near to ground level will flow at a slower rate than wind higher above the ground. Measurements taken at heights differing by only a few metres can be different.

Although an averaging mechanism has been built into the software, always observe the meter for several seconds, mentally noting the range of values between which the readings change.

NEXT MONTH

In next month's issue, the construction of a simple wind tunnel will be described. This uses the same basic wind sensing circuit and software, but additionally includes a circuit which controls the rate at which an electrical fan rotates, so allowing the rate of air flow through the tunnel to be changed.

The system is ideal for demonstrating how air flows around differently shaped structures placed within the tunnel. From this it is possible to see how winds can damage buildings, cause wings to lift aircraft, and how important streamlining can be for any vehicle, airborne or road-based.

The airflow pattern can be enhanced by using an equivalent to beekeepers' smoke, which is normally created by burning various traditional substances (particular types of wood and cardboard) and used to pacify bees. More modern options will be discussed. We do not recommend the use of tobacco products to create tunnel smoke!

THANKS

The author wishes to thank the following for their help during the development of this PIC Wind Speed Meter:

Andy Flind for the loan of his thermal anemometer.

Mike Tooley for arranging access to the wind tunnel at Brooklands College, Surrey.

Barry Baker, for demonstrating the Brooklands College wind tunnel.

Peter Hemsley, for his excellent multiply, divide and binary-to-decimal conversion routines, used extensively in this design's software.

Malcolm Wiles, for his informative article on using PIC interrupts. □

Special Feature

PIC MACROS AND COMPUTED GOTOS

MALCOLM WILES

Describing two sophisticated programming techniques for advanced PIC users.

BACK in the days of ox carts when the author started programming, computers hardly any more powerful than one of today's PICs filled large aircraft hangars, required a dedicated power station to run them, ate paper tape (literally), and broke down every few minutes.

The folks who programmed them were all technical experts who used all sorts of extremely clever and devious programming tricks to extract the maximum grunt they could from these slow and primitive beasts. Programs were written in assembly language, and programmers would routinely do things like write self-modifying code, where a program would change its own instructions as it went along, as a device to minimise the amount of scarce memory that a program needed.

It didn't take too long for the realisation to dawn that many of these clever tricks were perhaps not quite so clever after all. Programs needed to be updated as requirements changed over time, and bugs that only showed up months later needed finding and fixing.

It's pretty hard to maintain a program if it's changing itself all the time and you can't be sure what it is any more. Nobody but the expert who wrote it stands any chance, and probably not even him if it was more than two weeks ago. Always assuming he's still around and can be prised away from his latest pet project.

SPAGHETTI CODE

Other tricks, like the undisciplined use of GOTO instructions to create "spaghetti code", and directly modifying the program counter, were also soon identified as very good ways to create incomprehensible programs, and therefore a *Bad Thing*.

Some notions and consensus about what constituted "structured programming" began to emerge. High level languages with cleaner control constructs in which GOTOs and such were unnecessary were developed, as were computers with enough memory and speed to run better and more powerful software development tools. Software engineering arose as a discipline where programmers took care that the products they made were designed, structured, clear, documented, compartmentalised, legible, testable, and tested, like products of other branches of engineering.

The author watched all this happen, and can see that, however painful and slow the process was, today's software development techniques are considerably better than they were when he started out. It is recognised that this is not all relevant to microprocessors and hobbyists, but nevertheless the author reacts with horror to the PIC's computed GOTO, because it incorporates so much that his industry learned the hard way is bad practice.

From a software point of view it is easily the worst design feature of the PIC16x processor core, which otherwise is reasonably clean. He is pleased to see that with their new 18F core, Microchip have introduced a much better way to implement data tables.

PIC-COMPUTED GOTO

The PIC16x's computed GOTO is most often used to implement data tables – to return one of a set of values specified by an offset. But it is very hard to use. It is necessary to know how the PC (and PCL) are updated as instructions are executed – e.g., does the PC point at, before, or after the current instruction, and exactly when is it incremented? It is also necessary to be conversant with the intricacies of the PCLATH register, and how addresses are formed by the PIC in the different cases of:

a. writing to the PCL register, and
b. using a CALL or GOTO instruction.

Things get even more tricky in the case of a data table which happens to cross a 256-byte boundary in memory, because then PCLATH base values will need to be different in different parts of the table. These are not issues that crop up often enough in everyday PIC programming for most people to have them at their fingertips, so they are more likely to get them wrong when they do have to use them. PCLATH programming was covered by John Waller in his article *Using the PIC's PCLATH Command* (July '02) and so is not discussed further here.

Bugs in computed GOTO code are hard to find and fix. Errors in programming PCLATH will produce a jump to some random piece of program memory. What happens then depends entirely on what happens to be in memory at this random address. Any number of unpredictable things could happen, but most likely is that the PIC will just hang.

Further, there is no protection if a bug in the program causes the table offset to be calculated incorrectly. If the offset is off the end of the table, then the program will also lurch to some undefined address, and again the effects are completely unpredictable. Such behaviour is not at all helpful when trying to debug what is going wrong.

It is suggested that the computed GOTO is avoided wherever possible. Storing data in the EEPROM is often a better and safer alternative, and the data sheets contain full example code samples showing how to read and write the EEPROM memory (note that the necessary code is different on the 16x84 compared to the 16F87x and the 16F62x). If an EEPROM access is wrongly coded, then incorrect data may be returned, but at least the PIC should not crash horribly. This gives a much better chance to find and fix the bugs.

CALLTAB AND DEFTAB MACROS

If, for some applications, there is no alternative to the computed GOTO, perhaps because there is insufficient EEPROM, then the following pair of macros are offered as a programming aid. **CALLTAB** and **DEFTAB** encapsulate the access to a data table so that the necessary PCLATH programming is done automatically. The offset supplied for the table access is checked, and zero is returned if it is outside the scope of the table.

The macros cope with tables located and accessed anywhere in an 8K memory space, and also with tables which cross a 256-byte boundary. Thus when using these macros, PIC crashes should not occur. The author thinks these macros go some way to getting round the weaknesses of the raw computed GOTO, at the expense of a little efficiency – but it is hoped that most will see that as an acceptable compromise.

The macros are only available for programs assembled by MPASM. There is unfortunately no good way of doing something equivalent for TASM, nor for

LISTING 1

```
; MPASM file
; testtabs.asm for PIC16F87x computed goto tables test
         list p=16f877,r=dec
         include p16f877.inc
; Macros
CALLTAB macro Tab,idx
         movf idx,W              ; load offset into W
         LCALL Tab
         endm

DEFTAB macro ofs,no
         LOCAL __Table
         movwf ofs               ; save offset in ofs
         movlw no                ; no. of entries in table
         subwf ofs,W             ; subtract the offset
         btfsc STATUS,C          ; if 'ofs' > no entries
         retlw 0                 ; return 0
         movlw LOW __Table       ; add ls 8 bits of table
         addwf ofs,F             ; addr to offset
         movlw HIGH __Table      ; load ms 5 bits of table
         btfsc STATUS,C          ; addr and if C set from
                                   previous addition
         addlw 1                 ; add 1 for the carry
         movwf PCLATH            ; set PCLATH
         movf ofs,W              ; load PCL from ls 8 bits
         movwf PCL               ; of offset calculation
         __Table:
         endm

         #DEFINE BANK0 BCF 0x03,5
         #DEFINE BANK1 BSF 0x03,5

         ; Data locations
offset:  equ 0x20                ; used as working var by
                                   macros
ans:     equ 0x21                ; store result
disp:    equ 0x22                ; a different working var
ZERO:    equ 0x23                ; some constants
ONE:     equ 0x24
TWO:     equ 0x25
THREE:   equ 0x26

         ORG 0
         goto START
         ORG 4
         retfie                  ; not using interrupts!
         ORG 5
START:
         clrf ZERO               ; set up some offset
                                   constants
         movlw 1
         movwf ONE
         movlw 2
         movwf TWO
         movlw 3
         movwf THREE
; read table located in high memory from page 0
         CALLTAB Tab1,ZERO
         movwf ans               ; returns 'a'
         CALLTAB Tab1,ONE
         movwf ans               ; returns 'b'
         CALLTAB Tab1,TWO
         movwf ans               ; returns 'c'
         CALLTAB Tab1,THREE      ; off end of Table
         movwf ans               ; returns 0
; must use LGOTO here, both because CALLTAB has corrupted
; PCLATH, and because NEXT is in a different page
         LGOTO NEXT
; some code running in high memory calling a table in lower
; memory
         org 0x1800
NEXT:
         CALLTAB Tab2,ZERO
         movwf ans               ; returns 'Y'
         CALLTAB Tab2,ONE
         movwf ans               ; returns 'Z'
         CALLTAB Tab2,TWO        ; off end of table
         movwf ans               ; returns 0
; verify that we can call Table from here too
         CALLTAB Tab1,ONE
         movwf ans
; and also Tab3 in very high memory.
         CALLTAB Tab3,TWO
         movwf ans
; must use LGOTO here (or reload PCLATH) because
; CALLTAB has corrupted PCLATH
STOP:    LGOTO STOP              ; loopstop

; define Tab1 – it overflows into sub page 0x13xx
         org 0x12F3
Tab1     DEFTAB offset,3
         retlw 'a'
         retlw 'b'
         retlw 'c'
; define Tab2 with overflow into sub page 0x07xx
         org 0x06F3
Tab2     DEFTAB offset,2
         retlw 'Y'
         retlw 'Z'
; a Table at very high memory. Uses a different working
; variable
         org 0x1EF3
Tab3     DEFTAB disp,3
         retlw 'j'
         retlw 'i'
         retlw 'm'
         END
```

programs that are assembled with the built-in facilities of TK3, because essential use is made of several language features supported only by MPASM.

CALLTAB is a macro which encapsulates a table data access. The two arguments are:

Tab. The label of the table (DEFTAB statement) to be accessed.

IDX. The label of a data location containing the offset in the table of the item to be returned, base 0.

DEFTAB is a macro used to define a table for access using **CALLTAB**. The two arguments are:

OFS. The label of a data location in memory which is used to calculate the offset address.

NO. The number of items in the table. (This is used to check the **IDX** argument.)

Table entries are defined immediately following the **DEFTAB** statement using **RETLW** statements in the usual way. Note that neither macro preserves the value of PCLATH, so PCLATH must be reloaded before the next CALL or GOTO instruction.

Listing 1 shows a sample program which contains the macro definitions and illustrates how the macros should be used. It is suggested that readers may find it instructive to run this program using a simulator such as Microchip's MPLAB SIM (MPSIM), perhaps pausing the program after each table access to display the results, or even single stepping through the various table access calculations.

HOW MACROS WORK

Readers who simply want to use the macros **CALLTAB** and **DEFTAB** as if they were a cookbook without necessarily understanding all the details may skip this section. For those who are interested in more details, first a quick explanation of what a macro is, since the topic of macros has not really been discussed in *EPE* before.

A macro is a set of programmer-defined instructions and directives which are given a name. When the name is encountered by the MPASM assembler, it is automatically expanded into the defined set of instructions. Thus a macro is a useful shorthand notation for sequences of code that recur frequently in a program.

Most readers will already be familiar with the simplest form of macro – the **#DEFINE** statement (which strictly speaking defines a text substitution label, but we won't split such arcane hairs). For example, by convention the macros:

#DEFINE PAGE0 BCF 0x03,5
#DEFINE PAGE1 BSF 0x03,5

appear at the head of most PIC programs (though these macros should more accurately be called **BANK0** and **BANK1**). When the assembler encounters the statements **PAGE0** and **PAGE1**, it replaces them with **BCF 0x03,5** and **BSF 0x03,5** respectively, and then assembles the result.

This illustrates another use for macros, which is to make a program more legible and understandable. On reading a program, most folks would have to reach for the data sheet to figure out what a **BCF 0x03,5** instruction does, whereas a **PAGE0** statement is immediately recognisable. The macros **Enter_Critical_Section** and **Leave_Critical_Section** were used in the author's *Programming PIC Interrupts Part 2* (April '02) for a similar reason.

The **#DEFINE** statement is a restricted form of macro definition (but the only one which is supported by TASM and the TK3 assembler). It can expand to only one statement, and cannot have arguments. The more general form, available in MPASM, removes both of these restrictions.

An MPASM macro definition is introduced by the line:

NAME macro <optional list of arguments, separated by commas**>**

It is terminated by the statement

endm

In between these lines are the statements defining the macro. Wherever **NAME** is subsequently encountered in the program, these statements will be substituted by the assembler.

If you assemble the example program **testtabs.asm** (Listing 1) in this article and then examine the **testtabs.lst** file output by the MPASM assembler, you will see how this substitution process works. After each **CALLTAB** and **DEFTAB** statement, the lines of the expanded macro follow. For each substituted line, the line number column contains an 'M' character in place of the source line number.

LABELS IN MACROS

In general, the statements included in a macro will need to refer to data (register) memory, or to statement labels. If the objects referenced are always the same then they can be coded explicitly as the absolute location or its equated symbol. Thus **CALLTAB** and **DEFTAB** contain references to STATUS and PCLATH, because it is always these special function registers that are intended.

In other cases the macros need to refer to different objects depending on where they are invoked. This is achieved by passing in the names of these objects as arguments. The macro is defined in terms of "formal arguments", but when the macro is invoked actual arguments are supplied, and the assembler's macro expansion process replaces the formal arguments with the actual arguments.

Thus **CALLTAB** is defined in terms of the formal arguments **Tab** and **IDX**. When it is called for the first time, the actual arguments **Tab1** and **ZERO** are supplied, and the expanded code will use **Tab1** and **ZERO**. The second invocation of **CALLTAB** will be in terms of **Tab1** and **ONE**, and so on. Readers who have used high level languages such as C or BASIC will be familiar with this idea of parameter (argument) substitution.

In an assembly program, whenever you define (use) a statement label, the assembler remembers the label (and its corresponding address or value) in a symbol table. You can see this symbol table displayed at the end of any **.LST** assembler output file. This is how it is that you can refer to a label from elsewhere in the program and the assembler knows what you mean. To avoid ambiguity, all labels in a program must be unique.

Normally, labels defined in macros get stored in the symbol table too. But the **DEFTAB** macro needs to refer to the label **__Table** (the start of the current group of table entries), which is different each time it is invoked. If we didn't do something special, then on the second and subsequent invocations of **DEFTAB** an assembly error would occur, because the assembler would already have an entry for **__Table** (with the previous address) in its symbol table.

This problem is avoided by the macro directive **LOCAL**. This declares **__Table** to be of local significance (i.e. to this expansion of the macro) only. So the assembler does not permanently record **__Table** in its symbol table, and no errors are produced if the **DEFTAB** macro is used more than once in a program. On each occasion that the **DEFTAB** macro is expanded, **__Table** is assigned the address of the current data table.

MPASM ADDRESSING AIDS

MPASM provides two operators, **HIGH** and **LOW**, to help with 13-bit address manipulation. (On the 16F series) **HIGH** operating on a label returns the most significant five bits of the corresponding program memory address, and **LOW** the least significant eight bits. As well as being employed by **DEFTAB**, these useful operators can be used in ordinary assembler code. Study the **DEFTAB** macro definition to see exactly how they are used.

MPASM also provides two pseudo-instructions **LCALL** and **LGOTO** ("long CALL" and "long GOTO"). (**LGOTO** is not actually documented in the MPASM manual (see reference later) for the PIC 16F core, but appears to be supported by versions of MPASM from V2.30 onwards, and maybe earlier versions too.)

LCALL and **LGOTO** are effectively macros built into the assembler. They expand to code (**bsf** and **bcf** instructions) to set PCLATH correctly for the destination label, followed by the **CALL** or **GOTO** as appropriate. Thus they can be used to reference any label anywhere in 8K of program memory. Again, refer to the **testtabs.lst** file for details of exactly what they do (but note that these pseudo- instructions only set the two most significant bits of PCLATH).

LCALL and **LGOTO** are obviously very useful to anyone writing programs longer than 2K bytes. **CALLTAB** includes an example of **LCALL**, and **LGOTO** is used in the demo program **testtabs.asm**.

HOW CALLTAB AND DEFTAB WORK

CALLTAB loads the table offset required into **W**, then uses **LCALL** to call the table code. This allows **Tab** to be located anywhere in memory.

DEFTAB first checks the offset against the declared table size in the **IDX** argument. If the **OFS** value is off the end of the table, zero is returned and no table access is performed. If the offset is OK, a full 13-bit address for the table location is calculated (using standard 2-byte, 16-bit arithmetic) and loaded into PCLATH and PCL. This allows the table to be in any page, and (since carry is checked in the calculation) to span a 256-byte boundary.

There's quite a lot more to macros than this very quick introduction has covered. For more information, see especially the *Directive Language* and *Macro Language* chapters of the *MPASM User Guide*, filename **33014g.pdf**. This can be found on Disc 2 of the cover CDs supplied with *EPE* Oct '01, or downloaded from **www.microchip.com**.

MACROS vs SUBROUTINES

Macros and subroutines (or procedures) both do a similar thing, namely encapsulate some piece of code that is used in several places so that it only needs to be coded once. The difference is that a macro is expanded in-line each time it is invoked, so that even though, as a programmer, you don't have to type the instructions in every time, they still appear several times in the assembled code. The instructions making up a subroutine are only present once in a program.

Macros are generally more efficient, that is they tend to use fewer executed instructions than subroutines. Subroutines require at least a call instruction to get to the subroutine, and a return to get back, both of which are overhead in the sense that they do no useful calculation or algorithmic work.

Usually there are also a few instructions before a call instruction which set up the parameters that the subroutine will use in the places that it expects to find them, and so which are probably also overhead. Often macros can be arranged so that the parameters are passed in as substitution arguments, which incur no overhead. On the other hand, programs using subroutines will tend to be shorter overall.

So if you have plenty of program memory available, and require top performance, then you will tend to use macros. If total memory capacity is a problem, but you don't need code that is ultra-fast, then you will tend to use subroutines. If neither memory capacity nor ultimate speed are issues for your particular application, then you can use either subroutines or macros, or both as you choose.

MPASM macros are a "higher level" construct than subroutines, at least in the way that subroutines have to be implemented in assembly language. For example, they can have many arguments, and can be used to provide some of the more powerful features normally associated with high level languages.

Both subroutines and macros are good for structuring programs. It is generally a good idea where you can to break down the overall programming task into smaller (and hopefully simpler) sub-tasks that can be tackled in turn. It is never a good idea to write the same sequence of instructions many times over in a program. Apart from being very boring to do, if you subsequently find a bug in that sequence of code, or you need to change what it does, then you have lots of instances to find and fix.

If you have implemented the sequence as either a macro or a subroutine, then you only have to fix one place, and let the assembler do the rest of the work for you. □

READOUT

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

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

All letters quoted here have previously been replied to directly.

WIN A DIGITAL MULTIMETER

A $3\frac{1}{2}$ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a Digital Multimeter to the author of the best *Readout* letter.

★ LETTER OF THE MONTH ★

INSPIRED CLOCKING

Dear EPE,

The *PIC World Clock* on the cover of August *EPE* caught my eye a few months ago, and inspired me to march through *Teach-In 2000* series, build *Toolkit TK3*, race through the *PICtutor* CD-ROM and scour back issues to satisfy my curiosity for how you achieved it.

This is all great learning material for which I am grateful. The enthusiasm you demonstrate in this area is infectious. (With hindsight, what would be very handy is a "PIC reference" showing the *EPE* issues needed for all PIC learning materials: *PIC Tutorial*, *TK3*, *'87x Extended Memory*, *PCLath*, *Keypads*, *Interrupts*, etc., or even better a composite CD-ROM with collected articles.

My interest is most definitely in programming PIC/l.c.d. combination projects. I'm reminded of my misspent youth when I spent far too long cramming space invaders and word processors into a 1K ZX81 with a low resolution screen.

However, I'm still on a learning curve with regard to the surrounding circuitry and I have a query with regard to most of your recent designs, including my favourite, *Canute Tide Predictor* of June '00. (Actually, my reworking the software for this is worthy of separate communication!)

Most of the PIC/l.c.d. combination projects I read in *EPE* are not truly portable. That is, they are able to run off a 9V battery, but you nearly always suggest a battery eliminator because of relatively high current drawn from the circuit. I would like to be able to use *Canute* and other projects (including *PIC World Clock* when travelling!) for extended periods without access to mains power, which presents a problem because I want to maintain date/time information without having to enter it more than once.

I realise I can store to EEPROM, but this does not really help with maintaining time. To maximise battery life, I'm thinking along the lines of having a "warm" on/off switch that engages/disengages sleep mode on the PIC and somehow switches the l.c.d. display on and off as well.

In addition, I probably need to go into this sleep mode after a set period of inactivity, instead of maintaining a permanent display, and I (think) need some sort of other backup so that date/time is not lost during replacement of the 9V battery. Is any of this feasible, or would the battery life be so poor as to make the end result impractical?

Another thought was to have a PIC with its own supply just acting as an uninterruptible clock, or maybe a similar alternative, but again I'd still have to maintain 5V for extended periods and double up the batteries. As I understand it, the 5V regulator itself is part of the problem being so power hungry.

Can you recall any published designs or articles that I can learn from to help me with my goal?

Andrew Jarvis, via email

Glad to know that you are enjoying EPE, *Andrew, and that you're being "inspired"!*

You make a good point about a list of PIC projects. In fact we've been talking about taking this idea further through the CD-ROM route. During the next few months I shall be upgrading my original PIC Tutorial *of Mar-May '98, using MPASM grammar, and suiting to use with the* TK3 *board. It is likely to be released on CD-ROM, on which we shall quite likely include the main PIC features such as those that you mention, together with a selection of* PIC Tricks *that are now on our ftp site. I expect you are aware that the ftp site contains folders for all the PIC projects published over several years.*

Running Canute *off a battery is not as easy as you may think. I put a lot of time in on this and in brief the l.c.d. cannot be turned off to save power, and it is the main cause of current consumption. Putting the PIC to sleep solves nothing, regretably. To physically switch off the l.c.d. would be problematic as it then needs to be rebooted when switched on again. It can be done, but to be honest I felt I had already spent enough time on this project. If you try further, good luck!*

In principle the PIC will run at a voltage as low as 3V, so you might consider using a 3V battery to maintain clocking while the rest of the system is switched off. Sorry I can't enter into discussion on it though, nor can I think of specific designs we've done that show the principle.

Best wishes for enjoying your electronics.

GENEROUS VINTAGE OFFER

Dear EPE,

The supplement *Collecting and Restoring Vintage Radios* (Oct '02) reminded me that I have accumulated a surplus stock of germanium (and a few early silicon) transistors and diodes. They are tested and sorted, hence accessible and available! If any reader needs one of these devices, they are welcome to write to me to enquire as to availability. A pre-paid reply envelope is *essential*. If the reply envelope is suitable, then I will send the requested device in it, if available. No charge, while stocks last, as long as the recipient states a genuine need (e.g. piece of equipment to repair) and pays postage.

Note that the following popular types are NOT available: AF117, OA70, OA79, OA91, OC45, OC7l, OC72, OC78, OC78D, OC81, OC81D. If a 4-wire device is needed I can offer OC17. Requests for OC44 will be met with CV7003, a metal-can equivalent. I hope this offer helps someone, somewhere.

I am also trying to build a collection of such old devices and any offers would be gratefully received. If writing with your needs, please suggest equivalents that you can accept.

Godfrey Manning G4GLM, 63 The Drive, Edgware, Middx HA8 8PS

Thank you Godfrey, that's most generous. We hope that readers too can help you to increase your collection.

CLOCKING PICS

Dear EPE,

Do you publish your annual contents on a CD-ROM? Also, could you please inform me of any PIC-controlled clock projects published after Dec 2000 and how can one access them?

Fernando Bentes de Jesus, via email

Do you mean an Annual Index? If so, sorry but we don't do one on CD-ROM but it is on our UK website. Each December issue, though, has two pages of index for that year. If you mean are the full contents of EPE *for one year published on CD-ROM, then the answer is almost yes – if you look at the* Back Issues *section of any issue (preferably a current one) you will see that we have mini CD-ROMS that hold six issues of* EPE. *These are released every six months, six months after the publication of the sixth issue covered.*

Regarding the clock – well Fernando, you are aware of course, though readers are not, you and I have been discussing this at length and the upshot is that I have designed the type of PIC-controlled clock you are looking for – a large circular face with l.e.d.s around the edge indicating seconds, minutes and hours, "rotating" appropriately, plus four large (2-inch × 1-inch) digits each comprised of many l.e.d.s which variously display minutes and hours, months and days, and temperature. It will hopefully be published around the middle of 2003. Thank you for inspiring the design.

Apart from this design, it is Andy Flind's Synchronous Clock Driver *of Sept. '01 that is the most recent PIC-controlled clock project, and is a dual-frequency 50Hz/60Hz converter for mains operated synchronous clocks.*

MIXED PRAISES

Dear EPE,

I would add my voice to yours (*News* Oct. '02) regarding the retirement of Frank Jackson the Director of Radio Component Specialists. Many years ago (about 25) I obtained some variable capacitors from them. I had need of some more a few years ago and contacted them. They advised me that they no longer kept components in this field. However ten minutes later they came on the phone to say they had found a couple in a drawer which I could have. They had to find my telephone number and take the trouble to do this. I was extremely grateful and I can't help but contrast this with the present image of suppliers.

I wanted a computer part, but the supplier only dealt with internet orders, and this necessitated setting up an account. This involves a long process of questions to be answered. I gave up at the "Enter a secret question" and "Enter a secret answer" bit. I got the phone bill yesterday and the cost of this abortive visit to the internet was £12. And I never got the part I wanted. Their telephone number was just an answering service. They had only a box number address. Is the business run by someone sitting alone in their residence on a computer sending items from a supplier wherever to whoever? And this is progress?

Peter McBeath, Morpeth

Agreed, and certainly not, Peter.

C-ING TO PICS

Dear EPE,

I have recently renewed my annual subscription for your electronic edition. After receiving *EPE* for the past year I am pleased to comment that the download is compact and efficient, taking about 15 mins on average on a 56K modem; the ZIP file works first time with the Acrobat reader; the magazine content is focussed and well understood, with practical, theoretical, and educational articles.

The importance *EPE* has placed on Microchip PIC products turns out to be in my opinion a very good strategy, as is maintaining this focus rather than having many articles covering other manufacturers, which can be very confusing for microcontroller technology.

Microchip have a global presence, and are able to provide complete product support, even arranging here in Singapore with Polytechnics to run courses for the general public based on their products.

Consequently I perceive your magazine is positioned to provide even higher levels of customer service – by having a direct reader forum/exchange on PIC microcontrollers and their use. This could be web-based with the magazine content highlighting/selecting the best on a monthly or quarterly basis.

Furthermore, with the move towards microcontrollers having more operations, meaning assembly code instructions increasing, there is a move towards "C" programming. Obviously tutorials on "C for PIC" would be very helpful (anyway "C" is not a difficult language to learn, it only needs more practice).

Thank you for a good technology magazine.

William Rance,
via email

Thank you William for confirming the benefits and ease of downloading our electronic editions. Many readers have found how well this service suits their needs, particularly those who are not resident in the UK.

We agree that we have made a good decision to promote PICs as the principle type of microcontroller we support, although we do not totally exclude other controllers if an interesting design using one is offered to us. One of the benefits readers enjoy from our standardising on PICs, though, is that many now have the programming facilities dedicated to them. Other microcontrollers are less likely to be widely supported by readers' own facilities.

As you have noted, there is considerable discussion generated amongst readers on PIC subjects, not only here on these pages, but also via our web-based Chat Zone. This option seems suited to the needs of most readers and we do not currently feel the need for a dedicated PICs-only type of forum. There are already many accessible via the web for those who do wish to become more intense in their PIC-chatting.

Regarding "C", the evidence suggests that most of our readers are not familiar with the language, although we know that there are those who are. At present we cater for them though the C For PICmicros *CD-ROM, which is advertised elsewhere in this issue. The majority of readers who program PICs do so through one of the two principle assembly dialects that prevail, TASM and Microchip's own MPASM. It is the latter on which the latest* Assembly for PICmicros *CD-ROM is based, being an updated version of my original paper edition* PIC Tutorial *of Mar-May '98, in which the emphasis then was on TASM.*

As you will see from the November and December issues, plus this one, we are now catering for those readers who have yet to become involved in PIC assembly language programming by publishing a series of three articles by Max Horsey, a lecturer at one of the country's leading colleges. He shows how to use a variant of Basic through which to program specially prepared PICs, known as PICAXE devices.

We appreciate your input, William, thank you.

VB6 ASSEMBLY CODE

Dear EPE,

In his *EPE Morse Code Reader* (Sept '02), John Becker asks for ways to use assembly code in VB6 programs. This can be done by assembling the code as a DLL and calling the routines (with proper headers) from VB. An excellent example of this is **vbasm.dll**, a free program from Softcircuits Programming (**www.softcircuits.com**), which contains assembly coded routines for peeking, poking, shifting, I/O, and many other things for use in VB.

Incidentally, I am very impressed by the things you are able to do with PICs, as in the above mentioned article. Your projects like this are a main reason I subscribe to *EPE*. I wonder, however, why you used a PIC16F84, when a PIC16F628 is pin (and mostly code) compatible, much more capable, and costs about half as much (at least in the USA).

Ed Grens,
via email

Thanks for the info Ed, which I'll look into. At present I don't know how to make a DLL but hope the site you give will tell me.

Thanks too for your kind comments. PIC16F627/8 projects from me are now in the pipeline! At the time Morse *was written '62x were not widely available and an '84 was the best option.*

PIC L.C.D. MATHS

Dear EPE,

I am an avid reader of your PIC projects, and have built many. It amazes me how you can purchase such a cheap i.c. and get so much power. However, I have been writing some code for myself (some good, some bad) and I have come across a problem which I am completely stumped by.

The problem is that I have an A/D converter which provides a result in the W register in the range 00h to FFh (0 to 255) and I want to send this result to an l.c.d. The l.c.d. requires a digit by digit input so I need to convert the 8-bit result into separate hundreds, tens and units digits, then instruct the l.c.d. to display them . . . how?

Also, I understand that PICs are rather limited in the maths but would it be possible to actually display the result in the form e.g. 2.94V to represent, say, a voltage reading in respect of an ADC value of 150?

Richard Harrison,
via email

Many of my PIC designs that use an l.c.d. have such code conversions in them. Lately they are based on Peter Hemsley's binary to decimal routine (BIN2DEC) that is held in the PIC Tricks *folder on our ftp site – the routine is excellent. There are also some of Peter's maths routines there too, which enable the PIC to perform multiplication and division, and other functions.*

PRE-PROGRAMMED?

Dear EPE,

I have always been interested in PIC projects, so I decided to try out the *PIC Intruder Alarm* (April '02). The Components list states "PIC16F877 pre-programmed (see text)". I have never understood what "pre-programmed" means. Can you please tell me, and how you identify a programmed one from one that is not?

Andrew Debono,
via email

PICs are manufactured without any program code, therefore buying one that has not been programmed with the required code written by the author of a published design will do nothing. A pre-programmed PIC is one that has been programmed by this code. Externally you cannot tell if a PIC has been programmed. To find this out use my Toolkit TK3 *of Oct/Nov '01 – it allows you to read back the PIC's contents.*

Magenta sell pre-programmed PICs for most of our projects. They program them with the author's code as supplied by us.

TK3 BUG?

Dear EPE,

Using a *Toolkit TK3* standard board, with *TK3* V1.32 software, I am getting some odd effects when trying to set the Config data for "RC oscillator", mostly on 16F84 chips (I thought I had an expensive dud batch for a while!), but also with 16F877s.

I select Send/Read Config Data, and select Reset Config Defaults and get the XT osc option. I send this and the chip works fine with a crystal.

Then I select the RC/EC Oscillator radio button and, sure enough, the OS1 and OS0 bits change, but also the most right-hand CP bit changes, to 0, while still showing "off" and staying grey. If I now send this to the PIC I get the "A CP value may have been set . . . " message, and the read-back values show all CPs set to "on". I also find I cannot disassemble the chip.

If, however, I press Clear CP, then select Reset Config Defaults, then press the RC/EC button and then manually click the right-most CP window, it changes to "1 on" and goes green. If I then send it I get the happy little red Config Sent OK message, everything works and I can disassemble.

I get something similar with the '877 chip, when the CP0 bit is the culprit.

I seem to have sorted out how to get round the problem, but I thought you'd be interested.

Curiously, I don't remember this happening a few weeks ago when I last used the RC option. Another clue may be that, occasionally, the central row of labels in the Configure PIC window (i.e. CP CP CP . . . . WDT OS1 OSO) sometimes gets corrupted – could these come from a file that has been misread, or corrupted? – most odd.

Otherwise, all is well and *TK3* is still a great product!

Roger D. Redman,
via email

Thanks for telling me, Roger. There does seem to be a problem somehow, which I shall look into when I get a suitable opportunity. There are one or two other minor bugs that have come to light and I'll try to fix them at the same time.

Yes, there is a file with config vals, which you can read/amend through the Select PIC Type screen.

BEYOND THE PAIL?

Dear EPE,

I have recently picked up the Dec '02 copy of *EPE*. Thomas Scarborough's capacitive device (*Fluid Finder* in *I.U.*) for differentiating between water and milk would have been extremely handy when I lived in Africa. It was common in our region for the locals to dilute the milk with cows' pee because it has the same specific gravity, so couldn't be detected by a hydrometer. I wonder if it has the same permeability – do any readers know?

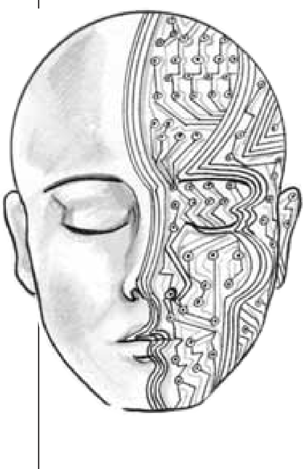
I'll bet someone does – that's what I love about *EPE*, you've got a dedicated involved core of readers, and you've turned into something beyond being just a magazine.

Nick Tile,
via email

So I asked Thomas (who we know is overflowing with the milk of human kindness) for his opinion:

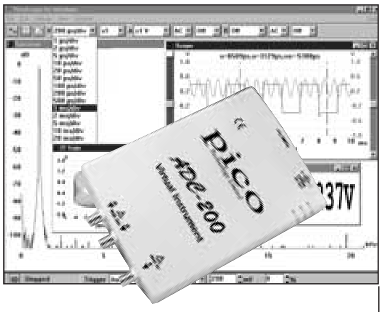
In fact while testing the *Fluid Finder* I did tests with watered-down milk. I can't now remember what percentage water it reliably picked up, I think it was around one-third, which is a lot of water admixture! Ten per cent water would probably bring joy to the heart of any crooked farmer. But the circuit as shown is relatively crude, and just an idea really. I have no doubt that with a little refinement it would pick up pretty small admixtures of water.

Thomas Scarborough,
via email



INGENUITY UNLIMITED

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



WIN A PICO PC BASED OSCILLOSCOPE WORTH £586

- 100MS/s Dual Channel Storage Oscilloscope
- 50MHz Spectrum Analyser
- Multimeter ● Frequency Meter
- Signal Generator

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours.
Every 12 months, Pico Technology will be awarding an ADC200-100 digital storage oscilloscope for the best IU submission. In addition, a DrDAQ Data Logger/Scope worth £69 will be presented to the runner up.

Frequency Switch – Sound Sense

Most sound switches are characterised by a distinct lack of selectivity – among them the well known clap switch and doorbell extender. Contrasted with this, the Frequency Switch of Fig.1 responds only to a narrow passband, which has the width of about one tone at all frequencies. It is also exceedingly sensitive with a potential range of some 50 metres when triggered with a tin whistle.

A two-stage preamplifier is formed by IC1, which uses an inverting amplifier (IC1a) feeding a non-inverting amplifier (IC1b). Trimmer VR1 controls the gain. The amplified signal is sufficient to clock a decade counter IC3. Assuming that the Frequency Switch is "hearing" the specific frequency to which it has been tuned, IC2a will reset IC3 at one-ninth of the frequency of the incoming sound. This means that IC3 will be sequenced through outputs Q0 to Q8 and then it will be reset. If however, a lower frequency is heard then fewer than 9 outputs will go high to logic 1. If a higher frequency is heard then all ten outputs will go high.

To distinguish between the desired frequency and a higher or lower rate, one needs to differentiate between an incoming sound that sequences IC3 through outputs Q0 to Q8 from one that sequences it through outputs Q0 to < Q8, or Q0 to > Q8. This simple logical problem is solved using NAND Schmitt trigger gates IC2b to IC2d. The 100pF capacitors C8 and C9 shunt the pulses from outputs Q8 and Q9. When these outputs form binary 1-0 then IC2d output pin 11 goes high thus illuminating l.e.d. D4. However, a binary 0-0 represents a lower frequency, and a binary 1-1 a higher one. For this to work, C8 must go high more slowly than C9, and low more quickly, for which components D3 and R8-R9 are employed.

In order to build a more "tolerant" circuit use outputs below Q8 and Q9 instead, e.g. Q4 and Q5 would cause the Frequency Switch to respond to a passband of about two tones at all frequencies. The frequency coverage may be altered by changing the value of C4, with a smaller value yielding higher frequencies, and vice versa. Output pin 4 of IC2b may be taken to the trigger input of a 555 monostable timer and output pin 11 of IC2d may be used to clock external logic. Three 100µF capacitors (C1, C7 and C10) are used close to each chip for supply decoupling.

Select the desired frequency by adjusting VR2, which covers approximately 170Hz to 2kHz. Adjustment of the circuit is made easier if a few of IC3's outputs (say Q5 to Q9) drive a series of l.e.d.s., wired to 0V through a 1 kilohm resistor. This also creates an interesting frequency-to-light display that might have other applications.

Rev. Thomas Scarborough,
Fresnaye, South Africa

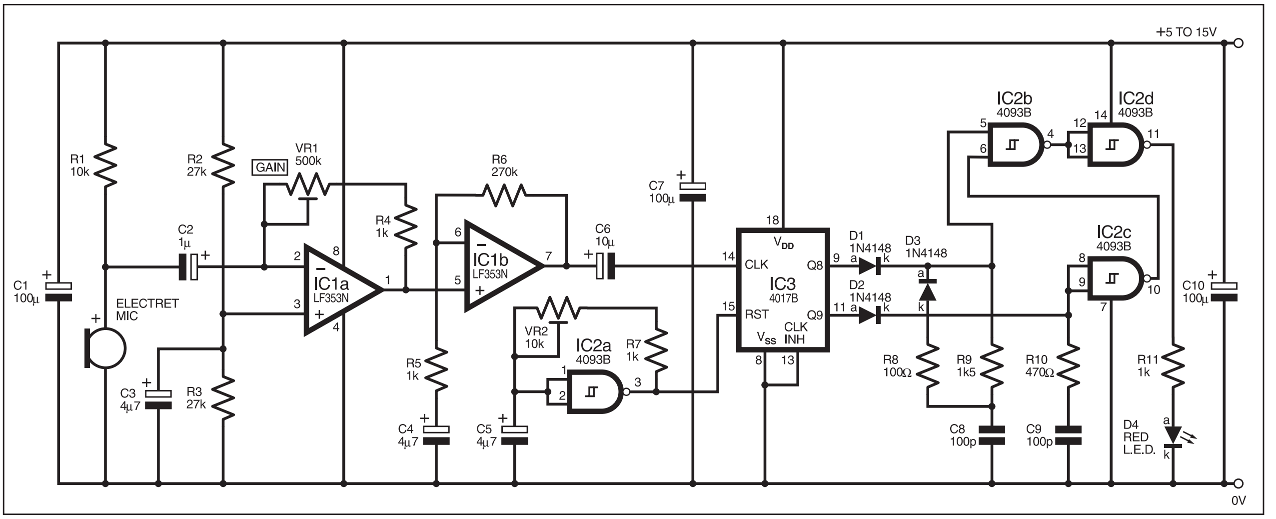


Fig.1. The sensitive Frequency Switch circuit.

Dual Action Regulator – Switching Modes

THE power loss through heatsinking a linear regulator makes them inefficient, but for some circuits, a linear type is more preferable than a switching type. The circuit diagram shown in Fig.2 is a combination of linear and switching circuitry.

Resistor R1 sets the critical key point. Using Ohm's Law (*V=IR*), if resistor R1 is set at 10 ohms and the current flowing through it is 70mA then the voltage across it is 0·7V. When the output current is 70mA, IC1 therefore works as an ordinary linear regulator.

At currents above roughly 70mA, the circuit changes into a switching type, as the voltage across R1 turns transistor TR1 on. Current flows through inductor L2, magnetizing its core. Resistors R2 and R3 form a voltage pedestal network that provide positive feedback to IC1. When V_{out} rises above 5V, the current through IC1 decreases and thus TR1 turns off. Inductor L2 discharges its stored energy into V_{out} via D1 and C3. The cycle repeats, generating little heat in the heatsink.

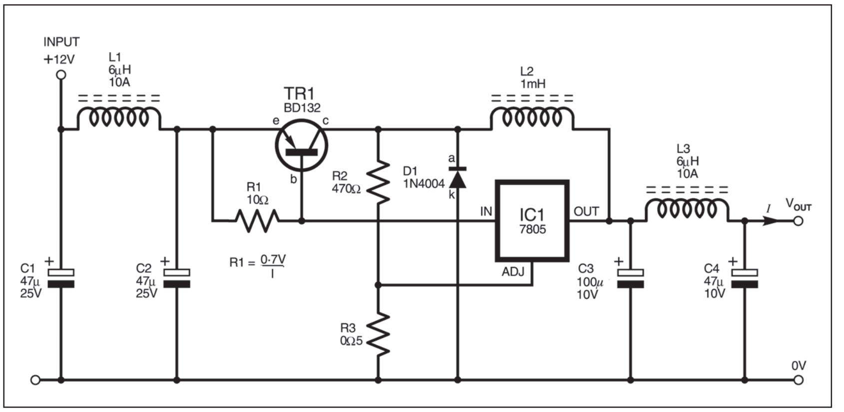


Fig.2. Dual Action Regulator circuit diagram.

When tested with a 12V bulb at the output, efficiency was measured at 69%. Using this circuit meant that a 9V adapter could be used without changing to a higher wattage version. Preferably use switched-mode type electrolytic capacitors, or if not available, use two or more capacitors in parallel without changing the value. A toroid type is most suitable for L2 although Ll and L3 can be any type of ferrite based coils.

Myo Min, Myanmar

Obstacle Sensing For Small Robots – Eyes Open

OBSTACLE detection for small robots is often achieved ultrasonically. The detection circuits can be simplified by taking advantage of the directivity of ultrasonic transducers. For nearby obstacles, the reflected pulse strength is much greater than the transmitter breakthrough, even when the transducers are mounted side by side. So, unlike a pulsed radar – where the receiver must be switched off during the transmit pulse – an ultrasonic receiver can be left on. Fig.3 shows the principle of operation.

The timing pulses which switch the transmitter on and off are shown at "A" and the received reflected pulses after demodulation at "B". (The interval between the transmitter pulses must be sufficiently long to avoid ambiguous interpretation of the received pulses, i.e. which received pulse is caused by which transmitter pulse.) The pulse stream at "A" is taken to the data (D) input of a 4013 D-type bistable and "B" to the clock (CLK) input.

If the received signal arrives before the end of the transmitter pulse, the Q output of the D type will go high. The speed of sound is about 325mm per millisecond, so if the transmitter pulse is, say, 2 milliseconds long then an obstacle at a range of 325mm or less will cause the D type's Q output to go high. The length of the transmitted pulse can be used as a sort of range gate; if the pulse length is increased to 3 milliseconds, obstacles will be detected at about 490mm or less. In practice, the range gate is adjusted to suit the spacing and layout of obstacles which the robot is likely to encounter. In the writer's small wheeled robot, three pairs of transducers are fitted looking ahead and to the sides. The outputs of three D-types are used to determine what action to take when obstacles are detected.

Stephen Stopford, London W2.

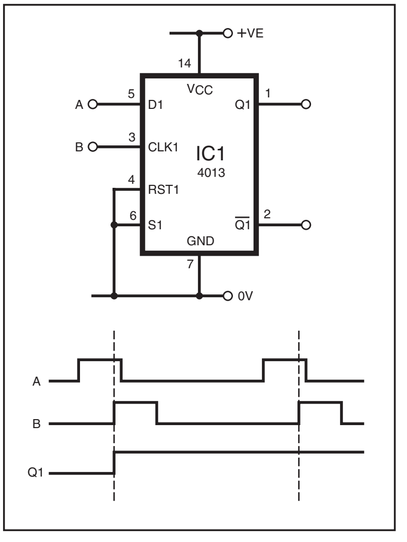
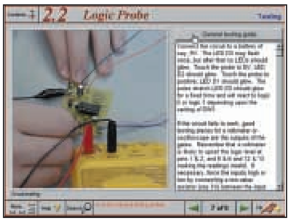


Fig.3. (right) Obstacle Sensing circuit.

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

ELECTRONICS PROJECTS

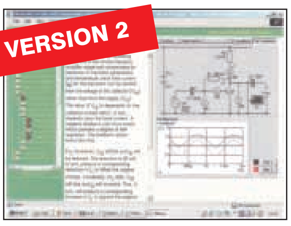


Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture**, **circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

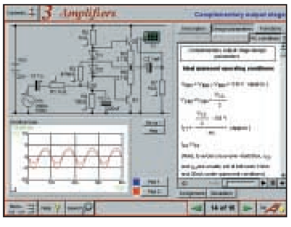
VERSION 2



Circuit simulation screen

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

ANALOGUE ELECTRONICS

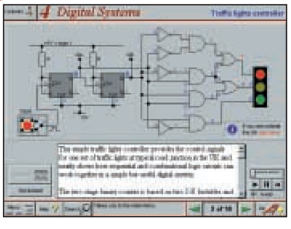


Complimentary output stage

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

DIGITAL ELECTRONICS V2.0

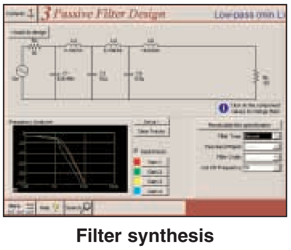
VERSION 2



Virtual laboratory – Traffic Lights

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

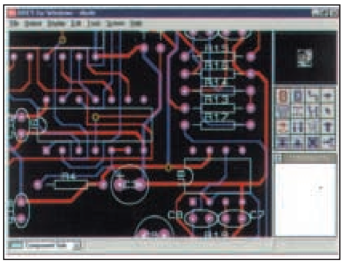
FILTERS



Filter synthesis

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

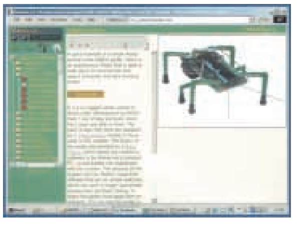
ELECTRONICS CAD PACK



PCB Layout

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

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

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

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

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student ....£45 inc VAT
Institutional (Schools/HE/FE/Industry)..............£99 *plus* VAT
Institutional 10 user (Network Licence)..........£199 *plus* VAT
Site Licence...£499 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

PICmicro TUTORIALS AND PROGRAMMING

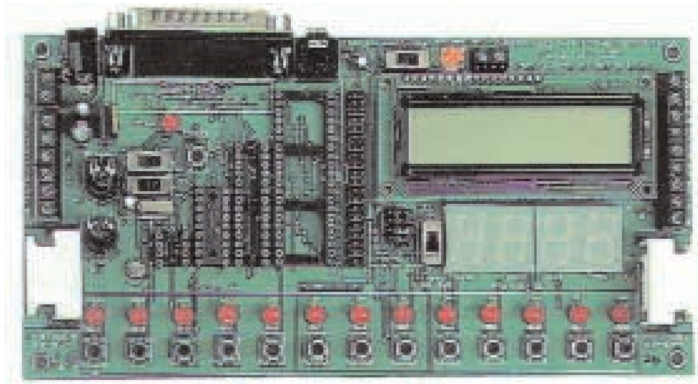
HARDWARE

VERSION 2 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 13 individual l.e.d.s, quad 7-segment display and alphanumeric l.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- All inputs and outputs available on screw terminal connectors for easy connection



£145 including VAT and postage

12V 500mA plug-top PSU (UK plug) £7

25-way 'D' type connecting cable £5

SOFTWARE

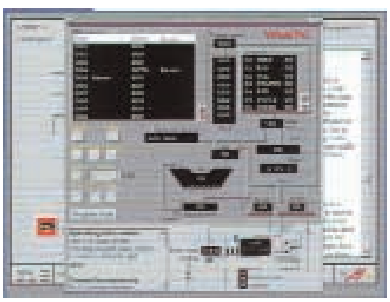
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V2

(Formerly PICtutor)

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

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



Virtual PICmicro

'C' FOR PICmicro VERSION 2

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

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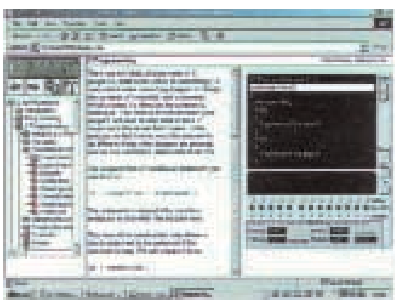

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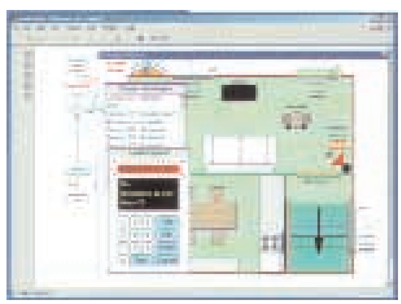

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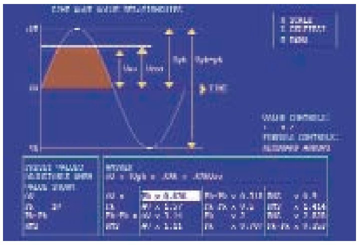

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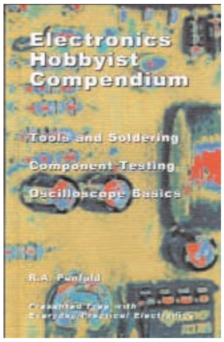

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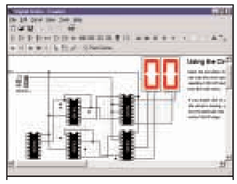

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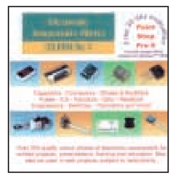

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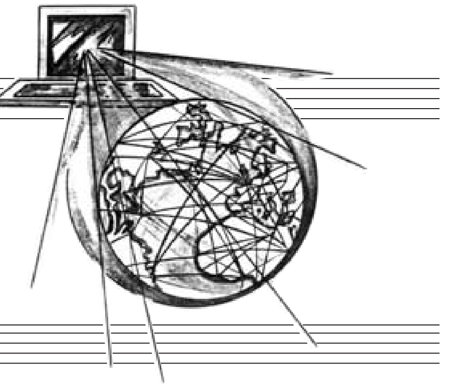


ALAN WINSTANLEY

This is the BBC

LAST month *Net Work* looked at the web site of WorldSpace, the digital satellite radio broadcaster. Before you rushed out to buy a new receiver, a brief review of a typical unit was also included. This month it's back to the Internet again, and we look at the latest version of the BBC web site (**www.bbc.co.uk**), which is a cutting-edge project that is fast becoming one of the world's premier online web resources. The BBC's global expertise in broadcasting shines through, with news available online in no less than 43 languages, from Albanian to Vietnamese and everything in between. The BBC really has played every trick in the book with their web site, which incorporates almost every interactive Internet development you can think of.

As one would expect, the site publishes latest news, sport, weather, TV and radio programme scheduling. News stories are easy to read on-screen, thanks to the use of bite-size layouts and newsprint-style narrow columns that are easy on the eyes, though some pages seem to scroll down for an eternity. Further interactive resources are provided which support TV programmes, including message boards and chat rooms. Comments can be entered into an online form and sent to the BBC editors for possible publication.

There's more: dig deeper, and thousands of web pages are revealed with information split into dozens of different categories including education, technology, science and nature, regional and local information, plus in-depth articles on a hundred or more other topical subjects. As if that isn't enough, the BBC News is also accessible on your personal digital assistant (PDA) and even on a WAP phone. The BBC broadcasts a dizzying array of information over the Internet, and even manages to squeeze in Real Video extracts, though this seems to suffer from jerky motion at times, so it isn't quite there yet.

London Calling

Then there are the BBC's Internet radio channels, which transmit BBC Radio's output (the six Greenwich time signal pips and all!) via a streaming RealAudio player, and I have a surprise: it really does work extremely well! Go to **www.bbc.co.uk/radio/** and find a station, then allow a short period for the audio signal to "buffer" in your installed RealAudio player. After the buffer has filled, you can enjoy good quality audio over your computer's loudspeakers. The BBC's description of "Live" radio is however a misnomer – it's late into the evening as I write, but I'm hearing this morning's Terry Wogan breakfast show! Like playing a two-hour tape loop from the beginning, the BBC Radio Player applet lets you skip through the programme in five minute intervals.

Screenshot of the BBC Internet radio player applet, listing a selection of some current shows.

The streaming audio quality is slightly transistor-tinny, but proves to be absolutely acceptable; even when using my overworked 56K dial-up connection at peak evening times, I managed to achieve a good 35 kilobits per second rate with hardly any interruptions, all this on a very modestly specified PC. The quality and selection of program is really commendable, all things considered.

Whilst Internet radio is not new – there are plenty of other stations available, it opens up a welcome new dimension for overseas users and ex-patriots as well, who can now receive the best of British broadcasting via their Internet connection. You can also check the Open Directory listing of radio channels at **http://dmoz.org/Arts/Radio/Internet/**. There is a useful guide at the International Broadcasting Web Directory at **www.ilgradio.com/ibwd**, which describe itself as "a Yellow Pages of world wide broadcasting". Enjoy streaming radio programs to your home computer and bookmark the BBC web site now.

Going, going...

Previously I suggested the services of Email Filtering (**www.emailfiltering.co.uk**), which is a paid-for service that intercepts spam from your mailbox automatically. The quality of service (as defined by the numbers of spam mails blocked) is rising steadily and EMF have now refined their service further with their enigmatically named "List R" filter. The company remains very tight-lipped about this latest enhancement, but I can report that the success rate has leapt noticeably, now with a consistently very high rate of interception (say 98%). Also new is their webmail front end, where custom filter rules can be created.

At the time of writing, no less than 1,500 spams and viruses have been automatically intercepted without the writer lifting a finger, saving days of work in handling them. Unfortunately, the success rate was dented by a glitch at the end of November 2002 when EMF's mailservers seemed to get stuck in a loop. One morning I was deluged by almost 200 emails! In fact it was about half a dozen genuine emails that had been copied 30-40 times by EMF's mailservers, filling my mailbox with junk and unravelling my email management routine in the process. Let's hope it is a one-off fault. The service is £21 per mail account per year and is worth checking out if you are plagued by spam.

Back in Pole-land

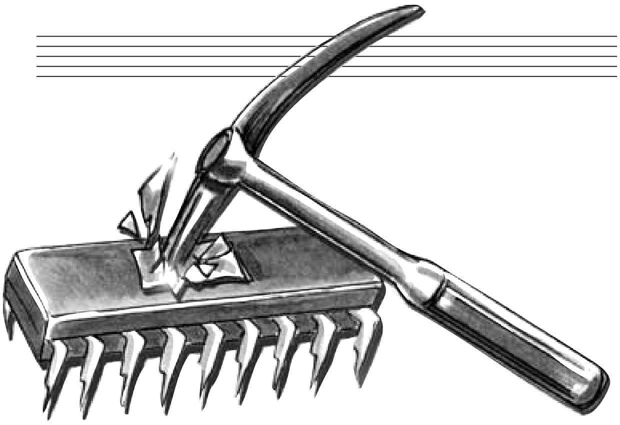
To round off this month's column, regular followers will remember the plight of the official *EPE Net Work* telegraph pole, the one that carries the writer's telephone lines. Having just had another outage on one line, it seems that a short circuit at the local phone exchange (a wooden hut several miles away) caused someone else's ISDN line to be shorted over to my own. All I could hear on the line was data (theirs, not mine) and my modem was unable to dial out for days. The telegraph pole also has a "D" symbol on it, meaning that it's dangerous to climb, so the BT engineer wouldn't go up it. It took four days to fix.

Naturally, the exchange isn't going to be upgraded for ADSL. As some final food for thought, a typical 56K dial-up user paying £14.99 per month now pays, in terms of bandwidth, about *six times more* for their Internet access than a comparable ADSL or cable user does at £28 per month. Thus, all those users who are beyond the reach of ADSL or cable continue to be heavily penalised for their Internet access in terms of both the user's wasted time as well as their money, and there is little sign of it improving.

Lastly, if you really do enjoy Spam (the foodstuff, that is) then you will enjoy the merchandise available at the official Spam website, so bounce along to **www.spamgift.com**, where you will find plenty of gifts that are ideal for harassed Internauts everywhere. I especially like the plastic beach sandals that imprint the word "Spam" in the sand . . . See you next month for more *Net Work*.

You can e-mail me at **alan@epemag.demon.co.uk.**

PICAXE PROJECTS



MAX HORSEY

Part 3 – Chaser Lights

Using the PICAXE system, you do not need specialised equipment or knowledge to program the PIC microcontrollers used in these designs.

IN the previous two parts of this three-part series we described six projects controlled by a PICAXE-18, a microcontroller based on Microchip's PIC16F627 device but which has been modified so that it can be programmed by using a version of BASIC via a serial link connected to a PC-compatible computer. The PICAXE-18 was discussed more fully in Part 1.

The projects in Part 1 were an Egg Timer, Dice Machine and a Quiz Game Monitor and used the PICAXE's digital options. In Part 2 the PICAXE's analogue inputs were used to create a Temperature Sensor, Voltage Sensor and a VU Indicator.

Here in Part 3 we describe a Chaser Lights system which uses both analogue and digital functions and has the following features:

- Six channels
- Auto speed (speed changes during chasing)
- Sound controlled speed (higher sound level = increased speed)
- Auto switch-off (no sound causes lights to switch off)
- Display via six mains powered lamps and/or six l.e.d.s

IRRESISTIBLE

The author could not resist making the PICAXE-18 behave as a Chaser Lights controller, and the device's programming method is ideal for making modifications to the chasing sequences. Additionally, since the PICAXE-18 features analogue inputs, it was easy to add a sound function. A separate mains interface lamp driver circuit was also developed, and this additionally provides a regulated 5V supply for the control circuit.

The complete circuit diagram, upon which the general purpose printed circuit board (p.c.b.) used in this series is based, was shown in Part 1. The modified circuit diagram as used in the Chaser Lights controller is shown in Fig.1, with the PICAXE-18 microcontroller designated as IC1. Note that the component numbering is the same as used in the full general-purpose circuit shown in Part 1 Fig.1.

When adapting the system for use as a Chaser Lights controller, it was decided to set the number of light outputs to six. This reduces the cost of the mains interface described later and the quantity is more than is often used for elaborate chaser patterns. In fact, many commercially available Chasers are based on a 4-channel system.

PICAXE-18 outputs RB0 to RB5 are used to drive the interface board and its connected lights. Light emitting diodes (l.e.d.s) D1 to D6 are also connected to these outputs and indicate that the control circuit is working.

Switch S2 is connected to input RA1 and is used to select whether the Chaser speed is set to "auto" or controlled by sound. An external sound signal can be connected to input RA0, which is configured as an analogue input.

CONTROL PROGRAM

The command **let pins = %00000001** turns on l.e.d. D1 via output RB0. Remember that in binary the bit numbers run from right to left, 0 to 7. As discussed in Part 1, the percentage sign tells the PICAXE's compiler that the value is expressed in binary. The program control sequence is:

```
let pins = %00000001
pause 100
let pins = %00000010
pause 100
let pins = %00000100
pause 100
let pins = %00001000
pause 100 etc.
```

This sequence causes the lit l.e.d. to "move" one place to the left, pausing for 100 milliseconds (0·1s) at each stage, reappearing from the right after the sixth l.e.d. (D6) has been turned on and then off. Hence the lights will appear to chase. Clearly it is possible to chase more than one light at a time and to vary the direction and speed as required.

GETTING MATHEMATICAL

However, a problem occurs when a number of sequences are cascaded in a PICAXE-18. The memory is quite limited, and you could soon find that a download will fail with a "memory exceeded" warning. So a more intelligent chasing system is required.

Examination of the actual Chaser program in Listing 1 shows little resemblance to the example above. In fact, the only reference to the output pins is the line near its end: **let pins = b9**. In this case **b9** is a variable expressed in decimal whose binary equivalent sets the pattern of lights displayed. For example, the decimal number 12 has the 8-bit binary equivalent of %00001100, hence the command **let pins = 12** will cause l.e.d.s D3 and D4 to light (controlled by bits 2 and 3).

By advancing the variable **b9** in set sequences it is possible to produce a number of chasing patterns across the six channels. If you wish to modify the system for only four channels, then several lines will need changing, in particular the command **for b0 = 1 to 5**. (Use your text editor's search or find facility to locate **b0**.)

CHASING SPEED

The speed of the chase is quite critical, and two modes are provided: "auto" where the speed changes automatically, and "sound" where the speed increases with the sound's amplitude. The modes are controlled by switch S2 – off for "Auto", on for "Sound".

Auto speed is determined by variable **b5**, and each time the program loops, having stepped through the entire chase

LISTING 1

```
'chaser5
'with optional sound input on analogue AN0
'if input IN1 is low, speed varies automatically
'if input IN1 is high, speed depends on sound input
'quiet sounds = slow, loud sounds = fast
'designed for 6 lights

'b5 = non-sound input speed i.e. auto speed
'b8 = final speed
'initial speed is 0 (i.e. 256)

start:   let b5 = b5 – 40          'speed up display by 40
         for b3 = 1 to 5           'start of outer loop
         let b1 = 1                'reset b1

         for b0 = 1 to 5           'start of first inner loop
         readadc 0, b7             'read sound level
         let b8 = b7 + b7          'double analogue reading
         let b8 = 200 – b8         'make b8 lower if sound level higher
         if pin1 = 1 then skip     'skip next line if IN1 is high
         let b8 = b5               'set final speed to auto speed
         let b7 = 20               'ensures lights do not auto shut-off

skip:    let b1 = b1 * 2           'make b1 rise, 2,4,8,16,32
                                    per inner loop
         let b9 = b1 * b3          'make b9 rise, per outer loop
         if b7 = 20                'ensures lights do not
         if b3 = 2 then invert     'add variety by inverting lights
         if b3 = 5 then invert     'add variety by inverting lights
         goto norm

invert:  let b9 = 63 – b9          'provide inverse display

norm:    if b9 > 64 then jump      'prevents chasing too far
         let pins = b9             'switch on lights
         pause b8                  'pause lights

jump:    next b0                   'end of first inner loop

         let b1 = 32               'start of count down

         for b0 = 1 to 5           'start of new inner loop
         let b1 = b1 / 2           'make b1 fall, 16,8,4,2,1
         let b9 = b1 * b3          'make b9 rise per outer loop
         if b3 = 2 then invert2    'add variety by inverting lights
         if b3 = 5 then invert2    'add variety by inverting lights
         goto norm2

invert2: let b9 = 63 – b9          'provide inverse display

norm2:   let pins = b9             'switch on lights
         pause b8                  'pause lights
         next b0                   'end second inner loop
         next b3                   'end outer loop .
         goto start
none:    let pins = 0
         goto start
```

Chaser Lights modules (left to right, top to bottom), 6-Channel Mains Interface, Lights Controller and Simple MOSFET Low Voltage Interface.

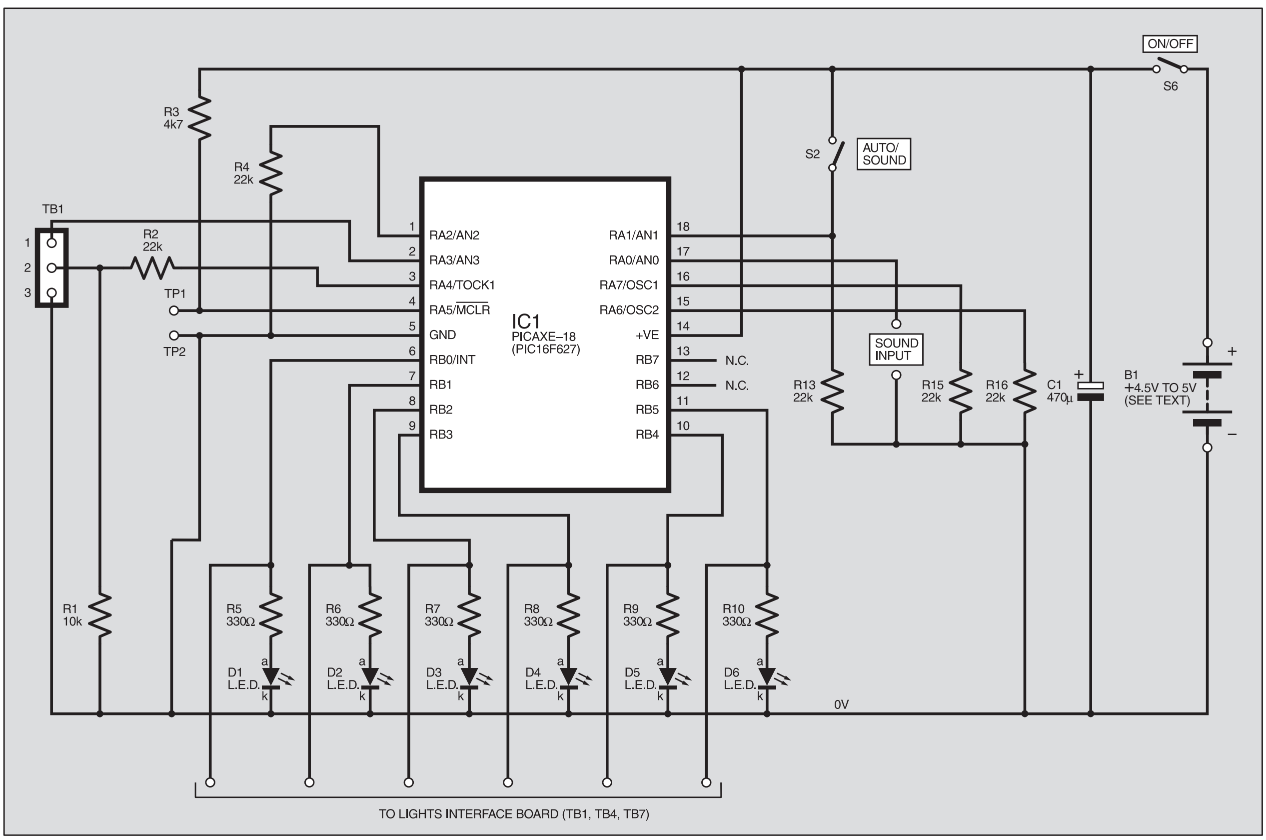


Fig.1. Complete circuit diagram for the Chaser Lights Control section.

sequence, **b5** is reduced by a decimal value of 40. The time for which the program holds the lights is determined by the command **pause b8**. In this mode **b8** copies **b5**, and hence the chasing speed slowly increases, eventually resetting.

The basic sound interface circuit was described in Part 2 (diode pump – Fig.6) to which readers are referred for more information. The circuit is intended for connection to an amplifier's normal loudspeaker or headphone terminals. Note that the system is not designed to be connected to a "100V line level" as used by some high-power speaker systems. If you wish to use a microphone input in place of a connection to loudspeaker terminals, a suitable circuit based on two transistors was described in Part 2, Fig.7.

The sound level output from potentiometer VR1 in Part 2 Fig.6 is connected to PICAXE-18 pin RA0. The amplitude voltage level is read by the command **readadc 0, b7**, which places the digitally converted value into variable **b7**. The result is then doubled and subtracted from 200 to provide a reading (**b8**) which falls as the sound level increases. Hence the command **pause b8** sets the pause time in accordance with the sound level (higher sound = shorter time).

If no sound is being input, then the lights turn off completely. This is achieved by the command **if b7 < 10 then none,** which causes the program to jump to the routine at label **none:**, which turns off the lights.

INTERFACING 12V LAMPS

The current available from the PICAXE-18 is only suitable for driving l.e.d.s. If you wish to drive larger lamps, an interface is required. A suitable circuit for a single interface channel is shown in Fig.2.

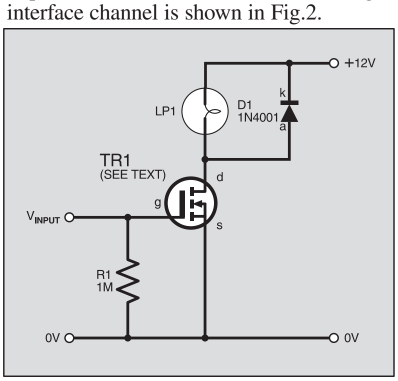


Fig.2. MOSFET driver circuit for 12V low power lamps.

A suitable type for transistor TR1 would be a Darlington such as a TIP121 bipolar device. However, MOSFET transistors are quite competitive in price and require even less current than a bipolar transistor. Types BUZ11 or BUZ11A are suitable, though if you wish to interface between the 5V powered PICAXE-18 circuit and lamps powered at 12V d.c., then MOSFETS are essential. These are able to switch 12V even though their gates are driven by 0V/5V input voltage levels.

Note that unlike with a "normal" bipolar transistor, no current limiting input resistor is required in series with the gate.

If the gate is not permanently connected to a signal source (e.g. the PICAXE-18) then a pull-down resistor of 1MΩ is required to prevent the gate from "floating" and thus being subject to picking up damaging static electricity. However, if the gate is permanently connected to the PICAXE-18, then this resistor is unnecessary, but it will do no harm if left connected.

Diode D1 is shown in parallel with the lamp in case the interface is used to drive inductive loads such as motors or relays. If the interface is only to be used with lamps, then the diode may be omitted.

INTERFACING MAINS LAMPS

Mains lamps remain the most popular way of creating Chaser Light effects and a wide variety of coloured reflector bulbs are available. The main advantage is that although each lamp may be rated at say 230V 60W, the current required will be only 0·26A. By comparison, a 12V 60W lamp requires a massive 5A. So a 6-channel

COMPONENTS

Control Circuit

See SHOP TALK page 71

Resistors

R1	10k
R2, R4, R13, R15, R16	22k (5 off)
R3	4k7
R5 to R10	330Ω (6 off)

All 0.25W 5% carbon film.

Capacitors

C1	470µ radial elect. 16V

Semiconductors

D1 to D6	red l.e.d. (6 off)
IC1	PICAXE-18 microcontroller, pre-programmed (see text)

Miscellaneous

B1	4.5V battery and clip (see text)
S2, S6	min. s.p.s.t. toggle switch (2 off)
TB1	3-pin serial connector (shrouded 3-pin header, see text)
TP1, TP2	1mm terminal pins (2 off)

Printed circuit board, available from the *EPE PCB Service*, code 373; 18-pin d.i.l. socket; transparent plastic case 120mm x 65mm x 40mm approx (see text); p.c.b. supports (4 off); connecting wire; solder, etc.

Mains Interface Circuit

Resistors

R1, R4, R7, R10, R13, R16	120Ω (6 off)
R2, R5, R8, R11, R14, R17	56Ω (6 off)
R3, R6, R9, R12, R15, R18	330Ω (6 off)

All 0.25W 5% carbon film.

Capacitors

C1	1000µ radial elect. 25V
C2	100n ceramic disc

Semiconductors

REC1	W005 bridge rectifier, 1.5A 50V
CSR1 to CSR6	BTA08-600B or TIC226 triac, isolated tab (6 off)
IC1 to IC6	TLP3042 triac opto-isolator, zero crossing (6 off)
IC7	7805 5V 1A voltage regulator

Miscellaneous

T1	mains transformer, twin 6V a.c. secondary windings, 1.5VA, p.c.b. mounting
TB1, TB4, TB7, TB10	2-way screw terminal block, p.c.b. mounting (4 off)
TB2, TB3, TB5, TB6, TB8, TB9, TB11	3-way screw terminal block, mains rated, p.c.b. mounting (7 off)

Printed circuit board, available from the *EPE PCB Service*, code 381; 6-pin d.i.l. socket (6 off); locking cable grommet (8 off) (see text); robust plastic case, minimum size 150mm x 90mm x 55mm (see text); p.c.b. supports (4 off); d.p.d.t. mains rated toggle switch, 1A minimum (see text); panel mounting fuseholder and fuse rated to suit lamps (see text); connecting cable, mains rated, length to suit application; chaser lights assembly, components as required; solder etc.

MOSFET Circuit – Single Channel

R1	1M 0.25W 5% carbon film resistor
D1	1N4001 rectifier diode
TR1	MOSFET (see text)
LP1	lamp to suit (see text)

Stripboard, 5 strips, number of holes to suit channel quantity (see text).

Sound Interface Circuits

For components required see Part 2.

Approx. Cost Guidance Only **£36** *excl. case, batts. and lamps* chaser running on 12V might need a supply of 30A. This current is much too large to be viable, and so the 12V interface described earlier is suitable only for lamps with much lower power ratings.

A mains interface circuit operates with much more manageable currents. The penalty, of course, is that care must be taken against the risk of a 230V mains a.c. shock.

The mains lamp interface circuit was designed on a printed circuit board (p.c.b.) which also houses a power supply for the PICAXE-18 circuit. Opto-isolators are employed to ensure that the mains supply cannot find its way into the PICAXE-18 circuit.

The principle of operation is shown in Fig.3. The low voltage signal from the PICAXE-18 circuit is kept entirely separate from the mains supply by means of the opto-isolator. This houses an l.e.d. and triac sensor in a single enclosed unit. Within the manufacturer's specified voltage limits (several thousand volts), there is no risk of the dangerous mains voltage reaching the l.e.d.

Any type of triac opto-isolator should work, but the recommended one is a "zero crossing" type. This ensures that the sinusoidal a.c. mains supply is only switched on or off at the moment when its voltage is near to zero. This greatly reduces the risk of radio interference and other unwanted effects to the extent that no precautions are needed in this circuit. Hence the only remaining components required are two resistors and a power triac.

The latter device is able to switch a high-current a.c. supply on and off and the type suggested is rated at 8A. However, a current of 8A should not be allowed to flow through the tracks of the p.c.b., which are only rated at about 1A maximum.

The triacs are provided with isolated heatsink tabs, but in extensive tests they were not found to heat up at all and so additional heatsinking was not found to be necessary.

The full circuit diagram for the 6-Channel Mains Interface is shown in Fig.4. Each mains-rated output terminal block

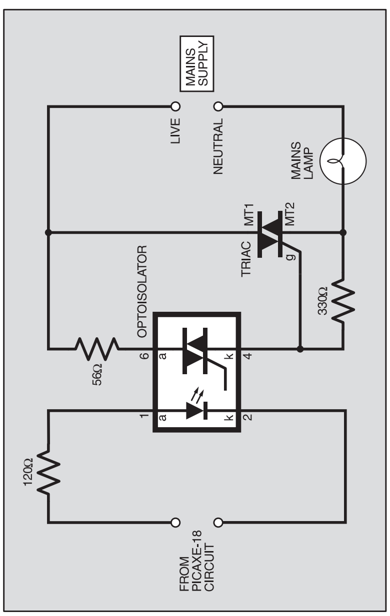


Fig.3. Basic circuit diagram for the Mains Interface

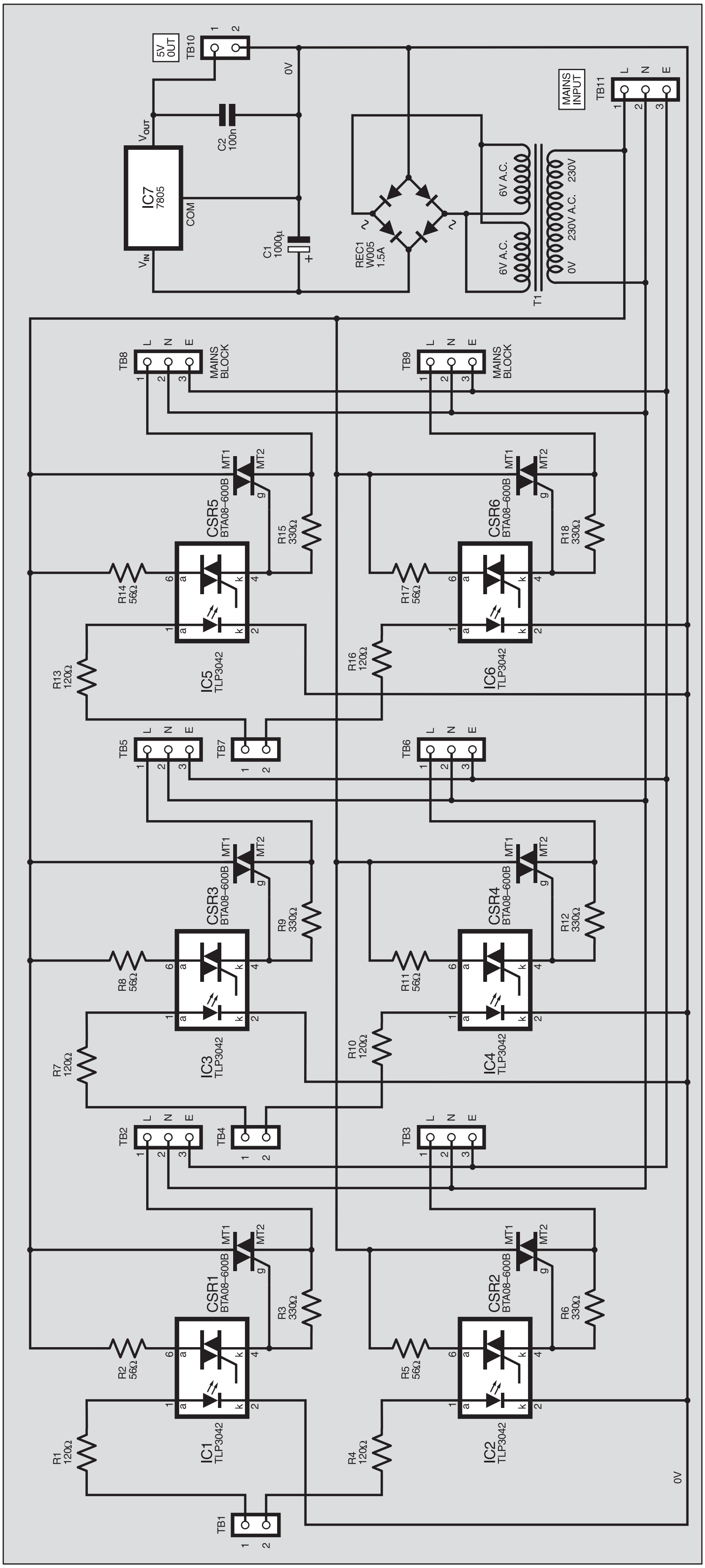


Fig.4. Full circuit diagram for the 6-Channel Mains Interface

(e.g. TB2) provides a Live/Neutral/Earth supply to each lamp. It is possible, of course, to connect several lamps to each mains block in order to power several sets of lights, providing the maximum current handling of the system is not exceeded. A number of factors will affect this figure, but a maximum of 1A per channel is a good guide.

POWER SUPPLY

The interface circuit in Fig.4 includes a 5V d.c. power supply, comprising transformer T1, bridge rectifier REC1, voltage regulator IC7, plus capacitors C1 and C2. This provides power for the PICAXE-18 circuit.

Transformer T1 is a p.c.b. mounting type with a total rating of 1·5VA. It has two windings used in parallel, each capable of providing 6V a.c. at 0·125A. When bridge-rectified by REC1 and smoothed by capacitor C1, the d.c. voltage is approximately 6V × 1·414 – 1·4V (the latter being the voltage drop across the bridge rectifier's internal diodes). The theoretical output supply is about 7V at 180mA.

In practice, though, small transformers are very badly regulated and so the actual voltage produced may be nearly twice the total expected when "off load" i.e. no current is being drawn.

Voltage regulator IC7 provides an accurate 5V supply for the PICAXE-18 circuit. Capacitor C2 helps to removes any spikes which may be present on the supply. Variations in the rectified voltage fed to the regulator do not affect its output voltage, provided the input voltage is at or above 7V d.c.

CONSTRUCTION

Assemble the PICAXE Chaser printed circuit board (p.c.b.) first. The board is the same as that used in Parts 1 and 2 of this series. This board is available from the *EPE PCB Service*, code 373. The component layout and interwiring details for the Chaser p.c.b. are shown in Fig.5.

Note that if using the fully assembled board as shown in Part 1 Fig.2, leaving in

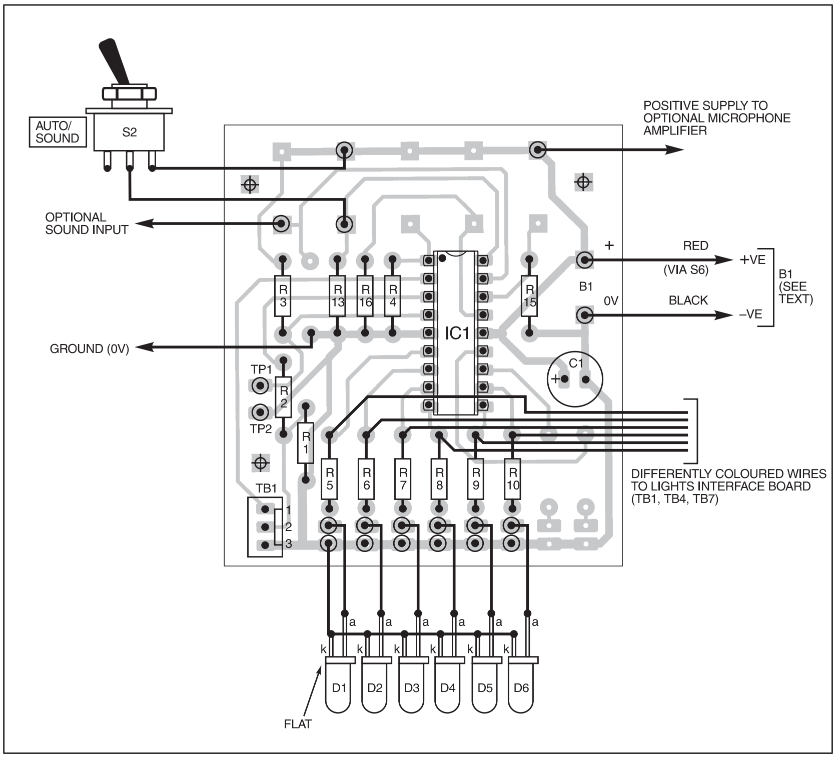


Fig.5. Chaser Controller printed circuit board component layout and wiring details. The multiboard full-size copper foil master pattern is shown below. (This board is available from the EPE PCB Service*).*

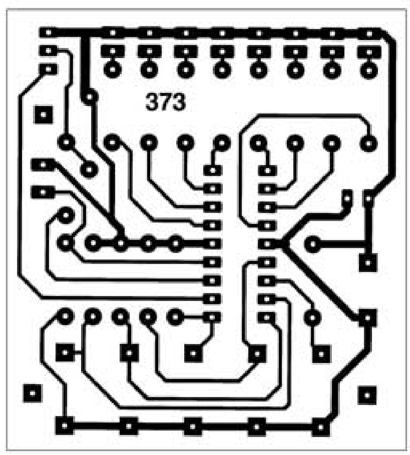
the components not required for the Chaser circuit will not affect its operation, apart from resistor R14 which *must* be omitted if a sound input is required.

Begin by soldering in the 18-pin d.i.l. socket, then fit the remaining components as shown. Ensure that the l.e.d.s and capacitor C1 are fitted the correct way round. Connector TB1 is required if the PIC is to be programmed in-circuit (as discussed in Part 1). Again, ensure that this is connected the correct way round.

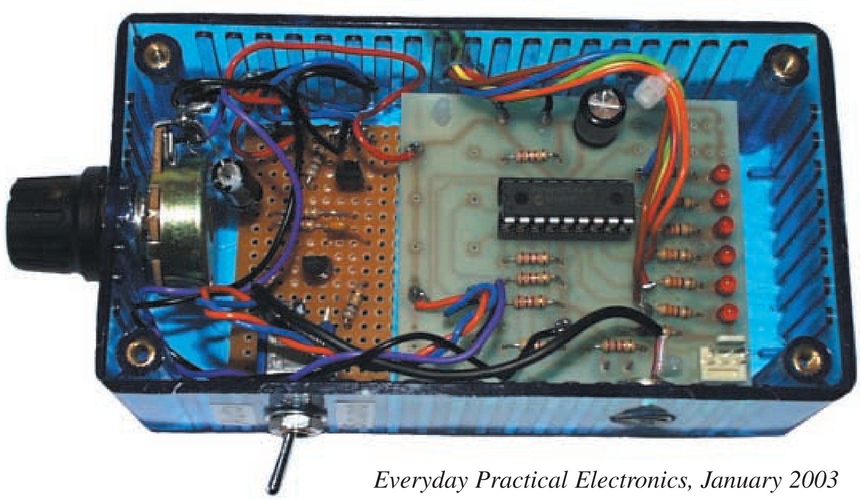
Terminal pins TP1 and TP2 are used in case the PIC needs resetting (also discussed in Part 1). Since this is likely to be an infrequent requirement it is not worth connecting a pushswitch, and a screwdriver blade (or any metal object) may be placed between the pins to reset the PICAXE.

The board is now usable as a standalone unit in which just the l.e.d.s provide the

2·2in. (56mm)



2·4in. (62mm)



Chaser lights, controlled by sound in conjunction with microphone amplifier and/or diode pump as discussed in Part 2 in relation to the VU Meter.

However, if this board is to be used with the mains lamp interface board, fit six colour-coded signal leads, soldering them to the same pads as used by resistors R5 to R11 (or direct to the appropriate resistor wires, as was done with the prototype). Also fit two colour-coded leads for the power supply connections.

MAINS INTERFACE CONSTRUCTION

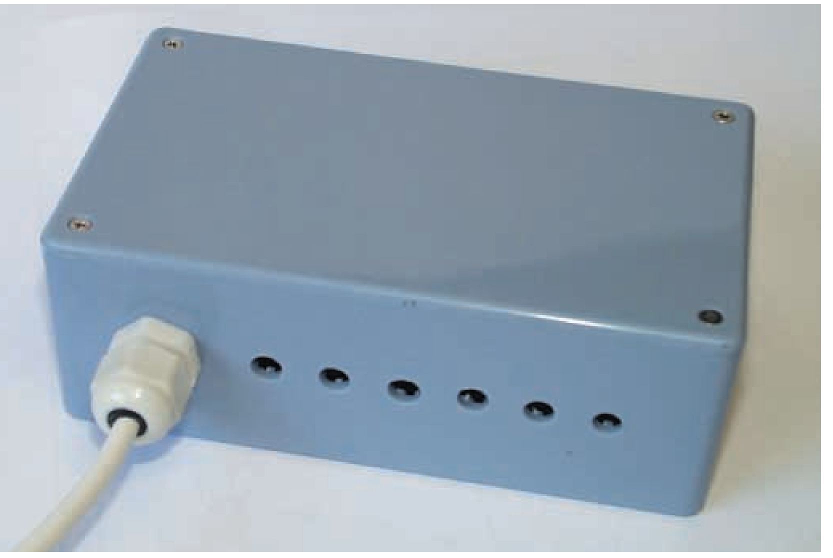
It is stressed that construction of the mains interface should only be carried out by those who are competently experienced in handling mains powered circuits.

Component and track layout details for the mains interface board are shown in Fig.6. This board is available from the *EPE PCB Service*, code 381.

Begin assembly with the 6-pin d.i.l. sockets, followed by the resistors and capacitor C2.

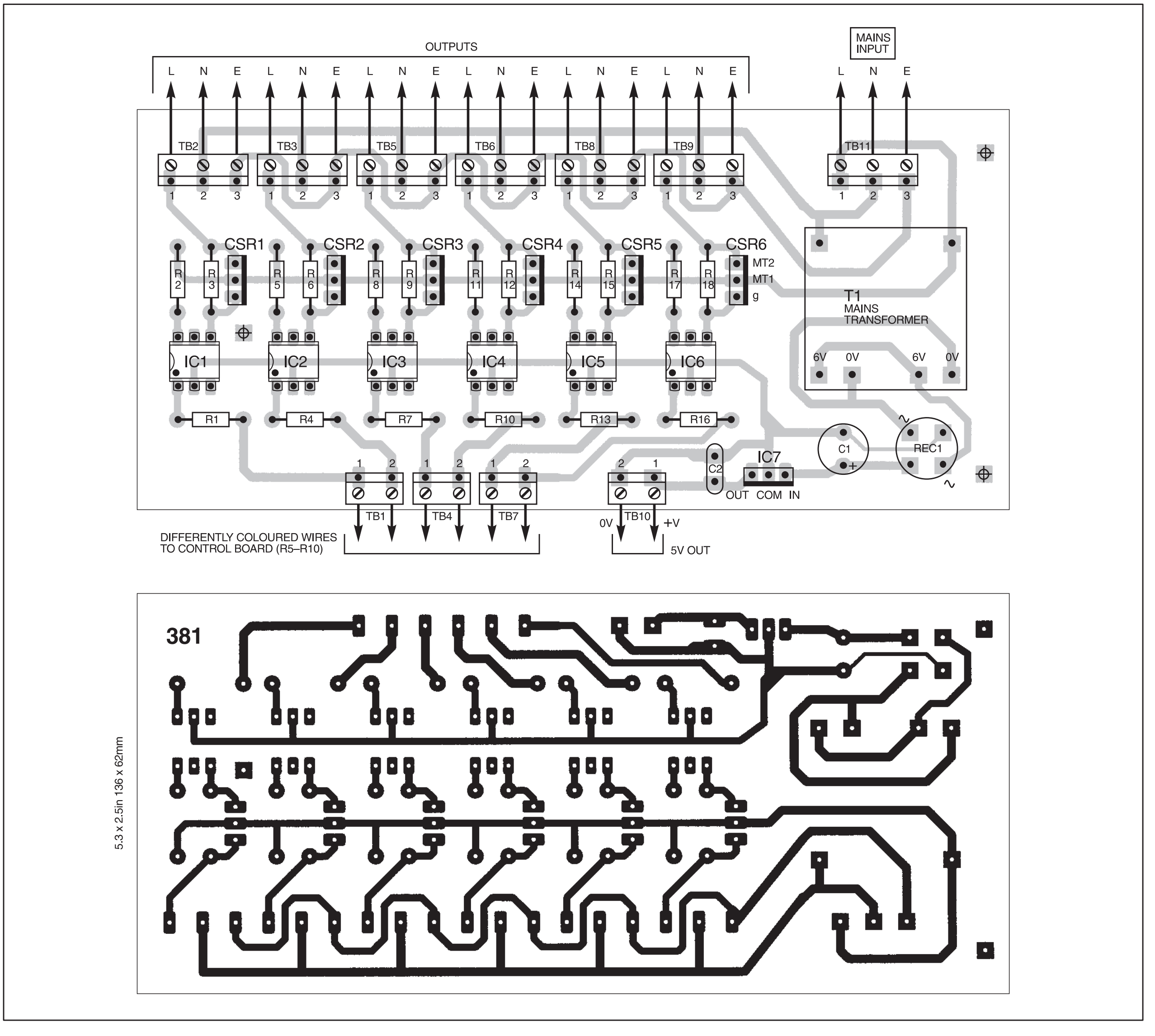
It is imperative that the triacs, capacitor C1, regulator IC7 and bridge rectifier REC1 are fitted the correct way round as shown. Next fit the terminal strips

6-CHANNEL MAINS INTERFACE



Completed Interface unit. The six holes for the mains output leads to the lamps must have lead clamping grommets mounted in them.

Fig.6. Printed circuit board component layout, interwiring details and full-size underside copper foil master for the 6-Channel Mains Interface.



ensuring that access for the external wiring is from the edge of the p.c.b.

Mount the mains transformer on the p.c.b. as the final item. Its pins must be carefully aligned before it can be pushed *fully* into place and soldered.

Finally, insert the opto-isolators (IC1 to IC6) into their sockets taking great care to fit them the correct way round, as shown.

Ensure that you fully check the assembly and soldering *before* applying power.

HOUSING AND DISPLAY OPTIONS

The prototype system was housed in separate cases to ensure that all the low voltage parts of the circuit were kept entirely separate from the mains parts. The two cases may be bolted together, or alternatively the mains interface can be housed as part of the mains lighting system.

If the Chaser is used only for an l.e.d. display then the case should be chosen with care, in order that an attractive display of l.e.d.s can be employed, mounted in its lid.

Note that a maximum of two l.e.d.s can be connected in series, since each l.e.d. has a forward voltage drop of about 2V. A maximum of two l.e.d.s can be connected in parallel, hence the total permissible number of l.e.d.s per channel is four. If more l.e.d.s are required per channel, then the MOSFET interface circuit is required as described earlier, and further discussed later.

The prototype system was intended for chasing mains lights, with which the single set of l.e.d.s on the p.c.b. were used to indicate that the circuit is working. The board was mounted in a transparent case so that the l.e.d.s can be seen, confirming that the control circuit is functioning. The case used in the prototype measures 120mm × 65mm × 40mm.

This case also houses the microphone preamplifier stripboard sub-assembly and the diode pump components. Holes were drilled for the sound level potentiometer, VR1, switch S2, electret microphone insert MIC1, and the wires for connecting to the Mains Lamp Interface in a separate case.

MAINS INTERFACE HOUSING

As with all mains projects, care must be taken to ensure that nothing can come into contact with the mains voltage. Hence a good quality plastic case is required for the mains lamp interface.

Holes are required for the mains input lead locking grommet, and for the mains output leads to the lamps. These too should be secured by locking grommets or "P" clips.

Also drill a hole for the low voltage wires required between the Chaser and Interface. These too should be used in conjunction with a locking grommet.

To comply with adequate safety requirements, a mains rated power on/off switch and panel mounted fuseholder should be included as well. The fuse rating should be chosen to suit the wattage of the lamps used.

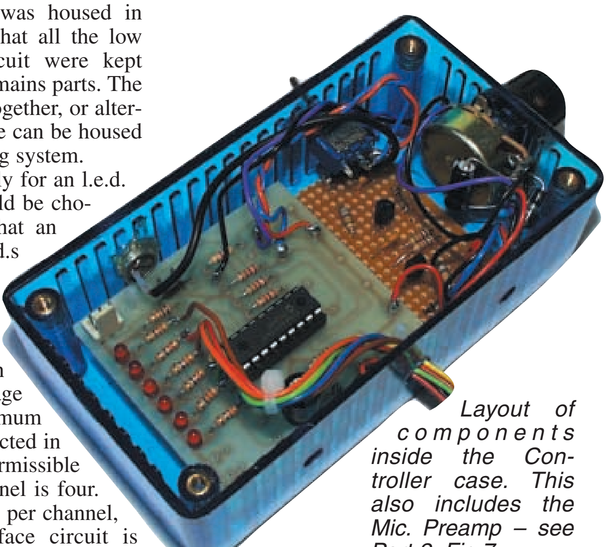
Note that the additional grommets, switch and fuseholder will require the use of a case larger than that used in the prototype, which measures 147mm × 88mm × 54mm.

Secure the board firmly to the base of the case by means of robust p.c.b. supports. Fully check the accuracy of your wiring and then screw down the case lid before connecting the interface to the mains.

TESTING

First check the Chaser unit on its own with a separate battery power supply of around 4·5V (as discussed in Part 1).

As discussed in Part 1, the PICAXE-18 may either be programmed in situ on the p.c.b., or purchased from the author as a pre-programmed device, as stated later.



Layout of components inside the Controller case. This also includes the Mic. Preamp – see Part 2, Fig.7.

With the programmed PICAXE-18 inserted, switch on the power and check that the l.e.d.s respond as expected when switch S2 is set to "Auto", and also when sound is input by the chosen method and S2 is switched to "Sound". Sounds received by the microphone should cause a small varying voltage to be applied to pin RA0. The varying voltage levels should make the lights switch on and chase as discussed earlier.

It is essential to check the accuracy of the 5V d.c. supply from the interface unit before connecting it to the Chaser in place of the battery supply. You should obtain a reading of nominally 5V, but it could lie between 4·75V and 5·25V. A reading significantly different is likely to indicate that regulator IC7 is incorrectly inserted.

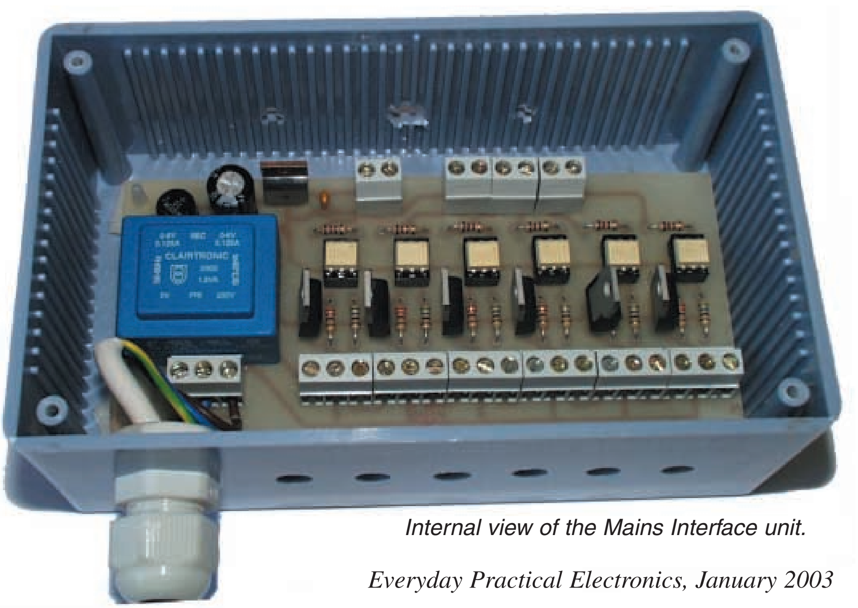
Simple lamp display box.

Ultimately, when the lamps are connected to the mains interface unit, they should copy the l.e.d.s. If any fault finding is necessary, ensure that the unit is disconnected from the mains before opening the case.

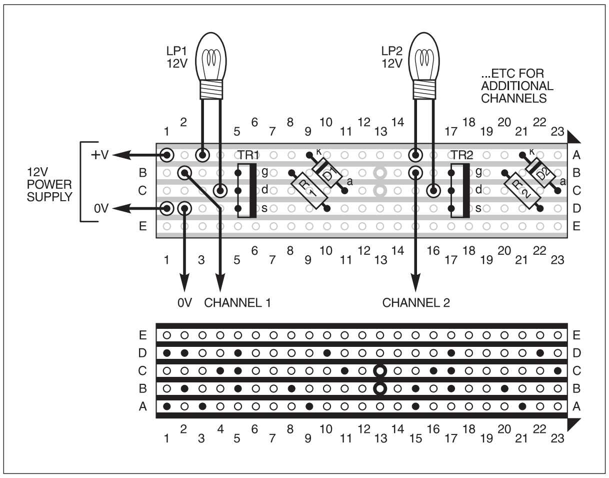
LIGHTING UNIT

With the prototype, a 6-lamp lighting unit provides a spectacular display, and can be constructed from wood painted black as shown in the photograph. No constructional details are offered.

A false bottom allows all the wires to be hidden. If required, the Interface unit can be housed in the gap between the false bottom and outside face of the unit.



Internal view of the Mains Interface unit.



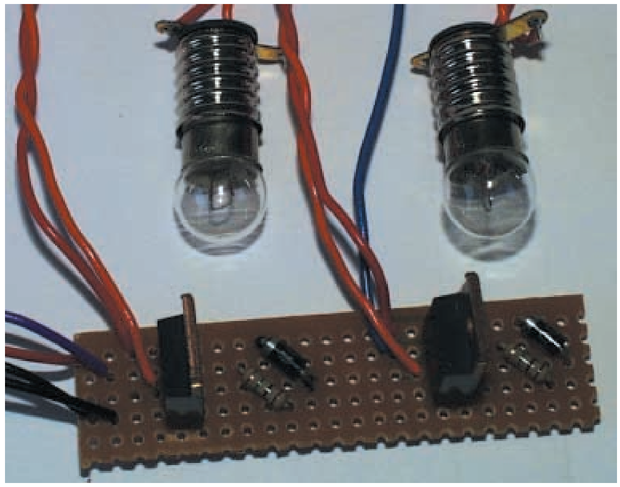


Fig.7. Stripboard component layout for the MOSFET 12V low power lamp driver. A 2-channel section is shown in the photograph above. This arrangement can be repeated for the required number of channels.

MOSFET INTERFACE

Assembly details of the stripboard arrangement of the MOSFET interface, discussed earlier in relation to Fig.2, are shown in Fig.7. A second channel is shown to the right, illustrating which tracks must be broken on the stripboard. This arrangement of components and breaks can be repeated for the required number of channels.

Since the MOSFET is being used as a logic level switch, it should be able to switch a current of up to 1A or so without a heatsink. However, if for any reason, the lamp fails to light at full brightness, this could be due to the MOSFET failing to switch on fully, causing it to become very hot.

Should this happen, disconnect the power immediately and correct the cause of the malfunction.

RESOURCES

Preprogrammed HEX versions of the PICs for these designs can be obtained (*mail order only*) from: M. P. Horsey, Electronics Dept., Radley College, Abingdon, Oxon. OX14 2HR. The price is £5.90 per PIC, including postage (overseas add £1 p&p). Specify the project for which the PIC is required. Enclose a cheque payable to Radley College.

Software for these three designs and for Parts 1 and 3 of the series, (except the PICAXE programming software) is available on 3.5in disk (*EPE* Disk 5), for which a nominal handling charge applies, from the Editorial office (see the *PCB Service* page). It is also available for free download from the *EPE* ftp site.

PICAXE programming software can be obtained from: Tech-Supplies, Dept. *EPE*, 4 Old Dairy Business Centre, Melcombe Road, Bath, BA2 3LR.

The telephone number of Revolution Education is: 01225 340563, and their web site is at: **www.rev-ed.co.uk**.

CONCLUSION

It is hoped that this 3-part series featuring PICAXE-18 microcontrollers has demonstrated how simple they are to use in a variety of useful applications.

The projects described have further illustrated how derivatives of Microchip's PIC microcontroller family are capable of being programmed without intimate knowledge of the commands and structure that is required when using "standard" PIC devices.

If you have been programming your own PICAXE-18 devices using the proprietary software from Revolution Education, you will have also discovered that you do not necessarily need sophisticated assembly software and programming hardware. □

SHOP TALK
with David Barrington

Wind Speed Meter

The ultrasonic transducers for the *Wind Speed Meter* are standard 40kHz devices, normally sold as a transmitter/receiver pair. Those used in the prototype came from **Rapid Electronics** (☎ ***01206 751166*** or ***www.rapidelectronics.co.uk***) codes 35-0175 (Tx) and 35-0180 (Rx).

The 20MHz version of the PIC16F628 microcontroller was purchased from RS, order code 379-2881, although it is likely to be stocked by other suppliers. RS devices can be ordered through any *bona-fide* stockist, including some of our advertisers. You can order direct (credit card only) from **RS** on ***01536 444079*** or through the web at ***rswww.com***. A post and packing charge will be incurred.

Fully programmed PICs can be purchased from **Magenta Electronics** (☎ ***01283 565435*** or ***www.magenta2000.co.uk***) for the inclusive price of £5.90 each (overseas add £1 p&p). The alphanumeric l.c.d. module used in the prototype also came from Magenta, but it is a standard two-line 16-character per line device and should present no problems in purchasing from many other suppliers.

The software is available on a 3.5in. PC-compatible disk (*EPE* Disk 6) from the *EPE Editorial Office* for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 75). It is also available for free download from the *EPE* ftp site, which is most easily accessed via the click-link option at the top of the home page when you enter the main web site at ***www.epemag.wimborne.co.uk***. On entry to the ftp site take the path **pub/PICS/WindSpeed**, downloading all files within the latter folder.

EPE Minder

Some readers may experience problems locating the RF Solutions 433MHz transmitter and receiver modules used in the *EPE Minder* project. The author purchased his from **Farnell** (☎ ***0113 263 6311*** or ***www.farnell.com***), codes 722-5647 (Trans.) and 676-585 (Rec.) They also supplied the 8-pin d.i.l. version of the TS932 mircropower dual op.amp, code 332-9392.

The encoder (HT12E) and decoder (HT12F) devices are currently listed by **FML Electronics** (☎ **01677 425840**).

F.M. Frequency Surfer

The TDA7000 f.m. radio i.c., called for in the *F.M Frequency Surfer* project, still appears to be widely stocked. It is currently listed by **Cricklewood** (☎ ***020 8452 0161***), **FML Electronics** (☎ ***01677 425840***) and **Sherwood Electronics** (*mail order only – see advert*). Prices seem to vary from about £3 to just over £5.

The a.m./f.m. tuning capacitor VC2 is the type associated with small radio i.c.s (e.g. ZN414 and MK484) and should be fairly common. It is listed by **ESR** (☎ ***0191 2514363*** or ***www.esr.co.uk***), code 896-110. However, the 30pF single-turn, air-spaced, trimmer used in the prototype is only available from **J. Birkett Supplies** (☎ ***01522 520767***).

We understand that **Greenweld** (☎ ***01277 811042*** or ***www.greenweld.co.uk***) stock pad board, code CDT0137. An alternative would be plain matrix board.

PICAXE Projects Pt.3 – Chaser Lights

Ready-programmed HEX versions of the PICAXE-18 microcontroller for the *PICAXE Projects* can be purchased (*mail order*) from ***M.P. Horsey, Electronics Dept, Radley College, Abingdon, Oxon, OX14 2HR***, for the inclusive sum of £5.90 each (overseas add £1 p&p). Specify for which project the PICAXE is wanted and *make cheques payable to Radley College*.

Software for these designs (except PICAXE programming software) is available on a 3·5in. disk (Disk 5) from the *EPE Editorial Office* for the sum of £3 each (UK), see page 75. It is also available for *Free* download from the *EPE* ftp site.

Most of the components used in the prototypes came from **Rapid Electronics** (☎ ***01206 751166*** or ***www.rapidelectronics.co.uk***) and have the following code numbers: BTA08-600B (isolated tab) triac, 47-3254; TLP3042 triac driver opto-isolator, 58-0542; 1·5VA mains transformer, twin 6V sec., 88-3010. They also list a suitable MOSFET (logic level) for the low voltage lamp driver circuit, code 47-0350.

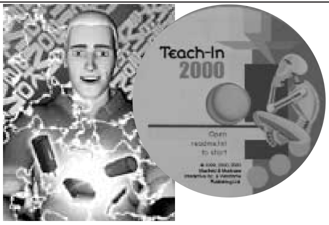
Printed Circuit Boards

Details of prices and code numbers for ordering all this month's printed circuit boards can be found on page 75.

PLEASE TAKE NOTE

Digital I.C. Tester *(Oct '02)*
Version 2 of the software will be placed on the FTP site shortly.

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



EPE TEACH-IN 2000 CD-ROM

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

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Robotics

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For a further selection of books see the next two issues of *EPE*.

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AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages | **Order code BP257** | **£5.49**

VALVE RADIO AND AUDIO REPAIR HANDBOOK
Chas Miller

This book is not only an essential read for every professional working with antique radio and gramophone equipment, but also dealers, collectors and valve technology enthusiasts the world over. The emphasis is firmly on the practicalities of repairing and restoring, so technical content is kept to a minimum, and always explained in a way that can be followed by readers with no background in electronics. Those who have a good grounding in electronics, but wish to learn more about the practical aspects, will benefit from the emphasis given to hands-on repair work, covering mechanical as well as electrical aspects of servicing. Repair techniques are also illustrated throughout.

A large reference section provides a range of information compiled from many contemporary sources, and includes specialist dealers for valves, components and complete receivers.

288 pages | **Order code NE34** | **£20.99**

Computers and Computing

MULTIMEDIA ON THE PC
Ian R. Sinclair

In this book, you'll find out what a CD ROM is, how it works, and why it is such a perfect add-on for a PC, allowing you to buy programmes, text, graphics and sound on a CD. It also describes the installation of a CD ROM drive and a sound card, pointing out the common problems that arise, and then shows how to use them to create a complete multimedia presentation that contains text, photos, a soundtrack with your own voice recorded as a commentary, even animation and edited video footage.

184 pages | **Order code PC112** | **£12.95**

HOW TO BUILD YOUR OWN PC – Third Edition
Morris Rosenthal

More and more people are building the own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a state-of-the-art computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. For non-specialists, there's even a graphical glossary that clearly illustrates technical terms. The author goes "under the hood" and shows step-by-step how to create a socket 7 (Pentium and non-intel chipsets) and a Slot 1 (Pentium II) computer, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows 98. The few existing books on this subject, although badly outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

224 pages – large format | **Order code MGH2** | **£20.99**

PIC YOUR PERSONAL INTRODUCTORY COURSE SECOND EDITION John Morton

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

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

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

The revised second edition covers the popular reprogrammable EEPROM PICs: P16C84/16F84 as well as the P54 and P71 families.

270 pages | **Order code NE36** | **£13.99**

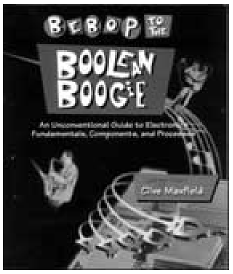
UNDERSTANDING PC SPECIFICATIONS
R. A. Penfold (Revised Edition)

If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.

This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!

128 pages | **Order code BP282** | **£5.45**

Theory and Reference



Bebop To The Boolean Boogie

By Clive (call me Max) Maxfield

Specially imported by *EPE – Excellent value*

An Unconventional Guide to Electronics Fundamentals, Components and Processes

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!). Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day. . . .

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

CD-ROM

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

Over 800 pages in Adobe Acrobat format
£21.95 including VAT and p&p

Order code BEB2 CD-ROM

ELECTRONICS MADE SIMPLE
Ian Sinclair

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

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

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

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

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

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

400 pages **Order code NE27** **£21.99**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

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

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

96 pages **Order code BP239** **£4.49**

DIGITAL GATES AND FLIP-FLOPS
Ian R. SInclair

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

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

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

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

Music, Audio and Video

QUICK GUIDE TO ANALOGUE SYNTHESIS
Ian Waugh

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

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

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

QUICK GUIDE TO MP3 AND DIGITAL MUSIC
Ian Waugh

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

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

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

Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

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

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ELECTRONIC MUSIC AND MIDI PROJECTS
R. A. Penfold

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

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

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

124 pages **Order code PC116** **£10.95**

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

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

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

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

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

420 pages **Order code NE32** **£16.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

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

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

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

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

124 pages **Order code PC115** **£10.95**

PC MUSIC – THE EASY GUIDE
Robin Vincent

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

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

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

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

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold

Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages **Order code BP277** **£4.49**

Circuits, Data and Design

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

88 pages **Order code BP299** **£5.49**

DIGITAL ELECTRONICS – A PRACTICAL APPROACH
With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality)
FREE SOFTWARE
Richard Monk
Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer aided design including the FREE software.
There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.
Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

250 pages (large format) **Order code NE28** **£19.99**

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**

HOW TO USE OP.AMPS
E. A. Parr
This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.

160 pages **Order code BP88** **£4.49**

CIRCUIT SOURCE BOOK 2
R. A. Penfold
This book will help you to create and experiment with your own electronic designs by combining and using the various standard "building blocks" circuits provided. Where applicable, advice on how to alter the circuit parameters is provided.
The circuits covered are mainly concerned with signal generation, power supplies, and digital electronics.
The topics covered in this book include: 555 oscillators; sinewave oscillators; function generators; CMOS oscillators; voltage controlled oscillators; radio frequency oscillators; 555 monostables; CMOS monostables; TTL monostables; precision long timers; power supply and regulator circuits; negative supply generators and voltage boosters; digital dividers; decoders, etc; counters and display drivers; D/A and A/D converters; opto-isolators, flip/flops, noise generators, tone decoders, etc.
Over 170 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.

192 pages **Order code BP322** **£5.45**

For a further selection of books see the next two issues of *EPE*

Project Building & Testing

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold
Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.
The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages **Order code BP371** **£5.45**

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold
This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:
Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.
In fact everything you need to know in order to get started in this absorbing and creative hobby.

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

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.
The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.
All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

RADIO BYGONES

We also carry a selection of books aimed at readers of *EPE*'s sister magazine on vintage radio *Radio Bygones.* These books include the *Comprehensive Radio Valve Guides* (five books with a Free copy of the Master Index) for just £15. Also Jonathan Hill's excellent *Radio Radio,* a comprehensive book with hundreds of photos depicting the development of the British wireless set up to the late 1960s.
The three volumes of our own *Wireless For the Warrior* by Louis Meulstee are also available. These are a technical history of radio communication equipment in the British Army from pre-war through to the 1960s.
For details see the shop on our UK web site at **www.epemag.wimborne.co.uk** or contact us for a list of *Radio Bygones* books.

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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 photostats of articles are available if required – see the *Back Issues* page for details. We do not supply kits or components for our projects.

Please check price and availability in the latest issue.
A number of older boards are listed on our website.
Boards can only be supplied on a payment with order basis.

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Monitor Unit		281	£5.23
Static Field Detector (Multi-project PCB)		932	£3.00
Two-Way Intercom	JAN '01	282	£4.76
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