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FEBRUARY 1997

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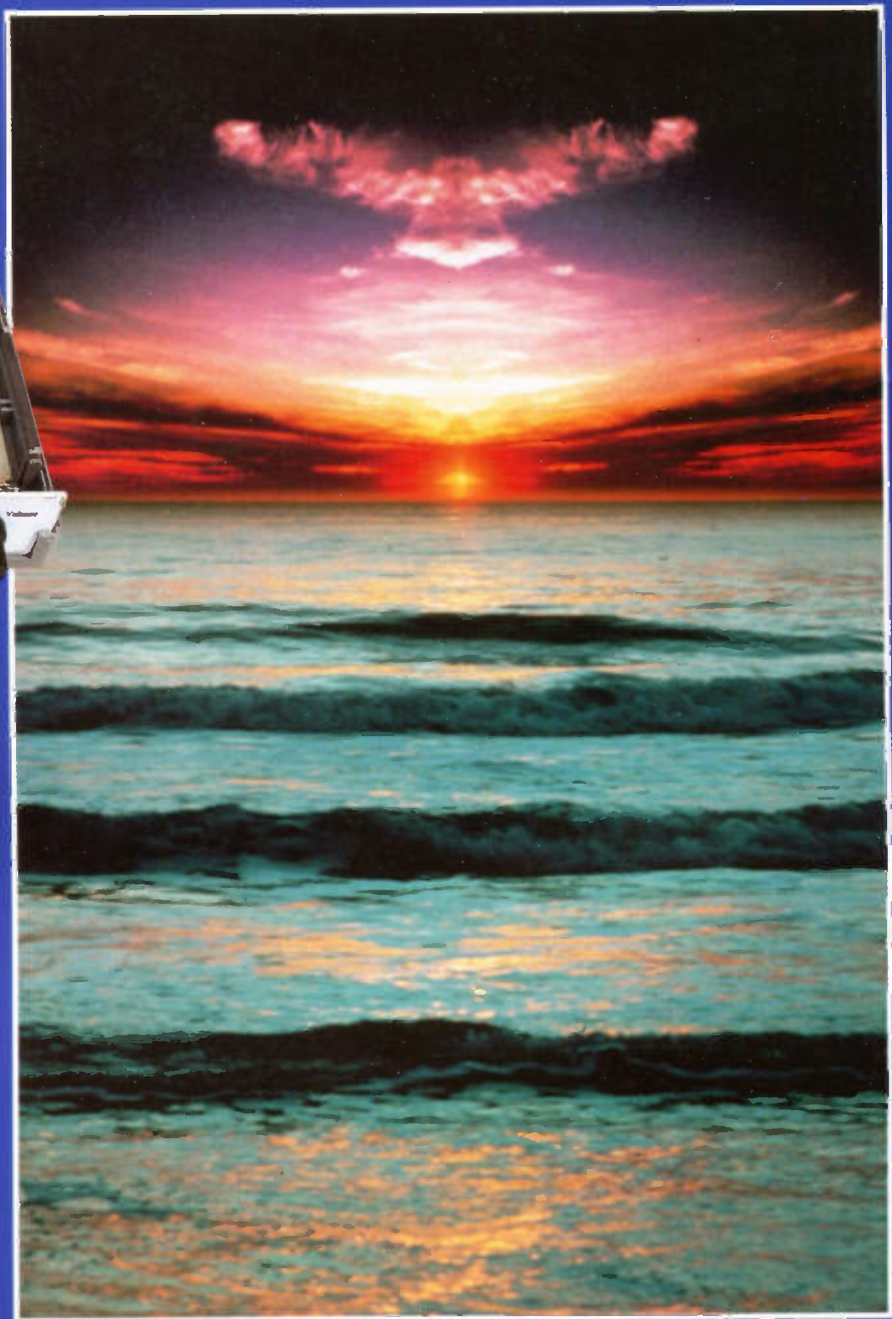

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COMMENT . . . POPULAR FEATURES . . .

VOL. 26 No. 2 FEBRUARY 1997

EVERYDAY PRACTICAL ELECTRONICS

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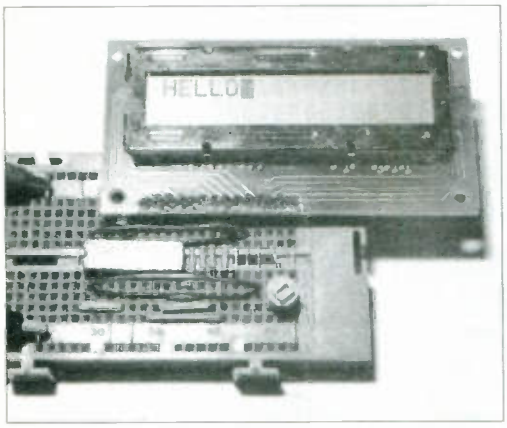
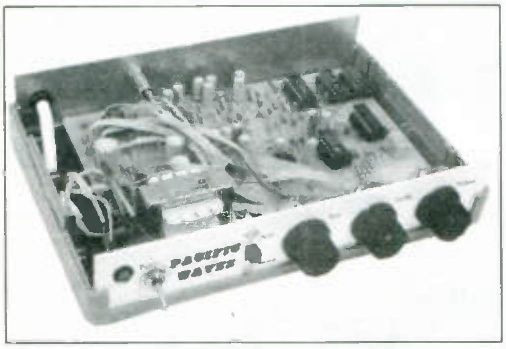
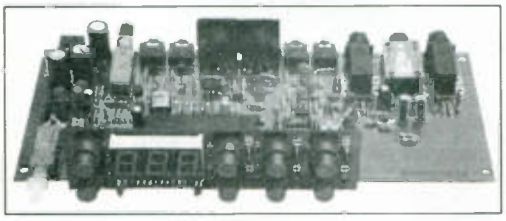
The No. 1 Magazine for Electronics, Technology and Computer Projects







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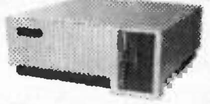
SPECIAL BUY 'AT 286'



40Mb HD + 3Mb Ram

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5¼" or 3½" from only £18.95 !

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Mitsubishi M2896-63-02U 8" DS slimline *NEW*	£285.00(E)
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3½" CONNER CP3044 40mb IDE I/F (or equiv.)RFE	£69.00(C)
3½" RODIME RO3057S 45mb SCSI I/F (Mac & Acorn)	£69.00(C)
3½" WESTERN DIGITAL 850mb IDE I/F *Brand New*	£185.00(C)
5¼" MINISCRIBE 3425 20mb MFM I/F (or equiv.) RFE	£49.95(C)
5¼" SEAGATE ST-238R 30 mb RLL I/F Refurb	£69.95(C)
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5¼" HP 9754B 850 Mb SCSI RFE tested	£89.00(C)
5¼" HP C3010 2 Gbyte SCSI *differential* RFE tested	£195.00(C)
8" FUJITSU M2322K 160Mb SMD I/F RFE tested	£195.00(E)
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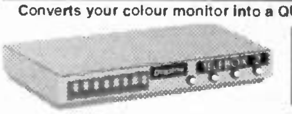
THE AMAZING TELEBOX

Converts your colour monitor into a QUALITY COLOUR TV!!



TV SOUND & VIDEO TUNER *CABLE COMPATIBLE*

The **TELEBOX** is an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by makers such as **MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD** etc. 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.** A composite video output is located on the rear panel for direct connection to most makes of monitor or **desktop computer** video systems. 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.

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

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One of the highest specification monitors you will *ever* see - At this price - Don't miss it!!

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, supplied in EXCELLENT little used condition.

Tilt & Swivel Base £4.75 **Only £119** (E) Order as MITS-SVGA
VGA cable for IBM PC included.
External cables for other types of computers CALL

As New - Used on film set for 1 week only!!
15" 0.28 SVGA 1024 x 768 res. colour monitors.
Swivel & tilt etc. Full 90 day guarantee. £145.00 (E)

Just In - Microvitec 20" VGA (800 x 600 res.) colour monitors. Good SH condition - from £299 - CALL for info

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 £95** (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)

KME 10" 15M10009 high definition colour monitors with 0.28" dot pitch. Superb clarity and modern styling. Operates from any 15.625 khz sync RGB video source, with RGB analog and composite sync such as Atari, Commodore Amiga, Acorn Archimedes & BBC. Measures only 13½" x 12" x 11". Good used condition. **Only £125** (E)

20" 22" and 26" AV SPECIALS

Superbly made UK manufacture. PIL all solid state colour monitors, complete with composite video & *optional* sound input. Attractive teak style case. Perfect for Schools, Shops, Disco, Clubs, etc.In EXCELLENT little used condition with full 90 day guarantee.

20"....£135 22"....£155 26"....£185 (F)

SPECIAL INTEREST ITEMS

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IBM 53F5501 Token Ring ICS 20 port lobe modules	£750
IBM MAU Token ring distribution panel 8228-23-5050N	£95
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE	£550
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ICI R5030UV34 Cleanline ultrasonic cleaning system	£POA
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Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
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Fujitsu M3041D 600 LPM printer with network interface	£1250
Perkin Elmer 2998 Infrared spectrophotometer	£POA
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3750
Andrews LARGE 3.1 m Satellite Dish + mount (For Voyager!)	£950
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
TAYLOR HOBSON Tallysurf amplifier / recorder	£750
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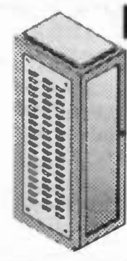
Test Lab - 2 mtr square quietised acoustic test cabinets	£300
Kenwood 9601 PAL Vectorscope - NEW	£650

Please call for further details on the above items

19" RACK CABINETS



Superb quality 6 foot 40U Virtually New, Ultra Smart *Less than Half Price!*

Top quality 19" rack cabinets made in UK by **Optima Enclosures Ltd.** Units feature designer, smoked acrylic lockable front door, full height lockable half louvered back door and louvered removable side panels. Fully adjustable internal fixing struts, ready punched for any configuration of equipment mounting plus ready mounted integral 12 way 13 amp socket switched mains distribution strip make these racks some of the **most versatile** we have ever sold. Racks may be stacked side by side and therefore require only two side panels to stand singly or in multiple bays. Overall dimensions are: 77½" H x 32½" D x 22" W. **Order as:**

OPT Rack 1 Complete with removable side panels.	£335.00 (G)
OPT Rack 2 Rack, Less side panels	£225.00 (G)

32U - High Quality - All steel RakCab

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 are 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. External dimensions mm=1625H x 635D x 603 W. (64" H x 25" D x 23¾" W)

Sold at LESS than a third of makers price !!

A superb buy at only £195.00 (G)

Over 1000 racks - 19" 22" & 24" wide
3 to 44 U high. Available from stock !!
Call with your requirements.

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The ultimate in **'Touch Screen Technology'** made by the experts - ***MicroTouch*** - but sold at a **price below cost !!** System consists of a flat translucent glass laminated panel measuring 29.5 x 23.5 cm connected to an electronic controller PCB. The controller produces a **standard serial RS232** or TTL output which continuously gives simple serial data containing positional **X & Y** co-ordinates as to where a finger is touching the panel - as the finger moves, the data instantly changes. The X & Y information is given at an **incredible matrix resolution of 1024 x 1024** positions over the entire screen size !! A host of **available translation software** enables direct connection to a PC for a myriad of applications including: control panels, pointing devices, POS systems, controllers for the disabled or computer un-trained etc etc. Imagine using your finger with 'Windows', instead of a mouse !! (a driver is indeed available !) ***The applications for this amazing product are only limited by your imagination!!*** Complete system including Controller, Power Supply and Data supplied at an incredible price of only: **£145.00** (B)
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Order as: XT RAM UG. 256k. £34.95 *or* **512k £39.95** (A1)

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FULL RANGE OF CO-PROCESSOR'S EX STOCK - CALL FOR £££

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MITSUBISHI MMF-08C12DM 80x80x25 mm 12v DC	£5.25 10 / £49
MITSUBISHI MMF-09B12DH 92x92x25 mm 12v DC	£5.95 10 / £53
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EX-EQUIP AC fans. ALL TESTED 120 x 120 x 38 mm specify 110 or 240 v £6.95. 80 x 80 x 38 mm - specify 110 or 240 v £5.95
IMHOF B26 1900 rack mnt 3U x 19" Blower 110/240v NEW **£79.95**
Shipping on all fans (A). Blowers (B). ***50,000 Fans Ex Stock CALL***

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SIMPLE PIC PROGRAMMER

INCREDIBLE LOW **PRICE!**

Kit 857 **£12.99**

INCLUDES 1-PIC16C84 CHIP SOFTWARE DISK, LEAD CONNECTOR, PROFESSIONAL PC BOARD & INSTRUCTIONS

Power Supply £3.99

EXTRA CHIPS: PIC 16C84 £7.36

Based on the design in February '96 *EPE* article, Magenta have made a proper PCB and kit for this project. PCB has 'reset' switch, Program switch, 5V regulator and test L.E.D.s. There are also extra connection points for access to all A and B port pins.

SUPER PIC PROGRAMMER

NEW!

- READS, PROGRAMS, AND VERIFIES
- WINDOWS™ SOFTWARE
- PIC16C6X, 7X, AND 8X
- USES ANY PC PARALLEL PORT
- USES STANDARD MICROCHIP • HEX FILES
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- PCB, LEAD, ALL COMPONENTS, TURNED PIN SOCKETS FOR 18, 28, AND 40 PIN ICs.

- SEND FOR DETAILED INFORMATION – A SUPERB PRODUCT AT AN UNBEATABLE LOW PRICE.

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INCLUDES 1-PIC16C84 WITH DEMO PROGRAM SOFTWARE DISK, PCB, INSTRUCTIONS AND 16-CHARACTER 2-LINE **LCD DISPLAY**

Kit 860 **£17.99**

Power Supply £3.99

FULL PROGRAM SOURCE CODE SUPPLIED – DEVELOP YOUR OWN APPLICATION!

Another super PIC project from Magenta. Supplied with PCB, industry standard 2-LINE x 16-character display, data, all components, and software to include in your own programs. Ideal develpment base for meters, terminals, calculators, counters, timers – Just waiting for your application!

★ Chip is pre-programmed with demo display ★

PIC STEPPING MOTOR DRIVER

NEW!

INCLUDES: PCB, PIC16C84 WITH DEMO PROGRAM, SOFTWARE DISK, INSTRUCTIONS AND MOTOR.

Kit 863 **£18.99**

FULL SOURCE CODE SUPPLIED. ALSO USE FOR DRIVING OTHER POWER DEVICES e.g. SOLENOIDS.

Another NEW Magenta PIC project. Drives any 4-phase unipolar motor – up to 24V and 1A. Kit includes all components and 48 step motor. Chip is pre-programmed with demo software, then write your own, and re-program the same chip! Circuit accepts inputs from switches etc and drives motor in response. Also runs standard demo sequence from memory.

PIC16C84 MAINS POWER 4-CHANNEL CONTROLLER & LIGHT CHASER

- WITH PROGRAMMED 16C84 AND DISK WITH SOURCE CODE IN MPASM
- ZERO VOLT SWITCHING – 10 CHASE PATTERNS
- OPTO ISOLATED
- 4 X 3 KEYPAD CONTROL
- SPEED CONTROL POT.
- HARD FIRED TRIACS
- 4 CHANNELS @5 AMPS

Now features full 4-channel chaser software on DISK and pre-programmed PIC16C84 chip. Easily re-programmed for your own applications. Software source code is fully 'commented' so that it can be followed easily.

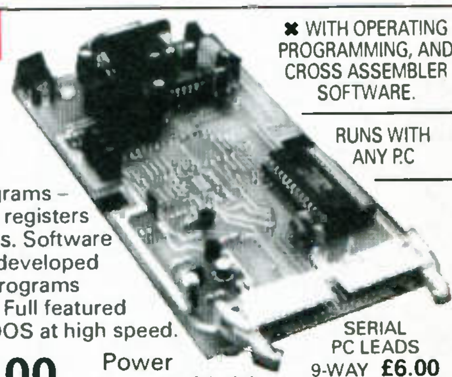
Kit 855 **£39.95**

LOTS OF OTHER APPLICATIONS

PIC16C5X

IN CIRCUIT EMULATOR – WITH ON-LINE MONITOR.

The easiest way to get started. Allows single stepping through programs – displaying the internal registers and driving the I/O pins. Software and hardware can be developed and tested together. Programs 16C54, 5, 6, & 7 chips. Full featured software runs under DOS at high speed.



✖ WITH OPERATING PROGRAMMING, AND CROSS ASSEMBLER SOFTWARE.

RUNS WITH ANY P.C

Kit 853 **£99.00**

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9-WAY **£6.00**
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- USED WORLDWIDE IN SCHOOLS COLLEGES & UNIVERSITIES
- DOUBLE EUROCARD, 2 SERIAL PORTS
- NOW WITH EXPANDED RAM & ROM
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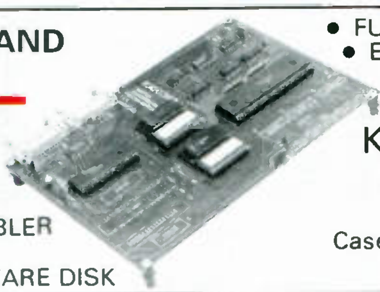

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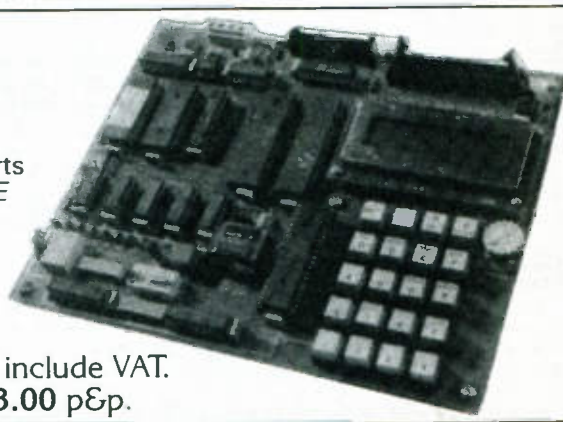

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WAKE UP TO ELECTRONICS . . .

Electronics encroaches on virtually every aspect of modern life. For most of us the bedside clock/alarm/radio, etc., kicks off the day thanks to some high tech. circuitry; even the morning cup of tea is likely to be brewed using a kettle with in-built electronics. It's worth thinking about how many things we do that are assisted by electronics and how much we all rely on technology these days.

Even when relaxing, electronics can offer assistance, as this month's *Pacific Waves* project shows. In fact this type of design, associated with rather unusual uses of electronics, is among the most popular we publish. The sound generated by this unit is just like the real thing and, even though it is impossible to get more than about eighty five miles away from the sea in the UK, this little gadget will put you "right there" in your own living room.

. . . AND COMMUNICATE

On a similar theme, just about every form of remote communication also relies on electronics – even the postal system is heavily dependent on computers for sorting, etc., these days. Many items of equipment communicate through displays of one type or another – everything from calculators and meters to computers and TV information systems. This month's look at the use of intelligent l.c.d.s shows how this important technology can be used by anyone.

Since this type of display is readily available at low cost from a number of "surplus" suppliers it is worth considering their use in any type of "intelligent" equipment, where they can easily enhance the user interface. The article shows how, with just a few switches, you can understand the workings of these displays and, next month, will go on to show how to interface them to control systems, etc.

Mike Kenward

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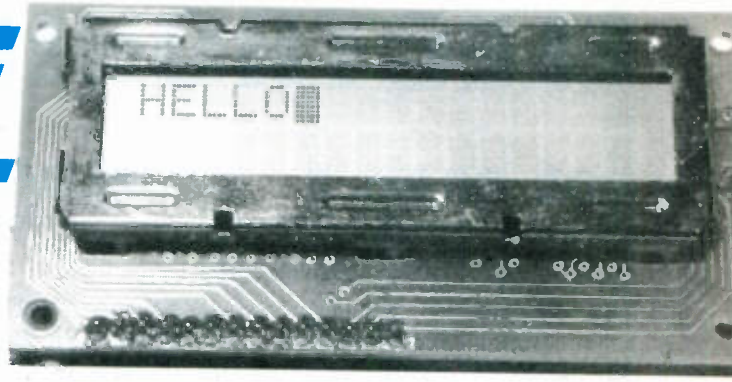
HOW TO USE INTELLIGENT L.C.D.s



JULYAN ILETT

Part One

An utterly "practical" guide to interfacing and programming intelligent liquid crystal display modules.

RECENTLY, a number of projects using intelligent liquid crystal display (l.c.d.) modules have been featured in *EPE*. Their ability to display not just numbers, but also letters, words and all manner of symbols, makes them a good deal more versatile than the familiar 7-segment light emitting diode (l.e.d.) displays.

Although still quite expensive when purchased new, the large number of surplus modules finding their way into the hands of the "bargain" electronics suppliers, offers the hobbyist a low cost opportunity to carry out some fascinating experiments and realise some very sophisticated electronic display projects.

BASIC READING

This article deals with the character-based l.c.d. modules which use the Hitachi HD44780 (or compatible) controller chip, as do most modules available to the hobbyist. Of course, these modules are not quite as advanced as the latest generation, full size, full colour, back-lit types used in today's laptop computers, but far from being "phased out", character-based l.c.d.s are still used extensively in commercial and industrial equipment, particularly where display requirements are reasonably simple.

The modules have a fairly basic interface, which mates well with traditional microprocessors such as the Z80 or the 6502. It is also ideally suited to the PIC microcontroller, which is probably the most popular microcontroller used by the electronics hobbyist.

However, even if, as yet, you know nothing of microcontrollers, and possess none of the PIC paraphernalia, don't despair, you can still enjoy all the fun of experimenting with l.c.d.s, using little more than a handful of switches!

SHAPES AND SIZES

Even limited to character-based modules, there is still a wide variety of shapes and sizes available. Line lengths of 8, 16, 20, 24, 32 and 40 characters are all standard, in one, two and four-line versions.

Several different liquid crystal technologies exist. "Supertwist" types, for example, offer improved contrast and viewing angle over the older "twisted nematic" types. Some modules are available with back-lighting, so that they can be viewed in dimly-lit conditions. The back-lighting may be either "electro-luminescent", requiring a high voltage inverter circuit, or simpler l.e.d. illumination.

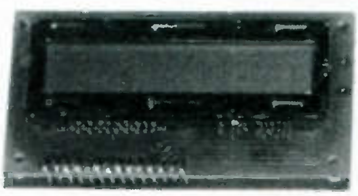
Few of these features are important, however, for experimentation purposes. All types are capable of displaying the same basic information, so the cheaper types are probably the best bet initially.

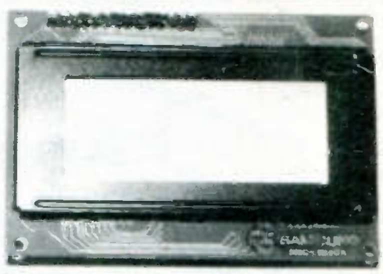
CONNECTIONS

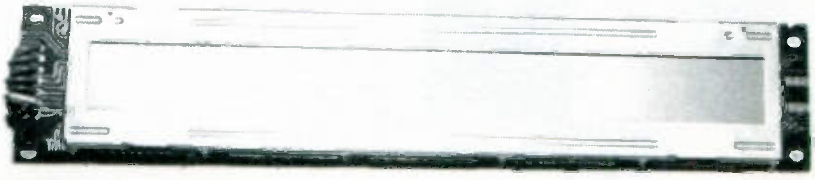
Most l.c.d. modules conform to a standard interface specification. A 14-pin access is provided (14 holes for solder pin insertion or for an IDC connector) having eight data lines, three control lines and three power lines. The connections are laid out in one of two common configurations, either two rows of seven pins, or a single row of 14 pins. The two layout alternatives are displayed in Fig. 1.

On most displays, the pins are numbered on the l.c.d.'s printed circuit board, but if not, it is quite easy to locate pin 1. Since this pin is connected to ground, it often has a thicker p.c.b. track connected to it, and it is generally connected to the metalwork at some point.

The function of each of the connections is shown in Table 1. Pins 1 and 2 are the power supply lines, V_{ss} and V_{dd}. The V_{dd} pin should be connected to the







positive supply, and V_{ss} to the 0V supply or ground.

Although the l.c.d. module data sheets specify a 5V d.c. supply (at only a few milliamps), supplies of 6V and 4·5V both work well, and even 3V is sufficient for some modules. Consequently, these modules can be effectively, and economically, powered by batteries.

Pin 3 is a control pin, V_{ee}, which is used to alter the contrast of the display. Ideally, this pin should be connected to a variable voltage supply. A preset potentiometer connected between the power supply lines, with its wiper connected to the contrast pin is suitable in many cases, but be aware that some modules may require a negative potential; as low as −7V in some cases. For absolute simplicity, connecting this pin to 0V will often suffice.

Pin 4 is the Register Select (RS) line, the first of the three command control inputs. When this line is low, data bytes transferred to the display are treated as commands, and data bytes read from the display indicate its status. By setting the RS line high, character data can be transferred to and from the module.

Pin 5 is the Read/Write (R/W) line. This line is pulled low in order to write commands or character data to the module, or pulled high to read character data or status information from its registers.

Pin 6 is the Enable (E) line. This input is used to initiate the actual transfer of commands or character data between the module and the data lines. When writing to the display, data is transferred only on the high to low transition of this signal. However, when reading from the display, data will become available shortly after the low to high transition and remain available until the signal falls low again.

Pins 7 to 14 are the eight data bus lines (D0 to D7). Data can be transferred to and from the display, either as a single 8-bit byte or as two 4-bit "nibbles". In the latter case, only the upper four data lines (D4 to D7) are used. This 4-bit mode is beneficial when using a microcontroller, as fewer input/output lines are required.

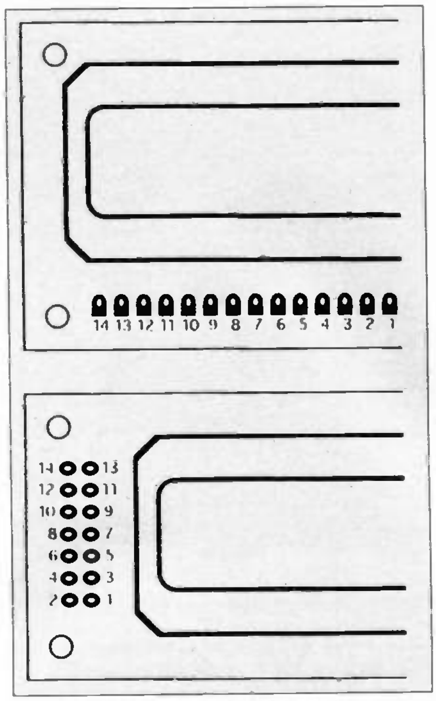


Fig. 1. Pinouts of the two basic l.c.d. formats.

PROTOTYPE CIRCUIT

For an l.c.d. module to be used effectively in any piece of equipment, a microprocessor or microcontroller is usually required to drive it. However, before attempting to wire the two together, some initial (and very useful) experiments can be performed, by connecting up a series of switches to the pins of the module. This can be quite a beneficial step, even if you are thoroughly conversant with the workings of microprocessors.

In Fig. 2 is shown the circuit diagram of an l.c.d. experimentation rig.

The circuit can be wired-up on a "plug-in" style prototyping board, using d.i.l. (dual-in-line) switches for the data lines (S1 to S8), a toggle switch for the RS input (S10), and a momentary action switch (or microswitch) for the E input (S9). The

Table 1. Pinout functions for all the l.c.d. types.

Pin No.	Name	Function
1	V_{ss}	Ground
2	V_{dd}	+ve supply
3	V_{ee}	Contrast
4	RS	Register Select
5	R/W	Read/Write
6	E	Enable
7	D0	Data bit 0
8	D1	Data bit 1
9	D2	Data bit 2
10	D3	Data bit 3
11	D4	Data bit 4
12	D5	Data bit 5
13	D6	Data bit 6
14	D7	Data bit 7

R/W line is connected to ground (0V), as the display is only going to be written to for the time being.

It is probably most convenient to use a s.i.l. (single-in-line) resistor pack for the eight pull-up resistors (R1 to R8) on the data lines. The other two resistors, R9 and R10, can be discrete types. Preset potentiometer VR1 is used for the contrast control and is shown with one end left disconnected. If desired, this end can be connected to the positive line via a resistor of about 47kΩ (it should be connected to a negative supply, via a similar resistor, for those modules which require negative biasing).

All the switches should be connected so that they are "on" when in the "down" position, so that "down" generates a logic 0 (low) and "up" provides a logic 1

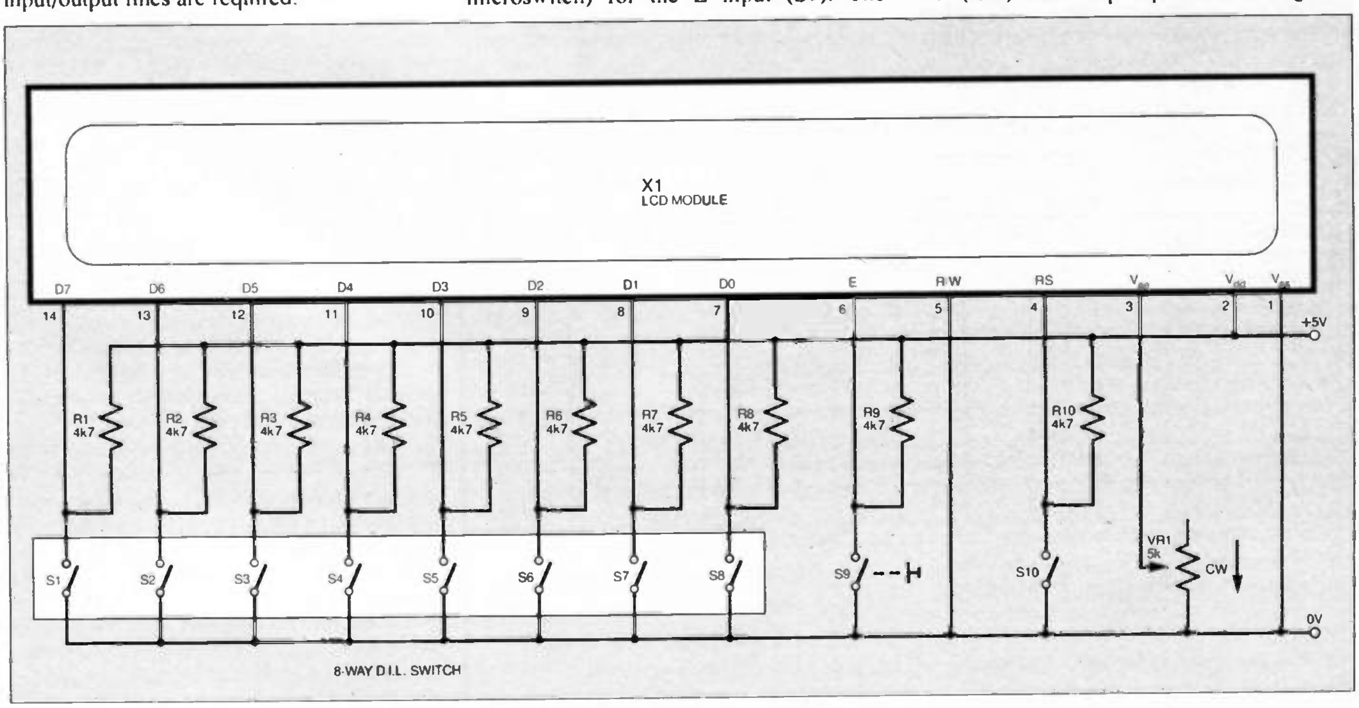
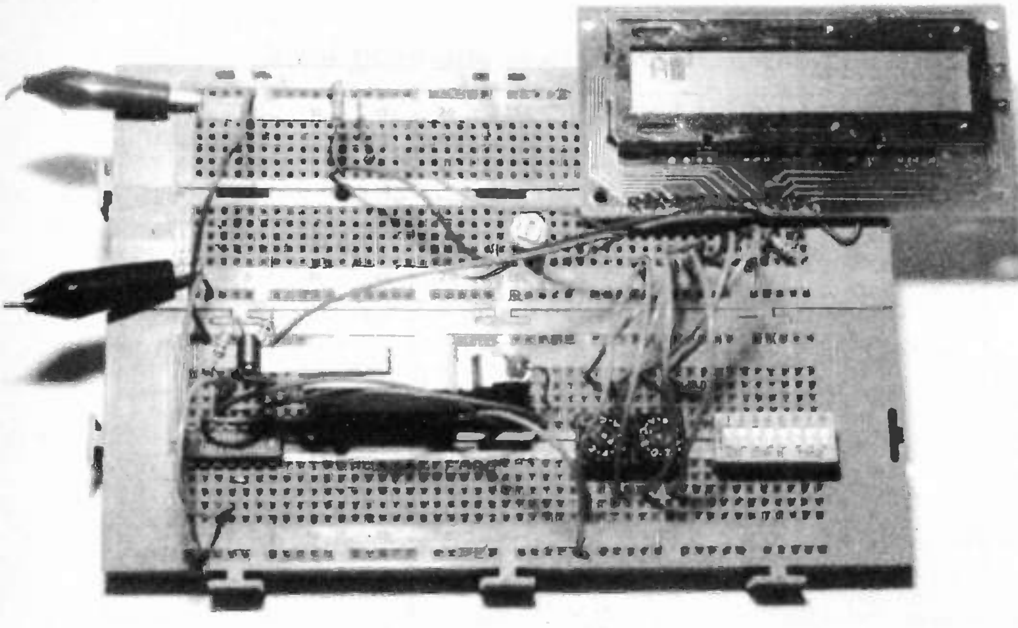


Fig. 2. Circuit diagram for an l.c.d. experimental rig.



The experimental circuit can be built on plug-in prototyping boards.

(high). The switches should also be arranged so that data bit D7 is on the left, and data bit D0 is on the right. In this way, binary numbers can be entered the right way round.

Initially, the contrast control should be adjusted fully clockwise, so that the contrast control input (V_{ee}) is connected to ground. The initial settings of the switches are unimportant, but it is suggested that the RS switch (S10) is "up" (set to logic 1), and the E switch (S9) is left unpressed. The data switches, S1 to S8, can be set to any value at this stage.

All is now prepared to start sending commands and data to the l.c.d. module.

EXPERIMENT 1

Basic Commands

When powered up, the display should show a series of dark squares, possibly only on part of the display. These character cells are actually in their off state, so the contrast control should be adjusted anti-clockwise (away from ground) until the squares are only just visible.

The display module resets itself to an initial state when power is applied, which curiously has the display blanked off, so that even if characters are entered, they cannot be seen. It is therefore necessary to issue a command at this point, to switch the display on.

A full list of the commands that can be sent is given in Table 2, together with their binary and hexadecimal values. The initial conditions of the l.c.d. after power-on are marked with an asterisk.

Throughout this article, emphasis will be placed on the binary value being sent since this illustrates which data bits are being set for each command. After each binary value, the equivalent hexadecimal value is quoted in brackets, the $ prefix indicating that it is hexadecimal.

The Display On/Off and Cursor command turns on the display, but also determines the cursor style at the same time. Initially, it is probably best to select a Blinking Cursor with Underline, so that its position can be seen clearly, i.e. code 00001111 ($0F).

Set the data switches (S1 to S8) to 00001111 ($0F) and ensure that the RS switch (S10) is "down" (logic 0), so that the device is in Command mode. Now press the E switch (S9) momentarily, which "enables" the chip to accept the data, and Hey Presto, a flashing cursor with underline appears in the top left hand position!

If a two-line module is being used, the second line can be switched on by issuing the Function Set command. This command also determines whether an 8-bit or a 4-bit data transfer mode is selected, and whether a 5 × 10 or 5 × 7 pixel format will be used. So, for 8-bit data, two lines and a 5 × 7 format, set the data switches to binary value 00111000 ($38), leave RS (S10) set low and press the E switch, S9.

It will now be necessary to increase the contrast a little, as the two-line mode has a different drive requirement. Now set the RS switch to its "up" position (logic 1), switching the chip from Command mode to Character mode, and enter binary value 01000001 ($41) on the data switches. This is the ASCII code for a capital *A*.

Press the E switch, and marvel as the display fills up with capital *A*'s. Clearly, something is not quite right, and seeing your name in pixels is going to have to wait a while.

BOUNCE

The problem here is contact bounce. Practically every time the E switch is closed, its contacts will bounce, so that although occasionally only one character appears, most attempts will result in 10 or 20 characters coming up on the display. What is needed is a "debounce" circuit.

But what about the commands entered earlier, why didn't contact bounce interfere with them? In fact it did, but it doesn't matter whether a command is entered ("enabled") just once, or several times, it gets executed anyway. A solution to the bounce problem is shown in Fig. 3.

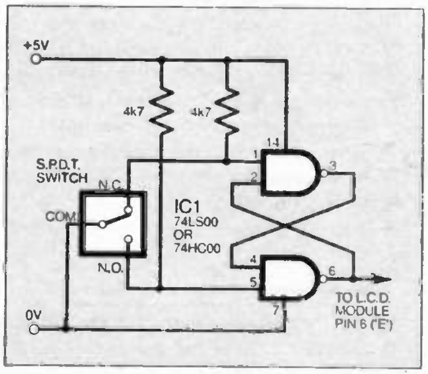


Fig. 3. Switch debounce circuit.

Here, a couple of NAND gates are cross-coupled to form a set-reset latch (or flip-flop) which flips over and latches, so that the contact bounce is eliminated. Either a TTL 74LS00 or a CMOS 74HC00 can be used in this circuit. The switch must be an s.p.d.t. (single-pole, double-throw) type, a microswitch is ideal.

After modifying the circuit, the screen full of *A*s can be cleared using the Clear Display command. Put binary value 00000001 ($01) on the data switches, set the RS switch to the "down" position and press the new modified E switch. The display is cleared.

Note that the output of the "de-bounce" circuit is high when the switch is pressed and low when the switch is released. Since it is the high to low transition that actually latches data into the l.c.d. module, it will

Table 2. The Command Control Codes.

Command	Binary								Hex
	D7	D6	D5	D4	D3	D2	D1	D0	
Clear Display	0	0	0	0	0	0	0	1	01
Display & Cursor Home	0	0	0	0	0	0	1	x	02 or 03
Character Entry Mode	0	0	0	0	0	1	I/D	S	04 to 07
Display On/Off & Cursor	0	0	0	0	1	D	U	B	08 to 0F
Display/Cursor Shift	0	0	0	1	D/C	R/L	x	x	10 to 1F
Function Set	0	0	1	8/4	2/1	10/7	x	x	20 to 3F
Set CGRAM Address	0	1	A	A	A	A	A	A	40 to 7F
Set Display Address	1	A	A	A	A	A	A	A	80 to FF

I/D: 1=Increment*, 0=Decrement
S: 1=Display shift on, 0=Display shift off*
D: 1=Display On, 0=Display Off*
U: 1=Cursor underline on, 0=Underline off*
B: 1=Cursor blink on, 0=Cursor blink off*
D/C: 1=Display shift, 0=Cursor move
R/L: 1=Right shift, 0=Left shift
8/4: 1=8 bit interface*, 0=4 bit interface
2/1: 1=2 line mode, 0=1 line mode*
10/7: 1=5x10 dot format, 0=5x7 dot format*
x = Don't care   * = Initialisation settings

be observed that characters appear on the display, not when the button is pressed, but when it is released.

EXPERIMENT 2

Entering Text

First, a little tip: it is manually a lot easier to enter characters and commands in hexadecimal rather than binary (although, of course, you will need to translate commands from binary into hex so that you know which bits you are setting). Replacing the d.i.l. switch pack with a couple of sub-miniature hexadecimal rotary switches is a simple matter, although a little bit of re-wiring is necessary.

The switches must be the type where On = 0, so that when they are turned to the zero position, all four outputs are shorted to the common pin, and in position "F", all four outputs are open circuit.

All the available characters that are built into the module are shown in Table 3. Studying the table, you will see that codes associated with the characters are quoted in binary and hexadecimal, most significant bits ("left-hand" four bits) across the top, and least significant bits ("right-hand" four bits) down the left.

Most of the characters conform to the ASCII standard, although the Japanese and Greek characters (and a few other things) are obvious exceptions. Since these intelligent modules were designed in the "Land of the Rising Sun", it seems only fair that their Katakana phonetic symbols should also be incorporated. The more extensive Kanji character set, which the Japanese share with the Chinese, consisting of several thousand different characters, is not included!

Using the switches, of whatever type, and referring to Table 3, enter a few characters onto the display, both letters and numbers. The RS switch (S10) must be "up" (logic 1) when sending the characters, and switch E (S9) must be pressed for each of them. Thus the operational order is: set RS high, enter character, trigger E, *leave RS high*, enter another character, trigger E, and so on.

The first 16 codes in Table 3, 00000000 to 00001111, ($00 to $0F) refer to the CGRAM. This is the Character Generator RAM (random access memory), which can be used to hold user-defined graphics characters. This is where these modules really start to show their potential, offering such capabilities as bargraphs, flashing symbols, even animated characters. Before the user-defined characters are set up, these codes will just bring up strange looking symbols.

Codes 00010000 to 00011111 ($10 to $1F) are not used and just display blank characters. ASCII codes "proper" start at 00100000 ($20) and end with 01111111 ($7F). Codes 10000000 to 10011111 ($80 to $9F) are not used, and 10100000 to 11011111 ($A0 to $DF) are the Japanese characters.

Codes 11100000 to 11111111 ($E0 to $FF) are interesting. Although this last block contains mainly Greek characters, it also includes the lower-case characters which have "descenders". These are the letters *g*, *j*, *p*, *q* and *y*, where the tail drops down below the base line of normal upper-case characters. They require the 5 × 10 dot matrix format, rather than the 5 × 7, as you will see if you try to display a lower-case *j*, for example, on a 5 × 7 module.

Table 3. Standard l.c.d. character table.

Upper 4 bits / Lower 4 bits	0 0000	1 0001	2 0010	3 0011	4 0100	5 0101	6 0110	7 0111	8 1000	9 1001	A 1010	B 1011	C 1100	D 1101	E 1110	F 1111
0 0000	CG RAM (1)			0	@	P	`	p				ー	タ	ミ	α	p
1 0001	CG RAM (2)		!	1	A	Q	a	q			。	ア	チ	ム	ä	q
2 0010	CG RAM (3)		"	2	B	R	b	r			「	イ	ツ	メ	β	θ
3 0011	CG RAM (4)		#	3	C	S	c	s			」	ウ	テ	モ	ε	∞
4 0100	CG RAM (5)		$	4	D	T	d	t			、	エ	ト	ヤ	μ	Ω
5 0101	CG RAM (6)		%	5	E	U	e	u			・	オ	ナ	ユ	σ	ü
6 0110	CG RAM (7)		&	6	F	V	f	v			ヲ	カ	ニ	ヨ	ρ	Σ
7 0111	CG RAM (8)		'	7	G	W	g	w			ァ	キ	ヌ	ラ	g	π
8 1000	CG RAM (1)		(	8	H	X	h	x			ィ	ク	ネ	リ	√	x̄
9 1001	CG RAM (2)		)	9	I	Y	i	y			ゥ	ケ	ノ	ル	⁻¹	y
A 1010	CG RAM (3)		*	:	J	Z	j	z			ェ	コ	ハ	レ	j	千
B 1011	CG RAM (4)		+	;	K	[	k	{			ォ	サ	ヒ	ロ	ˣ	万
C 1100	CG RAM (5)		,	<	L	¥	l	|			ャ	シ	フ	ワ	¢	円
D 1101	CG RAM (6)		-	=	M	]	m	}			ュ	ス	ヘ	ン	£	÷
E 1110	CG RAM (7)		.	>	N	^	n	→			ョ	セ	ホ	゛	ñ	
F 1111	CG RAM (8)		/	?	O	_	o	←			ッ	ソ	マ	゜	ö	█

Some one-line displays have the 5 × 10 format facility, which allows these characters to be shown unbroken. With 5 × 7 two-line displays, the facility can be simulated by borrowing the top three pixel rows from the second line, so creating a 5 × 10 matrix.

For this simulation, set line RS low to put the chip into Command mode. On the data switches, enter the Function Set command using binary value 00110100 ($34). Press and release switch E. Return RS to high, and then send the character data for the last 32 codes in the normal way (remembering to trigger line E!).

EXPERIMENT 3

Addressing

When the module is powered up, the cursor is positioned at the beginning of the first line. This is address $00. Each time a character is entered, the cursor moves on to the next address, $01, $02 and so on. This auto-incrementing of the cursor address makes entering strings of characters very easy, as it is not necessary to specify a separate address for each character.

It may be necessary, however, to position a string of characters somewhere other than at the beginning of the first line. In this instance, a new starting address must be entered as a command. Any address between $00 and $7F can be entered, giving a total of 128 different addresses, although not all these addresses have their own display location.

There are in fact only 80 display locations, laid out as 40 on each line in two-line mode, or all 80 on a single line in one-line mode. This situation is further complicated because not all display locations are necessarily visible at one time. Only a 40-character, two-line module can display all 80 locations simultaneously.

To experiment with addressing, first set the l.c.d. to two-line mode (if two lines are

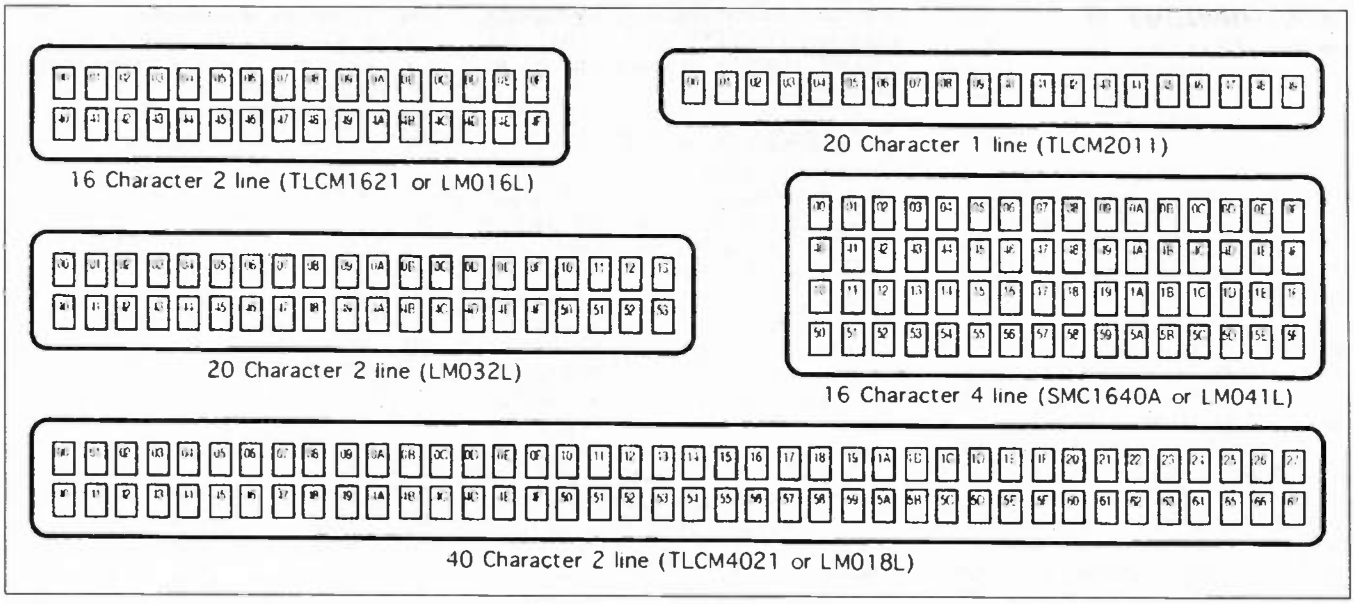


Fig. 4. Examples of the relationship between addresses and display locations for typical module formats.

available), 8-bit data and 5 × 7 format using the Function Set command, i.e. code 00111000 ($38). Note that the last two bits of this command are unimportant, as indicated by the *x* in the columns of Table 2, and either of them may be set to 0 or 1.

(From now on, we won't constantly remind you that RS must be set appropriately before Command or Character data is entered, or that E must be triggered after data has been entered – you should know by now!)

Using the Display On/Off and Cursor command, set the display to On, with Underline and Blinking Cursor, code 00001111 ($0F). Now set the cursor to address 00001000 ($08). This is done by sending a Set Display Address command, binary value 10001000 ($88).

The cursor will jump to the ninth position on the display, at which point text can now be entered. The Set Display Address command is always 10000000 ($80) greater than the display address itself.

Experiment with different display addresses and note their display locations. Be aware that display addresses 00101000 to 00111111 ($28 to $3F) and 01101000 to 01111111 ($68 to $7F) cannot be used on any of the display types.

The relationship between addresses and display locations varies, depending on the type of module being used, but some typical examples are shown in Fig. 4.

Most are laid out conventionally, with two lines of characters, the first line starting at address 00000000 ($00) and the second line at address 01000000 ($40).

Two interesting exceptions were discovered during this article's research. The single-line module shown in Fig. 4 is actually a two-line type, with the second line placed to the right of the first. In one-line mode, only the first 10 characters were visible.

The rather magnificent 4-line module is, actually, also a two-line type, with the two lines split and interlaced. This complicates the addressing a little, but can be sorted out with a bit of software.

EXPERIMENT 4

Shifting the Display

Regardless of which size l.c.d. module is being used, there are always 80 display locations that can be written to. On the smaller devices, not all 80 fit within the visible window of the module, but can be brought into view by shifting them all, either left or right, "beneath" the window area. This process must be carried out carefully, however, as it alters the relationship between addresses and their positions on the screen.

To experiment with shifting, first issue suitable Function Set, Display On/Off and Cursor commands, and, if necessary, the Clear Display command (you've met their codes above). Then enter all 26 letters of the alphabet as character data, e.g. 01000001 ($41) to 01011010 ($5A).

On a 16-character display, only *A* to *P* will be visible (the first 16 letters of the alphabet), and the cursor will have disappeared off the right-hand side of the display screen.

The Cursor/Display Shift command can now be used to scroll all the display locations to the left, "beneath" the l.c.d. window, so that letters *Q* to *Z* can be seen. The command is binary 00011000 ($18). Each time the command is entered (and using the E switch), the characters shift one place to the left. The cursor will re-appear from the right-hand side, immediately after the *Z* character.

Carry on shifting (*wasn't that a film title? Ed!*), and eventually the letters *A*, *B*, *C*, and so on, will also come back in from the right-hand side. Shifting eventually causes complete rotation of the display locations.

The binary command 00011100 ($1C) shifts the character locations to the right. It is important to note that this scrolling does not actually move characters into new addresses, it moves the whole address block left or right "underneath" the display window.

If the display locations are not shifted back to their original positions, then address $00 will no longer be at the left-hand side of the display. Try entering an Address Set command of value 10000000 ($80), after a bit of shifting, to see where it has moved to.

The Cursor Home command, binary 00000010 ($02), will both set the cursor back to address $00, and shift the address $00 itself back to the left-hand side of the display. This command can be used to get back to a known good starting position, if shifting and address setting gets a bit out of control.

The Clear Display command does the same as Cursor Home, but also clears all the display locations.

One final word about the Cursor/Display Shift command; it is also used to shift the cursor. Doing this simply increments or decrements the cursor address and actually has very little in common with shifting the display, even though both are achieved using the same command.

EXPERIMENT 5

Character Entry Mode

Another command listed in Table 2 is Character Entry Mode. So far, characters have been entered using auto-incrementing of the cursor address, but it is also possible to use auto-decrementing. Furthermore, it is possible to combine shifting of the display with both auto-incrementing and auto-decrementing.

Consider an electronic calculator. Initially, a single zero is located on the right-hand side of the display. As numbers are entered, they move to the left, leaving the cursor in a fixed position at the far right. This mode of character entry can be emulated on the l.c.d. module. Time for another experiment:

Send suitable Function Set, Display On/Off and Cursor commands as before. Next, and assuming a 16-character display, set the cursor address to 00010000 ($10). Then send the Character Entry Mode command, binary 00000111 ($07). This sets the entry mode to auto-increment/display shift left.

Finally, enter a few numbers from 0 to 9 decimal, i.e. from 00110000 to 00111001 ($30 to $39). Characters appear on the right-hand side and scroll left as more characters are entered, just like a normal calculator.

As seen in Table 2, there are four different Character Entry modes, 00000100 to 00000111 ($04 to $07), all of which have their different uses in real life situations.

EXPERIMENT 6

User-Defined Graphics

Commands 01000000 to 01111111 ($40 to $7F) are used to program the user-defined graphics. The best way to experiment with these is to program them "on screen". This is carried out as follows:

First, send suitable Function Set, Display On/Off and Cursor commands, then issue a Clear Display command. Next, send a Set Display Address command to position the cursor at address 00000000 ($00). Lastly, display the contents of the eight user character locations by entering binary data 00000000 to 00000111 ($00 to $07) in turn. These characters will initially show up as garbage, or a series of stripes.

Now, send a Set CGRAM Address command, to start defining the user characters. Any value between 01000000 and 01111111 ($40 and $7F) is valid, but for now, use 01000000 ($40). The cursor will jump to the beginning of the second line, but ignore this, as it is not important.

Data entered from now on will build up the user-defined graphics, row by row. Try the following sequence of data: 00001110, 00010001, 00001110, 00000100, 00011111, 00000100, 00001010, 00010001 ($0E, $11, $0E, $04, $1F, $04, $0A, $11). A little "stick man" will appear on the display, with his feet in the gutter (the cursor line)!

By entering another set of eight bytes, the second user character can be defined, and so on.

How the CGRAM addresses correspond to the individual pixels of the user-defined graphics characters is illustrated in Fig. 5. Up to eight graphics can be programmed, which then become part of the character set and can be called up using codes 00000000 to 00000111 ($00 to $07), or codes 00001000 to 00001111 ($08 to $0F), both of which produce the same result, i.e. 64 command codes available for user programming.

It can be seen that the basic character cell is actually eight pixels high by five pixels wide, but most characters just use the upper seven rows. The bottom row is generally used for the underline cursor. Since each character is only five pixels wide, only data bits 0 to 4 are used, bits 5 to 7 (the three "left-hand" bits) are ignored.

The CGRAM is volatile memory, which means that when the power supply is removed from the l.c.d. module, the user-defined characters will be lost. It is necessary for the microprocessor to load up the user-defined characters, by copying data from its own EPROM, early on in the program, certainly before it intends to display them.

EXPERIMENT 7

4-bit Data Transfer

The HD44780 l.c.d. control chip, found in most l.c.d. modules, was designed to be compatible with 4-bit microprocessors. The 4-bit mode is still very useful when interfacing to microcontrollers, including the PIC types.

Microcontroller input/output (I/O) pins are often at a premium and have to be rationed carefully between the various switches, displays and other input and output devices in a typical circuit. Bigger microcontrollers are available, which have more I/O pins, but miniaturisation is a key factor these days, along with cost, of course.

Once the display is put into 4-bit mode, using the Function Set command, it is a simple matter of sending two "nibbles" instead of one byte, for each subsequent command or character.

Nibble is a name devised by early computer enthusiasts in America, for half a byte, and is one of the more frivolous terms that has survived. By the time the 16-bit processors arrived, computing was getting serious, and the consumption analogies "gobble" and "munch" were never adopted!

When using 4-bit mode, only data lines D4 to D7 are used. On the prototype test rig, set the switches on the other lines, D0 to D3, to logic 0, and leave them there. Another experiment is now imminent.

In normal use, the unused data I/O lines D0 to D3 should either be left floating, or tied to one of the two power rails via a resistor of somewhere between 4k7Ω and 47kΩ. It is undesirable to tie them directly to ground unless the R/W line is also tied to ground, preventing them from being set into output mode. Otherwise the device could be programmed erroneously for 8-bit output, which could be unkind to lines D0 to D3, even though current limiting exists.

After power on, the l.c.d. module will be in 8-bit mode. The Function Set command must first be sent to put the display into 4-bit mode, but there is a difficulty. With no access to the lower four data lines, D0 to D3, only half the command can be applied.

Fortunately, or rather, by clever design, the 8-bit/4-bit selection is on data bit D4, which, even on the modified test rig, remains accessible. By sending a command with binary value 00100000 ($20), the 4-bit mode is invoked.

Now, another Function Set command can be sent, to set the display to two-line mode. Binary value 00101000 ($28) will do the trick. The value 00111000 ($38) may be a more familiar number, but it cannot be used now, or the display would be put straight back into 8-bit mode! Also, from now on, all commands and data must be sent in two halves, the upper four bits first, then the lower four bits.

Start by setting data lines D7, D6, D5 and D4 to 0010 ($2), the left-hand four bits of the 8-bit code, and press the E switch. Then we set the same four data lines to 1000 ($8), the right-hand four bits of the 8-bit code, and press the E switch again. It's a lot more laborious for a human being, but to a microcontroller, it's no problem!

Finish off by experimenting with other commands in 4-bit mode, and then try putting a few characters on the display.

A FINAL NOTE

The data sheets warn that under certain conditions, the l.c.d. module may fail to initialise properly when power is first applied. This is particularly likely if the V_{dd} supply does not rise to its correct operating voltage quickly enough.

It is recommended that after power is applied, a command sequence of three bytes of value 0011XXXX ($3X) is sent to the module. The value $30 is probably most convenient. This will guarantee that the module is in 8-bit mode, and properly initialised. Following this, switching to 4-bit mode (and indeed all other commands) will work reliably.

THAT'S IT - FOR NOW!

Well, that's about it, really. You've made it this far, so now you know everything there is to know about l.c.d. modules. Well, almost everything!

The next step, of course, is to connect the display up to a controller of some sort, such as a PIC microcontroller, as will be seen next month. Then we shall also consider such things as signal timing and instruction delays.

ACKNOWLEDGEMENT

The author expresses his gratitude to Bull Electrical in Hove and Greenweld Electronics in Southampton for their help in connection with this article.

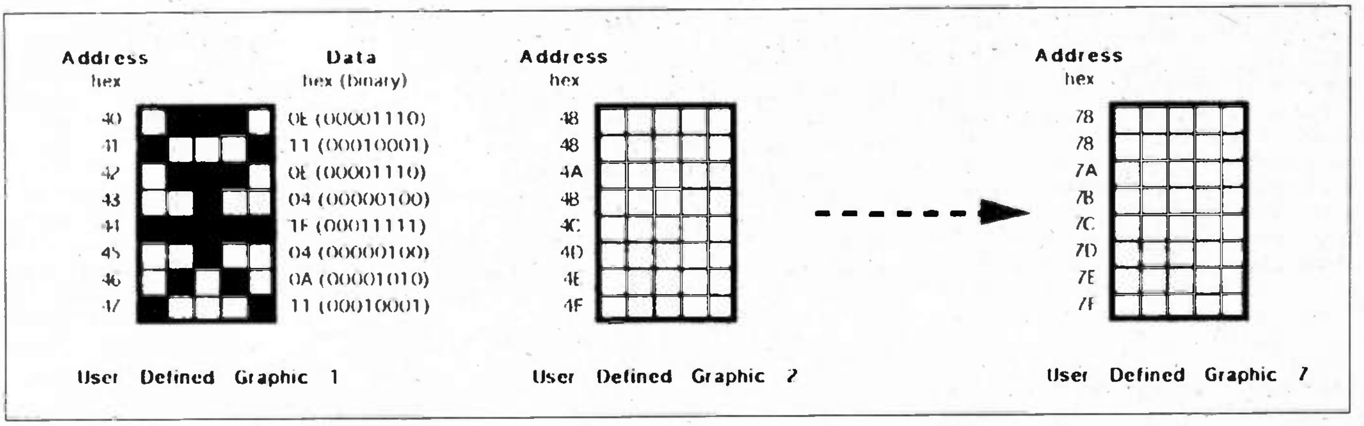


Fig. 5. Showing how the CGRAM addresses correspond to individual pixels.

New Technology Update

Multibit cell technology is enabling flash memories to push forward the boundaries of computer data storage – reports Ian Poole.

ONE of the major driving factors in i.c. technology today is to place more functionality into each chip. Nowhere is this more obvious than in memory devices. Computer technology is progressing at such a fast rate that more memory is always required. As an everyday example most PCs these days require at least 12 Mbytes to give reasonable performance, whereas only a few years ago 4 Mbytes was more than sufficient.

Flash Memories

Although not used as RAM, flash memories are finding far more uses these days. When they first arrived they had a number of performance limitations. Their life was limited to around 1000 read/write cycles and it was not possible to erase small parts of the memory, the whole chip had to be erased and new data stored. Now this has changed and the lifetime has risen to a hundred thousand or a million read write cycles dependent upon the chip, and many chips can be erased in small sectors.

Flash memory has a number of major advantages. It is a non-volatile memory and can be electrically erased. It is much cheaper to produce than the more traditional E^2PROM which has been available for many years. Flash is also replacing the traditional EPROM and a number of the big manufacturers have ceased to make them. In fact Intel dropped out a number of years ago, and when they did it sent major shock waves through the industry.

With the major developments that have been made to flash it has meant that it is far more attractive to use. As a result it is finding uses in a whole variety of areas. One of the most interesting is in flash disk drives. These "drives" consist of a flash memory card with around 40 Mbyte capacity, although sizes are rising all the time. This type of memory is particularly useful for portable systems in view of the ruggedness of a card against a mechanical disk drive which is a highly tuned mechanical assembly.

Flash Technology

The basic flash cell is very similar in outline to an ordinary EPROM cell. However, the way it is implemented and the way it operates are different. This allows for new data to be written without having to use UV light to erase the old data.

Each cell is made up from a single field effect transistor as shown in Fig. 1. Here the source and drain are separated by the channel which is about 1µm long. Above the channel there is a floating gate which is separated from the channel by an exceedingly thin oxide layer which is typically only 100Å thick. In turn there is a control gate above this which is used to charge up the gate capacitance when data is written into the cell.

The flash cell functions by storing charge on the floating gate. The presence of charge will then determine whether the channel will conduct or not. During the read cycle a "1" at the output corresponds to the channel being in its low resistance or ON state.

Multibit Cells

The requirement for any new integrated circuit these days is to be able to fit more functionality into a smaller space. Whilst feature sizes are decreasing, and announcements have recently been made about sub 0·2 micron processes, these developments alone do not give the capacity which is required. To overcome this problem a new approach has been investigated and this involves storing more than one bit of information in each cell. This instantly gives a major increase in capacity without the need to change the basic manufacturing process.

The system works by storing four different voltage levels in the same cell. This gives the four states required to store two binary bits. The states have a band of 0·4 volts and they are separated by at least 0·8 volts. This gives sufficient margin for them to be detected easily.

The technique is known as multilevel cell technology (m.l.c.); naturally it involves the use of additional sense circuitry to detect the level of charge in the cell. The way this is done is critical to the operation of m.l.c. technology. When Intel first started to investigate this method of increasing storage density they adopted what they call a binary search sensing scheme. However, they have since made a number of developments to this which are confidential and which they will not disclose.

Whilst reading the state of the cell is performed using sense amplifiers to detect the level of charge, writing the data into the cell also needs to be achieved easily. This is done by applying a number of programming pulses to the cell and, in this way, adjusting the amount of charge, and hence the voltage.

One of the problems which were foreseen with this type of technology are the errors which might be caused by considerations such as temperature stability, operating voltage and other factors which affect the operating environment. A normal binary cell only has two states which are well defined, but this new m.l.c. technology has at least four, requiring much greater degrees of stability.

With the technology in its current state no error detection and correction circuitry is required when only two bits are stored per cell; however, any increases on this will need some means of error detection and correction.

Performance

As indicated above a greatly increased quantity of data can be stored in each chip. However, there are a few parameters that have to be traded off against this improvement. The first is that the read/write performance is slower than the more traditional flash memory. Nevertheless it will still be possible to use this type of memory for most computer applications without undue degradation in the system performance.

Another problem is that the supply voltage cannot be reduced too far otherwise the windows between the different states become too small. This may prevent the migration of this technology to 3·3 volts in the foreseeable future. With the general migration of all logic families to 3·3V (and lower voltages) to preserve power and allow the development of smaller technologies, this may provide a problem in terms of supply voltage compatibility. It will not be a problem to interface the 5 volt flash to 3·3 volt logic, but it requires that any equipment using the new technology will need to provide a separate supply for it.

Despite these problems the m.l.c. technology shows great promise. Already Intel and Samsung are producing samples and a 32 Mbit chip is due to appear at any time. With this advance in capacity it looks as if any manufacturer without m.l.c. or a similar technology will be left in the slow lane.

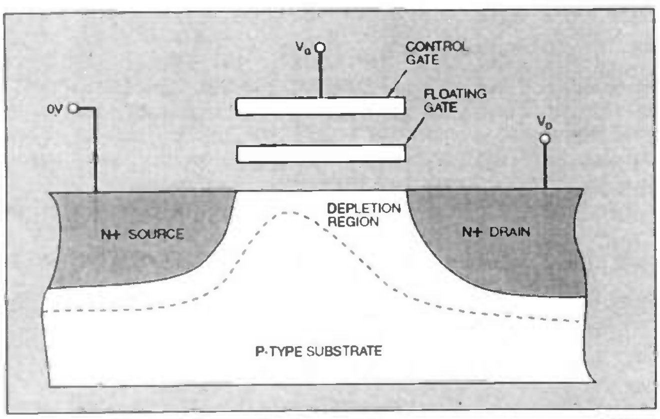
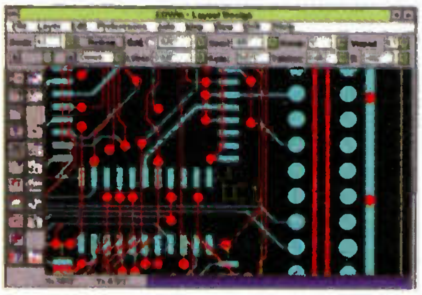
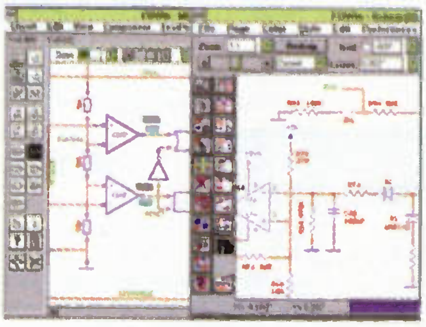


Fig. 1. Construction of a flash memory cell.





FOX REPORT

by Barry Fox

Child's Play Video

Six months ago VSLI Vision, of Edinburgh, struck deals with US toy company Tyco, and photo company Vivitar, to commercialise its single chip video camera. Tyco will use the chip in a toy video camera, that costs around £100 and plugs into a TV set or VCR to let children show or record black and white TV programmes. Vivitar will use a colour version of the single chip camera to make video phones for use with a PC.

Vision will say only that the chip is made in the "Far East", the Tyco camera is built by Tyco and the Vivitar camera is "assembled in the UK". But five years ago, when Vision was a small spin-off from Edinburgh University looking for publicity, the company was a lot more forthcoming with technical information.

In May 1990 Professor Peter Denyer and Dr David Renshaw, of Edinburgh's Department of Electrical Engineering, published two papers at IEEE conferences held in New Orleans and Boston. Together these papers described how to make a single chip video camera. The University won a small grant from the DTI, built a working prototype and secured venture capital from the Scottish Development Agency.

Chequered Imaging

Most modern video cameras rely on a solid-state image sensor array made up from a chequer board mosaic of photodiodes, each connected to a capacitor. The capacitors are charged to a fixed voltage. When a lens forms an image of the scene to be photographed on the diodes, the light causes the diodes to conduct and discharge the capacitors. The stronger the light, the faster the discharge. So the charge remaining on each capacitor after a fixed period of time represents the strength of light that fell on its associated diode.

The charges are read off, line by line, many times a second, with the diodes repeatedly recharged. This creates an electrical signal which is an analogue representation of the optical image. In conventional video cameras, the image sensor chip is connected to components which tailor its analogue output signal to match the local TV standard (625-line 50Hz PAL in Europe and 525-line 60Hz NTSC in the USA and Japan). The overall level of the signal is stabilised by controlling the light which falls on the sensor, with a mechanical iris diaphragm.

There is an obvious manufacturing advantage in combining all the electronics into a single chip, with electronic light or "exposure" control, so that a camera can be built from just one chip and a lens.

Hitachi was probably the first to build a one-chip camera. It converted the analogue signal coming from the sensor into digital code. A single digital chip then processed the signal and converted it back into an analogue TV waveform.

Applied Formatting

The Edinburgh idea was to break free from TV standards. Although the signal can be delivered as PAL or NTSC, the image can be formatted to whatever standard best suits the application, e.g. low resolution for a videophone or surveillance motion detector, or higher resolution for a digital snapshot camera or the artificial eyes of production line robots.

Using application specific integrated circuits, ASICs, Vision combined an analogue image sensor, analogue amplifiers and a digital signal processor, all on a single silicon wafer substrate. The video signal remains analogue but its processing is digitally controlled. The processor can tailor the signal to any TV, computer or industrial video standard, by adding synchronisation pulses to match the required line structure and picture repetition rate.

Exposure is automatically controlled by varying the time taken to read the signal from the photodiodes according to the light content of the image. A three colour filter over the image sensor gives colour. The manufacturing process is the same as for making microprocessors and RAM chips.

The first electronic cameras, from Sony and Fuji, flopped because they were sold to compete with photo film cameras which offer high quality paper prints at low cost. Early electronic cameras delivered TV quality images to a screen, and prints from a thermal dye system at high cost. The market for digital snapshot cameras is now taking off, because they are sold for use with PC-compatible computers.

The images are still quite poor but they can be sent by the Internet or printed out for next to nothing on a cheap colour bubble jet. The higher data speeds now available from a modem and conventional phone line allow video conferencing with coarse imaging. There is a market opportunity for low cost video cameras.

Will the British company win a slice of that market or see it devoured by the Japanese giants?

Legal Videosenders

How nice it would be to have a wireless loop round the home, that carries audio and video signals from one satellite receiver, VCR or hi-fi to every other room, without the need to lay cables and install distribution amplifiers.

Devices called "Videosenders" are on sale, often by mail order. They plug into a VCR or satellite receiver and transmit them locally on the same u.h.f. frequencies that are used for TV broadcasting. So they are *illegal* to use. Because they can cause interference to neighbours, there is a good chance that users will get caught by the Radiocommunications Agency and prosecuted under the Wireless Telegraphy Acts.

In any case, the videosender I tried gave such appalling picture and sound quality that it was unusable, even if legal.

In the USA, there are devices that work in the 900MHz band. But that band is used for cellphones in Europe and the American devices are also illegal to use.

Philips Research Labs in Redhill tried building a video device which works in the ISM (Industrial Scientific and Medical) band, at 2·4GHz. But microwave ovens also work in this band so there is too much interference.

The only other legally approved band with sufficient capacity to take a TV signal is at 5·8GHz. This is free from interference because the electronics needed to transmit and receive at such high frequencies has been too expensive for consumer use. Philips has modified the f.m. and i.f. circuitry now mass-produced for use in satellite receivers. Total component cost for a transceiver pair is £35, so the likely street price is around £100.

There is space in the 5·8GHz band for six separate TV channels. So the transmitter can connect to a security camera as well as a VCR and satellite receiver. It can also re-broadcast ordinary TV signals from the TV tuner inside the VCR.

So, there is no longer any need to lay aerial cable round the house. There is space in the signal for hi-fi stereo sound, so the system becomes a wireless hi-fi and speaker link, too. The wavelengths are so short that the transmitter and receiver aerials are small enough to hide inside the casings.

The regulations limit transmission power to 25 milliwatts. At this rating, the signals can go through a wall but then reach only 15 or 20 metres. So there should be little risk of neighbours interfering with each others' sets.

Having just struggled to distribute video round a large house, I would be first in line for a set of 5.8GHz wireless links. So when can I buy them? Philips reckon a year or so.

Constructional Project

PsiCom EXPERIMENTAL CONTROLLER

ANDY FLIND

How to use your Organiser to control external equipment as well as your normal affairs.

THIS PROJECT should allow owners of the *Psion Series 3a* "palmtop" computer to use it for controlling external equipment with simple software programs, either by switching, or with an analogue control voltage.

Psion report total sales of over a million organisers to date, of which many must be Series 3a's, and quite a few of these are probably in the hands of *EPE* readers.

PURELY EXPERIMENTAL

This design is to some extent experimental. There is no guarantee it will work with all Series 3a's or the earlier Series 3 (perhaps a reader with this model could try it and report results). It does work reliably with the author's Series 3a and experienced constructors might like to adapt the techniques used to suit other similar computers.

Psions are programmed with a simple but powerful language called OPL, which is easy to learn. Programs are written in a versatile text editor and then assembled into object code before running for speed and efficiency.

Anything that can be programmed can be used for control so long as there is a method of interfacing to the real world, but this is difficult to do with the Psion.

There is a socket for connection to a PC, but the plug is an unusual type normally found only with an expensive adapter containing additional electronics. Any attempt to communicate through the socket without the adapter will result in an error message, as the Psion expects handshake signals from it.

Sound could be used to achieve external control, but this might be subject to external interference and the user might find the controlling "bleeps" intrusive.

Radio frequency (R.F.) noise is an interesting possibility. The Psion, like most computers, radiates plenty of R.F. noise when running (and some when switched off!). The author has been unable to identify a specific component in this that could be used for control, though. OPL does have a timed "off" command but as it synchronises to the "seconds" of the internal clock, generating an analogue signal with reasonable resolution through this would require lengthy transmission periods for each value.

This leaves the screen. Attempts to read this optically with reflected light, using both infra-red and visible sources, proved unsuccessful. It is not clear why this was so, but it probably has something to do with the polarization technique used by liquid crystal displays (l.c.d.s).

SCREEN PROBING

The detection method used in the PsiCom evolved after an oscilloscope probe happened to touch the screen of the Psion whilst it was switched on. Large voltage spikes were observed, induced by capacitive coupling to the probe. Curiosity arose as to whether these spikes came from the signal used for screen driving, and if so whether their amplitude would change if the area of display under the probe were to be "on" or dark.

A simple program was written to generate a black square and, sure enough, the spike amplitude increased by about four per cent, sufficient to operate a sensing circuit. This made simple control via the screen a realistic proposition.

Some further problems arose as the design progressed. Closer examination of the signal showed that it consisted of alternate positive and negative spikes with a period between two of the same polarity of about 266ms, probably from the edges of a 376Hz square wave pixel-driving signal.

Coupled by a few picofarads of capacitance through the screen, the signal has very little power. Just passing it through a metre of screened cable almost completely loses it through core-to-screen capacitance so a simple active probe with

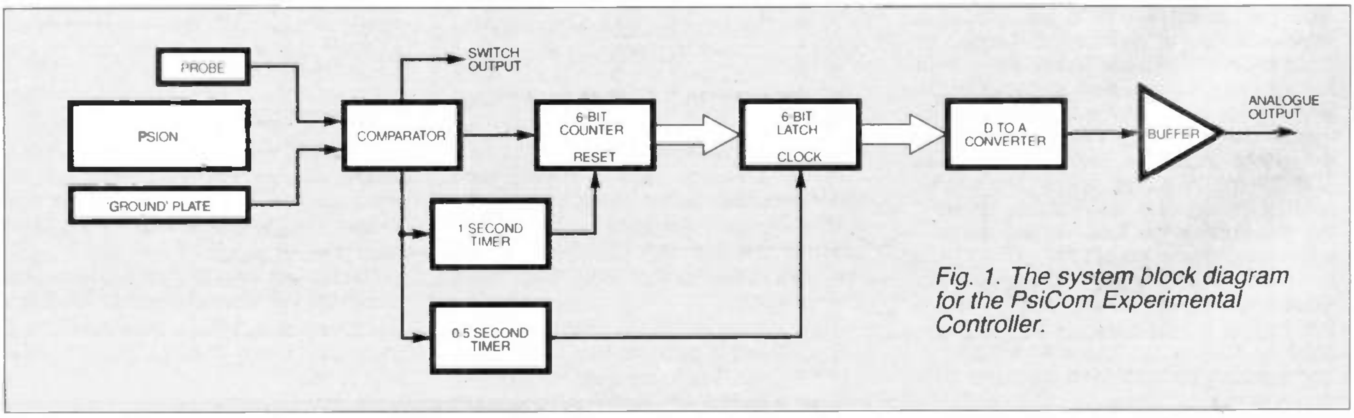


Fig. 1. The system block diagram for the PsiCom Experimental Controller.

an f.e.t. (field effect transistor) buffer was used to overcome this.

Low-pass filtering then shapes the spikes so they are more suitable for operating a comparator stage. Not all of them have the increased amplitude. Higher and normal amplitude pulses seem to alternate in groups of three to five, so the circuit must take this into account.

The ratio of high to low pulses is probably the way in which grey scales are implemented on the screen, this being borne out by the fact that it seems to change when the screen contrast is altered. However, it alters the timing of graphics on-off action slightly, making precise timing of very short periods impossible.

PAUSE TIME

A further timing problem arises from the way OPL appears to control the screen. A "pause" instruction is used for timing, with a minimum value of 1/20th of a second. The command "Pause 20" should therefore give a period of one second.

In practice, the times generated vary slightly and are rarely exact, especially for short periods. "Pause 1" in particular seems to give much less than 50ms when applied to the screen, values obtained were between 20ms and 30ms. This rules out the use of timing for analogue control applications, but it speeds data transfer when used with a counting circuit.

BLOCK DIAGRAM

The block diagram of the PsiCom system is shown in Fig. 1. The Psion drives the probe through its screen and the comparator processes the probe output into an on-off signal which is available for direct use if required.

To generate an analogue signal, a program is used to "flash" the screen for an appropriate number of comparator output pulses and these increment a binary counter. Shortly after the pulses stop a timer sends a "clock" signal to a latch which stores the counter output and a digital-to-analogue converter (DAC) turns it into an analogue output voltage.

With the output now stored in the latch, a second timer resets the counter ready for the next group of pulses. Six counter bits are used with a CMOS hex latch. This gives a resolution of about 1·6 per cent, which should be sufficient for most simple control applications.

The shorter than expected period given by the "Pause 1" instruction enables the maximum value of 63 flashes to be transmitted in about three seconds, plus a further second for the latch and reset operations.

CIRCUIT DIAGRAM

The full circuit diagram of the project is shown in Fig. 2. The Psion rests on a metal plate to give a capacitive "ground" connection. The probe is a metal disc with an f.e.t. source follower built onto it. Resistors R1 and R2 attenuate the input signal which has quite a high amplitude.

The output is taken from the source (s) of f.e.t. TR1 through coupling capacitor C2 to the comparator IC1a, with adjustable d.c. bias supplied from potentiometer VR1 through resistor R4 to set the threshold.

Peak positive signal amplitude at the comparator input (pin 2) is about 240mV with a blank screen, rising to 340mV over a black square. Positive pulses of sufficient amplitude cause the open-collector output of IC1a (pin 1) to turn on and discharge capacitor C4.

The time constant for recharging C4, set by resistor R10 to about 30ms, compensates for the "missing" pulses described earlier. While C4 is discharged, the output of IC1b (pin 7) is continuously low and may be used as a direct output signal.

Power is provided by IC2, a CMOS 5V positive regulator. This has advantages over the standard 78L05 in this circuit, which will probably be battery powered. It draws very little quiescent current and can operate with a supply below 6V. It is also

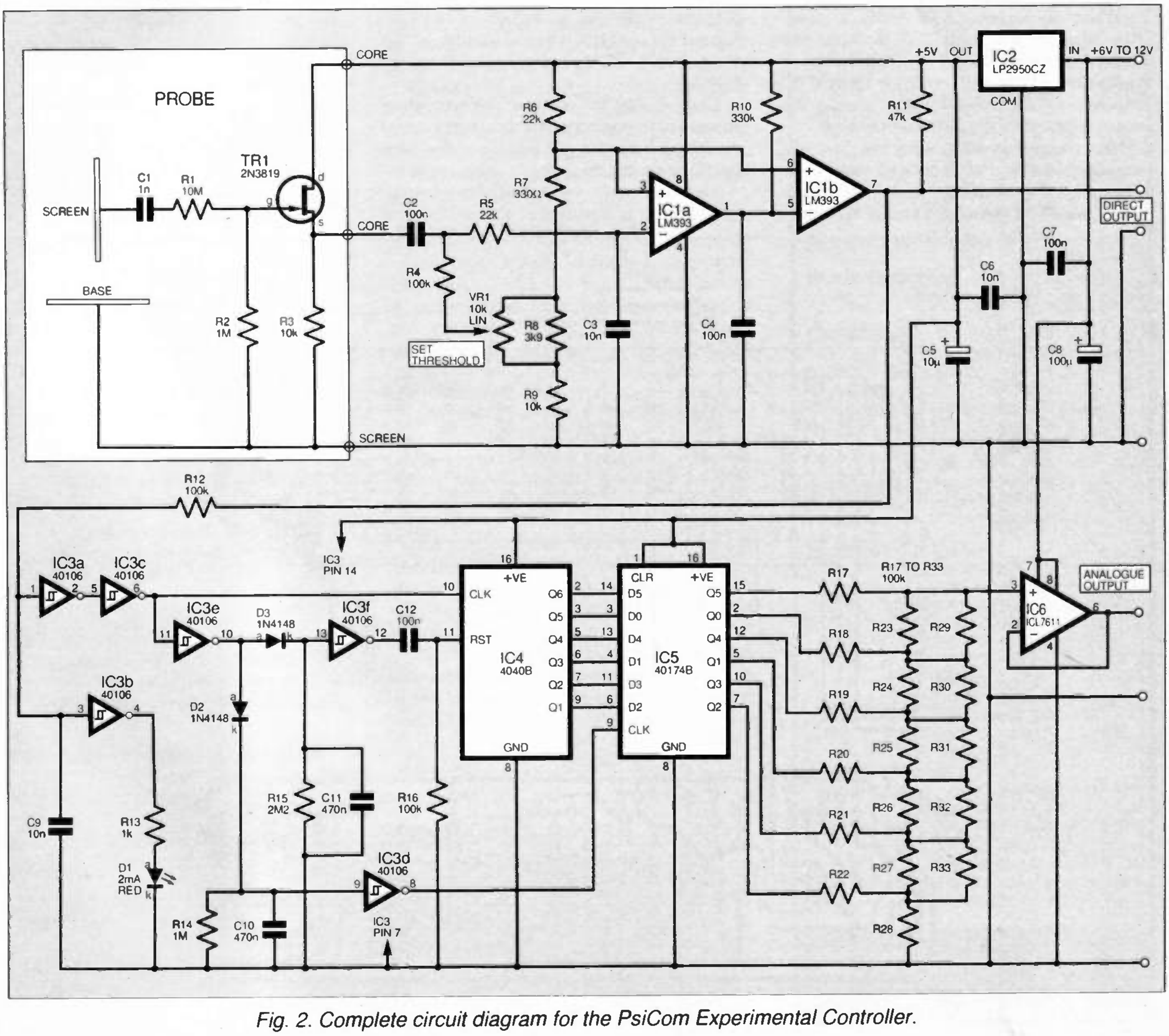


Fig. 2. Complete circuit diagram for the PsiCom Experimental Controller.

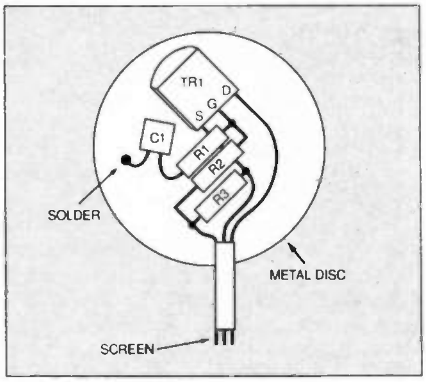
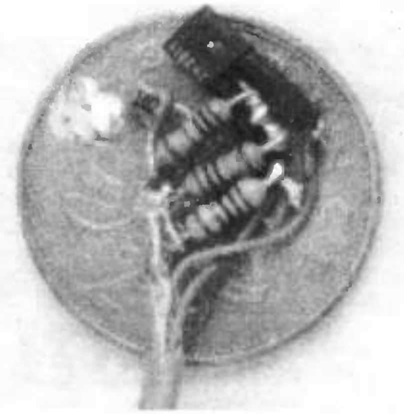


Fig. 3. Probe components and wiring.



very accurate, which is useful for providing a stable offset bias from VR1.

For analogue signal generation, the hex Schmitt inverter IC3 provides signal conditioning and timing functions. Resistor R12 and capacitor C9, together with the Schmitt action of IC3a, remove any glitches that may be present in the comparator output to give a clean signal to the counter "clock", whilst IC3c corrects polarity.

Inverter IC3b indicates the presence of the input signal by means of light emitting diode (l.e.d.) D1, useful when setting VR1 to the correct level. IC3e keeps capacitors C10 and C11 charged through diodes D2 and D3 whilst the input is present.

When it ceases, IC3d sends a positive edge to the latch IC5 to store the counter output states. Then IC3f sends a pulse through the differentiator formed by capacitor C12 and resistor R16 to reset the counter ready for the next input pulses.

The counter is IC4, with the first six outputs connected to inputs of latch IC5. The digital-to-analogue converter comprises an *R-2R* network formed by resistors R17 to R33, used instead of an integrated D-A device as they use less current.

Finally, IC6 acts as a buffer to prevent loading of the resistor network. IC6 is a CMOS micropower op.amp with a rail-to-rail output voltage capability.

The complete circuit draws a quiescent current of about a milliamp, plus another 2mA for the l.e.d. whilst energised, so prolonged operation from a PP3 battery is possible.

PROBE

The following construction procedure assumes that the PsiCom is to be used with a Psion Series 3a, so the probe will be needed for construction and testing of the main board. This is built as shown in Fig. 3.

Care should be taken to prevent short circuits between components and the metal disc, which should not be in contact with anything except the input to capacitor C1.

The disc may be a brass washer or similar with a diameter of about 25mm to 30mm, though an excellent bronze disc is widely available for the princely sum of 2p! *(Mutilation of the Queen' currency could cost you more, though! Ed.)*

Connection is made through a thin two-core screened cable, with the screen as negative and the cores used for positive supply and output from the f.e.t. When powered with 5V, the sources connection should have a d.c. voltage somewhere between 1V and 3V. The completed probe circuit can be "potted" with a blob of Araldite for insulation and strength.

BOARD ASSEMBLY

The main board is simple to assemble, though its compact size requires careful soldering. If simple on-off switching is all that is required, only the comparator and voltage regulator are needed, though the addition of IC3 would provide active outputs of both polarities plus l.e.d. indication for setting Threshold control VR1.

Details of the printed circuit board are shown in Fig. 4. This board is available from the *EPE PCB Service*, code 137.

Construction should begin with the fitting of all passive components, resistors and diodes (correctly polarised!) first, then the small ceramic capacitors, followed by the sockets for the i.c.s, and then the two electrolytic capacitors C5 and C8, again observing correct polarity. The regulator IC2 can be fitted and leads attached for the power supply, input, output, l.e.d. D1 and the control VR1 as shown in Fig. 4.

If the power supply is connected, the regulated 5V supply line can be checked; a handy point at which to find this is pin 8 of the socket for IC1. The supply current should be monitored during testing – anything above 5mA indicates a fault.

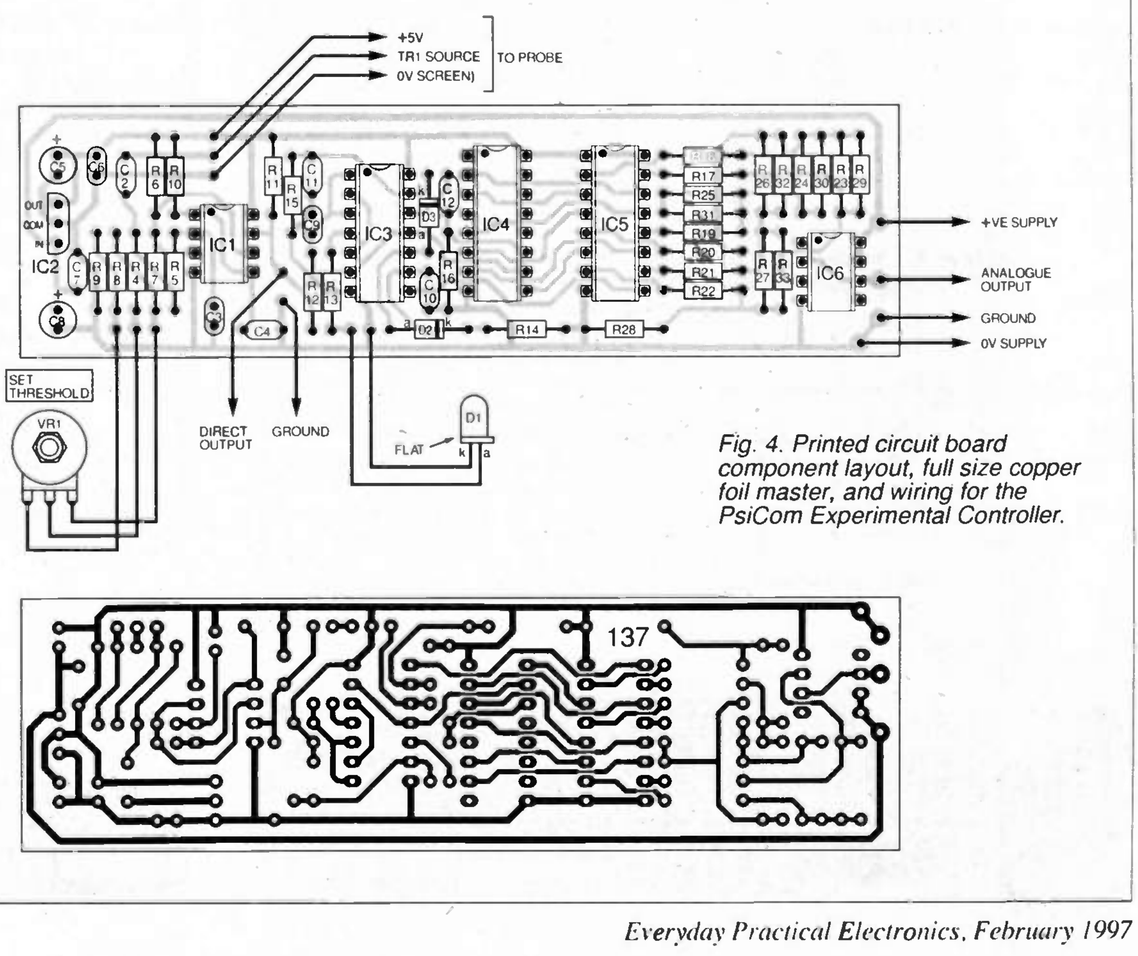


Fig. 4. Printed circuit board component layout, full size copper foil master, and wiring for the PsiCom Experimental Controller.

Most of the time the circuit will draw 1mA or less.

INITIAL TESTING

The next step is to connect the capacitive "ground" plate that the Psion will rest on. This can be a sheet of aluminium (size about the same as the Psion) with a solder tag bolted to it to take the ground lead or, to give a neat almost "scratch free" finish, a piece of printed circuit board can be utilized, with the ground lead soldered directly to the copper surface.

The Psion can then be placed in position and the "Setup" program activated, with a meter connected to the "Direct" output, just to the right of IC1 pin 5. This output is "active low" with a 47kilohm "pull-up" resistor, so, depending on the internal resistance of the meter, the positive "off" state may indicate less than 5V.

Regardless of whether the black square of the display is on or off, whilst the Psion is switched on it should be possible to turn the output on and off by repeatedly rotating the shaft of potentiometer VR1. If the square is turned on and the probe positioned so that only half the disc is over it, VR1 can be adjusted to the switch threshold. The probe can now be placed on top of the black square, and the switching action observed as it is toggled on and off from the keyboard.

The l.e.d. D1 should be connected next and IC3 fitted into its socket. Toggling the square should now turn the l.e.d. on and off. It is also possible to check the other outputs of IC3 with a meter or logic probe. Pins 2, 4, 6 and 10 should change instantly with the input. Pins 8 and 12 should go low immediately when the input turns on but delay briefly before returning high when it turns off, about half a second for pin 8 and one second for pin 12.

COUNTDOWN

Next the counter IC4 and latch IC5 can be fitted, and with the meter monitoring the voltage at pin 3 of IC6's socket, the "Test" program can be used to apply pulses to the input. If 26 pulses are transmitted, l.e.d. D1 should flicker briefly, then the output should settle to around 2V, though meter loading of the 50kΩ output resistance may lower the reading slightly.

Finally, IC6 can be fitted, and whilst monitoring the output, various numbers of input pulses can be entered to check the output. Each pulse should add 5/64 volts, or about 78mV, to the output, so a "full house" of 63 pulses should deliver about 4.92 volts. 64 pulses takes the output back to zero which is useful if this value is required as it is impossible to operate the latch without some input to the counter.

This completes the construction and testing of the PsiCom.

PSION PROGRAMS

The programs in Listings 1 to 3 show examples of how the Psion Series 3a can be programmed to output control data via the PsiCom. To keep the programs as simple as possible there is no method of exiting from them, they will loop endlessly. To escape, return to the System screen and use "delete" to stop the running program.

Having grasped the concepts by running the programs, you should be in a position to modify them to suit your own requirements.

The first program, "Setup" in Listing 1, consists of a single procedure to draw a black square. The third line sets the position to the bottom right of the screen and the fourth line draws the square.

The instruction "GET" causes the program to halt and wait for a keypress. When it gets one, "CLS" clears the screen and it then stops again. A further press causes it to return to the start of the program and redraw the square, so successive

Listing 1. "Setup"

```
PROC setup:          REM draws a black
                     square that can be
                     toggled on and off.
start::
GAT 380,55           REM sets position of
                     square
GFILL 100,100,0      REM draws square
GET                  REM stops, waits for
                     keypress
CLS                  REM clears the
                     screen
GET
GOTO start           REM loops back to
                     start
ENDP
```

COMPONENTS

Resistors

R1	10M
R2, R14	1M (2 off)
R3, R9	10k (2 off)
R4, R12, R16 to R33	100k (20 off)
R5, R6	22k (2 off)
R7	330Ω
R8	3k9
R10	330k
R11	47k
R13	1k
R15	2M2

All 0·6W 1% metal film

See SHOP TALK Page

Potentiometer

VR1	10k rotary carbon, lin.

Capacitors

C1	1n ceramic, resin-dipped
C2, C4, C7, C12	100n ceramic, resin-dipped (4 off)
C3, C6, C9	10n ceramic, resin-dipped (3 off)
C5	10μ radial elect. 50V
C8	100μ radial elect. 25V
C10, C11	470n ceramic, resin-dipped (2 off)

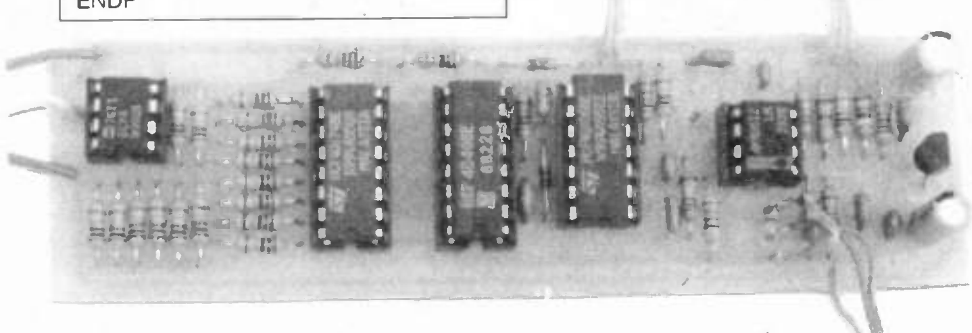
Semiconductors

D1	red l.e.d., 2mA
D2, D3	1N4148 signal diode (2 off)
TR1	2N3819 *n*-channel f.e.t.
IC1	LM393N dual comparator
IC2	LP2950CZ +5V regulator
IC3	40106B hex Schmitt inverting buffer
IC4	4040B binary counter
IC5	40174B hex D-type latch
IC6	ICL7611 op.amp

Miscellaneous

Printed circuit board, available from the *EPE PCB Service*, code 137; 8-pin d.i.l. socket (2 off); 14-pin d.i.l. socket; 16-pin d.i.l. socket (2 off); case (see text); metallic disc (see text); aluminium or p.c.b. ground plate, size slightly less than Psion; knob; connecting wire; solder, etc.

Approx Cost Guidance Only £17 excluding case



Innovations

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

BETTER BEER AND CHIPS

New sensors improve quality and speed production in the food and electronics industries – *by Hazel Cavendish*

THE continued development of sensors has been the subject of exciting advances recently, particularly benefitting the food and drink industry in Britain and Europe, as well as in the US and Japan.

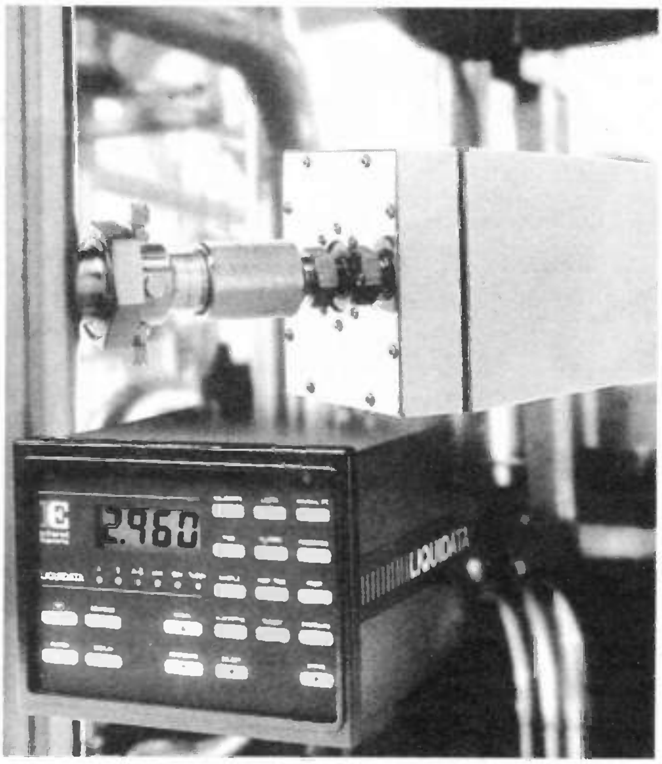
Some of the most interesting news comes from Britain's Fairey Group, which attributes 70 per cent of its £20 million turnover to investment in electronic products, and announced a healthy 32 per cent pre-tax profit for the first six months of last year. The original Fairey Aviation Company has gone through many changes and shifts in direction over the years, developing into the present group which has been in existence for nine years, with market capitalisation of over £400 million.

98% PROOF

Infrared Engineering of Maldon, Essex, a firm under the Fairey umbrella which specialises in sensors for on-line analysis, recently launched Liquidata as a powerful aid in the blending of beer. This new analyser, aimed at high specific-gravity brewing lines, has not only resulted in a consistently better beer from those international breweries already using it, but also increases the volume produced and cuts overheads.

It is claimed to be the first instrument on the market which offers brewers the chance to automate in-line control of the blending station. Major European, US and Japanese breweries have reported figures indicating "right-first-time" blending of 98 per cent.

Liquidata feeds back real-time measurements of the beer's alcohol and original gravity to the blending station, which adjusts the flow valves automatically to keep the blend within specification. It is insensitive to ambient or product temperature, the colour of the beer or the presence of dissolved gases. The system saves much of the time, effort and cost of laboratory analysis of samples, and maximises production.



Infrared Engineering's Liquidata in-line beer analyser provides real-time measurement and control of alcohol content and original gravity.

FAST FOOD

The same company has produced the MM55E-SF Sensor for measuring oil and moisture content in snack foods, which has been snapped up by one of the leading US manufacturers in the market. Close control of oil and moisture levels in products such as potato crisps, corn chips, pretzels and puffed snacks is important with the public's insistence on "low fat" variants.

Infrared Engineering's near-infrared (NIR) sensor uses selective absorption techniques and a unique dual detector head for stable repeatable measurements in the harsh and changeable conditions of the food process line. NIR technology offers the opportunity to measure an exceptionally wide range of process parameters, including moisture, fat, starch, sugar protein and organic layer thickness, many of which have until now defeated other methods of analysis.

FLATTER CHIPS

Luxtron Corporation, an important American company in the Fairey Group, has introduced a new optical technique for monitoring the production of integrated circuit wafers undergoing the chemical polishing process (CMP). As conductive tracks on semiconductor chips get closer together, and more layers are needed to build up sophisticated circuits, so optical flatness at each level becomes more critical.

Luxtron's new optical system for monitoring chemical and mechanical polishing of semiconductor wafers.

Luxtron is meeting this requirement by using optical interferometry, a process which monitors the interference pattern formed by combining two light beams derived from a single source. The principle recognises that changes to one beam of light made by passing it through a medium such as silicon dioxide on a silicon semiconductor wafer will produce a phase delay that leads to interference patterns when the two beams are recombined.

This technique, used in the study of gas flow and plasma physics, has been adapted by Luxtron for a technique to measure oxide removal during the chemical polishing process. The scheme involves illuminating the back side of the wafer with infrared radiation, to which silicon is substantially transparent. This allows the radiation to probe the front side of the wafer while it is being polished. The system is relatively simple to implement since only the polishing head needs to be modified.

Although still in its early stages, the optical interference technique is believed to hold considerable promise for real-time wafer process control.

YOUNG ELECTRONIC DESIGNER AWARDS

MORE AWARDS

YEDA, the *Young Electronic Designer Awards* for 1997, are now open for entries. The scheme is aimed at challenging school and university students across the UK to demonstrate their ideas and skills by developing solutions to everyday needs with the help of modern technology.

By entering YEDA, students have the chance to exploit their innovative talents, to improve their technical know-how and to develop business acumen, all essential requirements in preparing for an engineering career.

Completed entry forms for the 1997 competition have to be submitted by 31 January 1997. For further information, contact *The YEDA Trust, Dept EPE, 60 Lower Street, Pulborough, West Sussex, RH20 2BW. Tel: 01798 874767.*

Another rewarding competition is on offer as well. The annual nationwide search to find the *Young Engineer for Britain* has commenced for 1997.

The competition is run as a joint venture by the Engineering Council and Young Engineers clubs. The three principal sponsors are Lloyd's Register, GEC and British Airways Engineering.

The competition seeks out Britain's most ingenious and inventive students and is open to entries from bright 11 to 19 year olds, who will be competing for prizes totalling more than £25,000.

Entry to the competition can be from individuals, teams of up to four, and from Young Engineers clubs.

Entry details are available from *Young Engineers for Britain, Dept EPE, 10 Maltravers Street, London WC2 3ER. Tel: 0171 240 7891.*

The Radiocommunications Agency announced recently that the *Young Radio Amateur of the Year Award* has been won by 14 year old Christopher Davies from Shropshire, who received £300 as his prize.

Christopher has worked on two special event stations, "Jamboree on the Air" and "Thinking Day on the Air". He is an active member of his local amateur radio club and has been instrumental in persuading his club to support the Novice course for which he intends to become a Novice Instructor.

If you would like know about next year's YRAYA competition, contact *The Radio Society of Great Britain, Dept EPE, Lambda House, Cranbourne Road, Potters Bar, Herts EN6 3JE. Tel: 01707 659015.*

SURVEYING A BUMPER-BUNDLE!

MANY THANKS to all of you who completed and returned our Readership Survey forms distributed with the November '96 issue of EPE. *The wealth of information provided is of tremendous value and will help us to guide* EPE *forward into the next Millennium.*

We have given prizes of £75 to the two readers whose forms were randomly drawn out on November 25. The lucky readers were ***Mr Gary Lee*** *of Fowey, Cornwall, and* ***Mr J. Rogerson*** *of Chorley, Lancs. Congratulations!*

GREENWELD'S NEW CAT

THE 1997 New Look Greenweld Catalogue has been released. Containing all the essential components for hobbyists of every description, it's completely *free of charge*.

Greenweld have stripped out the slow selling and difficult to procure lines, concentrating instead on the parts constructors really need – all at hard to beat prices, and with a 95% stock availability.

But they haven't forgotten what they're famous for – their Bargain Lists of surplus and redundant stock! A recent Greenweld survey sent to nearly 50,000 people revealed that what you like best about the company are their bargains galore.

So, go on, get your own copy and delve into its treasures. Just ring 01703 236363, or write to Greenweld at 27D Park Road, Southampton, SO15 3UQ.

BEWARE THE PC-MILLENNIUM

SOME computer companies are still selling software which cannot cope with the millennium date change, said Science and Technology Minister Ian Taylor in a recent press announcement at The Department of Trade and Industry.

There are numerous implications for businesses who unwittingly purchase software that will not take into account the so-called Millennium Problem. The problem arises from a deceptively simple issue. Generally, computer systems have been written to recognise two digits for the year component of the date.

For most applications in the 20th Century this has been fine. However, as the year 2000 approaches, systems have to interpret the "00" and many will interpret this as 1900 rather than 2000, causing problems in validation display, calculation, storage and printing.

To make us all aware of the problem, Taskforce 2000 was established in July 1996 as a not-for-profit organisation co-sponsored by the Confederation of British Industries and the Computing Services and Software Association.

If you need to know about how to tackle the Millennium 2000 problem, contact Taskforce 2000 on 01582 832110; and if you are buying software, double-check with your dealer that it will cope with the Millennium change.

DRILL KIT

MINICRAFT'S 12V drill kit now comes with 40 versatile accessories. This top-of-the-range kit is suitable for use by all hobby enthusiasts and professional users and is ideal for electronics construction, model building and repairing work as well as small DIY tasks.

It combines the MB1012 100 watt precision drill with the MB730 variable speed transformer and now comes with 40, instead of the original 15, accessories for drilling, grinding, cutting, routing, shaping, polishing and sanding.

The complete kit comes in a handy carrying and storage case. Its recommended retail price is £84.99.

For more information, contact Uta Harris at Delic Associates, Dept EPE, 3-5 Duke Street, London W1M 6BA. Tel: 0171 486 6644.

CHASING MAGENTA

REMEMBER the *EPE PIC-DATS Four-channel Light Chaser* project of June '95? Well, Magenta Electronics have introduced an updated version of the software for it. It uses the PIC16C84 (what else!) and they are supplying chips and disk with fully "commented" source code for both TASM and MPASM compilers.

The software's available alone for just £2.50 (which is really only a handling charge) including p&p. Alternatively, they can supply preprogrammed PIC16C84s for only £12.

Magenta also have details about a couple of hardware mods they've made for the project – ask them for a copy.

For more information, contact Magenta Electronics Ltd., Dept EPE, 135 Hunter Street, Burton-on-Trent, Staffs, DE14 2ST. Tel: 01283 565435.

EARTH RESISTIVITY METER

ROBERT BECK

Part 2

Your assistance to the local Archeological Society could be invaluable with this simple subterranean site detector at your command.

PART ONE of this project, last month, described the circuit principles and its construction. This concluding part is mainly concerned with field-work. But first, a bit more probe-work.

FRAMED SUPPORT

The schematic in Fig. 10 shows a support frame and probe assembly combined, specially developed for use with the Twin Probe configuration. The top member is a wooden batten, 30mm × 50mm × 1050mm, the ends of which are bound with self-amalgamating tape to form hand grips. An aluminium platform is attached to the centre of this batten to carry the resistivity meter, held on by rubber bands.

The bottom member is a similar wooden batten, but this piece must have good insulating properties. Either, dry and coat with varnish, or devise insulating collars of Tuffnol or similar material, and fit where the probes go through the wooden batten.

The top and bottom battens are held together by metal conduit pipes, threaded at each end and secured by lock nuts. The probes in this frame would be the C_2 and P_2 probes. The C_1 and P_1 probes being, for instance, the probes shown in Fig. 9b last month.

FIELD TEST UNIT

In Fig. 11 is shown the circuit diagram for a simple test unit which may be used to verify correct operation of the resistivity meter in the field. It consists of a rotary switch to select various resistors from zero to 1000 ohms.

The four 4mm plugs are to connect the C_1, C_2, P_1 and P_2 sockets on the resistivity meter. When the test unit is plugged in, the C_1 socket is connected to the P_1 socket, with the C_2 and P_2 sockets similarly connected.

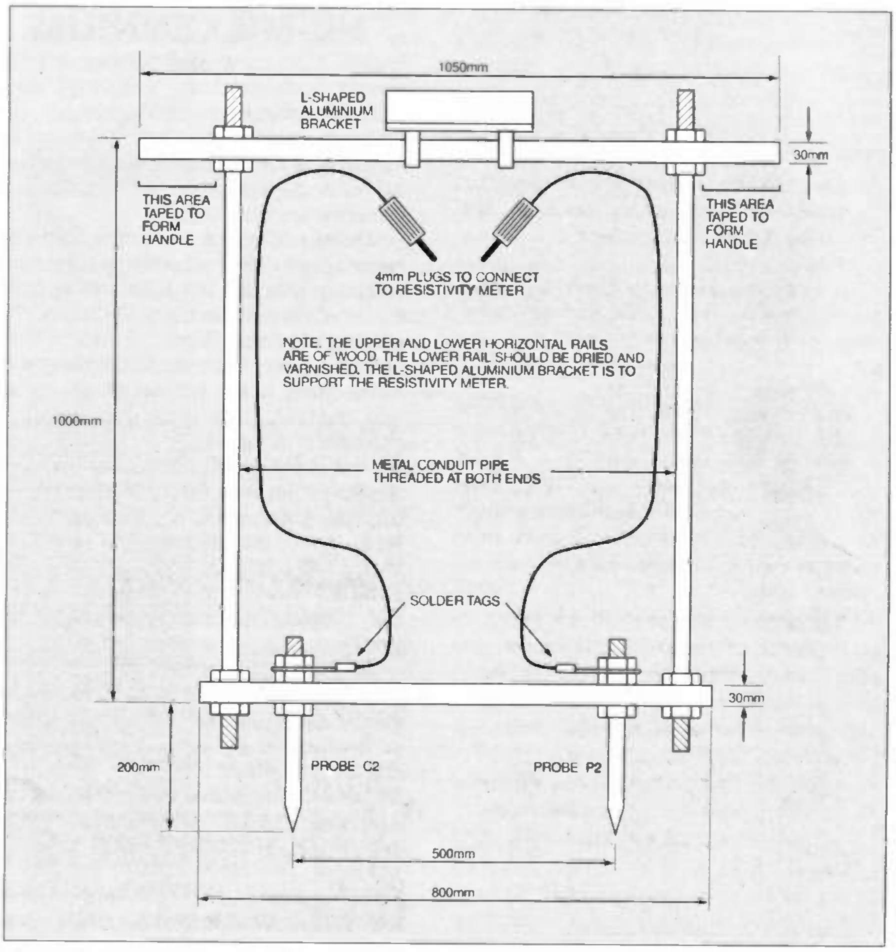


Fig. 10. Support frame for Twin Probe configuration.

The selected resistor is also placed across the current generator output. In use, the Field Test Unit is connected to the Resistivity Meter and checked against Table 4.

For ease of use, the circuit should be mounted inside a small diecast box.

DOING THE FIELDWORK

Decide what features may be present in the area under investigation. If it is likely to be a solitary linear feature, a Roman Road perhaps, then it is suggested that you try the Wenner configuration.

Table 4

Test Unit Resistor	Output Current	Resistor Volts	Volts Output		
			Amp Gain × 10	Amp Gain × 100	Amp Gain × 1000
0Ω	0.1mA	0	0	0	0
1Ω	0.1mA	0.1mV	1mV	10mV	100mV
100Ω	0.1mA	1mV	10mV	100mV	1V
1000Ω	0.1mA	10mV	100mV	1V	10V
0Ω	1mA	0	0	0	0
1Ω	1mA	1mV	10mV	100mV	1V
10Ω	1mA	10mV	100mV	1V	10V
100Ω	1mA	100mV	1V	10V	xxx
1000Ω	1mA	1V	10V	xxx	xxx
0Ω	10mA	0	0	0	0
1Ω	10mA	10mV	100mV	1V	10V
10Ω	10mA	100mV	1V	10V	xxx
100Ω	10mA	1V	10V	xxx	xxx
1000Ω	10mA	10V	xxx	xxx	xxx
0Ω	50mA	0	0	0	0
1Ω	50mA	50mV	500mV	5V	xxx
10Ω	50mA	500mV	5V	xxx	xxx
100Ω	50mA	5V	xxx	xxx	xxx
1000Ω	50mA	50V	xxx	xxx	xxx

NOTE: xxx indicates that the amplifier has saturated because the input voltage is too high and these indications should be ignored.

Have ready a map of the area, as large a scale as practicable – or draw your own if you can do so. Carefully measure from field boundaries or buildings to each end of your proposed traverse (the line that you are going to work along) both on the map and on the ground. Measure each end of the traverse from at least two different points to positively locate them.

Another method to save measuring is to set out the traverse to run from one corner of a field to the diagonally opposite corner. Note that when laying out traverses, they should cross features at right angles for maximum sensitivity of detection.

Put the C_1 probe in the ground at the start of the traverse. Measure one metre along the traverse and put in the P_1 probe. Measure a further one metre and insert the P_2 probe, and then a further one metre and insert the C_2 probe (as in Fig. 8a last month).

Connect the resistivity meter and take the first reading. This is the reading on the indicator divided by the amplifier gain setting. Move the C_1 probe to one metre further along from the C_2 probe.

Reallocate the probes so that they run in the same order as before and reconnect to the resistivity meter. This act of moving only one probe and reallocating the probe connections is in effect the same as moving the whole configuration one metre along the traverse. Take the second reading and proceed in a similar manner until the end of the traverse is reached.

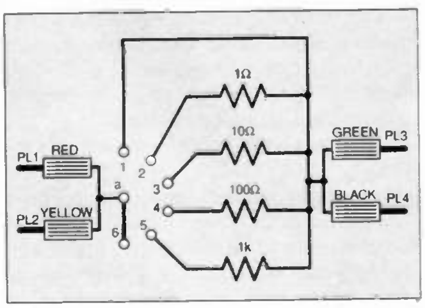


Fig. 11. Circuit diagram for a Field Test unit.

TWIN-PROBING

If the features under investigation seem complex, then the Twin Probe configuration is a better choice, because a whole plan area of ground is measured rather than the single straight lines of the Wenner technique.

Lay out a square in the field, 20 metres by 20 metres, as in Fig. 8c. The right angles may be formed by any of the conventional methods, i.e. magnetic compass, optical square, theodolite or the "3, 4, 5" triangle method. If you already own any of the first three items, you will presumably know how to use them, so we will only consider the latter.

Lay a triangle on the ground, using strings or tapes. Keep adjusting the sides until one side is three metres long, another is four metres long and the last side is five metres long. The angle formed by the three metre side and the four metre side will be a perfect right angle. Extending these sides to 20 metres will thereby give two of the sides of your 20 metre square.

Once this square is completed, place temporary markers (garden canes) along two opposite edges one metre apart, and lay a tape measure across the first set of markers. We now have a strip one metre wide between one edge of the square and the tape.

Place the moving pair of probes C_2 and P_2 about 500mm apart at the 500mm mark on the tape and equidistant between the tape and the edge of the square. Insert the fixed pair of probes, spaced about 500mm apart approximately 15 metres away from the square to be measured.

If you contemplate measuring an adjacent 20 × 20 metre square, then arrange the fixed probe pair position so that it will be about the same distance from this proposed adjacent square. Take the reading and then insert the moving pair adjacent to the 1·5 metre mark on the tape and take the second reading.

Carry on until 20 readings have been taken, which should occur at 19·5 metres on the tape. Move the tape to the second pair of markers and repeat for the next 20 readings. Continue as above until you have all 400 readings.

RECORDING READINGS

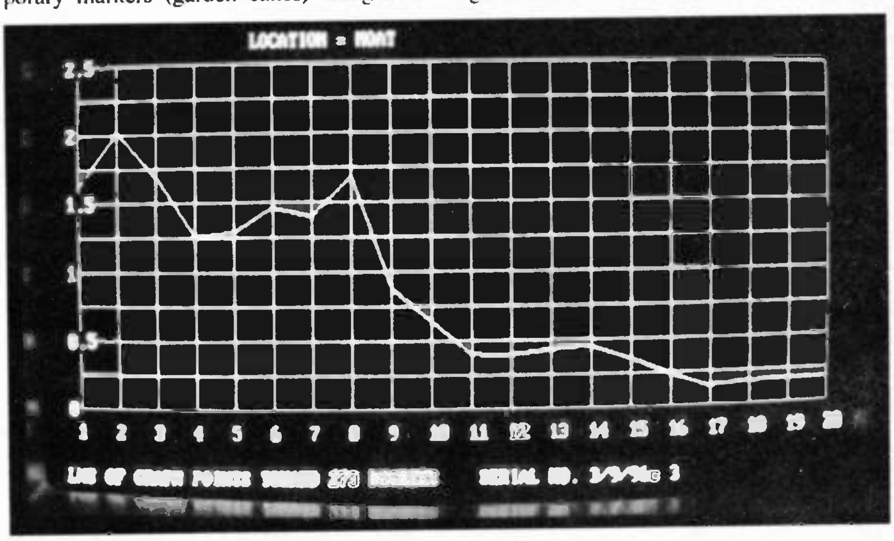
When recording site readings, note the amplifier gain setting, current used, and probe spacing.

Readings can be recorded on paper in columns for both types of survey. Make a note of which end of the column refers to which end of the transect on the plan, using possibly a combination of letters and numbers, e.g. A.B for the first transect, C.D for the second transect, and so on, numbering the individual readings from 1 to 20 (as in Fig. 8c).

The readings should be recorded as output voltage divided by gain setting of the amplifier. They can then either be left as comparative ohmic values, or converted to apparent resistivity figures.

Readings can also be spoken directly into a portable micro-cassette recorder, and transcribed at some later date. This is far more convenient than writing on paper in a wet field in a howling gale!

Linear transects can be presented as a graph, i.e., distance along transect in metres as the horizontal axis and resistivity readings along the vertical axis. Area investigations can be presented by drawing a grid of 20 × 20 units divided into 400



This graph was generated from readings taken at the same site as in last month's similar graph, but in a different position.

squares with each square having its individual reading noted in it.

This is difficult to interpret, so a series of colours may be used to represent bands of resistivity readings. These colours may be added with coloured pens, or generated by computer, perhaps using the author's program to draw linear graphs, area, colour, or shade plots of the results.

QBASIC PROGRAM

As stated in Part 1, a copy of the author's program, written in QBasic (for a PC-Compatible computer), is available from the Editorial Office for the sum of £2·50 UK, £3·10 overseas surface mail or £4·10 airmail. This is to cover admin costs and postage, the disk itself is *free*.

The program can also be downloaded *free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk**, in the sub-directory: **pub/PICS/Earth.Meter**.

The program prompts you to enter details of the survey and then print them if required. It will then show either an on-screen graph for a linear survey of 20 readings, or greyscale or coloured squares for a 20 × 20 metre square. There is no facility offered for outputting the data to disk, though if you are familiar with QBasic, you should find it an easy option to implement.

In the "square" display mode, the program converts the resistivity results into six bands which correspond to the level of the readings, to produce the variation of colour or greyscale. This data can then be printed using the "print screen" key on the computer. *(Some combinations of PC and QBasic may not have this option available directly, requiring a Graphics sub-program to be loaded from DOS before loading QBasic – check with your User Manual. Ed.)*

When running the program, reply to the on-screen prompts as necessary, just pressing ENTER if any prompt is not relevant to you, and print the data that you require. You will, of course, require a colour printer if you want a colour square print. If a colour printer is not available, then use the greyscale option.

ETHICS

Now, most importantly, a word or two about the ethics of resistivity surveying:

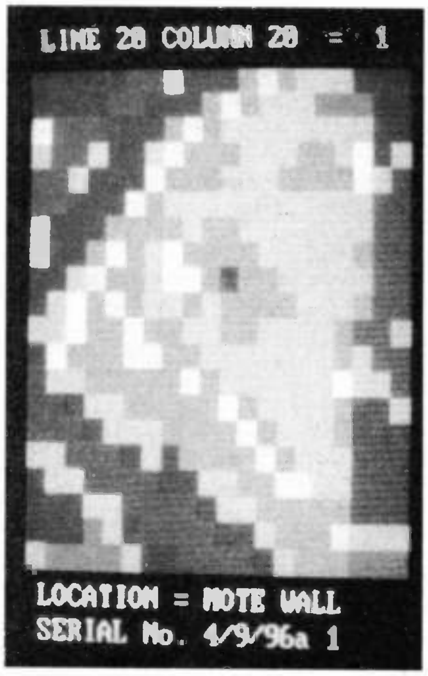
At some point, you will feel the urge to prove the results of your equipment by digging. Resist it! If it proves to be a site of any importance, your dig will certainly have destroyed information that is necessary to fully interpret it.

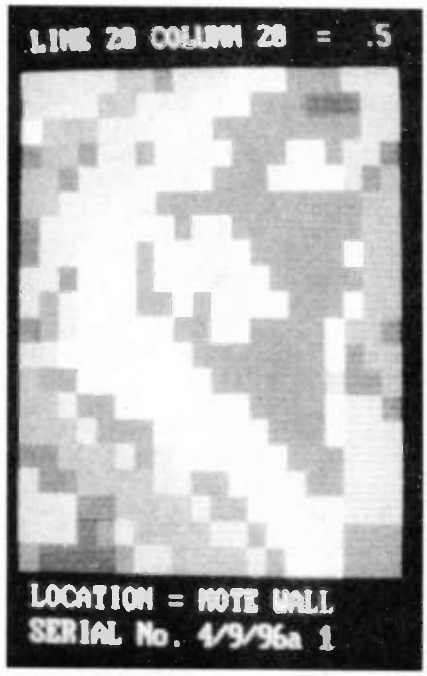
Do not dig without an Archeologist's involvement.

Although resistivity surveying itself is (apart the probing) non-invasive, do remember that *all land in the British Isles is owned or controlled by someone. Find who it is and ask their permission before you proceed.*

Only once has the author been unable to carry out a resistivity survey, being prevented by an over-zealous Town Council who wanted him to take out an expensive personal liability insurance.

Most landowners will not mind you using their land, providing you do not waste too much of their time with your enquiry. Explain to them that you will not dig holes. Show them your probes and how they are used.





These two 20 × 20 square computer displays were generated from the same set of readings but using different screen colour allocations for each reading.

Point out that you are unable to detect metallic artefacts such as coins and gold rings, etc. By stating this, you will indicate that you will not be competing with any metal detectorists who may already be allowed to use their land. It is also possible that some of them do not approve of metal detecting but see no harm in resistivity surveying.

Once you have got this far, you will probably be considered a harmless crank and left to it. When you ask for access, mention others that have previously given permission as this often helps. Conversely, if you antagonise any landowner, all the surrounding landowners will hear about it. Then you will have to go very far afield to gain access to suitable sites.

If the site that interests you is a Scheduled Ancient Monument, permission to carry out any form of research must be obtained from The Department of National Heritage, and it is doubtful if it would be granted to an amateur.

Scheduled Ancient Monuments appear on the Sites and Monuments Record held by the County Archaeologist of the county in question. If you have any doubt, phone him, and be prepared to experiment somewhere else if necessary.

LOCAL GROUPS

Also make yourself known to local amateur Archaeological Societies, as some of these use resistivity equipment and dig under the guidance of qualified Archaeologists. They may find you useful in surveying sites that they are interested in. Some professional archaeological groups encourage public membership and arrange lectures, etc.

Membership of one of these groups can be useful in enabling you to discuss your results and techniques with qualified archaeologists. Remember, though, that they are probably not electronics experts and, with very few exceptions, will have no knowledge of the internals of their "black boxes".

The Romney Marsh Research Trust (RMRT) is the organisation of which the author is a member. This organisation supports a group of academics and scientists practising in the fields of archaeology, geography and history. The purpose of this organisation is to combine results to provide information on the formation and history of the Romney Marshes in Kent.

If you want to find out what local groups exist in your area, your local library should be able to tell you who and where they are.

THANKS

The author expresses his gratitude to many members of the RMRT for discussions and practical assistance concerning resistivity surveying and many other technical subjects. He is especially grateful to Dr Mark Gardiner who allowed him access to his site at Broomhill in East Sussex to use known buried features to test the equipment.

FURTHER READING

Applied Geophysics, W.M. Telford, L.P. Geldart, K.E. Sheriff, D.A. Keys. Cambridge University Press. ISBN 0521-20670-7.

Applied Geophysics, Griffiths and King. Pergamon Press. 1965.

Seeing Beneath the Soil, Prospecting Methods in Archaeology. A. Clark. Batsford. 1990. ISBN 0-7134-5858-5

The first two books are written to cover large-scale Geological Prospecting and are relatively old publications. However, they contain a large amount of theory regarding various probe configurations.

The last book listed is written by Dr A. Clark, a consultant in archaeological prospecting and dating, and is highly recommended. It is clearly written in non-mathematical language. Methods of setting out survey grids, interpreting and processing data, and descriptions of the workings of various types of probe configuration are all covered in detail.

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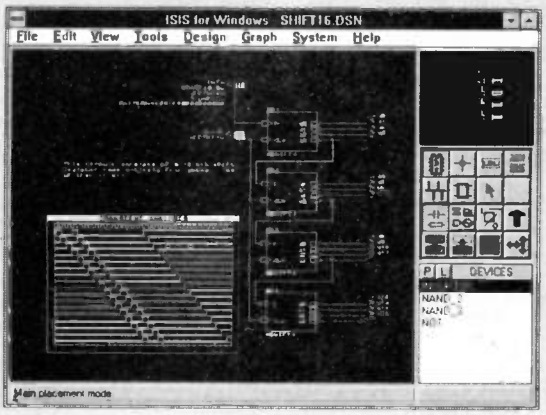

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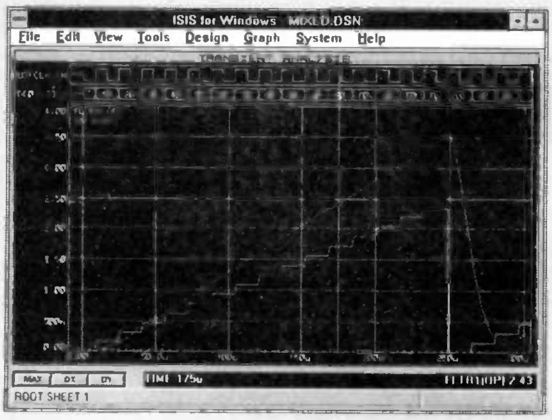

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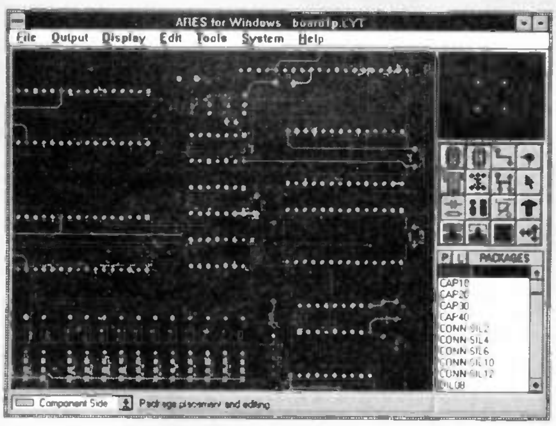

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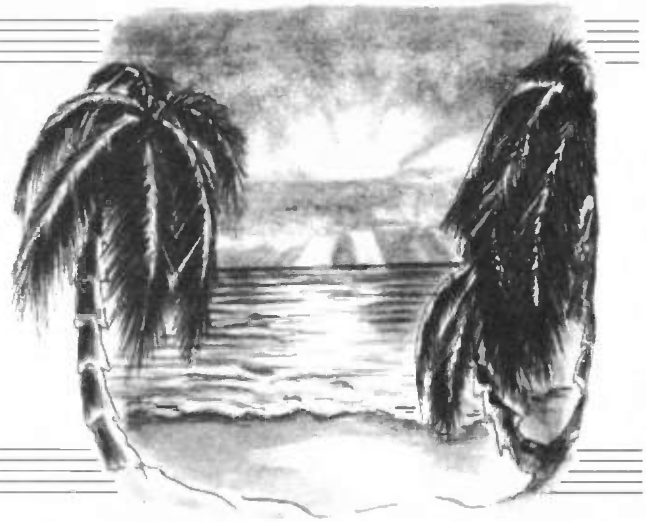
Constructional Project



PACIFIC WAVES

ANDY FLIND

In these days of high stress, why not relax to the soothing sounds of the "high seas" in the comfort of your own home!

THERE can be little doubt that one of the most relaxing sounds of nature is that of ocean waves breaking along a wide shore. It calms the soul, and in these stress-filled times a stroll along such a beach isn't simply a pleasure, it's a therapy.

Unfortunately, not all of us live within easy reach of the sea. Even those lucky souls who do will know that the weather isn't always favourable and, of course, the tide is often out!

A way of creating the sounds of wild surf in the comfort of the home is very useful as it lets users sit down, close their eyes and be instantly transported into realms of calm and serenity. Meditators can find it especially helpful as it masks intrusive external sounds whilst creating a perfect atmosphere for deep relaxation and concentration.

The Pacific Waves project described here is designed to create surf sounds as realistically as possible for playing through any ordinary domestic stereo system.

TROUBLED WATERS

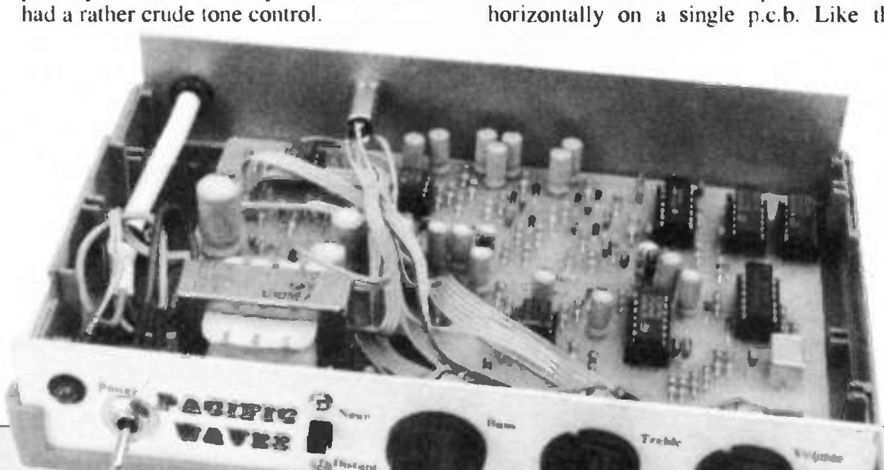
Readers may recall a previous surf sound generator by the author, published some years ago. This has been in constant use ever since, but recent problems with it have now led to this new version.

An objective for the original design was that it should be pocket-sized with a headphone output. This resulted in a very compact layout that was tricky to construct and had a rather crude tone control.

In practice it was never used with headphones, instead remaining permanently connected to the household stereo. For a realistic sound the amplifier Bass and Treble controls needed readjustment, and occasionally the battery needed replacing which seemed wasteful when mains power was always available.

A faulty component finally led to the new version though, as the compact layout meant repairs occupied most of a morning. The first replacement came from the workshop spares and proved worse than the original!

At this point the new design began to take shape with the objectives of mains power, tone controls giving sufficient bass boost and treble cut to eliminate the need for amplifier adjustments, and simple construction with all components fitted horizontally on a single p.c.b. Like the



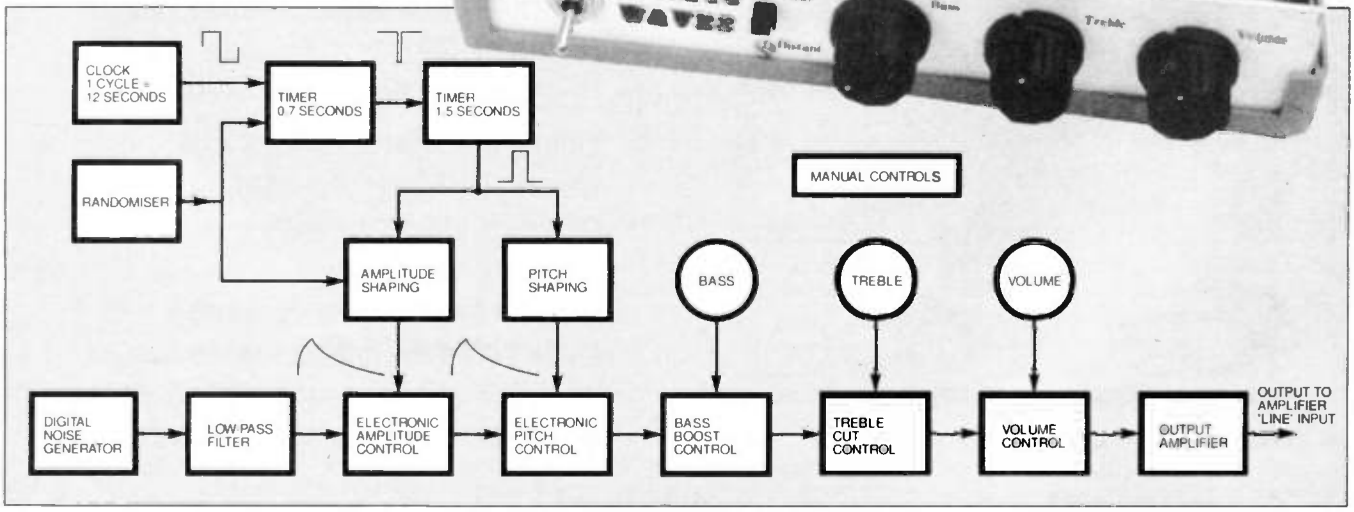


Fig. 1. Pacific Waves block diagram. Although only one signal path is shown, the project operates in stereo.

original, there would be no compromise of sound quality which had to be as realistic as possible.

Constructors of this project will probably agree that this last aim has been successfully met. Although primarily intended for operation through an external stereo amplifier, the project can drive "Walkman" type headphones for personal use if desired.

HOW IT WORKS

A glance at the circuit (Fig. 3) will show that it is quite complex, so the block diagram of Fig. 1 is provided to aid with the description of its operation. The lower part of this diagram shows a Digital Noise Generator for producing a random stream of "bits". Although only one signal path is shown, the project operates in stereo using two of most elements shown here.

The noise generator has two outputs, one for each channel. Low-pass filtering of the bit-streams converts them into analogue "white noise" signals for processing into "surf" sounds. Electronic Amplitude and Pitch control circuits shape the noise into "waves" whilst manual Tone and Volume controls allow adjustment for individual preference before final level boosting by the output stage.

The upper section of Fig. 1 shows the control circuit for creating "surf" from the white noise. It has a "Clock" with a frequency of around one cycle every twelve seconds to set the rate of the "waves".

Again following one of the channels, each clock cycle triggers a Timer with a period of about 0·7 seconds. As this times out it triggers a second timer with a period of about 1·5 seconds for creating the wave. Shaping circuits give the wave a fast "attack" and a gradual decay with pitch variations for a realistic effect.

The final block shown in Fig. 1 is a "Randomiser" which creates a slowly varying voltage to vary the period of the first timer and the input to the shaping circuits slightly. Two of these randomisers are used, one for each channel, resulting in "waves" that break sometimes together and sometimes initially to one side, with relative volumes and pitches constantly changing just as in real life. The resulting circuit is complex, but the final effect obtained is quite amazing and well worth the effort.

WHITE NOISE

A simplified version of the white noise generator is shown in Fig. 2. This is a "pseudo-random bit sequence" (PRBS) generator, built with a shift register and an Exclusive-OR gate.

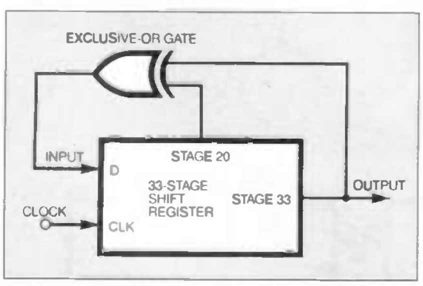


Fig. 2. Simplified pseudo-random bit sequence (PRBS) generation circuit.

The output of the shift register is Ex-ORed with the output of a tap part-way along its length and the result is fed back to the input, causing the generation of an apparently random stream of output bits. Actually they follow a precise sequence, but the length of this is considerable and appears to be random.

"Magic numbers" of register length and tapping point give the maximum sequence length for a given register size. In this design the register has 33 stages tapped at stage 20, and when clocked at 1MHz clock a complete sequence takes over two hours!

COMPONENTS

Resistors

R1, R3	10M (2 off)
R2	5M6
R4, R5, R23, R24, R25, R51, R52, R59, R60, R69, R70	100k (11 off)
R6, R7, R26, R27	4M7 (4 off)
R8, R9	330k (2 off)
R10, R11, R65, R66	220k (4 off)
R12, R37, R39	47k (3 off)
R13, R14, R41, R43	22k (4 off)
R15, R16, R17, R18, R21, R22, R29, R30, R31, R32, R38, R40, R47, R48, R49, R50, R53, R54, R55, R56, R61, R62, R63, R64	10k (24 off)
R19	120k
R20	150k
R28, R35, R36, R45, R46	1M (5 off)
R33, R34	1k (2 off)
R42, R44	560k (2 off)
R57, R58	2k7 (2 off)
R67, R68	12k (2 off)
R71, R72	47Ω (2 off)
R73	220Ω
R74	1k5
R75	15k
R76	1k2

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See SHOP TALK Page

Potentiometers

VR1, VR3	100k min. dual rotary carbon, log. (2 off)
VR2	10k min. dual rotary carbon, lin.

Capacitors

C1	1µ polyester layer
C2, C11, C14, C23, C24, C42, C43, C53, C54	100n resin-dipped ceramic (9 off)
C3, C4	22µ radial elect. 25V (2 off)
C5, C6, C19, C20	470n resin-dipped ceramic (4 off)
C7, C8, C52	100µ radial elect. 10V (3 off)
C9, C10, C21, C22, C25, C26, C29, C30, C31, C44, C45, C46, C47	10µ radial elect. 50V (13 off)
C12, C13	470p resin-dipped ceramic (2 off)
C15, C16	1n resin-dipped ceramic (2 off)
C17, C18, C27, C28, C38, C39	4n7 resin-dipped ceramic (6 off)
C32, C33, C48, C49	47p resin-dipped ceramic (4 off)
C34, C36, C40, C41	33n resin-dipped ceramic (4 off)
C35, C37	10n resin-dipped ceramic (2 off)
C50, C51	470µ radial elect. 16V (2 off)
C55	470µ radial elect. 35V

Semiconductors

D1 to D10	1N4148 signal diode (10 off)
D11, D12	1N4001 50V 1A rectifier diode (2 off)
D13	5mm 10mA l.e.d. green
IC1	4011B CMOS quad 2-input NAND gate.
IC2	4093B CMOS quad 2-input Schmitt NAND gate
IC3	LM358 dual op.amp
IC4	4070B CMOS quad Ex-OR gate
IC5, IC6	4006B CMOS 18-bit shift register (2 off)
IC7, IC8	TL072 dual low noise op.amp (2 off)
IC9	NE5532 dual low noise op.amp
IC10	LM317LZ 100mA adjustable positive voltage regulator

Miscellaneous

T1	min. mains transformer, with 12V-0V-12V 100mA secondary
JK1	3·5mm chassis mounting stereo jack socket
S1	d.p.s.t. slide switch
S2	sub-min. d.p.s.t. mains toggle switch (230V a.c. 2A)
L1	100µH wire-ended miniature choke

Printed circuit board available from the *EPE PCB Service*, code 136; plastic, low-profile, clip-together case, size 180mm x 120mm x 40mm; 8-pin d.i.l. socket (4 off); 14-pin d.i.l. socket (5 off); knobs (3 off); l.e.d. panel clips; small strain-relief rubber grommet; multi-strand connecting wire; single-ended solder pins; fixing nuts and bolts; solder etc.

Approx Cost Guidance Only **£41** **excluding case**

CIRCUIT DESCRIPTION

In the full circuit diagram of Fig. 3 the "clock" is a Colpitts circuit built with gate IC4d, using inductor coil L1 and capacitors C12 and C13 to give a frequency of about 1MHz which is buffered by IC4c. The shift register is built from two 4006B shift registers IC5 and IC6 with their stages connected in series for the desired length and tapping point. Gate IC4a combines the tap and output signals for return to the input.

A PRBS circuit of this type can enter a state where all the circulating bits are "0"s, but this possibility is prevented by capacitor C14 and resistor R28. If a stream of zeros occurs, R28 charges C14 until a "1" appears at IC4a pin 1 to restart the sequence.

One output is taken from pin 9 of IC6. The other is created by IC4b which combines the input signal with one taken from stage 16 of the register. Although related to the first output it neither sounds like it nor looks like it on a 'scope so it is suitable for use in the second channel of this circuit.

From this point onwards a single channel of the circuit will be described as the other is identical. The signal from pin 9 of IC6 is processed into an analogue white noise signal by the two-stage low-pass filter made up of resistor R30 and capacitor C15, also R32 and C17. Resistor R33 attenuates this to a level suitable for processing by the amplitude and pitch control circuits.

These utilise the fact that the apparent impedance of a silicon signal diode varies with a small d.c. current passing through it. The a.c. signal is applied to diodes D5 and D7 through capacitor C19 with a d.c. current supplied mainly by resistor R35.

The voltage applied to resistor R35 adjusts current flow which controls the signal amplitude appearing across resistor R38. This passes through capacitor C23 to the high-frequency attenuator consisting of R43 and C28, with the amount of attenuation controlled by the current supplied to diode D10 through resistor R44.

AMPLITUDE AND PITCH CONTROL

The amplitude and pitch control signals are generated by the upper stages of the circuit in Fig. 3. This starts with a "clock" built from NAND gates IC1a and IC1b which has a period of about 12 seconds.

Each time the output from IC1b goes "high" it is differentiated by capacitor C2 and resistor R3, causing the outputs of IC1c and IC1d to go "low" for about 0·7 of a second. These discharge C3 and C4 through diodes D1 and D2.

Following the lower channel, capacitor C4 charges through resistor R5, so after about 1·5 seconds the output of IC2a goes low. This produces a positive pulse of about 1·5 seconds at the output of IC2c, which charges capacitor C21 through diode D4 and resistor R14.

As the voltage across C21 rises the current flow through resistor R35 increases so the amplitude of the signal is increased. The voltage across capacitor C25 also rises as it charges through R37, increasing the current through R44 so that the apparent pitch of the output signal is reduced.

This effect lags slightly behind the amplitude, so the "wave" crashes with an initially high pitch that deepens rapidly. When IC2c output returns to the low state the two capacitors are discharged slowly through resistor R11, so the "wave" appears to die away slowly with gradually increasing pitch, creating a "backwash" effect.

RANDOM WAVES

Randomising is provided by the dual op.amp IC3. Following the lower channel again, IC3b is configured as an astable oscillator with a period of about 20 seconds.

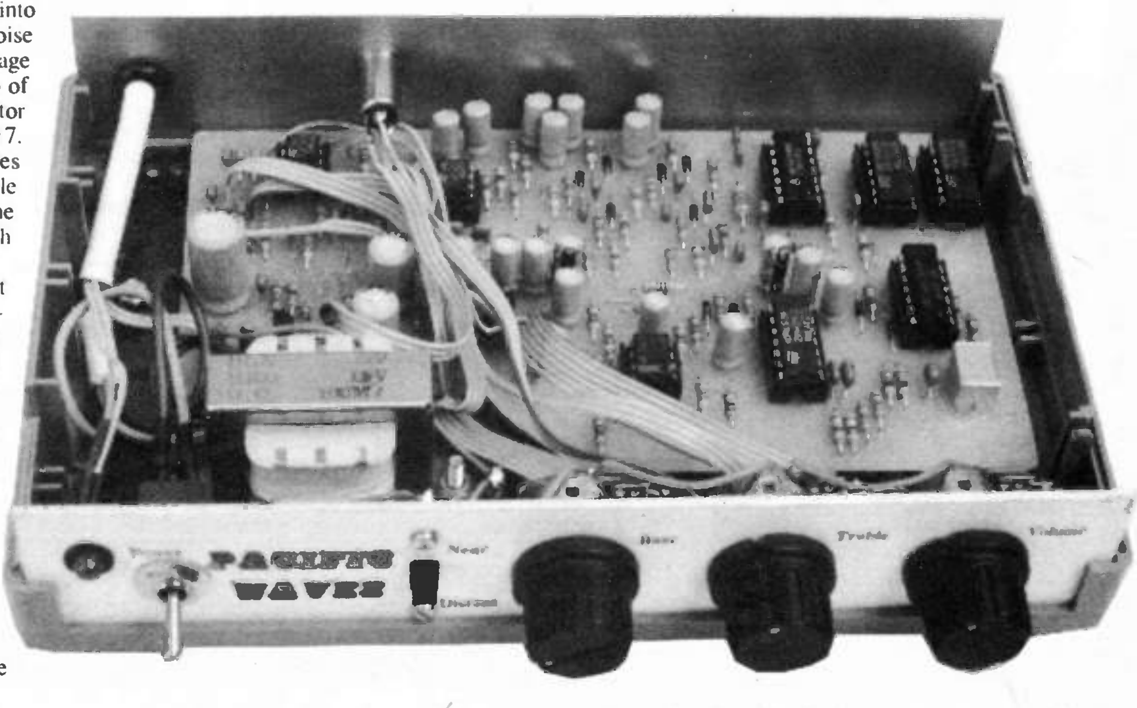
The resulting waveform across capacitor C8 is approximately triangular, swinging between 3V and 6V, and is applied to capacitor C4 through resistor R9. This has the effect of slightly varying the time between the clock output and the start of the "wave". At the same time the squarewave from pin 7 of IC3b is smoothed by R24 and C10 and used to cause small overall amplitude and pitch variations in the associated channel through resistor R26.

The other channel also has a randomiser IC3a, but resistor R19 has a lower value than that of R20 to give it a slightly higher frequency. These two op.amps therefore produce small differences in the relative starting points, amplitudes and pitches of sounds from each channel. To further enhance realism some cross-talk between the control signals takes place through resistors R12 and R25.

TONE CONTROLS

The rest of the Pacific Waves circuit, detailing the tone controls, output amplifiers and power supply, is shown in Fig. 4. and Fig. 5. Again following the lower channel, the signal is buffered and amplified by IC7a and passed through the tone control stage with VR1b for Bass and VR2b for Treble.

Compact layout of components inside the case.



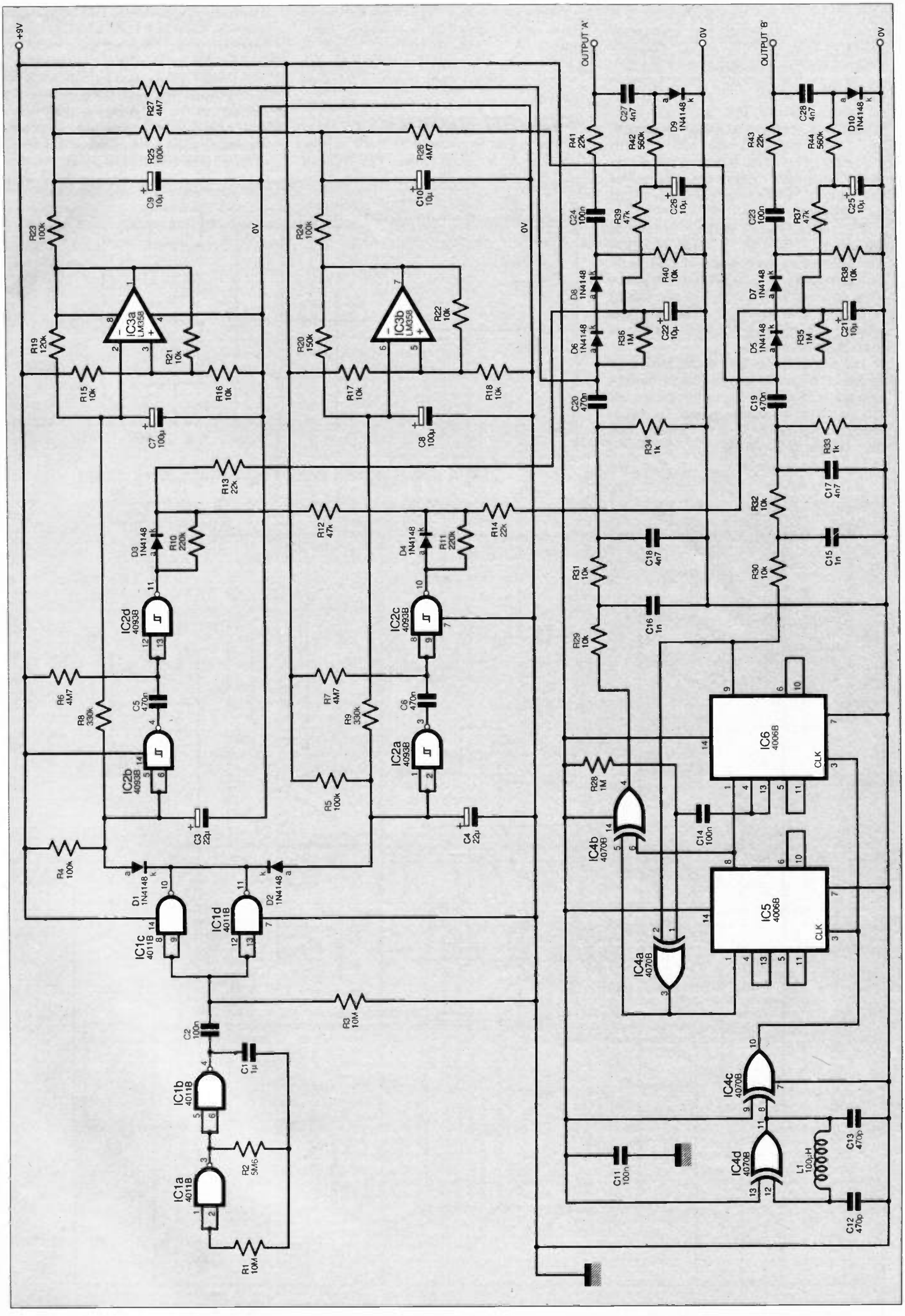


Fig. 3. Clock, amplitude, pitch control and randomising stages for the Pacific Waves circuit.

Feedback for this part of the circuit is provided by IC8a which also buffers the output to Volume control VR3b. The tone controls provide only bass boost and treble cut, with both at minimum the response is practically "flat".

Trials suggested that a "log" component was preferable for Bass control VR1 with the expanded end towards maximum. This gives it a reversed action but in use it feels "right" since the waves get "deeper" when either control is turned anti-clockwise.

The author was unable to decide whether a 4·7nF or a 15nF capacitor sounded best in the position of C39. Both had merits, so eventually 10n capacitors were provided with a switch to place them in parallel with the 4·7nF. The switch is labelled "Near" and "Distant" as this is the subjective effect!

The output stages use an NE5532 dual op.amp. This takes slightly more current than the 1458 used in the earlier design but can supply more output power for headphones. Like the 1458 it is virtually free from crossover distortion.

Some gain in this stage raises the output level to that needed by most audio "line" inputs. A 3·5mm stereo jack socket is fitted to the prototype for output, though a pair of phono sockets could be used instead.

POWER SUPPLY

The circuit is powered by a 9V supply, see Fig. 5. A centre-tapped 12V-0V-12V transformer, with diodes D11 and D12 and reservoir capacitor C55, supplies unregulated d.c. power from the mains and l.e.d. D13 indicates when the unit is operating.

A green l.e.d. is used here in preference to the usual red one since this is considered to be a more restful colour! An LM317LZ 100mA adjustable positive regulator, IC10, is configured for 9V by resistors R73 with R74 and R75.

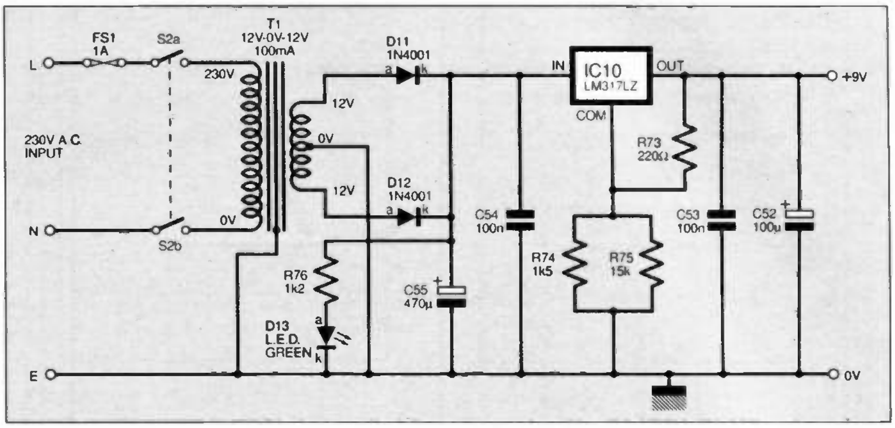


Fig. 5. Circuit diagram for the Pacific Waves power supply.

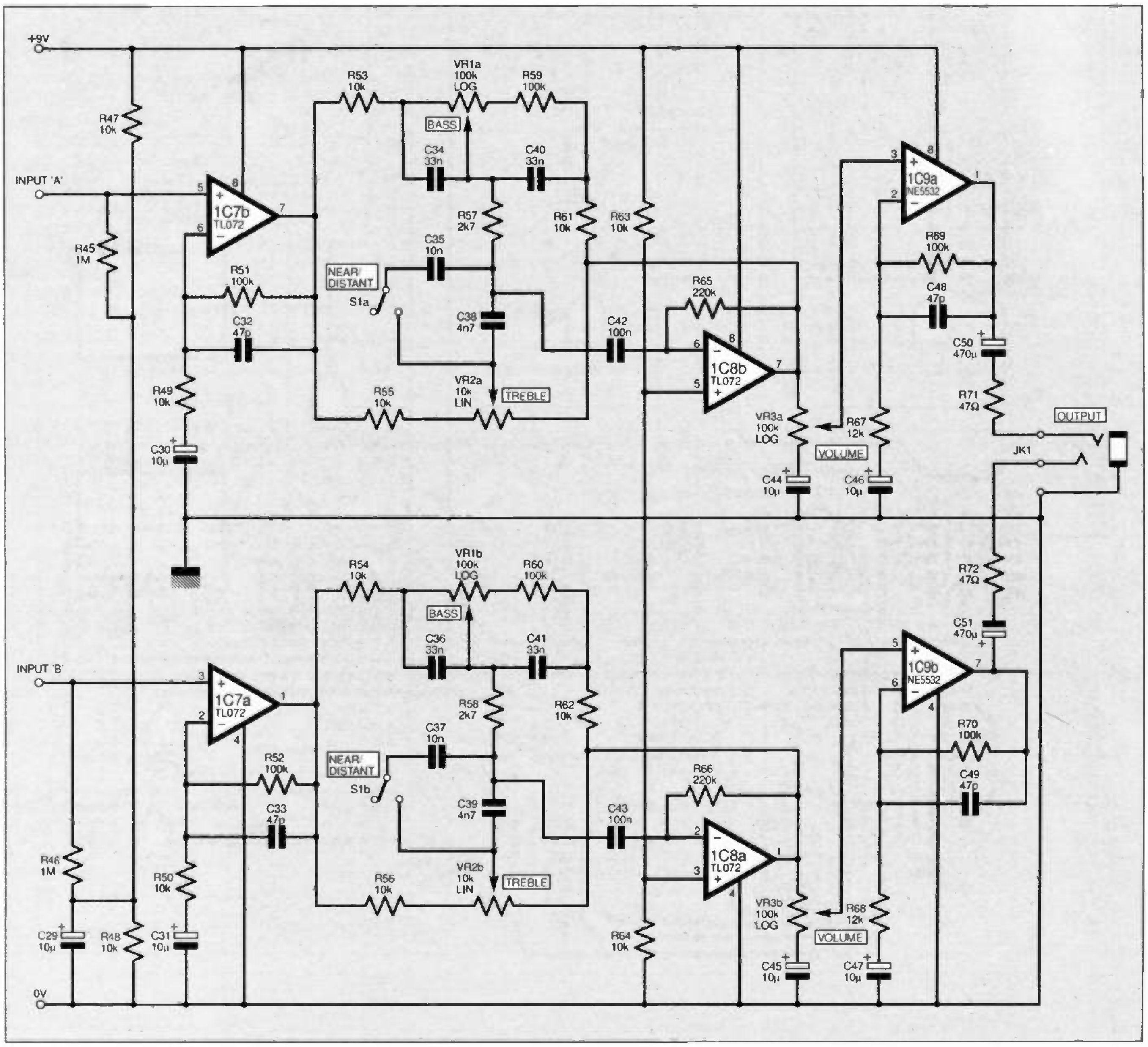


Fig. 4. Pacific Waves tone control stages and output amplifier circuits.

CONSTRUCTION

Construction of this project is relatively straightforward, although the large number of components used means that assembly will probably take a couple of hours. All parts except the controls, mains transformer, output socket and l.e.d. are fitted to the p.c.b. as shown in the component layout of Fig. 6.

The Pacific Waves printed circuit board is available from the *EPE PCB Service*, code 136. Depending on the case to be used it may be necessary to trim away a small part of the p.c.b. so the notes on Final Assembly should be read first.

The passive components may be fitted first in order of physical height for simplicity. This means the links, followed by the small signal diodes D1 to D10, then the resistors, rectifier diodes D11 and D12 and the resin-dipped ceramic capacitors. These can be followed by d.i.l. sockets for the i.c.s (but not the i.c.s themselves, as these will be fitted during the testing stage).

Finally, the polyester capacitor C1 and the small electrolytics (up to 100μF) can be fitted, finishing with the three 470μF electrolytics. Care should be taken with the polarity of C9 and C10 as these are positioned the opposite way up to all the others. Following this the board is ready for testing.

BOARD TESTING

The voltage regulator IC10 should be soldered into place first. Power should then be applied, preferably from a current-limited d.c. Bench Power Supply so that the current can be measured. This can be connected to the board by taking the

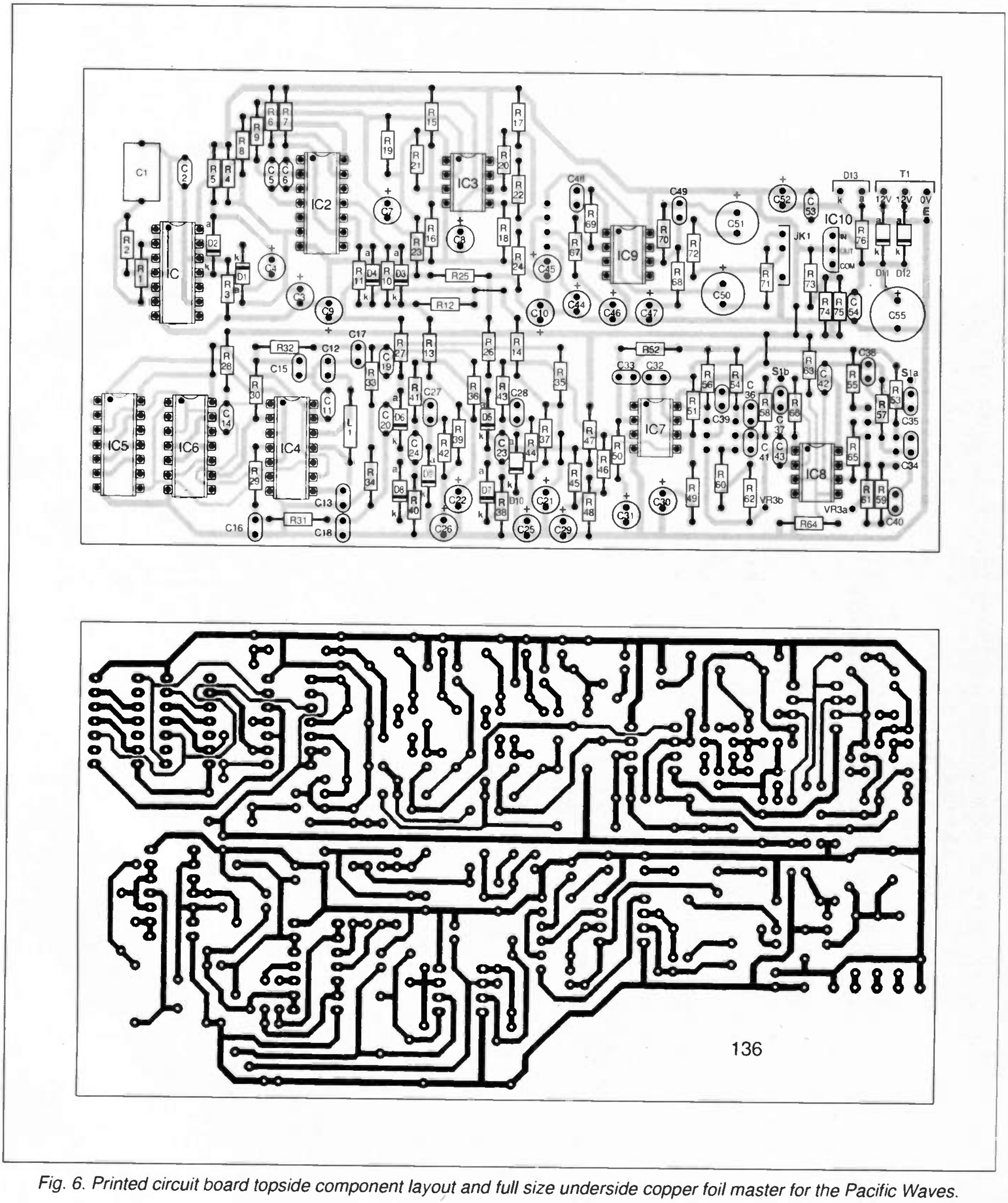


Fig. 6. Printed circuit board topside component layout and full size underside copper foil master for the Pacific Waves.

supply negative lead to the "centre tap" connection for transformer T1, and positive lead to the cathode (k) end of diodes D11 or D12. It is worth soldering a couple of lengths of wire temporarily to these points for testing.

A supply of about 15V will be needed, and the drain should be about 8mA. If it is, then all is probably well so far. The output of IC10 should be checked, this can be found at the top of resistor R73 and it should be close to 9V.

With the regulated supply working, the rest of the circuit can be tested step-by-step. Several of the i.c.s are CMOS types so precautions such as use of an earthed wrist strap should be taken to avoid static damage. Power should, of course, be disconnected during i.c. insertion.

Starting with the control circuit, IC1 can be fitted, pin 4 of this should change state about every six seconds. Pin 11 and pin 12 should normally be "high" but go "low" briefly each time pin 4 goes high. This will be observable on a meter, preferably an analogue type.

If this is OK, IC2 can be fitted. Pin 3 and pin 4 of this should normally be low but go high briefly with each pulse from IC1. Pin 10 and pin 11 should normally be low but go high for a couple of seconds each time pins 3 and 4 go low. If IC3 is inserted, the outputs, pin 1 and pin 7, should be seen to change state about every 10 seconds.

None of these times are precise, they're just "ball-park" figures to indicate that the circuit is operating correctly. Current drain by now should be around 9mA to 10mA.

As a final check, the voltages across capacitors C21 and C25, then C22 and C26 can be checked. They should rise fairly rapidly and then fall away gradually over 12 second periods.

Test points for locating these voltages are as follows: C21, the link just above it; C25, the bottom of R44; C22, the bottom of R36, and C26, the bottom of R42. The actual voltages observed will depend on loading by the impedance of the meter used, but if they are rising and falling in the appropriate manner, this part of the circuit should be OK.

NOISE TEST

The noise generation part of the circuit can be tested next. IC4, IC5 and IC6 should all be fitted. Note that IC4 is third

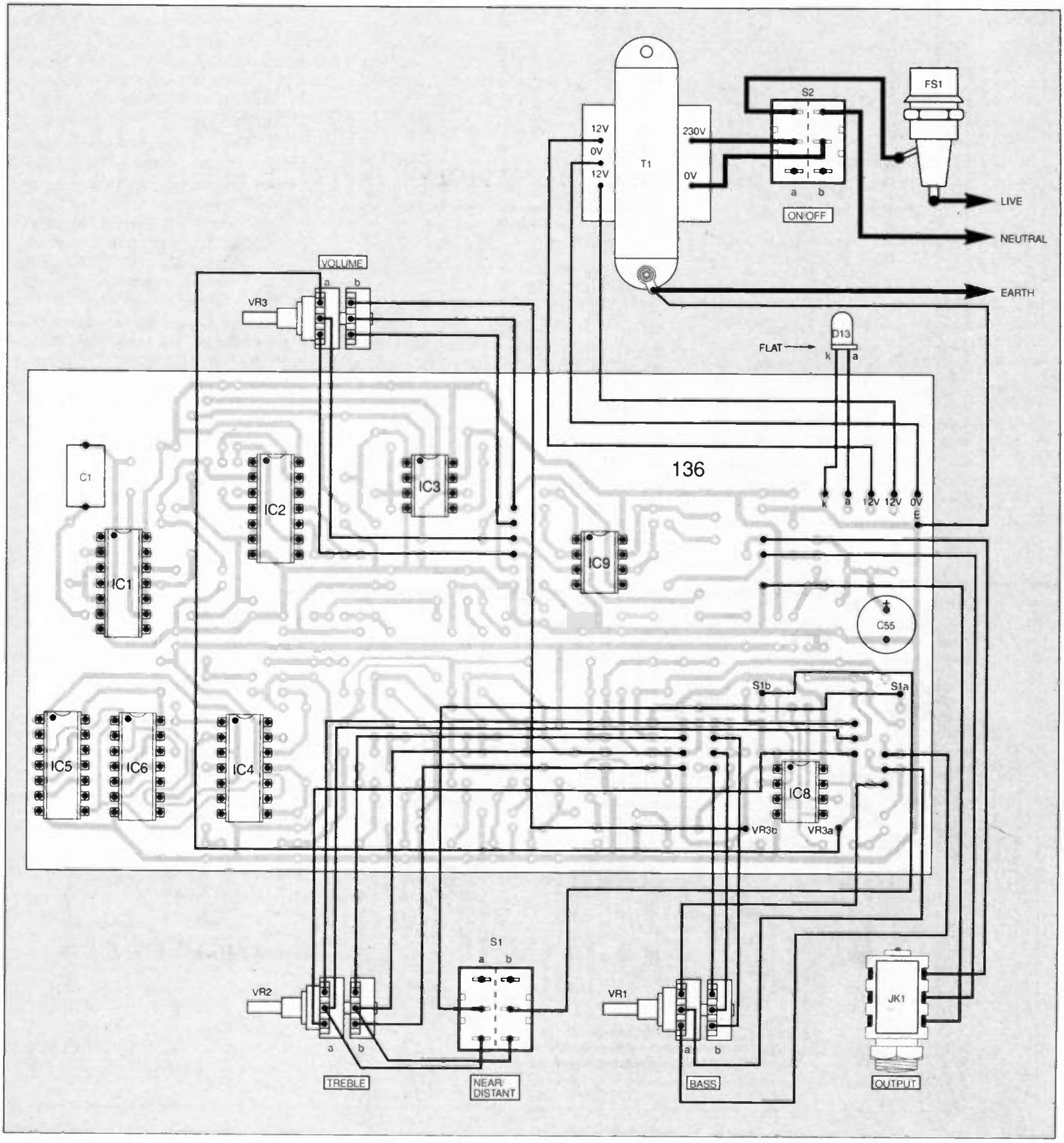


Fig. 7. Interwiring between off-board components and the p.c.b. The top right corner of the p.c.b. may need to be cut to give space for the power supply components, see photographs.

from left, not the first! Yours truly, made this mistake whilst testing the prototype, resulting in a supply current drain of about 50mA which at least demonstrates how current monitoring can be useful when testing, as it often gives rapid indication of a fault condition.

If an oscilloscope or frequency counter is available, pin 10 of IC4 can be checked for the clock frequency of about 1MHz. Otherwise its average d.c. value can be checked with a meter, a reading of about 4·5V indicates probable correct operation.

Similarly, IC5 pin 6, IC6 pin 9 and IC4 pin 4 can be checked, though if a 'scope is used for these it will be unable to lock on to a signal owing to the random nature of the bits being generated. It could be used to inspect the filtered "white noise" signals at the top of resistor R33 and bottom of R34, or alternatively an amplifier could be used to listen to these where they should be heard as hissing sounds.

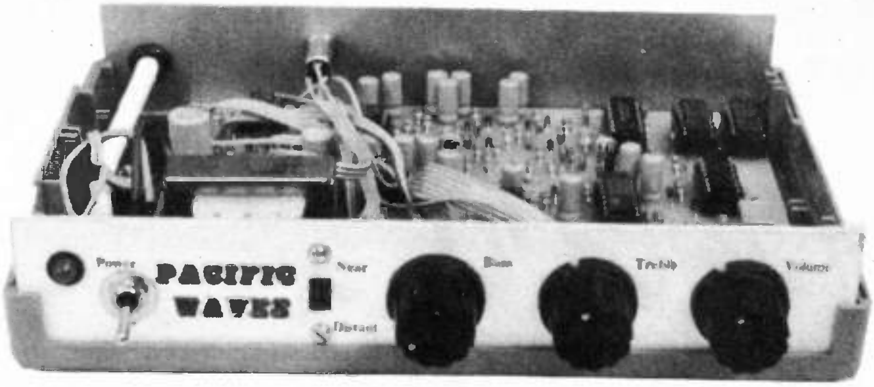
The amplifier might also be used to listen to the controlled output signals, which can be found at pin 3 and pin 5 of the socket for IC7. The levels here are low though, between 1mV and 5mV r.m.s. The overall supply current to the circuit should now be about 15mA.

TONE-UP

The tone control and amplifier stages can be tested next. IC7 should be fitted, and the outputs from pin 1 and pin 7 checked with an amplifier or oscilloscope. They should vary between about 10mV and 50mV r.m.s. The d.c. voltage at these two points should be about 4·5V, and the addition of IC7 will have brought the supply current up to about 18mA.

Next, Bass and Treble controls VR1 and VR2 should be connected as shown in Fig. 7, temporarily if preferred, and IC8 inserted. Using the test amplifier the output from pin 1 and pin 7 should be checked, and the effect of the controls observed.

The Bass control, VR1, operates in reverse with maximum boost obtained when it is rotated counter-clockwise. The d.c. voltage at pin 1 and pin 7 of IC8 should be about 4·5V, and the supply current about 20mA.



Finally, Volume control VR3 should be connected and IC9 inserted. The operation of VR3 can be checked. The outputs from pin 1 and pin 7 of IC9 should be around 100mV to 500mV r.m.s. maximum, varying with the control signal and position of VR3.

The d.c. level on pin 1 and pin 7 of IC9 should be about 4·5V and the overall supply current about 30mA, excluding, of course, the current for the l.e.d. D13. The p.c.b. is now ready for installation in a case.

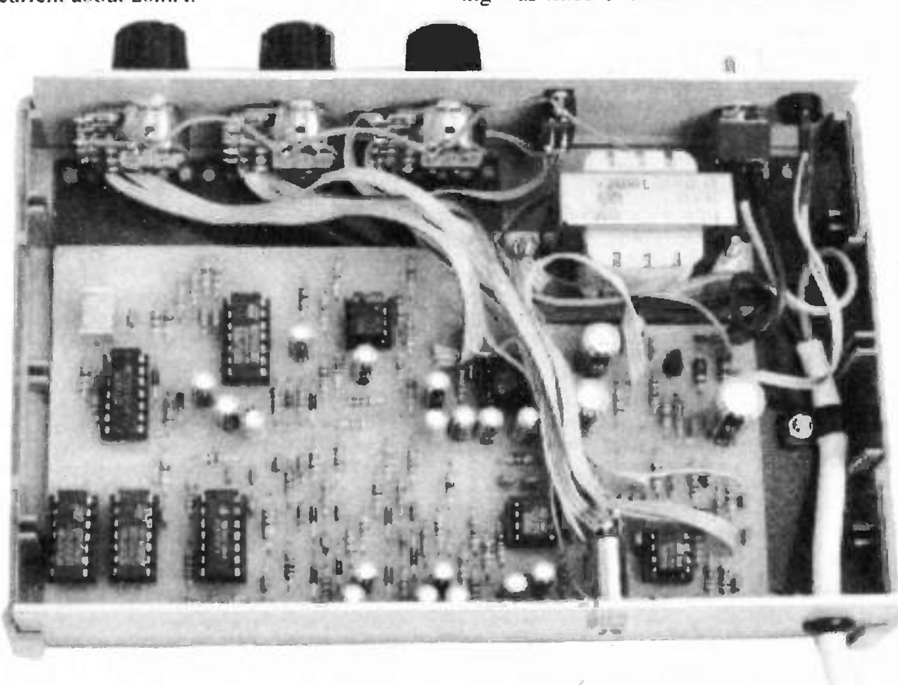
FINAL ASSEMBLY

The "Wave Machine" can be housed in any case of the constructor's choice, or it could even be fitted internally into another piece of equipment. The following notes may be helpful though.

The prototype is fitted into a low-profile ABS clip-together case measuring 180mm × 120mm × 40mm, with aluminium front and rear panels. The height only just accommodates the transformer so it is bolted directly to the bottom of the case. Use countersink bolts to mount the transformer.

Small pillars, provided internally for mounting boards or chassis, were removed with a sharp knife to create sufficient room for this project. The unused area of p.c.b. above IC9 was trimmed away to make room for the small mains transformer.

Connections to the mains On/Off switch S2 should be made as shown to prevent the unused connections becoming "live" when it is switched off. Heatshrink sleeving was fitted over the switch connections in the prototype, virtually eliminating the possibility of shock even when the unit is switched on. A 2A or 3A fuse should be used in the mains plug.



The general layout of the controls and other parts of the project can be seen in the photographs. Whilst this case and layout isn't essential, it is recommended for a compact and attractive final appearance.

UNWANTED INTRUSION

Some r.f. screening is advisable. With all those diodes biased to the threshold of conduction and placed in low-level signal paths the circuit will happily demodulate any strong r.f. signals that happen to be present. The earlier prototype version did so occasionally and, take it from the author, the sudden interruption of meditation by a blast of the local constabulary or CB operator is startling to say the least!

To minimise this problem the project could be housed in a metal case, but if a plastic one is used a few precautions are suggested. First, the unit should be "Earthed". Earthing connections to the transformer and p.c.b. negative rail are shown in Fig. 7.

In the prototype a piece of p.c.b. material was shaped to fit into the base of the unit with a cut-out to accommodate the mains transformer. This was glued into place and connected, via the copper surface, to the transformer "Earthing" point.

The rear metal panel is earthed by the Output socket JK1 as the common connection of this goes to the negative supply on the p.c.b. If an insulated socket is used separate earthing to the panel should be provided.

The metal housings of the three control pots are connected together with soldered wiring which is then soldered to one of the screws securing switch S1 and connected to the transformer earthing tag, to ensure screening of the control internal parts and earthing of the front panel.

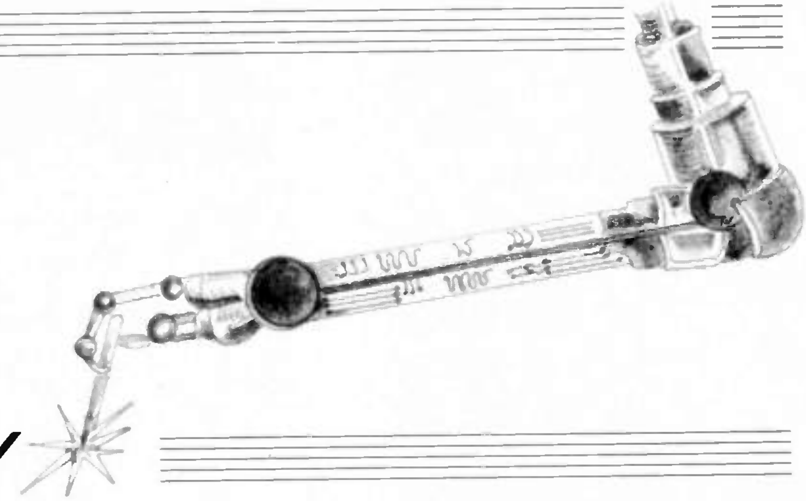
To date r.f. breakthrough has not occurred with the prototype, but if it does then foil screening will need to be added to the upper half of the case and "earthed".

BATTERY POWER

A 9V battery pack might be used if portability is really necessary. The voltage regulator IC10 could be omitted, along with the resistors R73 to R75, and the positive side of electrolytic capacitor C55 connected to that of C52 to provide extra decoupling.

The l.e.d. could also be omitted to save current. The circuit works quite reliably down to about 7V so an alkaline PP3 or a pack of six AA cells would provide a suitable power source. □

Regular Clinic



CIRCUIT SURGERY

ALAN WINSTANLEY

A selection of readers' letters and queries, answered by our monthly "Surgeon". We check out the TL431 reference diode and look at anti-static procedures described in the* Build Your Own Projects *series.

Good References

If you are looking for a handy voltage reference device, then you can consider using an ordinary Zener diode such as the old BZY88C (400mW) or the modern 500mW BZY55C ranges. Fig. 1 shows how they need to be used with an essential current limiting resistor, R_S: the current I_{in} flowing through the resistor is constant, and so when the load draws less current, the Zener absorbs more current, I_Z to compensate. Hence, special care is needed to ensure that the off-load power dissipation figure of the diode isn't exceeded, because if the load draws no current, all of the available current, I_{in} will flow through the Zener instead.

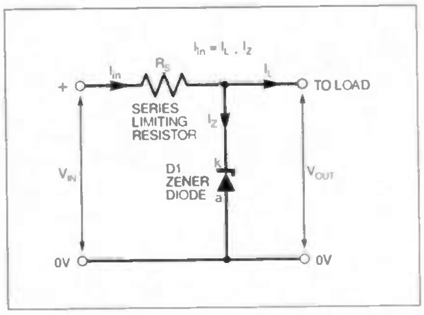


Fig. 1. Use of a Zener diode as a standard reference voltage device.

When reverse-biased as shown, the diode has a reasonably stable fixed voltage across it. Usually, the tolerance on the voltage is five per cent. Because the device effectively works by shorting out or "shunting" the voltage across the load, it's sometimes called a *shunt regulator diode.*

Connect the Zener the other way round, and it behaves just like a normal semiconductor diode, with a 0·7V forward voltage drop.

Mr. J. Silverton of Sparham, Norwich comments:

I've often seen useful circuits for voltage regulators and power supplies both in Circuit Surgery *and* Ingenuity Unlimited. *These often feature LM317 and the 78XX fixed regulators, but rarely the useful low power shunt regulator TL431, which can provide 2·5V to over 30V using only two external resistors. Could you describe how to use them, please? Thanks!*

Here goes! The Texas Instruments TL430 and TL431 are three terminal "programmable" shunt regulators which are useful for providing accurate reference voltages, whereas ordinary three-terminal regulators are convenient for use in ordinary power supply circuits.

They have a highly stable internal voltage reference, which is 2·75V for the TL430 and 2·5V, typically, for the TL431. The TL431 also includes a reverse-biased diode across its anode/cathode; if the device's cathode goes negative, then the TL431 behaves like an ordinary forward-biased Zener diode. The TL431 also offers an improved performance but which for many users will be negligible.

However, both devices offer a far superior "Zener-like" performance over an ordinary Zener diode, because they provide a very sharply defined reference voltage, rather than a rounder "knee" of a typical Zener (see Fig. 2).

The reference voltage is determined by two resistors, as Mr. Silverton rightly says. Fig. 3 shows the basic configuration. Firstly, a series resistor, R_S is still required, in order to limit the forward current in the usual way. The maximum recommended current through the device is 100mA.

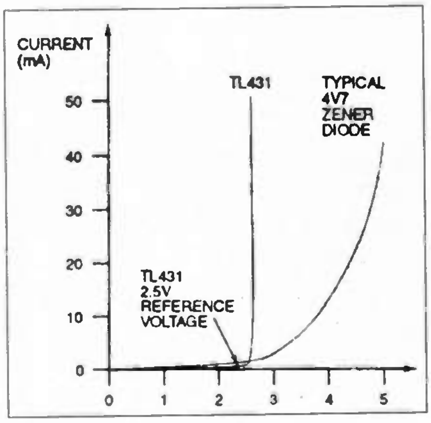


Fig. 2. How the TL431 compares against an ordinary Zener diode.

The formula is:

$$+V_{OUT} = V_{REF} \times \left(1 + \frac{R1}{R2}\right) \text{Volts}$$

For non-mathematicians (like myself!), calculate the part in brackets first – and, actually, the rules of maths say that you calculate the division in there first, so divide R1 by R2, then add 1. Multiply the result by V_{REF}, to calculate the voltage which will be seen across the anode/cathode.

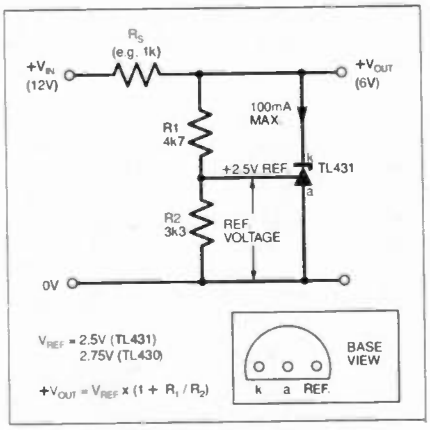


Fig. 3. Using the TL431 as a shunt regulator.

(By the way, a scientific calculator will sort all this out for you, but if you try this calculation with different calculators, you may obtain different results! True scientific calculators "know" about the correct order in which mathematical operations must be performed. Other more "stupid" calculators will simply do the calculation in whatever order you key in the equation!)

With the resistor values shown in Fig. 3, using the TL431 (V_{REF} = 2·5V) then the output voltage is 6V precisely. Resistor R_S limits the current to 6mA, because with a 12V rail, 6V appears across the resistor, too. You should allow for a minimum of 1mA to flow through the resistor chain for correct operation (the reference pin draws some 10μA) and allow say 5mA to flow through the device as a minimum, for correct operation. I used this arrangement in a constructional project *Multi Purpose Thermostat* (*EPE* March 1995 issue) to provide a stable reference voltage for an op.amp.

The TL431 adapts nicely to controlling external devices, and Fig. 4 shows how it could be used in conjunction with a fixed voltage regulator to raise the regulator's output. Here, a common 7805 5V 1A regulator has its "ground" terminal raised by the TL431 to increase the output voltage across the load.

Note that the *minimum* output of this circuit will be the TL431 reference voltage (2·5V) plus the 7805 output, i.e. 7·5V minimum. Fig. 4 is in effect a 9V regulator. A suggested circuit using an external *pnp* Darlington, which is added to form a higher-current shunt regulator, is shown in Fig. 5.

The TL431 is listed by Maplin, Part No. AV00A for £0·79, including VAT.

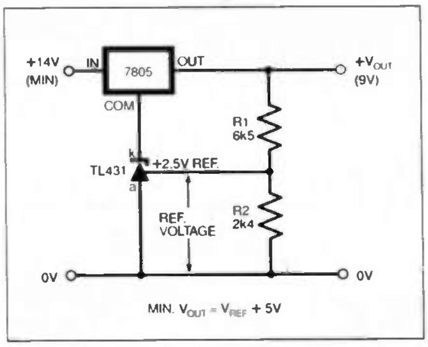


Fig. 4. Raising a fixed regulator's output with a TL431 (Texas Inst.).

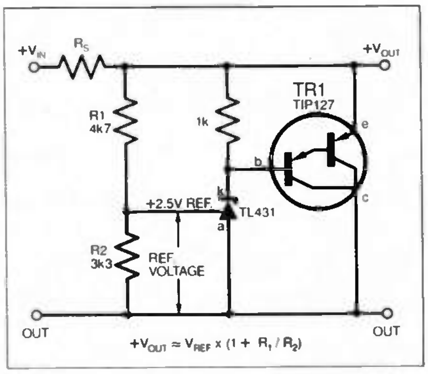


Fig. 5. Additional external pass transistor to boost the TL431's current rating.

Foiling Static

The *Build Your Own Projects* series which describes various techniques for constructing your electronic prototypes has continued to arouse a pleasing level of interest. I'm grateful to ***Mr. A.J. Wilson*** of Winchester, who comments:

My own home-brew treatment for dealing with static-sensitive devices is to work with a cotton boiler suit on a table covered with cooking foil, clamped down with a wire from the house Earth. I use plastic tweezers where possible, and power supplies also wired to earth.

By keeping components on foil or other earthed surfaces, this has enabled me to construct many projects. Your advice for low cost ideas which could help with static-sensitive devices would be appreciated.

I would say that there is nothing particularly wrong with your own way of handling these devices, Mr. Wilson, though it is rare for people to have to change into a cotton boiler suit! CMOS devices seem much more resilient now than in earlier days.

However, you can't be too careful and certain minimum precautions are still required. Nylon carpeting is a major cause of static, for example, and it's very easy to gain a charge of some 10 to 20,000eV (electron-volts) just by walking on it.

It is important that *any* electrostatic voltage is discharged to earth prior to handling ESD-sensitive systems; often, computer engineers simply touch the chassis of computers first to discharge themselves, always assuming that the chassis itself is plugged in and earthed properly.

If anything, your procedures exceed what many folks would do in practice, at hobbyist level anyway. Using tin foil as a mat will produce a far higher degree of conductance than an ordinary carbon-impregnated mat. I worry about the tin foil causing short circuits etc. if you place a circuit board on it (especially if it contains charged capacitors), or if it became "live" for any reason and the earth had failed.

Regardless of cost, I would much prefer to see a proper conductive mat, and there is no real substitute for a mat which is made of carbon-impregnated material. I recognise that they are not cheap but after some puzzling, I couldn't see a practical alternative. Any ideas, readers?

Mats are electrically connected to mains earth, usually via a 1M resistance which may be contained inside a special plug-style adaptor. Then, a wrist strap is the common way of earthing the person (e.g. Maplin LE82D), but you need to ensure that you have an earth point available to which you may connect it: you'll usually have a choice of hooking it to a spare terminal (if available) on a special mains earth adaptor, or you can connect to a spare press-stud which will be on the mat for this purpose.

Tin foil will certainly be effective when used in the way you describe but perhaps be wary of some of the potential hazards. I think you can consign the boiler suit to the bin, though! Incidentally, anti-static plastic tweezers are available, too.

Be with you next month for another round-up of queries and comments. E-mail **alan@epemag.demon.co.uk.**

SHOP TALK
with David Barrington

Pacific Waves

One of the main problems to consider when selecting components for the *Pacific Waves* project is "will they fit inside the low-profile case?" You can, of course, elect to use a large case, or even an all-metal one to enhance r.f. screening.

The wire-ended 100µH inductor may not be readily obtainable locally, but can be purchased from **Maplin**, code WH41U. It is also likely that **Cirkit** (☎ *01992 448899*) can supply one from their large range of inductor products. The mains transformer also came from **Maplin**, code WB02C. Other mains "trannies", with identical electrical ratings can be used provided they will fit inside the case. The case is a Verobox type 214 (202-21-37L) and was purchased from the above source, code LQ07H.

Finally, do not forget to specify dual *"log"* potentiometers for VR1 and VR3.

PsiCom Experimental Controller

Aimed at the Psion Series 3a version, most components for the *PsiCom Experimental Controller* project should be readily available from most of our component advertisers.

The micropower, low dropout, 5V voltage regulator type LP2950CZ may prove a little difficult to find locally, but it is currently listed by **Maplin** (code AV35Q), **Farnell** (☎ *0113 263 6311*) by type number and **Electromail** (*Tel. 01536 204 555*) code 648-567.

Earth Resistivity Meter

Apart from constructing the probes, the only items which may cause concern to constructors of the *Earth Resistivity Meter* are some of the specified semiconductors.

The 2072/81/82 op.amps are Texas devices that do not appear to be stocked by any of our advertisers. However, they appear to be up-grade versions of the readily available TL072, TL081 and TL082 series and these can be used in this circuit, and this will result in a significant saving.

The TIP29A and TIP30A power transistors seem to be "old hat" now and not that easy to find, but the 5A 40W TIP31A and TIP32A versions can be substituted instead.

A copy of the author's program written in QBasic (for PC-Compatible computers), is available from the Editorial Office for the sum of £2·50 UK, £3·10 overseas surface mail or £4·10 airmail. This is to cover admin costs and postage, the software itself is *free*. See *PCB Service* (page 139) for ordering details.

The program can also be downloaded *free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk**, in the sub-directory: **pub/PICS/Earth.Meter**.

Theremin MIDI/CV Interface

Some of the parts called-up for the *Theremin MIDI/CV Interface* are special items and will not be generally available.

The author/designer, Adam Fullerton, is able to supply the pre-programmed PC87C51FB microcontroller for the sum of £45 each, inclusive p&p. Orders should be sent to Adam at **The Dene, Hindon, Salisbury, Wilts., SP3 6EE**. Make cheques payable to **Adam Fullerton**.

So that readers can select their own requirements, Jake Rothman (author of the *EPE Theremin* – Nov/Dec '96) has put together a range of kits for the MIDI/CV. He is also able to supply a ready-programmed micro for the same price. See his advertisement on page 132 for details. – *Note the new address and phone number.*

How To Use Intelligent LCDs

Only a small observation to make concerning the informative *How To Use Intelligent LCDs* article. Before purchasing any of the "special offers" on the l.c.d. modules, be sure to check that they are based around the Hitachi HD44780 or compatible controller chip.

Most of the "bargains" on the market appear to carry compatible controller chips and the ones used to demonstrate their functions were "bargain buys" from two sources, namely **Bull Electrical** (☎ *01273 203500*) and **Greenweld Electronics** (☎ *01703 236363*).

Details for all this month's printed circuit boards can be found on page 139.

INTERFACE

Robert Penfold

I HAVE mentioned in previous *Interface* articles that some of the more recent PC printer ports have a bidirectional capability. This enables what are normally the eight data outputs to operate as inputs instead.

Methods of using the handshake inputs to operate as an 8-bit input port have been covered previously, but this is a relatively cumbersome way of doing things. Using the data lines as inputs offers a simple way of inputting bytes of data.

In The Mode

Until recently, I had been unable to obtain any worthwhile information about how this two-way capability can be utilized. I am indebted to Gert van Biljon of Silverton in South Africa for some useful information regarding enhanced parallel printer ports. Using one of these ports as an 8-bit input seems to be quite straightforward, but it has to be emphasised that *not all* PC printer ports actually have this capability.

It seems that enhanced printer ports date back to about 1987, but my 33MHz 80386 PC manufactured in 1991 shows no inclination to operate in this mode. At first, my 1995 75MHz Pentium PC was no more cooperative, even though it is fitted with an enhanced printer port. The problem seems to be that these ports can operate as normal PC printer ports, or as enhanced types, and in most cases they will default to normal operation.

In the case of my Pentium PC the serial and parallel ports are provided via electronics on the motherboard, and not by way of expansion cards. One of the pages in the built-in Setup program includes an on/off option for enhanced operation. A further option then enables the user to choose the required enhanced mode.

There are actually three enhanced modes available. These are the standard parallel port bidirectional (SPP), enhanced parallel port (EPP), and extended capabilities parallel port (ECP) modes.

In order to use the data lines as outputs it is only the SPP mode that is required. My Pentium computer offers the choice of SPP/EPP or ECP operation, and with this choice it is obviously the SPP/EPP option that must be selected.

With an enhanced parallel port that is provided via an expansion card it is presumably necessary to select the required mode via the usual DIP switches or links. The manual for the expansion card should provide details of how to select the SPP mode.

All Change

Changing the data outputs to operate as inputs is basically very simple. Output address &H37A (&H27A for Port 2) is used to provide the four handshake outputs, but only the four least significant bits are used for this purpose. Bits four to seven are normally left unused.

With the SPP mode selected, bit five becomes the direction control bit. If it is set to zero the data lines operate as outputs, or if it is set to one they operate as inputs.

Writing a value of decimal 32 to address &H37A will set the data lines as inputs, but it might also change the states of the handshake outputs. The "politically correct" method of doing things is to first read the states of the handshake outputs, bitwise OR the returned value with decimal 32, and then write the final value to output address &H37A. This only requires a couple of lines of QBasic or GW-Basic, as shown below:

```
10 X = INP(&H37A)
30 OUT &H37A,(X OR 32)
```

With the data lines set as inputs they can be read at address &H378 (&H278 for Port 2), which is the address that is normally used when writing data to the printer port. The inputs seem to have a very high input impedance, and in this respect they are more like CMOS inputs than standard or LS TTL types. They seem to work well with CMOS or TTL compatible outputs though.

There is a slight problem with this bidirectional operation in that it can result in two sets of outputs being connected together at switch-on, prior to the printer port being set for operation as an input port. One way around this is to drive the inputs via an octal tri-state buffer, which should be set to the high impedance state until the port has been set up to operate as an input type.

It is difficult to make this system fully foolproof though, and the safer option is to drive the inputs via current limiting resistors. This method has a slight drawback, which is that it makes the system more vulnerable to cross-coupling between lines due to the capacitance in the connecting cable.

With some types of connecting cable there could also be a significant loss in the switching speed through the lead. The connecting cable should therefore be kept as short as possible, and would ideally be no more than about half a metre long.

A/D Converter

The Analogue-to-Digital Converter circuit of Fig.1 shows how the bidirectional feature of a suitable printer port can simplify interfacing to 8-bit peripherals. Connection details for the printer port are shown in Fig.2.

This circuit is a straightforward 8-bit successive approximation converter based on a ZN448E. The full scale input sensitivity is approximately five volts, and the input resistance is just over 16 kilohms. Preset potentiometer VR1 provides a small bias voltage that optimises accuracy at low input voltages.

Capacitor C2 sets the frequency of the internal clock at just under 1MHz, which means that each conversion takes under 10µs. IC2 generates a −3V supply for the "tail" resistor (R10) in the comparator stage of IC1. This enables the circuit to operate from a simple +5V supply.

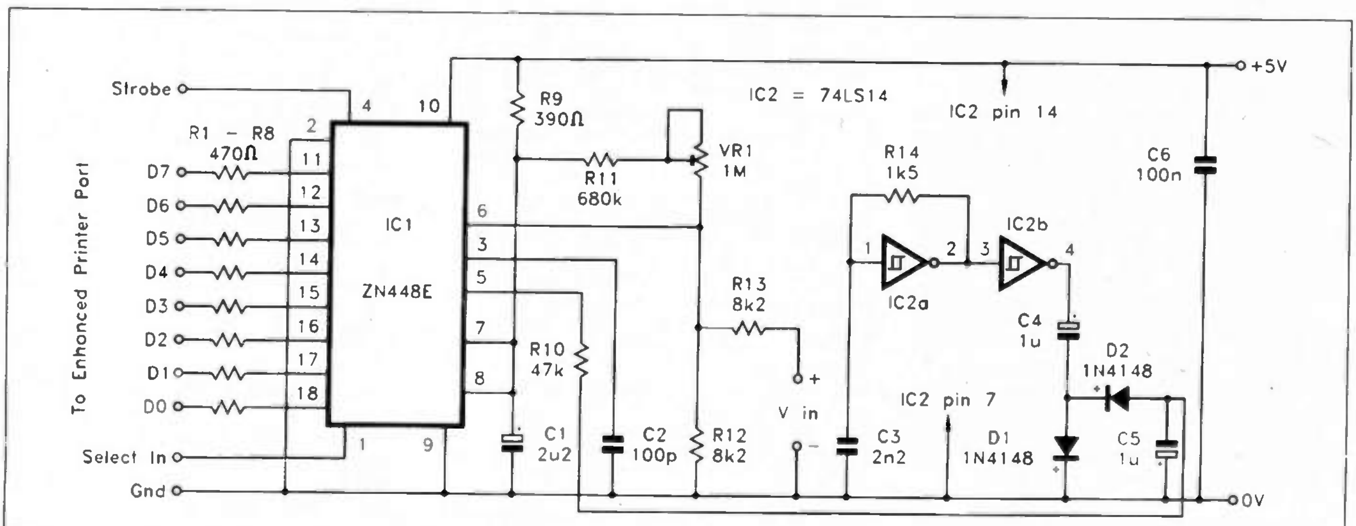


Fig. 1. The circuit diagram for the A/D Converter. This will only work with a bidirectional printer port.

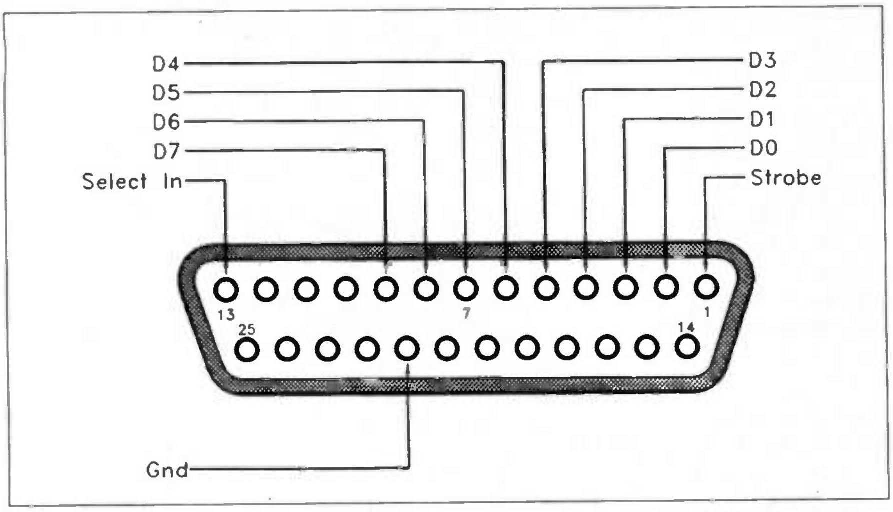


Fig. 2. Details of the connections to the printer port. A 25-way male 'D' type connector is required.

A circuit of this type can be interfaced to a normal PC printer port via the handshake lines, but this requires data to be read as two 4-bit nibbles. Apart from complicating the software side of things, this also requires some additional hardware.

Using a bidirectional printer port, it is possible to dispense with the extra hardware, and the outputs of IC1 are simply connected to the data lines of the printer port via current limiting resistors R1 to R8. On the down side, with this method of interfacing the data lines of the printer port are no longer available for use as outputs.

The value of 470 ohms for resistors R1 to R8 is a conservative one, which limits the maximum current flow to a little over 10 milliamps. In practice, the current flow is unlikely to exceed more than about half this figure. This ensures that there is absolutely no risk to the outputs of IC1 or the printer port.

On the other hand, it does mean that the circuit might not work reliably if it is used to take many thousands of readings per second. For high speed operation it would probably be necessary to reduce the value of the current limiting resistors to around 180 ohms, which should still be sufficient to ensure safe operation.

Alternatively, the tri-state output capability of IC1 could be utilized. Pin 2 being taken high in order to switch the outputs to their high impedance state.

Hold Off

In order to start a conversion, pin 4 of IC1 must be pulsed low. With the suggested method of connection this input is controlled by the "strobe" output at pin 1 of the printer port. The converter must not be read until the conversion has been completed, which occurs a little under 10µs after pin 4 is returned to the high state.

The speed of the program is usually too low to produce premature readings when using an interpreted Basic such as QBasic or GW-Basic. However, using a modern up-market PC this cannot be guaranteed. Using a compiled programming language or assembly language virtually guarantees that the converter will be read prematurely unless some form of hold-off routine is used.

One way of providing a hold-off is to use a delay loop after the start conversion pulse has been sent to the converter. This is the simple method, and the one I prefer, but some experimentation might be needed in order to get the system working reliably.

The alternative is to use a handshake input to read the status output at pin 1 of IC1. This goes low during a conversion, and its return to the high state indicates that valid data is available from the circuit.

With the suggested method of connection, the end of conversion output is read by the "Select In" line, which can be read at bit four of address &H379 (&H279 for Port 2). Of course, if you use a delaying loop or a slow programming language there is no need to connect the end of conversion output to a handshake input.

Software

The following GW-Basic program will repeatedly read the converter and display the returned value on the screen.

```
10 REM A/D Via Bidirectional Printer
   Port 1
20 CLS
30 X = INP(&H37A)
40 OUT &H37A,(X OR 32)
50 X = INP(&H37A)
60 OUT &H37A,(X OR 1)
70 OUT &H37A,(X AND 254)
80 LOCATE 10,30
90 PRINT "     "
100 LOCATE 10,30
110 PRINT INP(&H378)
120 FOR D = 1 TO 1000:NEXT
130 GOTO 50
```

Lines 30 and 40 set up the data lines as inputs. The next three lines of the program pulse the strobe output low and initiate a conversion. This is achieved by first reading the value from the appropriate register. The returned value is then bitwise ORed with 1 to set bit 0 high without altering the states of any other bits.

The returned value is then bitwise ANDed with 254 to set bit 0 low again without affecting any of the other bits. This may seem to be pulsing the strobe output high rather than low, but it does actually give a low pulse because there is a built-in inverter on the strobe line.

The rest of the program reads the converter and prints the returned value on the screen. Line 120 provides a short delay before the program loops back to take another reading. There is no built-in method of halting the program, but the usual CONTROL-BREAK key combination will stop the program.

The enhanced modes of the printer port certainly seem to be very useful and interesting, and we will no doubt return to this topic in future articles.

VIDEOS ON ELECTRONICS

A range of videos designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. They have proved particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc.

BASICS

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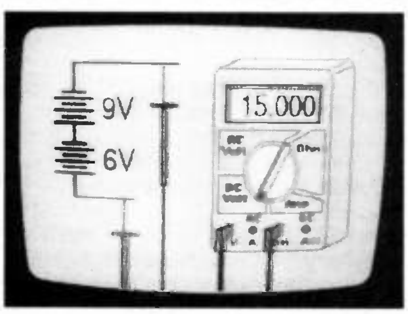

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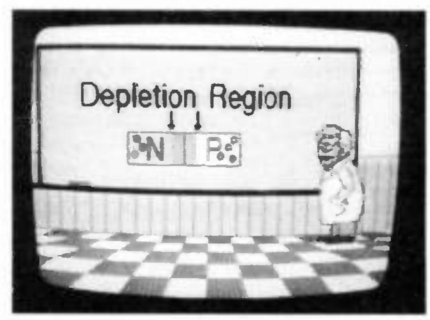

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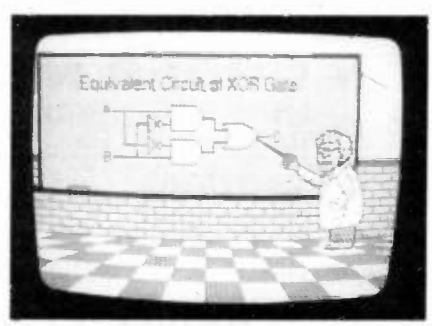

Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier. (All videos are to the UK PAL standard on VHS tapes)

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FURTHER INFORMATION

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NEXT MONTH

SIMPLE DUAL OUTPUT TENS UNIT

A TENS device is an electronic painkiller. The name is an acronym for "Transcutaneous Neural Stimulation", which means that it passes brief pulses of current through the skin to stimulate underlying nerves. This can alleviate pain, in many cases as effectively as powerful painkilling drugs but without the harmful and unpleasant side effects often associated with these.

Two TENS projects featured in the May and June 1994 issues of EPE *proved very popular and letters from constructors left no doubt about their effectiveness. These two designs were not without problems for constructors, though.*

This new design once again uses the principle of generating a high voltage to start with, but the converter is a switch-mode type which is much simpler to construct. The output is controlled by simple astable and monostable circuits which are easier to understand and trouble-shoot than the counter and decoder circuits of the previous designs. It also lends itself more easily to modification and experiment if constructors are unable to resist this!

Another new feature is dual output, useful for treating larger or more deep-seated sources of pain. This is simply a pair of outputs in parallel from a common driver stage, made possible by the ample power available from the switch-mode converter.

HOW TO USE INTELLIGENT L.C.D.s – Part 2

As we have discovered in Part 1 this month, intelligent l.c.d.s are really quite simple to program just using switches, once you know the rules. Next month, in Part 2, we take matters the logical step forward and put the displays under automatic control, using a microcontroller. Naturally, it is one of the PIC microcontrollers, the familiar PIC16C84, that has been chosen since these, too, are so versatile and easy to program. The techniques, of course, can readily be applied to other microcontrollers.

VIDEO NEGATIVE VIEWER

With the addition of a simple and cheap light box type adapter most camcorders can be used to view slides. This simple unit allows colour negatives to also be viewed. It changes the picture from a negative image to positive and provides control of contrast and brilliance. It will also prove interesting to those with an interest in generating special effects.

OIL CHECK REMINDER

Guard against running out of central heating oil with this easy to build reminder. It could save you an expensive call-out fee for the heating engineer.

EVERYDAY PRACTICAL ELECTRONICS

DON'T MISS THIS ISSUE

MARCH ISSUE ON SALE FRIDAY, FEBRUARY 7

BUILD YOUR OWN PROJECTS

Alan Winstanley

Part 4

IN THIS short series of articles, we are describing modern methods for constructing your electronic projects. This fourth part discusses workshop techniques related to plastic and metal enclosures. We also check out basic "metal bashing" methods plus some useful tricks and tips. It's easier than you might think!

Future parts will look at circuit board assembly, case and enclosure preparation, workshop tips and tricks – in fact, everything you need to know to get satisfying results when building your latest *EPE* project!

Alan is, of course, Surgeon-in-Chief at *Circuit Surgery*, and enjoys all aspects of electronics.

PART 3 of *Build Your Own Projects* described methods of producing printed circuit boards using the ultra-violet light system, and we checked out techniques for soldering both stripboard and printed circuit boards successfully.

Having assembled the circuit board, this month we look at more workbench tasks, especially ways of dealing with plastic and aluminium boxes which typically will be used to house your project.

BOXING SHORTS

Sometimes, the designer of the project may have reason to specify a particular type of enclosure for that project. Considerations might include the kind of environment in which the project may be used. It may need to be weatherproof, or it might have to withstand rough treatment. It may need to be a certain size to accommodate the circuit board.

Quite often, though, the designer will only specify the *minimum dimensions* a box needs to have, after which you're free to choose your own box. Let's check out the variety of cases available to house your projects, and discuss some pros and cons.

It is, unfortunately, a fact of life that even for a modest project, the cost of a box can outweigh the cost of all the other electronic components put together. Invariably, everyone is limited by a budget and many people won't wish to spend £15 to £20 or so on a box which might double their building costs.

Budget apart, another factor which will influence your choice of housing will be whether you are particularly concerned about the final appearance. If you're anything like me, you worry about these things, and you'll enjoy producing a "smart job". There is undeniably a certain pleasure in "making it look good" and I always encourage novices and constructors to try to develop their skills so that they can produce professional-looking results which can be shown off with pride.

Even with a simple project, there are various ways of enhancing the appearance of the project to make it a little more "special", as we'll describe in this feature. However, rest assured that much of what is about to be described is not at all compulsory, as it all revolves around your available budget, time and level of interest – so in short, do your own thing and most of all, enjoy yourself!

BOXES CATEGORICAL

A quick check through any of the mail order catalogues will reveal that a very wide range of boxes are on offer, so quite often you will be spoilt for choice. Boxes fall into three main categories:

* all-plastic
* all-metal
* plastic-metal combinations

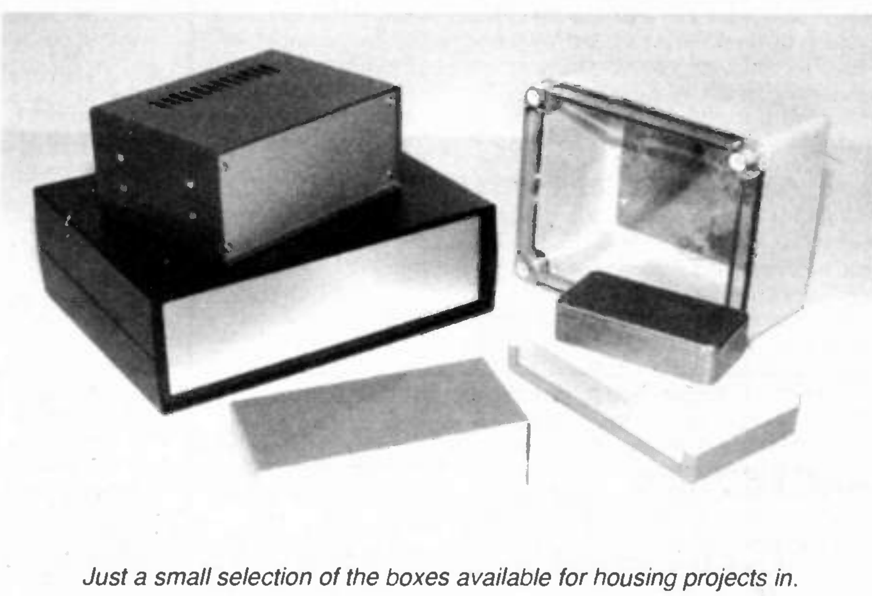
Plastic boxes are injection moulded and are usually made of high-impact polystyrene (PS) or ABS, which is a tough, shock-resistant polymer. Mouldings may sometimes be available in several colours which enhances the appearance (I remember going through a phase of building everything into groovy orange-coloured ABS boxes, at one time!).

The simplest plastic boxes really are cheap and cheerful mouldings with lids held on with a couple of self-tapping screws. If you're more discerning and can afford it, better-quality boxes are available which have internal fittings to hold printed circuit boards in place (more on this later), and their lids may be retained by machine screws which screw into brass bushes in the main box.

This latter type is the standard style of plastic box which can be used for many constructional projects. More specialised types might even have moulded-in battery compartments, sealing gaskets, or some may be fitted with transparent lids which are especially handy for projects that incorporate photocells or solar cells. Check out some of the larger catalogues for ideas.

SAFETY FIRST

Potential problems exist with plastic boxes, though, when they are used with *mains-operated* projects. Some plastic boxes may simply clip together, **but these should not be used if there is the risk of inquisitive children opening them and exposing themselves to an electric shock**



Just a small selection of the boxes available for housing projects in.

risk. If the mains project is likely to be treated roughly (in the mechanical sense), then a plastic case may be unsuitable and you should look at a metal type instead.

If the prototype is to be used at low temperatures (e.g., outdoors in winter time) then many plastic boxes may crack or shatter at near-zero temperatures, especially if knocked: this was seen as a potential problem with the *Pond Heater Thermostat* (*EPE* Jan. '94), and the plastic case specification was chosen specially for its ruggedness at sub-zero conditions. It had a sealing gasket on the lid to ensure it was waterproof when assembled, too.

DOWN TO EARTH

Also, and more importantly, mains-powered projects will often need panel-mounting switches, connectors etc., which, if made of metal, creates a problem straight away – unless the project is "double insulated" (which is rare in this market) then all exposed **metal** parts should be earthed soundly, so that if they should become "live" for any reason (e.g. a mains wire breaks off inside, and touches the metal switch) then a fuse will blow or a circuit breaker will trip.

Even the humblest panel-mounted screw should be earthed to avoid an electric shock risk. So it's sometimes far simpler to use a metal box, or at least a plastic box with metal panels, so that the whole project or panel can be earthed easily.

All-metal type boxes include simple folded aluminium or steel types which are held together with self-tapping screws. Many steel types have a vinyl "leatherette" finish to make them more appealing.

For the ultimate in project protection in adverse conditions, it's worth checking out the ranges of diecast boxes which are readily available. These are cast in an zinc alloy and are virtually unbreakable. Only those types which have sealing gaskets incorporated should be used outdoors if weatherproofing is needed.

For the majority of projects, I usually prefer a plastic casing with aluminium panels. The panels are removable and can be drilled or punched as needed, to accept any switches, indicators, cables, sockets etc. and they can be earthed easily.

Such cabinets generally look quite appealing, too, and so they enhance your project. Unfortunately, they are not cheap; for instance, the cabinet used for the *Multi-Purpose Thermostat* (Mar '95) project measures roughly 230mm × 180mm × 75mm and cost £17, almost as much as the rest of the electronic components combined.

Some boxes may be made from sheet steel, but be aware that these are hard work to drill and punch (see later) and aluminium is far preferable to work with: it's lighter and much easier to work by hand. Steel is more rugged though; one range of metal cabinets uses an aluminium chassis plus a steel cover, which offers the best of both worlds in terms of ease of working and ruggedness.

PROTECTION

Instrument cases are sometimes specified in terms of their "IP" protection rating, which is an indication of how well they protect the circuitry inside from dust or moisture. This is summarised in Table 1. The higher the IP value, the more watertight and dustproof (and expensive) the box will be.

Table 1. IP Protection Ratings

Digit	First Digit (Protection against entry by solid objects)	Second Digit (Protection against entry by liquids)
0	Nil Protection	Nil Protection
1	Protected against solid objects >50mm diameter	Protected against dripping water
2	Protected against solid objects > 12mm diameter	Protected against spray entry up to 15 degrees from vertical
3	Protected against solid objects > 2·5mm diameter	Protected against spray entry up to 60 degrees from vertical
4	Protected against solid objects > 1·0mm diameter	Protected against water splashing from any direction
5	Limited protection against entry by dust particles	Protection from low pressure water jets
6	Fully protected against dust entry	Protection against heavy sea spray
7	–	Protected when immersed between 15cm to 1 metre depth
8	–	Protected when fully submerged for long periods

CASE PREPARATION

Having outlined the choice of cases available, we now move to the workshop to examine various techniques for dealing with case preparation. There is a certain degree of drilling, sawing and soldering to be performed next, and not everyone is fortunate enough to have a fully equipped workshop available. A lot of the work can be carried out on a well-protected kitchen table or in a spare room, but having a proper workbench or work area at your disposal is undoubtedly a boon.

The next aspect of construction deals with any fabrication and panel work, which will involve preparing the enclosure for your project. Before even *thinking* about drilling any holes, though, a golden rule is to check that everything will indeed fit together in the prototype! Will that toggle switch touch the circuit board when you fit it all together? Is that mains transformer likely to touch that panel-mounted fuseholder nearby? And will it block the route needed by the mains cable when you bolt it down?

Double check the dimensions of each component and work out the best position for everything, so that you won't find at the last minute that something, somewhere is obstructing something else when you try to close up the box. I strongly recommend that you have a "dry run" by laying out the major parts and planning their positions. It's essential to compare the location of any panel-mounted parts

If you're serious about project building, you will need a set of high speed steel (HSS) twist drills and preferably a rechargeable drill.

against any components actually inside the box, to ensure there's room to spare when you finally close up the casing for good.

GOOD PLANNING

By "marking out" the case properly, you can plan the "drilling centres" of any holes which may need drilling. If switches or indicators are supposed to be in line on a front panel, for example, then use a short stainless steel rule and a scribe (or a soft pencil) to measure and mark the required hole positions on the box.

Likewise, the "centres" of cut-outs needed for large sockets, meters etc. should be carefully worked out and clearly marked. Unwanted markings might spoil the appearance of the finished item, though, so don't get too carried away with the scribe.

A good "cheat" is to use the component itself as a guide when marking out the centres. You can certainly do this with non-critical parts: for example, you can simply place a mains transformer in roughly the right position on the base of the housing, and just use a felt-tip pen to trace the drilling centres of the mounting lugs. That's all it takes.

Other parts may be of a more critical nature. For example, a panel-mounting mains socket may require a 50mm diameter cut-out (see later) together with two small holes to accept mounting screws.

It's sometimes not a bad idea to consult the supplier's catalogue for any drawings, and use these to carefully plan out the work required on the cabinet by marking with a scribe at the appropriate locations. To avoid disappointment, take your time, take nothing for granted, double check everything and – most of all – don't rush!

Many components have standard mounting dimensions and you'll soon learn the diameters of the holes required to accept most common parts. Rotary switches and potentiometers nearly always need a 10mm or ⅜" (9·5mm) diameter hole in the panel, whilst sub-miniature switches require a 6·2mm hole – but you can easily get away with a ¼" (6·35mm) drill, which can often be used for l.e.d. clips too.

COVER-UP

It's also worth remembering that it's much easier to produce neat-looking prototypes if you choose panel-mounting parts which fit into the panel from the *front*. The part then hides the cut-out together with a multitude of sins if your work is less than tidy!

This especially applies to switches, and you'll find a variety of types (e.g. rocker switches) which panel-mount neatly from the front without the need for ugly mounting screws, instead of protruding out from behind (where you might see the edges of the cut-out).

Furthermore, some parts (notably potentiometers) often call for a nearby anti-rotation hole in the panel, to accept a "lug" which locates the body securely. To be honest, I never bother with them (unless I'm looking for work), so I snap the spigot off the potentiometer body (otherwise the pot can't fit flush behind the panel), and I seldom use the anti-rotation lugged washer which is usually provided with switches. Remember, do your own thing!

BENCHMARKS

Having planned the drilling work which is needed, it's now down to business on the workbench. Plastic boxes are, of course, very simple to work with. You can use a hand drill (even a hand-cranked "cogwheel" type) for much of the drilling work, and indeed I did do that quite happily for quite a few years: everyone has to start somewhere, after all!

A cordless rechargeable drill, however, is extremely convenient, both for drilling and screwdriving, and is perfect for this type of work. A mains-powered electric drill is likely to be too cumbersome, and there is the additional factor that too high a drill speed will simply melt the plastic, and produce inaccurate results; a rechargeable drill is the best bet if you can afford it – remembering Murphy's Law which says that when you need to use the drill, its rechargeable battery will be flat, so remember to keep it charged and ready for use!

The plastic box should be firmly fixed down when drilling it, perhaps using a vice if available, or a G-clamp arrangement. Small pieces of scrap wood can be used to prevent the vice jaws from marking the plastic surface. It's worth remembering that plastic is far more brittle in cold weather, so if you're working in a chilly garage or wherever, it may be worth warming the box with a hairdryer, or immerse it in hot water for a few minutes. This will help prevent the plastic from cracking when working.

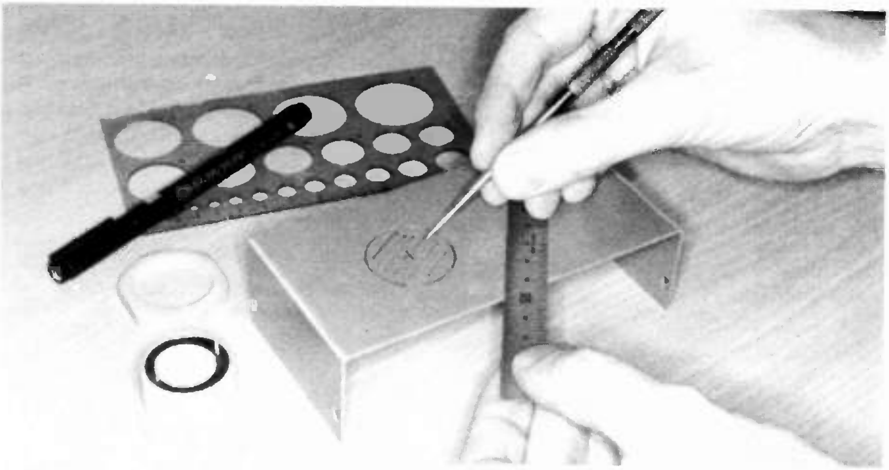
Now choose your weapons! Using the markings as a guide, drill out all holes to the appropriate diameter. A 7-piece set of metric twist drills (made of high speed steel – HSS) will offer a range of sizes from, say, 1·5mm to 6mm as a good starting point. Fill in any in-between sizes by buying individual drills as needed.

Anything much over ¼" (6.35mm) may require holes to be enlarged after drilling a smaller "pilot hole" first, and there are several techniques for doing this. Personally, I quickly open out a hole using a round needle or "rat's tail" file, but larger holes can be made by using a reamer (a tool which crudely cuts out a larger diameter), or, if you can afford it, larger diameter drill bits up to say 10mm or so. Don't use them too enthusiastically, though, or you may crack the plastic.

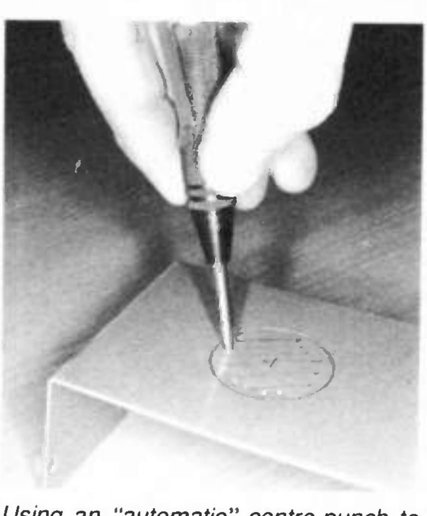
CASE-FILE

It's an easy task to open out a hole to the desired diameter using round or half-round files, trying not to scratch the surrounding plastic by accident. Square or rectangular cut-outs are also easy to form, using suitably-shaped hand files (consider buying a small selection).

You should be aware that it is **extremely dangerous** to use hand files without a suitable plastic or wooden handle being fitted. Your hand or the file may slip and you could seriously injure yourself on the pointed "handle end" (the tang) of the file: so if the file is designed to be used with a handle, don't take any shortcuts.



Marking out a metal panel with a hand scribe.



Using an "automatic" centre-punch to mark a drilling centre (NOT on plastic).

Using a G-clamp to hold the work piece, with wood blocks to prevent scratches.

Also, you may find that square or rectangular files have one edge which has no teeth (a "safe edge") and you can rest your hand on this edge without fear of injury; alternatively, the safe edge also enables you to file out a square corner to an accurate shape, filing one face at a time.

Large-diameter cut-outs – such as a loudspeaker exit – can be produced by drilling a ring of smaller holes inside the perimeter of the cut-out, and then joining these holes together using, for example, an "Abrafile" – a special hand file with a very aggressive cutting action which will easily slice through plastic and aluminium alike, see photographs.

Then knock out the centre, and continue by using a half-round file to smooth the edge to the required size and finish. Jobs like this can be rather a chore, unfortunately, and a rechargeable electric drill helps considerably: there will be times, though, when you need a good dollop of elbow grease, too! A set of "warding files" (small fine-tooth files for finishing) is very useful to smooth off any rough edges. (A "file card" is a specially-made flat wire brush which can be used to clean out the teeth of the file and prevent it from clogging with debris.)

Individual holes can be helped along by deburring them, with one or two twists of a countersinking tool, to remove any messy-looking edges on the plastic. This is an extremely good idea if you are drilling a pattern of holes for a loudspeaker or ventilation grille, as it tidies up the finish considerably.

Finally, having drilled and fabricated the plastic box as required, if you're not happy with the colour or finish, you can always consider spray-painting the box. You can obtain an excellent finish using a modern acrylic-based spray paint, such as "Weldtite" (from cycle shops), or an enamel aerosol spray.

Avoid very old car touch-up sprays you've found hidden in the garage, as these will probably be cellulose-based and will melt the plastic surface before your very eyes . . . Test the finish by spraying inside the box lid, if in doubt. Obviously, painting is best done after all drilling work has been carried out, to minimise damage to the finish, and you should build up the colour gradually by using two or three light coatings.

METALWORK

Dealing with aluminium or metal boxes requires somewhat more skill and experience, and can be hard work at times. The box or control panel is still marked out in the same way, preferably with a scribe. Prior to drilling, though, it's essential that a *centre punch* (or "centre pop") is used with a hammer to punch a small, central starting point for the drill. Otherwise, the drill bit will wander off course and you will stand no chance at all of drilling the hole accurately.

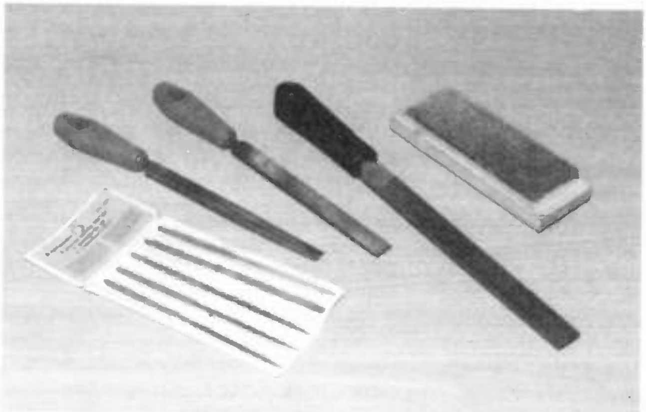
An *automatic centre punch* is actually the most convenient way – these are spring loaded impact devices having a control knob to enable you to produce varying indentations without the need for a hammer. You will need the heaviest punch mark when working with diecast alloy boxes, but less of an indent with, say, aluminium sheet. As before, the work piece should be held in place firmly. Flat metal panels can be held down on the bench using a couple of G-clamps. Preferably place some scrap wood underneath for you to drill into, to avoid damaging the bench, and also use some wooden scrap under the G-clamp jaws to prevent marking the project, especially if it's an expensive anodised aluminium panel.

Diecast aluminium boxes should be clamped in place using a vice, for example. More awkward shapes (e.g. the chassis of a box) can also be held using G-clamps on the appropriate panels, against a scrap of wood.

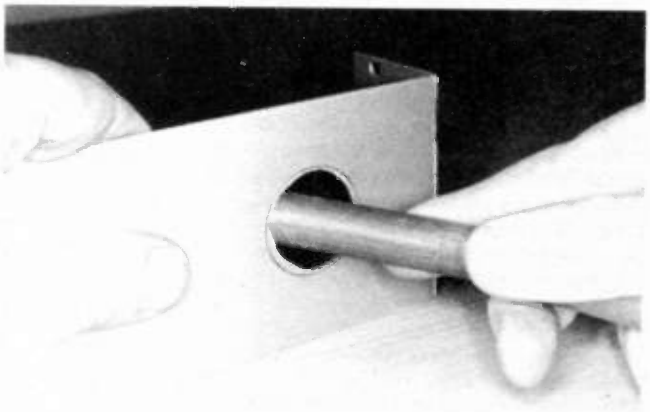
Work continues by drilling any holes or pilot holes, and then enlarging them to size and finishing off neatly. Anything up to 6mm diameter or so is easily achieved with a drill, though a modest rechargeable drill may start to struggle with thicker metal panels or sheet steel and a variable-speed mains drill may be preferable at times.

HSS twist drills are compulsory for this type of work, and ideally commence at the slowest speed available, to establish an accurate starting point. Any screw holes which are intended to accept countersunk screws, can easily be finished by using a countersink bit in a rechargeable drill.

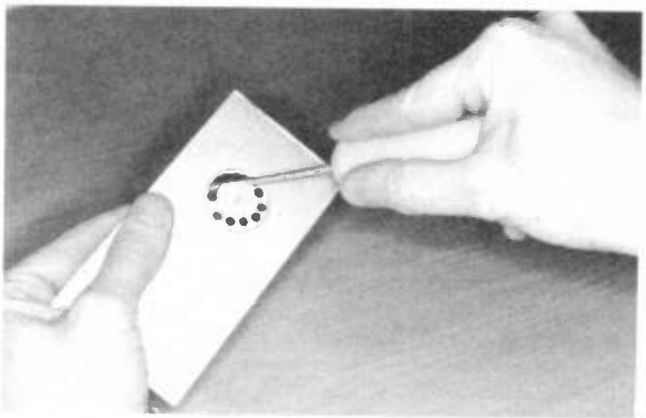
Take sensible precautions when dealing with metalworking this way, wearing safety glasses to avoid swarf infiltrating into the eye, and being wary of unfinished sharp edges causing cuts. It is also good practice to remove any burrs (or "rags") from edges with a countersinking tool, or possibly a special hand-held deburring tool which has a swivelling blade that follows the perimeter of the cut-out.



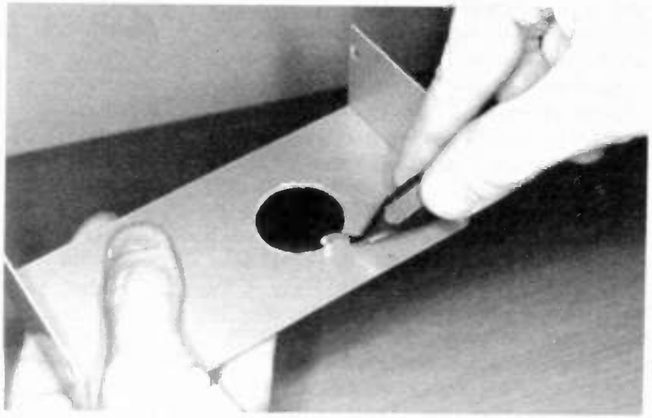
A selection of hand-held files, a needle file set for fine work, and a "file card" for cleaning the teeth of files.



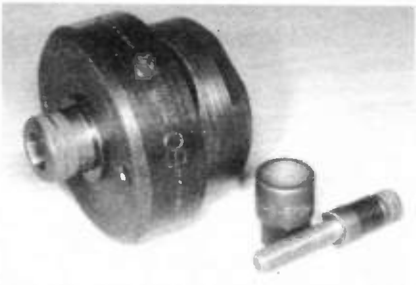
Smoothing the cutout to the desired size using a half-round file.



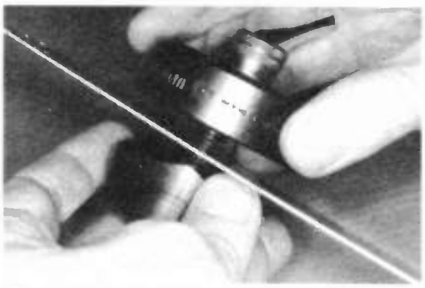
Joining up the ring of small holes with an Abrafile to produce a larger, "rough" cut, hole.



Using a special hand-held deburring tool with a swivelling blades remove the rough edges of the hole.

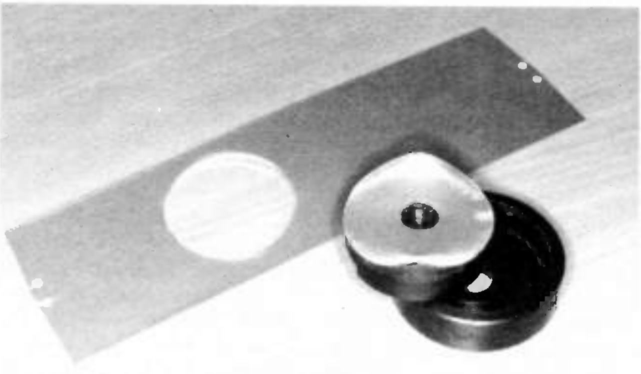


Q-Max sheet metal punches come in a variety of sizes (3/8 and 50mm shown here).



After making a central pilot hole, the punch is assembled through the hole.

Using an Allen hex key, the punch is tightened up until the two halves make a clean cut in the panel.



The Q-Max cutter is ideal for larger holes and, as shown here, will make neat holes every time.

Finish off the panel with rub down letters/symbols and protect the legends with an aerosol lacquer.

CHASSIS PUNCH

By far the neatest and most convenient way of producing larger cut-outs (say 10 – 75mm diameter), is to use a *hole punch* or *chassis cutter*, of which the famous *Q-Max* brand is easily the best known type in the UK. If you are at all serious about construction work, you will definitely wish to build up a small range of these punches for chassis or panel preparation.

I use 10mm (slightly larger than 3/8" diameter) for potentiometers and rotary switches, 12·5mm (½") for certain switches, sockets etc., and 15mm (5/8") for other parts. A luxury item is the 50mm diameter punch I use for panel-mounting mains sockets, which saves an awful lot of work and time (see photos)!

Q-Max cutters will punch through 16s.w.g. steel, and can also be utilised successfully on aluminium, and often, certain plastic boxes too (although this is unofficial). The principle of operation is as follows:

A central hole is drilled through the panel, to accept the Q-Max bolt. Depending on the design of the cutter, the punch part itself may be at one end of the bolt, which is passed through the hole in the panel. On the other side of the panel, a receptacle piece is screwed onto the end of the bolt, which is then tightened together using a hexagonal Allen key.

Gradually, the cutting punch and receptacle are tightened and driven through the panel, like a piston being forced into a cup, until the cutter passes all the way through the panel into the receptacle. This leaves a perfectly-formed hole with no sharp edges, so no cleaning up is needed. There is the possibility, though, that the hole may be slightly convex on the side from which the cutting punch entered the panel. It is usually neater to ensure that this curve occurs on the outer side of the panel.

The largest holes may need two such operations – one Q-Max punch being used for a suitable pilot hole (e.g. 12 or 16mm dia.) to accommodate the bolt, followed by the main punching operation itself.

Alternatively, you can once again drill a ring of holes and join these together with an Abrafile, for example, then smooth the edges with a half-round hand file, but this is a real chore. There is, otherwise, no substitute for this manual work, and it's at this point that you could be forgiven for envying those manufacturers who spend thousands of pounds tooling up to stamp out the panels of professional equipment!

Producing a fully punched panel is a satisfying experience, and the attractive finish of many anodised aluminium panels will enhance your project enormously. Plain aluminium can be improved by finely brushing it in one direction only, using fine-grade wet-and-dry abrasive paper, to produce a matt effect. Alternatively, adhesive aluminium laminates or vinyl may help, if you're discerning. Diecast boxes may benefit from a brush-on coat of "Hammerite" paint (available in various colours), but you may need to "key" the box by sanding it, to enable the paint to adhere.

PANEL GAME

When all "metal bashing" and preparation has been completed, the next aspect of construction involves the completion of any panels, by labelling any controls, switches and indicators etc., and there are various ways in which pleasing effects can be achieved for modest cost.

Rub-down lettering is very popular, and it is much easier to purchase this in a variety of typefaces in High Street stationery shops than ever before. You can be as elaborate as you wish (or not), but it's worth practising a little to centralise (or "justify") any text so that all legends align properly with any switches etc. Straight and curved lines can be produced by using p.c.b. transfers (see last month) in a new role.

Any mistakes can easily be rectified by lifting off the transfer with Sellotape or similar. Marking out the settings of rotary switches can be a real hassle, and happily it's possible to purchase ready-made rub-down legends for multi-pole switches, which make the job of identifying the positions very simple. To finish off, so that the panel transfers are reasonably hard-wearing, it's usual to add a few coats of spray-on aerosol lacquer which will provide a protective film, trying to avoid dust settling until it's dry.

Otherwise, if you have access to a computer and laser printer, you can create symbols and legends on-screen using a word-processing or graphics package, and print these onto semi-transparent laser labels (e.g. as produced by Avery).

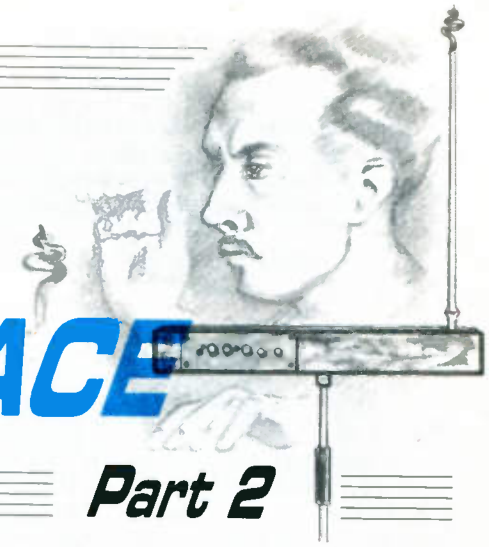
More adventurous (and wealthier!) constructors may be interested in the 3M Dynamark™ label system, which uses advanced ultra-violet techniques to produce laminated plastic labels from your artwork (available from *Farnell Components, Tel. 0113 263 6311*). Don't forget that pre-printed warning labels are also available from major component suppliers, so you might wish to enhance your project by adding appropriate warning symbols (e.g. High Voltage, etc.).

NEXT MONTH

Next month, in the final part of this series, we look at installing the components and circuit boards within the now-prepared enclosure, interwiring techniques, fasteners and fittings, and the finishing touches which will help you derive the most satisfaction from constructing your own electronic prototypes to a high standard.

You can contact Alan with your construction queries and comments by writing to Circuit Surgery *at the Editorial address.*

Constructional Project



THEREMIN MIDI/CV INTERFACE

ADAM FULLERTON

Part 2

Retro-fit your Theremin into a MIDI chain for 21st Century music control!

FOLLOWING on from last month's description of all the various circuits associated with the Theremin MIDI/CV Interface, we move on to its construction and use.

CONSTRUCTION

As said in Part 1, construction of this MIDI project is not recommended for the beginner. Since more advanced readers will already be familiar with the construction techniques required, such description is kept to a minimum.

Details of the component layouts on the two p.c.b.s. are shown in Fig. 9 and Fig. 10. Since these boards are double-sided p.t.h. (plated-through-hole), their manufacture is beyond the capabilities of most readers and so separate tracking details are not shown. The tinted underlay below the component detail is of the upper track side.

The boards are available ready-made as a set, complete with p.t.h. and silk screen printing of the component positions, from the *EPE PCB Service*, code 130.

POINTS TO NOTE

In some instances, the silk-screened component legends differ from those used here in Fig. 9 and Fig. 10. The details are as follows:

Fig. 9/Fig. 10	Silk Screen
IC1 to IC9	U1 to U9
L6	R33
S1 to S10	SW1 to SW10
SK1 to SK9	J1 to J9
SK10, SK11	P1, P2
TR1 to TR10	Q1 to Q10
X1 (crystal)	Y1
X2 (display)	DS1

Note also that the silk screen legends show the wrong orientations for diodes D3 to D10 – the orientations shown in Fig. 10 are correct.

Two corrections to the main board are also required, one of them to incorporate the circuit change around preset VR1 discussed in part 1 (CV Interface, Fig. 6):

During assembly, when you reach VR1, leave its right-hand leg omitted from the p.c.b., but solder in its other two. Next, solder R53 between the exposed leg of VR1 and the +AV power line (pin 8 of IC3 is a convenient point, once the i.c. is soldered in).

Solder Zener diode D27's cathode to VR1's exposed leg, and its anode to VR1's left-hand leg (on 0V line). Finally, solder C39 across D27. Observe polarities of D27 and C39! See also the photos that show this change.

The other correction is to add resistor R54, for which no holes exist: it should be soldered to the back of the main p.c.b. between pins 3 and 11 of IC6.

Just to clarify a small point the eagle-eyed among you may have spotted about IC6 in the photos: it is seen to be a surface mount device. This was purely a convenience for the author and it is the standard d.i.l. pinned-type i.c. which is called for in the Components List.

Finally, confirmation that components C12, D13, R21 and R33 no longer exist.

BOARDING UP

As always, build both p.c.b.s from board level up, checking carefully the orientation of each component before it is placed.

Do not solder l.e.d.s D1, D2, D14, D15, D16, D18, D19, D20 and the display X2 until the entire assembly has been tested and mounted in the case. These components should be soldered only when aligned with the front panel.

Because the p.c.b. has plated-through-holes, the above parts may simply be pushed into place for test purposes (the plating should automatically make contact with their leads). However, it is necessary to spread their leads slightly so they do not fall out during testing.

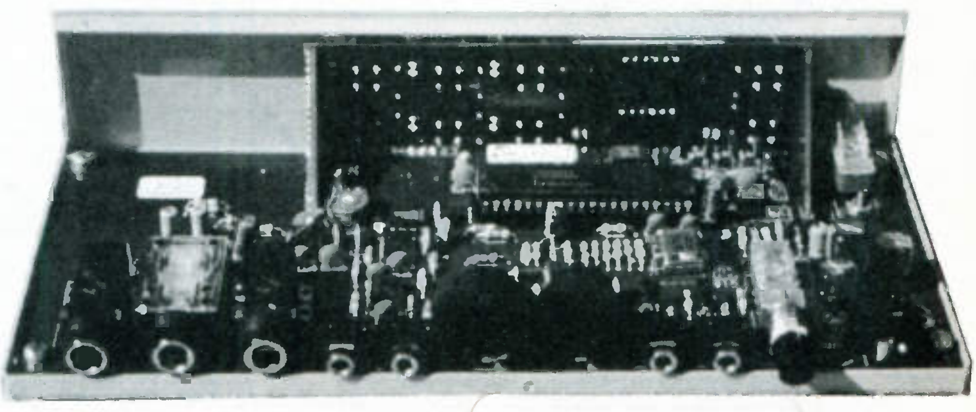
Sockets should be used for the microcontroller (IC1) and the EEPROM (IC8). It is optional as to whether you use them for the other i.c.s; they were not used on the prototype board, but remember i.c.s are virtually impossible to remove from a p.t.h. board without damage.

Note that the crystal is additionally secured to the board by a wire link fitted across it. For greater physical stability, it is recommended that regulator IC2 should be bolted to the p.c.b. The inductor beads, L1 to L6, are each simply threaded over a short link wire.

When both p.c.b.s are fully populated, they must be assembled together. The first operation is to affix the two triangular supports to the main board. (These are supplied as part of the p.c.b. set.) Identify the orientation of each support and push each one through the milled slot in the main board, and solder into position.

The second operation is to push the front panel onto the edge connector of the main board. Ensure that the front panel is flat against both the main board and the supports. Also check that the assembly is straight. First solder the supports, then the edge connector, on the *top side*.

At this stage it is necessary to test the circuit, before it is mounted in the case.



TEST AND SETUP

To test the circuit, a voltmeter or an oscilloscope is essential. The first things to check are the +AV (+17V), −AV (−17V) and +5V supplies without either IC1 or IC8 in their sockets. If these voltages are all OK, switch off and insert IC1 but not IC8.

Switch on again and the message "Error U8" should scroll endlessly across the display. If this does not happen, inspect the p.c.b. for missing components or faulty assembly. Also check that the microcontroller's oscillator circuit is functioning and a reset signal is evident at power up.

If everything has gone to plan, switch off once more and insert IC8 and short together the two points marked "TP1", so taking the test pin to ground. When you power on again there will be a short delay before "U1.3A ---" (this is the software version number) is scrolled across the display. This delay is due to the initialisation of IC8.

Once the initialisation is seen to have been done, switch off and remove the TP1 link.

The next operation is to set the CV output voltage range. Potentiometer VR1 adjusts the output from +10V in the fully clockwise position, to −10V in the fully anti-clockwise position. Although you may set this to suit your own application, the recommended setup procedure is as follows:

1. Turn VR1 to its fully clockwise position, viewed from the front
2. Power on, making sure no external connections except to the power supply are made
3. Have a cup of tea! This pause is to allow IC3, IC4 and IC5 to "warm up and drift a bit"
4. Turn VR1 anti-clockwise until the voltage measured between IC4 pin 7 and ground is −3·2V
5. Check that the AUX voltage is also at approximately −3·2V.

The following test procedure requires a MIDI keyboard and a signal generator to assess that the unit is fully operational:

1. Front Panel Test

With no external connections except the power supply, press the following switches once only and check that the display response listed scrolls, where appropriate, across its three digits, as in Table 1.

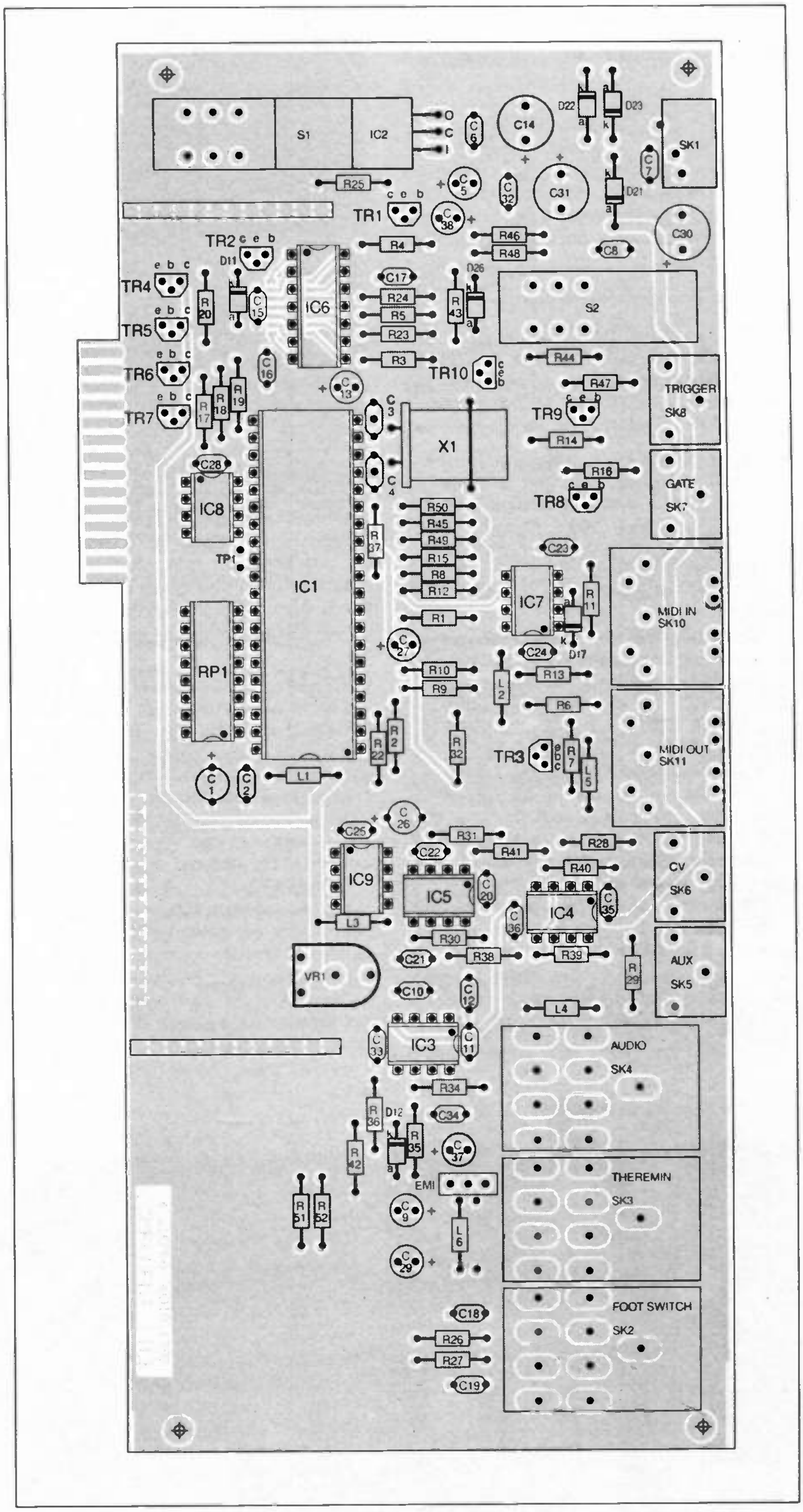
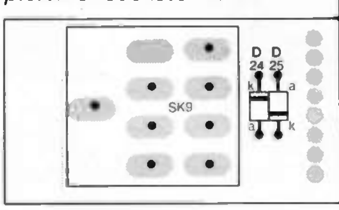


Fig. 9. (right). Component layout on the main p.c.b. Only the upper side tracking is shown.

Fig. 10. Component layout on the display p.c.b. (right). The inset below is the footswitch p.c.b. for socketSK9.



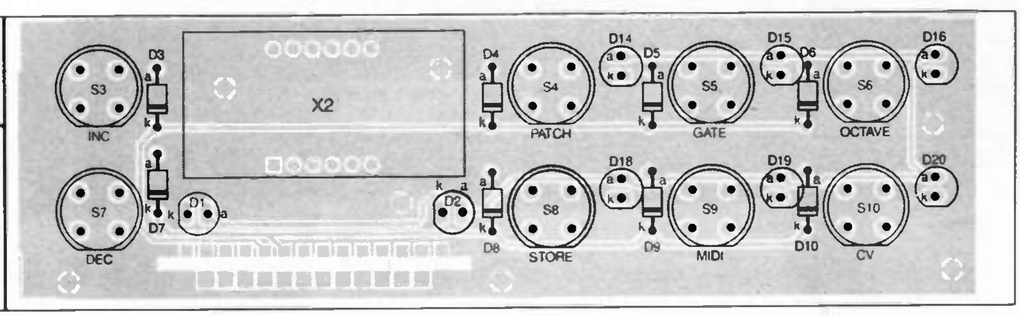


Table 1.

SWITCH	DISPLAY	L.E.D. ACTIVE
PATCH	Pn – 000	PATCH
GATE	On – 000	GATE
OCTAVE	bEnd – b12	OCTAVE
STORE	StorE to – 000	STORE
MIDI	t01	MIDI
CV	Src – Int	CV
INC	r01	CV STORE flashing
DEC	Int	CV STORE flashing

If one or more of the keys do not work, check the orientation of the respective diode. Check also the continuity of the scan lines from TR4 to TR7 and return lines KD0 and KD1.

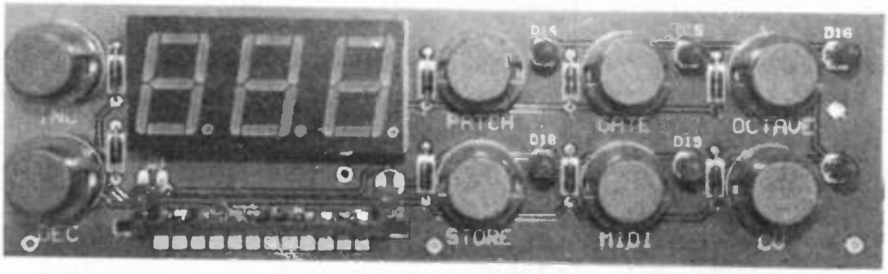
2. MIDI IN and CV Interface Test

Press the INC switch once more and the display should read "r01". Plug the MIDI OUT of the keyboard into the MIDI IN socket and press note "C_0" (this is the lowest key on most 4- or 5-octave key boards).

Make sure that the MIDI keyboard is transmitting on Channel 1. The voltage measured at the CV output should be 0V. (If it is still reading −3·2V this indicates that there is a fault with either the MIDI IN circuitry or the CV circuitry.)

Press the highest "C" on the keyboard. The number of octaves of the keyboard determines what voltage will appear at the CV output (i.e. a 4-octave keyboard will produce 4V). Press the PATCH switch and the display should read "---".

Check that the GATE output reaches +5V when a key on the keyboard is pressed. The TRIGGER can also be seen briefly at "key on". Press switch S2 and check that the GATE output reaches +15V when a key on the keyboard is pressed.



3. Theremin Input Test

Connect the MIDI OUT socket to the MIDI IN of the keyboard; check that it is set to receive on Channel 1. Set the signal generator to produce a 1kHz 0·5V pk-pk square wave and connect this to the tip connection of a *mono* jack plug inserted into the THEREMIN OUT socket.

The display should now read "b 4" and both the GATE and PATCH l.e.d.s should illuminate, and note "B_4" should sound from the keyboard. If this does not happen, trace the signal through to IC6 pin 11 and pin 5. Also check the orientations of transistors TR1 to TR3.

SHUT THE LID!

The display filter must be glued into the chassis, it requires heavy pressure to make it "snap" into place, a super-glue is recommended for this. Also a drop of super-glue on the four compressible rubber washers to affix them to the hank bushes in the chassis base eases assembly. The order of washer placement is shown in Fig. 11.

The two l.e.d.s (D1 and D2) on the front panel underneath the display must be "kinked" down by 2mm. The p.c.b. assembly should then be slid into the chassis front panel. Care must be taken to ensure that all the l.e.d.s locate in the respective holes on the front panel.

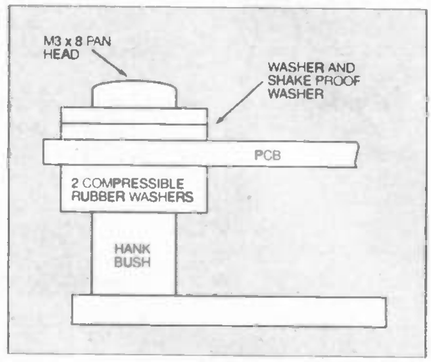
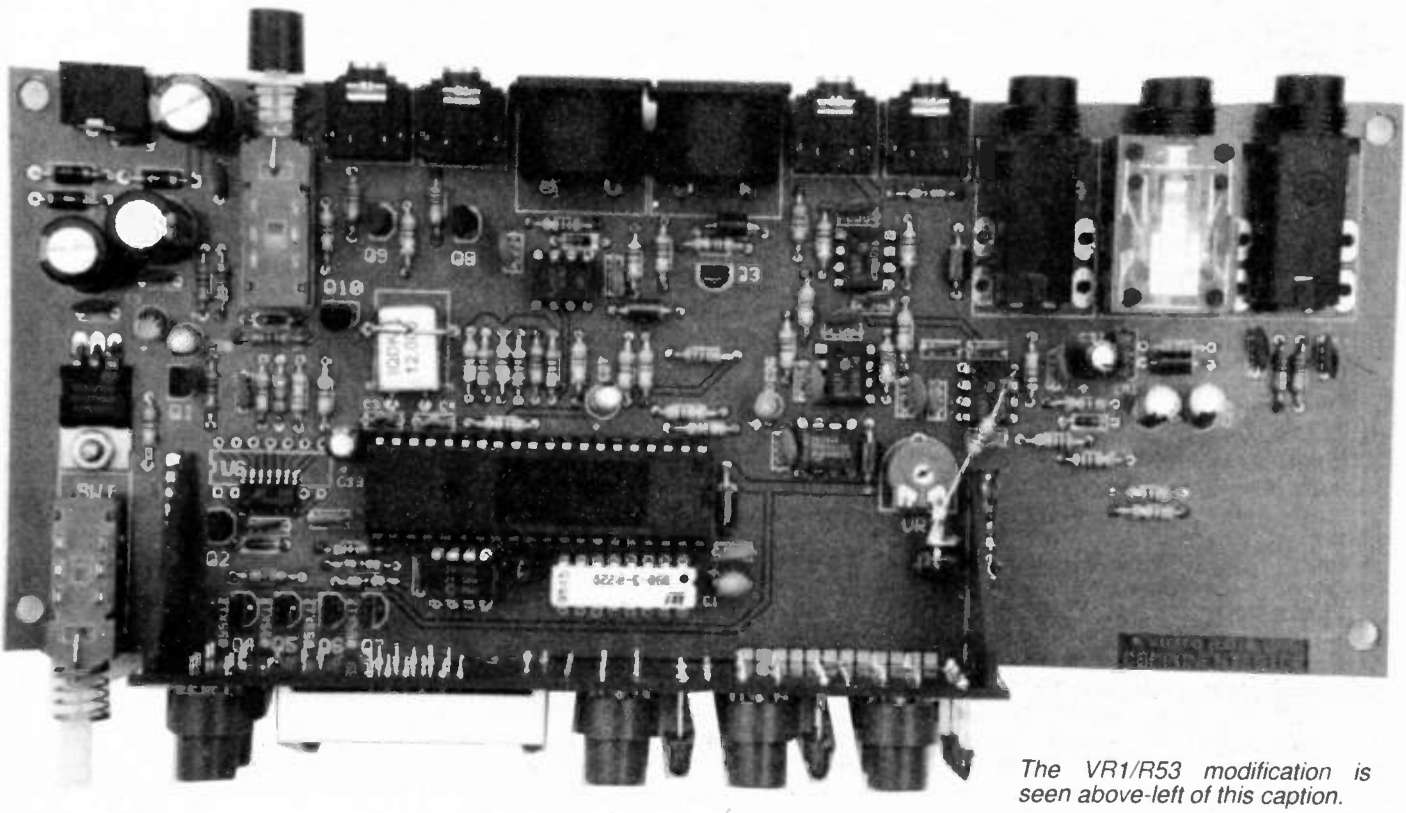


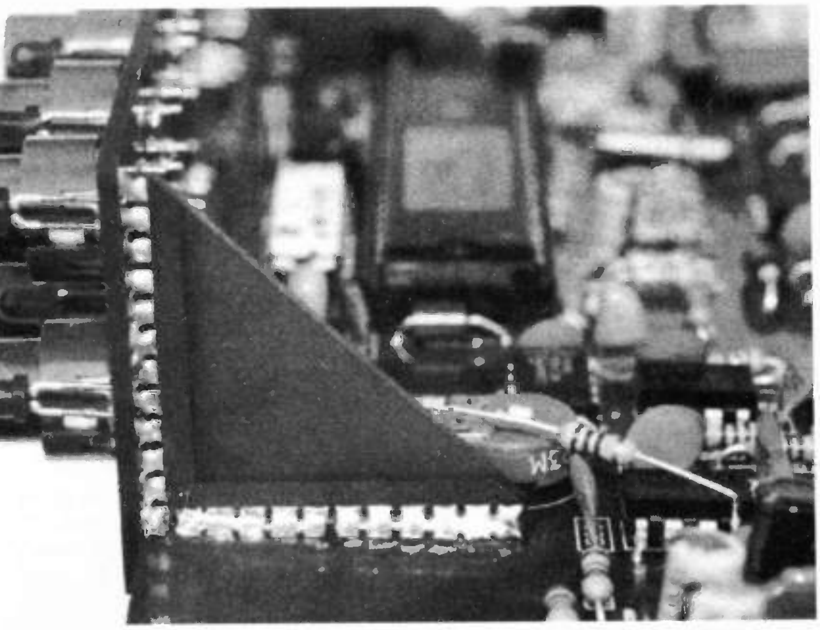
Fig. 11. Washer placement for p.c.b. mounting.

The two fixing screws at the front of the p.c.b. are used to adjust the vertical displacement of the front panel, while there is ±0.5mm of horizontal adjustment provided by the oversized fixing holes. The position of the p.c.b. relative to the front panel should be adjusted so the switches are as concentric as possible with the holes and do not bind when pressed.

All four fixing screws should be tightened so that the p.c.b. is parallel with the lip surrounding the chassis. Now the display X2 and all the l.e.d.s should be soldered in place. The lid should be slid on from the rear, and the five self-tapping screws tightened, taking care not to strip their threads.



The VR1/R53 modification is seen above-left of this caption.



Close-up detail of one of the side brackets soldered into position. The VR1/R53 modification is also evident.

THEREMIN CONNECTIONS

The *EPE Elysian Theremin* may be connected directly with a stereo jack to jack cable into the THEREMIN IN socket and mounted on the rear panel of the MCV.

The Theremin audio signal is available from the THEREMIN OUT socket mounted on the rear panel of the MCV. If the input signal to the MCV is too great, this is indicated by the OCTAVE l.e.d. illuminating when in default display mode, and the Aux/Amp Plate controller data will also be corrupted. Turn the output of the Theremin down until the OCTAVE l.e.d. no longer illuminates and the Aux/Amp data is no longer corrupted.

A Theremin with no continuous pitch output may be connected with a mono jack cable directly to the THEREMIN OUT socket mounted on the rear panel of the MCV. The THEREMIN IN must be left unconnected. *Note that no AUDIO OUT is available.*

It will be necessary to raise the Gate on the threshold parameter if you wish the MCV to display the pitch of the Theremin signal before the note is played. If you wish to modify your Theremin to provide a continuous pitch output, then connection must be made as follows:

¼ inch stereo jack socket:

Tip	Theremin audio signal
Ring	Continuous pitch signal
Collar	Signal ground

MIDI CONNECTIONS

Connect the MIDI OUT of the MCV to the MIDI IN of a tone generator. If you have more that one tone generator, then "daisy chain" the others using the THRU terminals. Alternatively, with several tone generators, use a MIDI THRU box, or a programmable MIDI junction controller.

Connect the MIDI OUT of your keyboard or sequencer to the MCV MIDI IN terminal. Data coming into the MCV may be "Echoed Back" and merged with Theremin controller data available from its OUT terminal if the "Echo" facility is enabled.

CV CONNECTIONS

The CV interface should work with all 1V per octave synthesizers. *But note that this CV output is NOT Hz/Volts.* All the outputs are current limited so it should be very difficult to damage your synthesizer or the MCV by incorrect connection, but check the synthesizer user's manual first!

Connect the CV output of the MCV to the CV IN of the synthesizer. Connect the GATE output of the MCV to the GATE IN of the synthesizer. In the case of ARP synthesizers, connect the TRIGGER output of the MCV to the TRIGGER IN of the ARP. For an ARP, press the 5V/15V switch to select the 15V trigger and gate option. The AUX output voltage may be used to control whatever your particular synthesizer allows.

Note that Moog synthesizers require a switch trigger: connect the GATE output of the MCV to the switch trigger input, and set the GATE option to "Lo".

CAUTION! To avoid damage to your synthesizer ensure that the voltage output levels are correct before connection.

Plug the footswitch stereo jack plug into the FOOT SWITCH socket on the MCV's rear panel before turning the power on. The footswitch has four switches, INC, DEC, HOLD and MODE.

The MODE footswitch allows selection of the PATCH menu options. The HOLD footswitch will either allow a note to be held, or prevent unwanted MIDI data transmission when moving around the Theremin. The INC and DEC footswitches perform identical operation to the ones on the front panel, except for the auto repeat functions.

OPERATION

The six keys to the right of the display provide access to the interface setup parameters. All the setup data can be stored in a memory location identified by the patch number (0<= >127). The INC and DEC buttons to the left of the display are used to set the parameter value.

If one of the INC or DEC switches is held pressed for a short time, the value will be repeatedly incremented or decremented. The rate can be doubled for faster parameter change by pressing the other INC or DEC switch.

The PATCH, GATE, OCTAVE, MIDI and CV switches are multifunctional. Each press of the particular switch selects the next menu item. The following is a description of each menu item and what it does, the display scrolling the information across the three digits where appropriate:

1. PATCH

The Patch menu contains three options:

Press 1 display = Pn- nnn
Function: Patch Number selection

where *nnn* is a patch memory location between 000 and 127. This is used to recall previously written patches.

Press 2 display = PC- nnn
Function: Program Change Number selection

where *nnn* is the program change number transmitted when the patch is loaded. Note: transmission of program changes must be enabled.

Press 3 display – as below
Function: Musical Notation display

This is the default display. Due to the limitations of the type of display used in the MCV, the following is the key to the "musical" meaning of the "strange" shapes displayed:

$$n

C	=>	C
db	=>	C# (D flat)
d	=>	D
Eb	=>	D# (E flat)
E	=>	E
F	=>	F
gb	=>	F# (G flat)
g	=>	G
Ab	=>	G# (A flat)
A	=>	A
bb	=>	A# (B flat)
b	=>	B

where *$$* = note name and *n* = octave.

2. GATE

The Gate menu contains five options:

Press 1 display = On- nnn
Function: Gate On Threshold selection

where *nnn* is the On threshold between 000 and 127. This determines at what amplitude level the MCV opens the gate (plays a note). If you are not providing a continuous pitch signal, raising this threshold allows the MCV to calculate and display the pitch before the note is played.

Press 2 display = SEn- nn
Function: Amplitude Sensitivity selection

where *nn* is the amplitude sensitivity ratio from –30 to 32, and where:

00 is full range
32 is a loud setting
–30 is a quiet setting
01 is good for most analogue synthesizers since it will produce a 0V-5V output on the AUX jack socket.

Press 3 display = CtrL- nnn
Function: Controller number selection

where *nnn* is the controller that the amplitude plate is assigned to (0-32). The default is 007 – channel volume.

Note: When recording the MIDI out onto a sequencer, ensure that the sequencer receives the control message number you have selected. If you wish to play it back through the MIDI/CV Interface, check that you have the AUX control number set to the correct number, see section 5, the CV menu options, later.

Press 4 display = touch- On/Off
Function: Aftertouch on/off

this switch press turns the transmission of aftertouch (channel pressure) on/off.

Press 5 display = FiLtEr- On/Off
Function: Filter on/off

There is a low pass filter on the amplitude plate which "smooths" its response. An interesting effect can be created by adding "steps" to this, selecting Off will slow the amplitude sample rate down to the pitch of the incoming audio signal, providing a frequency-related stepped output.

Note that this function must be set to On if you are not providing a continuous pitch input signal.

3. OCTAVE

The octave menu contains four options:

Press 1 display = bEnd- bnn
Function: Pitch Bend Range setting

This first function defines the pitch range that the pitch bend message represents, where *nn* is 00 to 48 bend range, or sensitivity. A setting of 00 plays only semitones. A setting of 48 gives ±4 octaves (eight octaves in total) of continuous pitch tracking.

The MIDI device that you are using the MCV with will have a similar parameter setting. To make the MIDI tone generator play the same pitch as the Theremin, it is essential that both the setting on the MCV and the tone generator are set to the same value.

Generally, the default setting is 02, this means that the pitch bend message will change the pitch by ±2 semitones. Some manufacturers (such as Kurzweil) define the pitch bend range in cents, which means that a setting of 48 semitones on the MCV represents a setting of 4800 cents.

It is recommended that you use the biggest setting that the tone generator will allow, since the greater the range the fewer times that the MCV will have to switch notes. The most common maximum setting is 24 for newer tone generators, and 12 for older ones. Even a setting of 12 allows two octaves of continuous pitch tracking, which is often enough.

Press 2 display = Port- On/Off
Function: Portamento on/off

This turns the transmission of the RPN portamento controller on/off. This control change helps reduce the "glitch" when the transition from one octave to the next occurs. When recording MIDI data into a sequencer to be played back through the MCV's internal MIDI to CV converter, switching this function to On will provide a continuous glitch-free pitch CV output.

Press 3 display = Oct- rnn
Function: Octave Range Offset selection

where *nn* is from −3 to +3. The octave range offset allows the outgoing MIDI and CV data to be transposed in octaves.

Press 4 display = tonE- tnn
Function: Tone Offset selection

where *nn* is from −6 to +6. The tone offset allows the outgoing MIDI and CV data to be transposed in semitones. If you wish the MIDI or CV tone generator to play one 1/5th above the Theremin, set the tone offset to 5.

4. MIDI

The MIDI menu contains the following five options:

Press 1 display = tnn
Function: MIDI Transmit channel selection

where *nn* is the Transmit channel from 01 to 16. MIDI data will be transmitted on the selected channel. If you cannot change the transmit MIDI channel this is because the gate is open. Mute the Theremin or remove the incoming audio signal and try again.

Press 2 display = rnn
Function: MIDI Receive channel selection

where *nn* is the Receive channel from 01 to 16. Note: this is for program changes only!

Press 3 display = Echo- On/Off
Function: Turns the echo-back (THRU emulation) on/off

MIDI data will be merged with the incoming MIDI data when this is set to On.

Press 4 display = tPC- On/Off
Function: Message Transmission control

This function enables/disables the transmission of program change messages, either when selected in the Patch menu or when a patch is loaded.

Press 5 display = rPC- On/Off
Function: Message Reception control

This function enables/disables the reception of program change messages.

5. CV

The CV menu contains eight options:

Press 1 display = Src rnn
Function: Receive MIDI channel selection

where *nn* is the Receive MIDI channel from 01 to 16, or Internal (Int) for the built-in MIDI to CV converter. The "Int" setting assigns the input audio signal to control the CV interface, or 01 to 16 selects the respective MIDI channel.

Press 2 display = Ctrl nnn
Function: Auxiliary Output channel selection

where *nnn* is the AUX controller output number from 00 to 32. This will translate the selected incoming controller data to the CV AUX output.

Press 3 display = bEnd- bnn
Function: Pitch Bend range selection

where *nn* is the range in tones from 00 to 48 that the pitch bend message represents (see Octave menu for more details).

Press 4 display = tonE- nn
Function: Semitone Offset selection

where *nn* is the semitone offset from −36 to +36. This is to allow the pitch control voltage output to be adjusted to within a semitone of the incoming audio signal. The fine tuning is left to the synthesizer's fine tune control.

Press 5 display = trig- Sng / All
Function: Trigger Signal Assertion control

When this is set to "Sng" the gate and trigger signals are not re-asserted if a note is held while a new one is played. If this is set to "All" the gate and trigger signals are re-asserted each time a new note, within the priority rules, is played.

Press 6 display = typE- ALL/Hi/lo
Function: Note Priority selection

The Type setting option allows the note priority for the occasions when more than one note is played at once. Setting to "Hi" means the highest note has priority, "Lo" means the lowest note has priority and "All" means the *last* note to be received has priority.

Press 7 display = gAtE – Hi / Lo
Function: Gate Output Signal Polarity selection

Most synthesizers use an active high trigger, but you may require an active low trigger for some applications. If you have a synthesizer that requires a switch trigger (MINI MOOG, for example) set this to "Lo".

Press 8 display = ScALE – nn
Function: Octave Scale Ratio selection

where *nn* is the fine adjustment value of the 1V/Octave scale ratio from −99 to +99. Because every synthesizer is different, you will have to set this scaling value for each of your analogue synthesizers, see the CV Tuning section.

6. STORE

Whenever you change a parameter, the Store l.e.d. flashes indicating that the change has not been saved to memory. To store the changes made, press the Store switch. The screen scrolls "Store to- nnn", where *nnn* is the memory location number from 000 to 127.

Use the INC and DEC buttons to choose the destination location (don't bother if you're just updating data within a patch), then press and hold the Store switch, after which press the Patch switch.

If the Store was completed successfully, then the message "donE" will scroll past briefly.

CV TUNING

Every analogue synthesizer has its own adjustment for tuning and scaling, but rather than adjust the synthesizer it is quicker and easier to adjust the MCV's control voltage outputs to suit. This has its advantages since the settings can be saved to the MCV's memory, vastly reducing the setup time and tuning problems associated with analogue synthesizers.

Since most digital tone generators do not suffer tuning instability and drift, unlike their analogue counterparts, they can be used as a tuning reference. The setup shown in Fig. 12 is recommended for setting up the MCV for use with an analogue synthesizer for the first time.

Once you have performed the setup procedure and understand what to do, the entire procedure can be carried out with a Theremin in the place of a digital keyboard.

The following steps show the method which must be used to set the semitone offset and scaling parameters of the MCV. If you are not familiar with tuning your analogue synthesizer, please read the relevant section in its user's manual. It is essential that your analogue synthesizer is in tune with itself before you start.

You must ensure that if you have a synthesizer with more than one oscillator, you only listen to one, since it becomes more difficult to tune with more running.

1. Set the MASTER TUNE knob (or equivalent) of your synthesizer to the centre position

2. Play the lowest note on the keyboard to which you can tune by ear

3. Set the semitone shift parameter to bring the two tones as close as possible

4. Use the MASTER TUNE knob of the synthesizer to tune the two tones for zero beats

5. Play the highest note on the keyboard to which you can tune by ear

6. Set the scaling parameter to tune the two tones for zero beats

7. Repeat steps 1 to 6, until both the lowest and highest notes played have zero beats.

Both the MCV and your analogue synthesizer suffer from temperature instability so it is a good idea to turn both units on and let them "stabilise" before tuning is attempted (have another cup of tea!). It will probably be necessary to make fine tuning adjustments to compensate for variations due to temperature and voltage fluctuations throughout the day.

HINTS AND TIPS

1. When using the CV source set to "Int" (internal), make sure the Bend range setting in the Octave menu is set to the same value as the Bend range in the CV menu if you wish the Pitch CV output to follow the Theremin pitch.

If the Bend range setting in the Octave menu is a smaller value than set in the CV menu, "over bend" is achieved, and likewise for "under bend" when a larger value is chosen. Over bend and under bend can be used as special effects.

2. The Octave range setting in the Octave menu and the Tone shift setting in the CV menu can be used in conjunction with the Theremin sound, to play three different octaves or notes.

3. Many sequencers have an "echo back" facility, this may be used to "echo" the MIDI data transmitted from the MCV back to its MIDI IN terminal. Ensure that the "Echo" setting in the MIDI menu is "Off", or a MIDI feedback loop will occur. This echoed data may be used to drive the CV interface in the MCV.

Although MIDI data transmitted from the MCV can be recorded with a sequencer and played back through the CV interface of the MCV to provide "glitch free" pitch tracking, when used like this some sequencers add a small delay in the "echo back" procedure which may cause unwanted "glitches" in the pitch tracking. The way to avoid this is to set the CV source to "Int".

4. If you wish to use the MCV to extract pitch information from another audio source, it will be necessary to remove any high harmonics from the incoming audio signal.

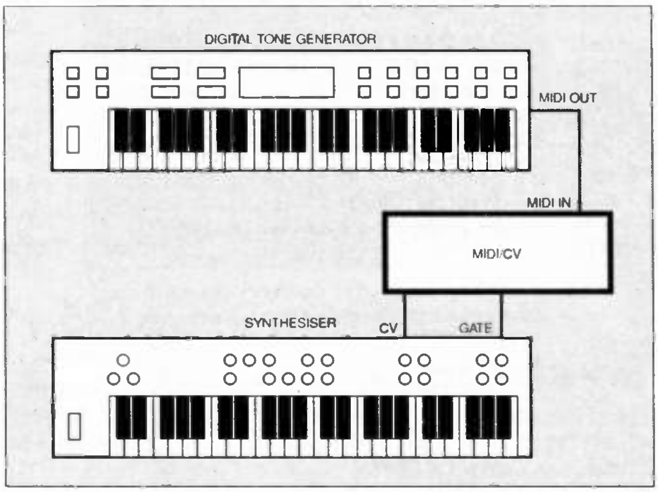


Fig. 12. Recommended first-time set up configuration for synthesiser use.

The use of a 6th order (36dB/Oct) low pass filter in the audio input line should be used to remove any frequencies above 3kHz which would prevent clean pitch extraction.

The Gate On threshold in the Gate menu may need to be raised to prevent incorrect pitch calculation on the attack of the incoming audio signal. Remember that the Audio Out socket is used to inject the audio signal and so the Theremin input must be left disconnected.

It is possible to obtain a "continuous pitch" output from most Theremins. This signal can be usually found somewhere before the VCA, but you will need the circuit diagram for the particular Theremin to identify the optimum. If the signal contains high harmonics, a low pass filter should be used.

The continuous pitch output should be connected to the ring connection of a stereo jack plug, and the audio output connected to the tip (used for amplitude data extraction).

5. This suggestion may be obvious to many users who are familiar with MIDI, but you can set the program change in the Patch menu to select the required voice on your MIDI tone generator. This way the MCV can be used to set up the voice and performance settings when a patch is chosen. Make sure that transmission of program changes is enabled (MIDI menu, Press 4).

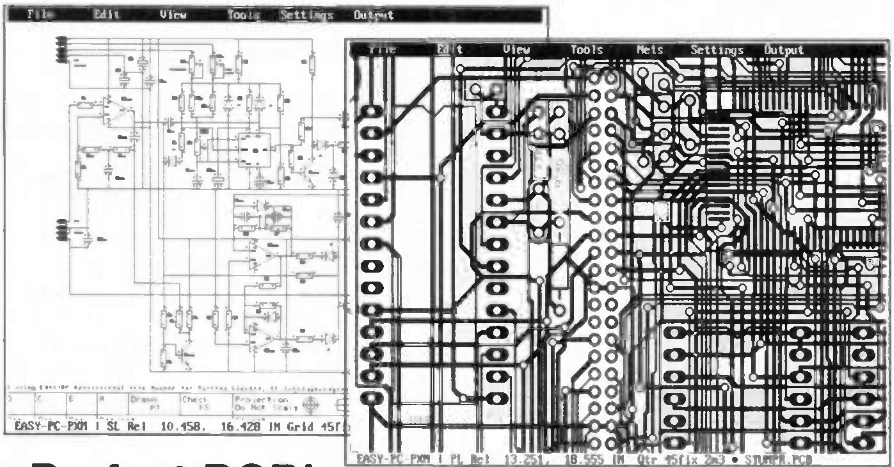
6. If your analogue synthesizer has a CV input to the filter cutoff frequency (i.e. a pedal input), connect the AUX CV out to this and use the dynamics of the Theremin to control the cutoff frequency of a resonant low pass filter. This effect is most pleasant when set up correctly. Use the amplitude sensitivity setting in conjunction with the level or depth control on the synthesizer to produce the desired effect. Add a delay effect and you have a rave machine for the new Millenium!

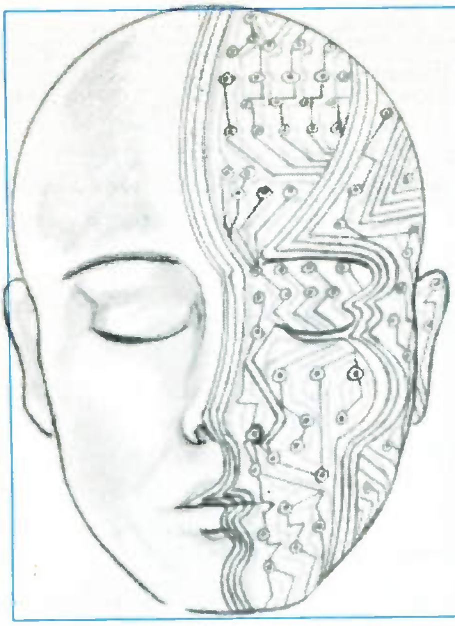
7. Set the Aux controller number to 001, and use the dynamics of the Theremin to control the modulation of the sound. Check the modulation and control routing of your MIDI synthesizer and see what other possibilities exist. Remember you can assign the Aux controller to 00 through 32!

RESOURCE

In Part 1 of this article, reference was made to various software listings of the control codes used by the CPU. These are partial extracts from the main software and may be of interest to programmers. Space prevents their inclusion here, but they are available on 3·5 inch PC-compatible disk from the Editorial office (see the *EPE PCB Service* page – you get all sorts of other software on this disk as well!). These listings are also available via our Internet site at **http://www.epemag.wimborne.co.uk.**

For copyright reasons, the *full* software code listing for the MCV is not available for examination.





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Strain Gauge Amplifier – winch in a cinch!

Being a hang-gliding enthusiast in a region sadly devoid of hills, we use a static winch to elevate the gliders up to about 1,000 feet, under a constant tension. One particular winch relies on strain gauges mounted on the rear drum axle, which flexes under the load.

This is then measured electronically and drives a meter which is easily visible to the winchman. It is critical on this particular winch to monitor the tension because it does not automatically "pay out" and the tension builds up rapidly as the glider comes overhead.

It was the sudden failure of the existing strain gauge amplifiers, costing some £55 each, that found me designing a cheap and simple solution using conventional op.amps, as depicted in Fig. 1.

This circuit is essentially a buffered bridge (resistors R1 to R4), feeding a differential amplifier of fixed gain (IC2) and then a non-inverting amplifier IC3. A potential divider provides a close approximation to a mid-point between the rails, effectively producing +V/2, 0V and −V/2.

Experience resulted in the addition of IC1, to provide the bridge with its own regulated supply to keep the bridge as low-noise as possible. The Balance point is kept approximately in the middle for the best performance; the Balance control VR1 also accounts for the loading of the "0V" potential divider.

The strain gauge should be mounted on the rear of the drum axle under tension, such that it stretches when a load is applied. For the winch used in my application, the required gain is in the order of 500 to give 1V when 100lbs was on the drum.

This makes the circuit very sensitive, and multi-turn cermet presets should be used for both VR1 and VR2. These were mounted via flying leads on the housing to allow external trimming, whilst keeping the circuit secure inside.

R. Hunt,
Diss,
Norfolk.

Background Noise Headphone Interrupter – canned sound!

In order to enable a headphone wearer to listen to louder music, yet also be aware of a telephone call or knock at the door, I designed the circuit of Fig. 2 which is intended for use with stereo headphones.

Ambient noise is picked up by MIC1, a f.e.t.-input microphone biased by resistor R1 and amplified by transistors TR1 and TR2. The signal level into TR2 base is set by potentiometer VR1. The output from TR2 is used to trigger a 555 monostable (IC1) at pin 2, such that a period of approximately 242ms is generated at pin 3 when TR2 saturates.

IC2 is a MAX383 analogue switch i.c. which is wired such that, when no input pulse is present on pins 10 and 15, the output pins 3 and 4, plus pins 5 and 6 will have a low impedance and will therefore allow the music signal to pass between the sockets SK1 and SK2.

If the phone should ring, for example, the circuit will act and the analogue switch, IC2,

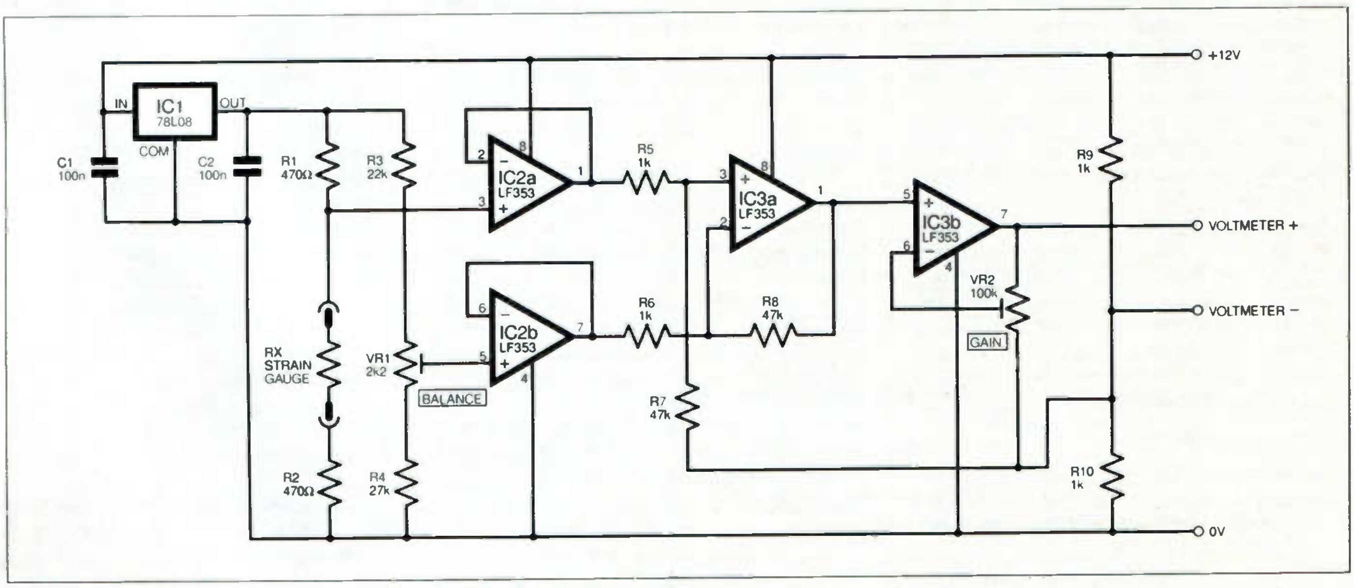

Fig. 1. Circuit diagram for the Strain Guage Amplifier. Note that multi-turn cermet presets should be used for the Balance and Gain controls.

will receive a high pulse, thereby interrupting the music signal. This condition lasts for as long as the background noise level remains above the level determined by VR1, which may need some trial and error. The main limitation is that you cannot sing along to the music! *(N.B. The MAX383 is a new device which may not be widely available, but the author advises that the alternative Maxim DG403DJ is suitable, this is available from RS or Farnell Components – A.R.W.)*

Martin Campbell, Bradford, W. Yorks.

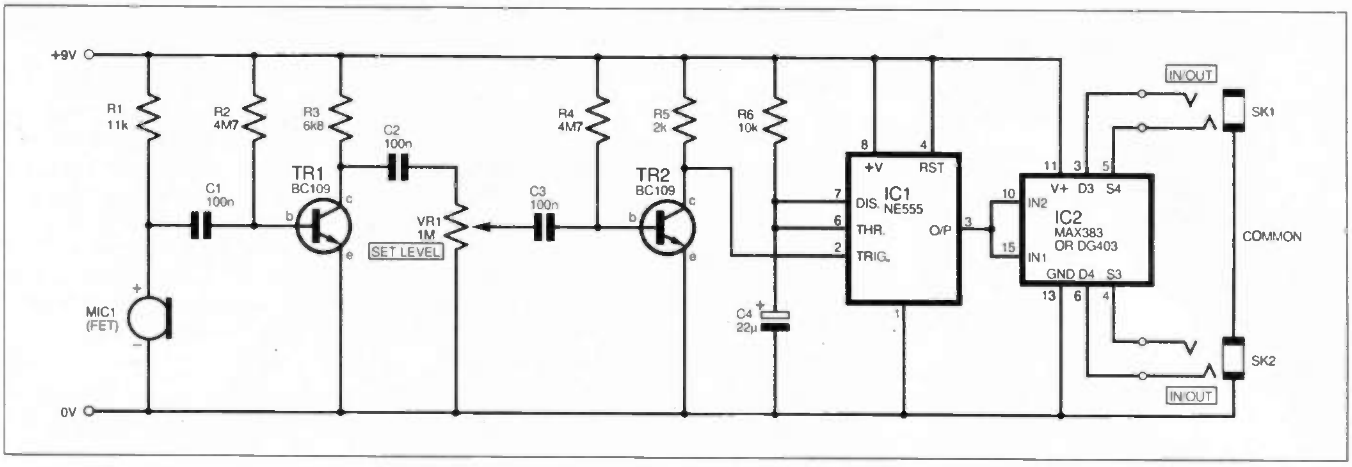

Fig. 2. Circuit diagram for the Background Noise Headphone Interrupter.

Ohm Sweet Ohm

Max Fidling

Mixed Feelings

The New Year's celebrations and yours truly, don't mix. I'm much happier leaving the Boss drinking sherry whilst watching the telly, and reminiscing over those "Best of 1996" TV compilations, whilst I go and find something useful to do in the shack.

So, munching a packet of potato chips and drinking some tea in my favourite mug, I smooched around in the workshop, accompanied by Piddles, my cat. I'd brought a bag of marshmallows for good measure, and I was casually flicking the odd rubbery mallow in the direction of the moggie, who munched them with gusto, whilst I rustled through the pages of my favourite electronics magazine, in search of inspiration.

Aha! Another labour-saving gadget was spotted which was bound to be a hit with the Boss, I reckoned. I had in mind a "boiling milk" alarm: a simple alarm which warned when a pan of milk was approaching its boiling point.

Normally, temperature-sensing circuits implied using a thermistor (for which read that dreaded word: expensive) somewhere, but browsing through the circuit, I spotted that it used a silicon diode as a temperature sensor. The circuit's principle function was to use the diode's forward voltage, which would gradually change with temperature, and this was used to drive a simple alarm circuit. This was far cheaper than using a thermistor, a fact which didn't escape my attention!

Sensitive Point

The diode "sensor" needed encapsulating to form a probe, and for this I rifled through my biscuit tin of glass test tubes and similar stuff. An old glass test tube with yellowed markings was selected for the job, although it had seen better days as part of my nephew's chemistry set and looked a bit grubby on the outside. Anyway, I would hazard a guess that the Boss would never notice once it was dunked in the milk!

The test tube was thus pressed into service, as I gleefully sealed in the diode with an old cork bung and two very thin wires trailing out to the plastic housing, which contained a buzzer and the small electronics board. An uncontrollable blob of vinegary-smelling silicone sealant was splodged over the cork bung – if nothing else, it would look purposeful and would maybe give the milk a certain "piquancy" which you don't seem to find in your ordinary milk!

On the Boil

The Boiling-Milk Alarm would be powered by the usual PP3 and held together in a plastic box, using my customary mixture of Blu-Tak and double-sided sticky pads. Thus the device gradually took shape, as I drifted into my world of soldering and drilling, and the New Year celebrations became but a hazy memory.

I lobbed a marshmallow towards Piddles the cat, every so often and he polished it off in a trice. For my part, having scoffed the potato chips, I'd now plugged in the hot air gun and was heating a marshmallow stabbed on the end of a screwdriver (a clean one, honest), and thus the shack filled up with a heady and rather unique fragrance of solder flux and cooked marshmallows. Scrummy!

With a battery fitted, I dunked the probe in my mug and gave my lukewarm tea a good stir, and then twiddled a preset potentiometer in order to fix the temperature set-point. I twirled the control a bit more, just to be on the safe side and the temperamental buzzer gave a gratifying wail, which I reckoned would easily warn of imminent milk-pan meltdown.

If this doesn't get me into the Boss's good books, I told the cat, then nothing will, and I closed the box together and headed back to the house carrying my newly-built booty in the general direction of the kitchen.

Boiling Point

The moment of truth arrived that evening when the Boss produced the milk pan, and I gleefully demonstrated the basic operation of the new gizmo. The boss eyed the test-tube probe with deep suspicion (I guess because by now it smelled strongly of silicon sealant) but before she could protest, I plopped the test tube into the pan, emptied a bottle of milk over it and turned on the heat!

The Boss watched anxiously as the milk started to simmer and I reassuringly nodded towards the plastic project, grinning confidently and waiting for the telltale buzzing sound. Nothing happened . . .

Determined not to lose out in this battle of brinkmanship, I stood my ground resolutely, as the Boss gradually became more agitated, at this precise point, with a sudden volcanic "woosh" the pan boiled over as a milky, steamy geyser erupted over the cooker! Shortly afterwards, the alarm sounded!

"Oh well, just needs a slight adjustment," I blurted, as I helped myself to another mug of tea, as Piddles nosed the puddle of milk on the floor inquisitively.

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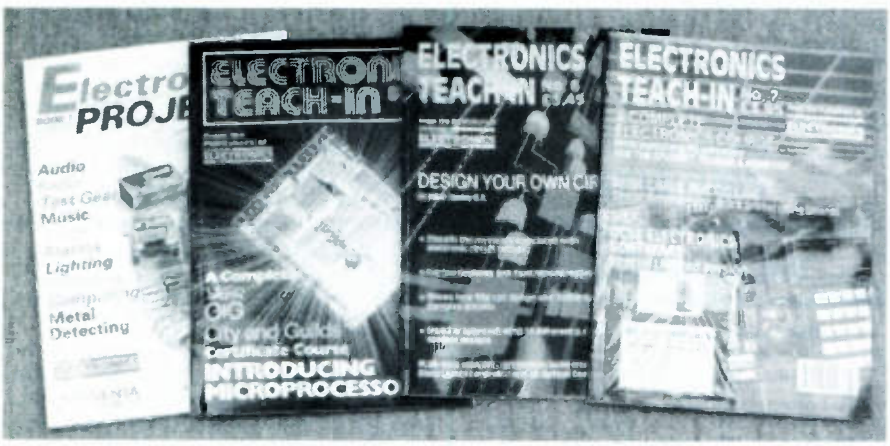

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It provides a practical and comprehensive collection of circuits, rules of thumb and design data for professional engineers, students and enthusaists, and therefore enough background to allow the understanding and development of a range of basic circuits.
Contents: Passive components, Active discrete components, Discrete component circuits, Sensing components, Linear I.C.s, Digital I.C.s, Microprocessors and microprocessor systems, Transferring digital data, Digital-analogue conversions, Computer aids in electronics, Hardware components and practical work, Standard metric wire table, Bibliography, The HEX scale, Index.
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R. M. Marston
A vast range of audio and audio-associated i.c.s are readily available for use by amateur and professional design engineers and technicians. This manual is a guide to the most popular and useful of these devices, with over 240 diagrams. It deals with I.c.s such as low frequency linear amplifiers, dual pre-amplifiers, audio power amplifiers, charge coupled device delay lines, bar-graph display drivers, and power supply regulators, and shows how to use these devices in circuits ranging from simple signal conditioners and filters to complex graphic equalizers, stereo amplifier systems, and echo/reverb delay lines etc.
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R. M. Marston
This manual is concerned mainly with waveform generator techniques and circuits. Waveform generators are used somewhere or other in most types of electronic equipment, and thus form one of the most widely used classes of circuit. They may be designed to produce outputs with sine, square, triangle, ramp, pulse, staircase, or a variety of other forms. The generators may produce modulated or unmodulated outputs, and the outputs may be of single or multiple form.
Waveform generator circuits may be built using transistors, op.amps, standard digital i.c.s, or dedicated waveform or "function" generator i.c.s.
The manual is divided into eleven chapters, and presents over 300 practical circuits, diagrams and tables. The subjects covered include: Basic principles; Sine wave generators; Square wave generators; Pulse generator circuits; "Timer i.c." generator circuits; Triangle and sawtooth generators; Multi-waveform generation; Waveform synthesizer i.c.s; Special waveform generators; Phaselocked loop circuits; Miscellaneous "555" circuits.
267 pages **Order code NE18** **£13.95**

OPTOELECTRONICS CIRCUITS MANUAL
R. M. Marston
A useful single-volume guide to the optoelectronics device user, specifically aimed at the practical design engineer, technician, and the experimenter, as well as the electronics student and amateur. It deals with the subject in an easy-to-read, down-to-earth, and non-mathematical yet comprehensive manner, explaining the basic principles and characteristics of the best known devices, and presenting the reader with many practical applications and over 200 circuits. Most of the i.c.s and other devices used are inexpensive and readily available types, with universally recognised type numbers.
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R. A. Penfold
The first part of this book covers standard operational amplifer based "building blocks" (integrator, precision rectifier, function generator, amplifiers, etc), and considers the ways in which modern devices can be used to give superior performance in each one. The second part describes a number of practical circuits that exploit modern operational amplifiers, such as high slew-rate, ultra low noise, and low input offset devices. The projects include: Low noise tape preamplifier, low noise RIAA preamplifier, audio power amplifiers, d.c. power controllers, opto-isolator audio link, audio millivolt meter, temperature monitor, low distortion audio signal generator, simple video fader, and many more.
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R. A. Penfold
Getting started with logic circuits can be difficult, since many of the fundamental concepts of digital design tend to seem rather abstract, and remote from obviously useful applications. This book covers the basic theory of digital electronics and the use of CMOS integrated circuits, but does not lose sight of the fact that digital electronics has numerous "real world" applications.
The topics covered in this book include: the basic concepts of logic circuits; the functions of gates, inverters and other logic "building blocks"; CMOS logic i.c. characteristics, and their advantages in practical circuit design; oscillators and monostables (timers); flip/flops, binary dividers and binary counters; decade counters and display drivers.
The emphasis is on a practical treatment of the subject, and all the circuits are based on "real" CMOS devices. A number of the circuits demonstrate the use of CMOS logic I.c.s in practical applications.
119 pages **Order code BP333** **£4.95**

AUDIO AND MUSIC

INTRODUCTION TO DIGITAL AUDIO (Second Edition)
Ian Sinclair
Digital recording methods have existed for many years and have become familiar to the professional recording engineer, but the compact disc (CD) was the first device to bring audio methods into the home. The next step is the appearance of digital audio tape (DAT) equipment.
All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.
This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product.
128 pages **Order code PC102** **£7.95**

PROJECTS FOR THE ELECTRIC GUITAR
J. Chatwin
This book is for anyone interested in the electric guitar. It explains how the electronic functions of the instrument work together, and includes information on the various pickups and transducers that can be fitted. There are complete circuit diagrams for the major types of instrument, as well as a selection of wiring modifications and pickup switching circuits. These can be used to help you create your own custom wiring.
Along with the electric guitar, sections are also included relating to acoustic instruments. The function of specialised piezoelectric pickups is explained and there are detailed instructions on how to make your own contact and bridge transducers. The projects range from simple preamps and tone boosters, to complete active controls and equaliser units.
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MIDI SURVIVAL GUIDE
Vic Lennard
Whether you're a beginner or a seasoned pro, the MIDI Survival Guide shows you the way. No maths, no MIDI theory, just practical advice on starting up, setting up and ending up with a working MIDI system.
Over 40 cabling diagrams. Connect synths, sound modules, sequencers, drum machines and multitracks. How to budget and buy secondhand. Using switch, thru and merger boxes. Transfer songs between different sequencers. Get the best out of General MIDI. Understand MIDI implementation charts. No MIDI theory.
104 pages **Order code PC111** **£6.95**

PRACTICAL ELECTRONIC MUSICAL EFFECTS UNITS
R. A. Penfold
This book provides practical circuits for a number of electronic musical effects units. All can be built at relatively low cost, and use standard, readily available components. The projects covered include: Waa-Waa Units; Distortion Units; Phaser; Guitar Envelope Shaper; Compressor; Tremolo Unit; Metal Effects Unit; Bass and Treble Boosters; Graphic Equaliser; Parametric Equaliser. The projects cover a range of complexities, but most are well within the capabilities of the average electronics hobbyist. None of them require the use of test equipment and several are suitable for near beginners.
102 pages **Order code BP368** **£4.95**

LOUDSPEAKERS FOR MUSICIANS
Vivan Capel
This book contains all that a working musician needs to know about loudspeakers; the different types, how they work, the most suitable for different instruments, for cabaret work, and for vocals. It gives tips on constructing cabinets, wiring up, when and where to use wadding, and when not to, what fittings are available, finishing, how to ensure they travel well, how to connect multi-speaker arrays and much more.
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For a further selection of books see next month's issue.

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PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749; Fax 01202 841692 (NOTE, we cannot reply to orders or queries by Fax); E-mail: editorial@epemag.wimborne.co.uk.** Cheques should be made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**

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

Back numbers or photostats of articles are available if required – see the *Back Issues* page for details.

Please check price and availability in the latest issue.

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

PROJECT TITLE		Order Code	Cost
EPE HiFi Valve Amplifier –	JUNE'95		
Phase splitter		941	£6.71
PIC-DATS 4-channel Light Chaser		942	£7.90
HV Capacitor Reformer	JULY'95	943	£5.60
Ramp Generator			
Logic Board (double-sided p.t.h.) & Analogue			
board (pair)		944/5	£32.00
Automatic Curtain Winder		946	£6.75
Windicator		947	£4.10
Microcontrolled 3-Digit Timer	AUG'95	933	£6.61
IR Remote Control – Transmitter		948	£5.76
– Receiver		949	£6.14
Personal Practice Amplifier		950	£6.09
Low-Range Ohmmeter Adaptor	SEPT'95	926	£5.55
Simple Theremin		952	£6.68
Vandata			
Boot Control Unit		953	£10.52
Display Unit		954	£6.61
Sound Switch	OCT'95	915	£6.55
Multiple Project PCB		932	£3.00
Audio Sinewave Generator			
Treble Booster			
Infra-Red Controller/Alarm (2 boards required)			
Capacitor Check		955	£5.76
Ginormous VU Meter		956	£9.31
Multiple Project PCB	NOV'95	932	£3.00
Video Enhancer – Current Tracer –			
Distortion Effects Unit			
Digital Delay Line		958	£8.04
50Hz Field Meter		959	£8.32
Temperature Warning Alarm (Teach-In '96)		960	£6.15
Stereo "Cordless" Headphones	DEC'95		
Transmitter		961	£8.04
Receiver		962	£7.66
* EPE Met Office – Sensor/Rainfall/Vane		963/965	£11.33
Spiral transparency free with above p.c.b.			
Light-Operated Switch		966	£6.37
Modular Alarm System (Teach-In '96)		967a/b	£7.12
Audio Meter and Amplifier		968	£5.99
* EPE Met Office –	JAN'96		
Computer Interface (double-sided)		964	£7.69
Audio Signal Generator		969	£6.58
Mains Signalling Unit, Transmitter and Receiver		970/971 (pr)	£9.09
Automatic Camera Panning (Teach-In '96)		972	£6.63
Printer Sharer		973	£9.93
Analogue Frequency Meter	FEB'96	957	£6.70
Vari-Speed Dice (Teach-In '96)		974	£5.69
Mains Signalling Unit – 2			
12V Capacitive PSU		975	£6.07
* PIC-Electric Meter – Sensor/PSU– Control/Display		977/978 (pr)	£9.90
Multi-Purpose Mini Amplifier	MAR'96	976	£6.12
* PIC-Electric – Sensor/PSU – Control/Display		977/978 (pr)	£9.90
High Current Stabilised Power Supply		979	£6.62
Mind Machine Mk III – Sound and Lights		980	£7.39
Infra-Zapper Transmitter/Receiver (Teach-In '96)		981/982 (pr)	£8.01
Mind Machine Mk III – Programmer	APRIL'96	983	£7.36
Bat Band Converter/B.F.O.		984a/b	£5.80
Hearing Tester		985	£6.87
Event Counter (Teach-In '96)		986	£8.39
B.F.O. and Bat Band Converter	MAY'96	984a/b	£5.80
Versatile PIR Detector Alarm		988	£6.76
Mind machine Mk III – Tape Controller		989	£6.70
Midi Analyser		992	£6.74
Countdown Timer (Teach-In '96)		993	£9.44
Sarah's Light	JUNE'96	996	£7.17
Home Telephone Link		997 (pr)	£10.72
* PulStar		998	£6.60
VU Display and Alarm		999	£7.02

PROJECT TITLE		Order Code	Cost
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and Counter – Oscillator/L.C.D. Driver		994/995 (pr)	£12.72
Timed NiCad Charger		100	£6.99
Single-Station Radio 4 Tuner		101	£7.02
Twin-Beam Infra-Red Alarm –			
Transmitter/Receiver		102/103 (pr)	£10.50
* Games Compendium		104	£6.09
Mono "Cordless" Headphones	AUG'96		
– Transmitter/Receiver		990/991 (pr)	£10.16
Component Analyser (double sided p.t.h.)		105	£12.18
Garden Mole-Ester		106	£6.07
Mobile Miser		107	£6.36
Bike Speedo		108	£6.61
* PIC-Tock Pendulum Clock	SEPT'96	109	£6.31
Power Check		110	£6.42
Analogue Delay/Flanger		111	£7.95
Draught Detector		112	£6.22
Simple Exposure Timer		113	£6.63
Video Fade-to-White	OCT'96	114	£6.98
Direct Conversion 80m Receiver		116	£7.52
Vehicle Alert		117	£6.55
10MHz Function Generator			
– Main Board		118	£7.33
– PSU		119	£5.39
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* Central Heating Controller		120	£7.85
D.C. to D.C. Converters			
– Negative Supply Generator		122	£5.96
– Step-Down Regulator		123	£6.01
– Step-Up Regulator		124	£6.12
EPE Elysian Theremin	DEC'96		
(double-sided p.t.h.)		121	£22.00
* PIC Digital/Analogue Tachometer		127	£7.23
Stereo Cassette Recorder			
Playback/PSU		128	£7.94
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* Earth Resistivity Meter	JAN'97		
Current Gen. – Amp/Rect.		131/132 (pr)	£12.70
Mains Failure Warning		126	£6.77
Theremin MIDI/CV Interface	FEB'97		
(double-sided p.t.h.)		130 (set)	£40.00
Pacific Waves		136	£9.00
PsiCom Experimental Controller		137	£6.78

EPE SOFTWARE

Software programs for the *EPE* projects marked above with an asterisk (*) are available altogether on a *single* 3.5 inch PC-compatible disk, or as needed via our Internet site. The same disk also contains the following additional software: Simple PIC16C84 Programmer (Feb '96), PIC Disassembler (unpublished).
The disk (order as "PIC-disk") is available from the *EPE PCB Service* at £2.50 (UK) to cover our admin costs (the software itself is *free*). Overseas £3.10 surface mail, £4.10 airmail. Alternatively, the files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

EPE PRINTED CIRCUIT BOARD SERVICE

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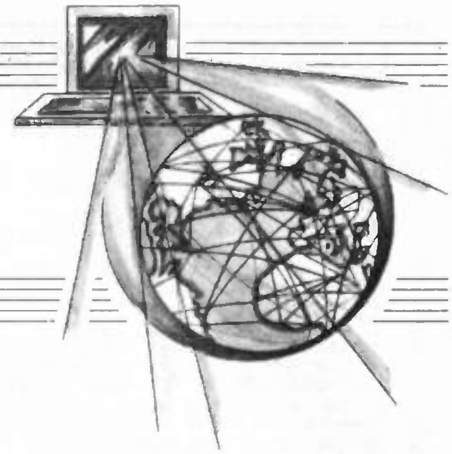
SURFING THE INTERNET

NET WORK

ALAN WINSTANLEY



WELCOME to this month's *Net Work* column, the feature specially written for *EPE* readers who access the Internet, the most exciting and fastest-moving communications medium on the planet! *Everyday Practical Electronics* publishes its own World Wide Web (WWW) site on **http://www.epemag.wimborne.co.uk** with up-to-the-minute information on Back Issue availability, plus an on-line order form to enable you to purchase back numbers by credit card.

Also, an on-line index for the past five years of *EPE* will hopefully be available on-line, by the time you read this. Our feedback from abroad tells us how much readers appreciate having instant access to our PIC microcontroller files, which are stored on our FTP site **ftp://ftp.epemag.wimborne.co.uk/pub/PICS** for you to download. We welcome ideas and suggestions for improvement or expansion of the sites.

CampusWorld

British Telecom (BT) have introduced an on-line education service called *CampusWorld*, giving pointers to thousands of resources, aimed at supporting those involved in education. This is on **http://www.campus.bt.com.**

Some of the resource is available to registered users only, but follow the signs for CampusConnect, then Open Area, Educational Suppliers, and you'll find *EPE* listed in the "Education High Street" Web Sites listing.

Don't Unzip PKZ300B.ZIP

Remember the story of the Trojan horse? The file utility PKZIP is familiar to every PC user as the program used to compress files down to a fraction of their size, to save disk space and transmit them more quickly over the Internet. PKWare, Inc. (**http://www.pkware.com**) which provides PKZIP software, is alerting computer users to bogus "Trojan" versions called PKZ300B.EXE or PKZ300B.ZIP which have been circulated on the net by hackers. These files attempt to reformat your hard disk, trashing its contents in the process.

Version 2.04G is the most recent *genuine* PKWare issue, and you are strongly advised to check out PKWare's site for up-to-date news and confirmation of all genuine version numbers. The latest PKWare V2.5 costs US$49 and can be ordered on-line.

An alternative package for Windows 95 users is *WinZip* which I can endorse as a friendly and easy to use Windows compression and decompression utility. It's available on **http://www.winzip.com.** This Windows 95 shareware has appealing and cute graphics, together with wizards for beginners, and the latest V6.2 only costs $29 (£17.50) so it's worth a trial.

CompuServe and Hot Dogs

CompuServe, the American Internet Access Provider (IAP), continues with its strategy of moving towards a web-based structure, away from its own proprietary technology. They expect the transition to have taken a year or more, delivering in mid 1997, in an operation codenamed "Hot Dog" which uses Microsoft's *Normandy* technology.

The resources needed for Hot Dog caused CompuServe to shelve plans early in 1996 to charge in local currency (we're still charged in US Dollars on our credit cards in the UK) and postpone their scheme to give each customer a human-recognisable "alias" (such as alan_winstanley) rather than their traditional numerical ID. Somehow, *100531.1437@compuserve.com* just hasn't got the same ring.

H.M. Government is said to be closing up a VAT loophole which will see our CompuServe bills rise: because it's billed from the USA, standard CompuServe subscriptions of US$9.95 per month (roughly £6.50 per month, minimum) do not presently attract Value Added Tax. This is set to change with a rubber-stamp marked "+17.5% VAT" bashing our bills when the VAT Commissioners have refilled their stamp pads with lots of red ink.

CompuServe's service deserved some criticism in the UK during 1996, as they struggled to get onto the front foot, but I have to say that I have always found their service incredibly convenient as a self-contained resource for software patches and fixes. Recent bugs and problems were ironed out by downloading fixes from the relevant CompuServe "forum", and at the same time, my posting in a Corel forum brought forth invaluable help from a fellow user, which resolved another nagging and persistent problem I'd experienced with network printing.

As more software houses open their own web sites, Internet users will tend to access those web sites directly, and the dependence of software on CompuServe's various forums is likely to subside. Where CIS *does* score is that it offers a complete, all-in-one Internet access package for family use, together with a generally reasonable level of service to its customers, and its discussion forums where you can exchange information with like-minded others. If you want an all-in one family-friendly package, then it's worth trying a CompuServe demonstration disk. Or, phone them on 0800 000 400. Alternatives include the now respected America On-Line (AOL), whose demo disks are everywhere to be seen. Both companies provide an easy, if slightly quirky, way of getting onto the Internet, offering E-mail, World Wide Web and FTP, with a range of other services.

Click on These

Here's this month's selection of electronics-related links which I discovered when midnight surfing. Check the *Net Work* page on our web site, where the hyper-text links are ready-made for you! A popular site of Windows shareware resides at the Simtel library, so try **http://www.simtel.net/simtel.net.** Choose your OS then follow your nose to the **elec** listing. In the Win 3.1 library, *lokon2b2.zip* helps with the construction and simulation of digital circuits, and looks interesting. *Crcuit10.zip* allows students to create complex series, parallel and combination circuits. Some programs may run in Win95 successfully as well. The Win95 page has a fuzzy logic software controller *fuzzysc.zip*. There is a DOS directory of shareware too.

A real find is the web site for the hugely successful electronics text book, the *Art of Electronics* by Horowitz and Hill. It's **http://www.artofelectronics.com.** To buy it, jump to the site of Cambridge University Press, **http://www.cup.org.** You can read reviews and purchase a massive range of text books on-line, at the *Internet Bookshop* **http://www.bookshop.co.uk.**

If you're into light bulbs you'll be in your "filament" at *Don Klipstein's Home Page* **http://www.misty.com/~don/** which holds the Blue LED FAQ, and also discusses fluorescent tube dimming, xenon tubes and more. Mr. Brian Smith asks if I can link to his own site which is aimed at home constructors and schools. It offers a range of electronic products and support for KS1-4 National Curriculum, and Brian maintains it at **http://dspace.dial.pipex.com/town/parade/nm48.** Thanks again to Dave Preston, who suggests the highly popular Electronic Cookbook Archive at **http://www.ee.ualberta.ca/html/cookbook.html.**

If you see any interesting FTP or web sites, please let me know: my E-mail address is **alan@epemag.demon.co.uk.** See you next month for more *Net Work!*

£1 BARGAIN PACKS

1,000 items appear in our Bargain Packs List – request one of these when you next order.

12V STEPPER MOTOR. 7.5 degree, pack of 1. Order Ref: 910.
SCREWDRIVERS. Pack of 10. Order Ref: 909.
REELS INSULATION TAPE. Pack of 5. Order Ref: 911.
10A 40V BRIDGE RECTIFIER. Pack of 1. Order Ref: 889.
LIGHTWEIGHT STEREO HEADPHONES. Moving coil so superior sound. Order Ref: 896.
25W CROSSOVERS. For 4ohm loudspeakers, pack of 2. Order Ref: 22.
REED RELAY KITS. You get 8 reed switches and 2 coil sets. Pack of 2. Order Ref: 148.
12V-0V-12V 6VA MAINS TRANSFORMER. P.C.B. mounting. Order Ref: 938.
MINI MONO AMP. 3W into 4 ohm speaker or 1W into 8 ohm. Order Ref: 495.
MINI STEREO 1W AMP. Pack of 1. Order Ref: 870.
0-1mA PANEL METER. Full vision face 70mm square. Scaled 0-100, pack of 1. Order Ref: 756.
12V SOLENOID. Has good ½" pull or could push if modified. Order Ref: 232.
6V 1A MAINS TRANSFORMERS. Upright mounting with fixing clamps, pack of 2. Order Ref: 9.
VERY FINE DRILLS. For PCB boards etc. Normal cost about 80p each, pack of 12. Order Ref: 128.
MOTORS FOR MODEL AEROPLANES. Spin to start so needs no switch, pack of 5. Order Ref: 134.
MICROPHONE INSERTS. Magnetic 400 ohm, also act as speakers, pack of 6. Order Ref: 139.
NEON INDICATORS. In panel mounting holders with lens, pack of 6. Order Ref: 180.
12V ALARMS. Makes a noise about as loud as a car horn. All brand new, pack of 4. Order Ref: 221.
OBLONG PUSH SWITCHES. For bell or chimes, these can switch mains up to 5A so could be footswitch if fitted in pattress, pack of 2. Order Ref: 263.
MIXED SILICON DIODES. Pack of 50. Order Ref: 293.
SHADED POLE MAINS MOTOR. ¾" stack, so quite powerful, pack of 1. Order Ref: 85.
5" ALUMINIUM BLADES. Could be fitted to the above motor, pack of 2. Order Ref: 86.
LUMINOUS ROCKER SWITCHES. 10A mains, pack of 4. Order Ref: 793.
BATTERY MODEL MOTORS. Tiny, medium and large, pack of 3. Order Ref: 35.
TEST PRODS FOR MULTIMETERS with 4mm sockets. Good length, very flexible lead. Order Ref: D66.
PAXOLIN PANELS, size 6" x 6", approximately $\frac{1}{16}$" thick, pack of 2. Order Ref: D103.
PIEZO BUZZER with electronic sounder circuit, 3V to 9V DC operated. Order Ref: D76.
ROTARY SWITCH. 6 pole 6 way, small size and ¼" spindle, pack of 2. Order Ref: D54.
FERRITE RODS. 7" with coils for long and medium waves, pack of 2. Order Ref: D52.
DITTO but without the coils, pack of 3. Order Ref: D52.
SLIDE SWITCHES. SPDT, pack of 20. Order Ref: D50.
TELESCOPIC AERIAL. Chrome plated, extendable and folds over for improved FM reception. Order Ref: 1051.
MES LAMP HOLDERS. Slide on to ¼" tag, pack of 10. Order Ref: 1054.
PAXOLIN TUBING. ¼" internal diameter. Pack of 2, 12" lengths. Order Ref: 1056.
HALL EFFECT DEVICES. Mounted on small heatsink, pack of 2. Order Ref: 1022.
PAXOLIN PANEL. 12" x 12". Order Ref: 1033.
WHITE PROJECT BOX with rocker switch in top left-handed side, size 78mm x 115mm x 35mm, unprinted. Order Ref: 1006.
NEON PILOT LIGHTS. Oblong for front panel mounting, with internal resistor for normal mains operation, pack of 4. Order Ref: 970.
WANDER PLUGS. Pack of 10. Order Ref: 986.
ANOTHER PSU. Mains operated, output 15V AC at 320mA. Order Ref: 989.
230V ROD ELEMENTS. 750W terminal-ended, 10" long, pack of 2. Order Ref: 943.
LOUDSPEAKER. 4" circular, 6ohm 3W, pack of 2. Order Ref: 951.
VERO OFF-CUTS. Approximately 30 square inches of useful sizes. Order Ref: 927.
PROJECT CASE. 95mm x 66mm x 23mm with removable lid, held by 4 screws, pack of 2. Order Ref: 876.
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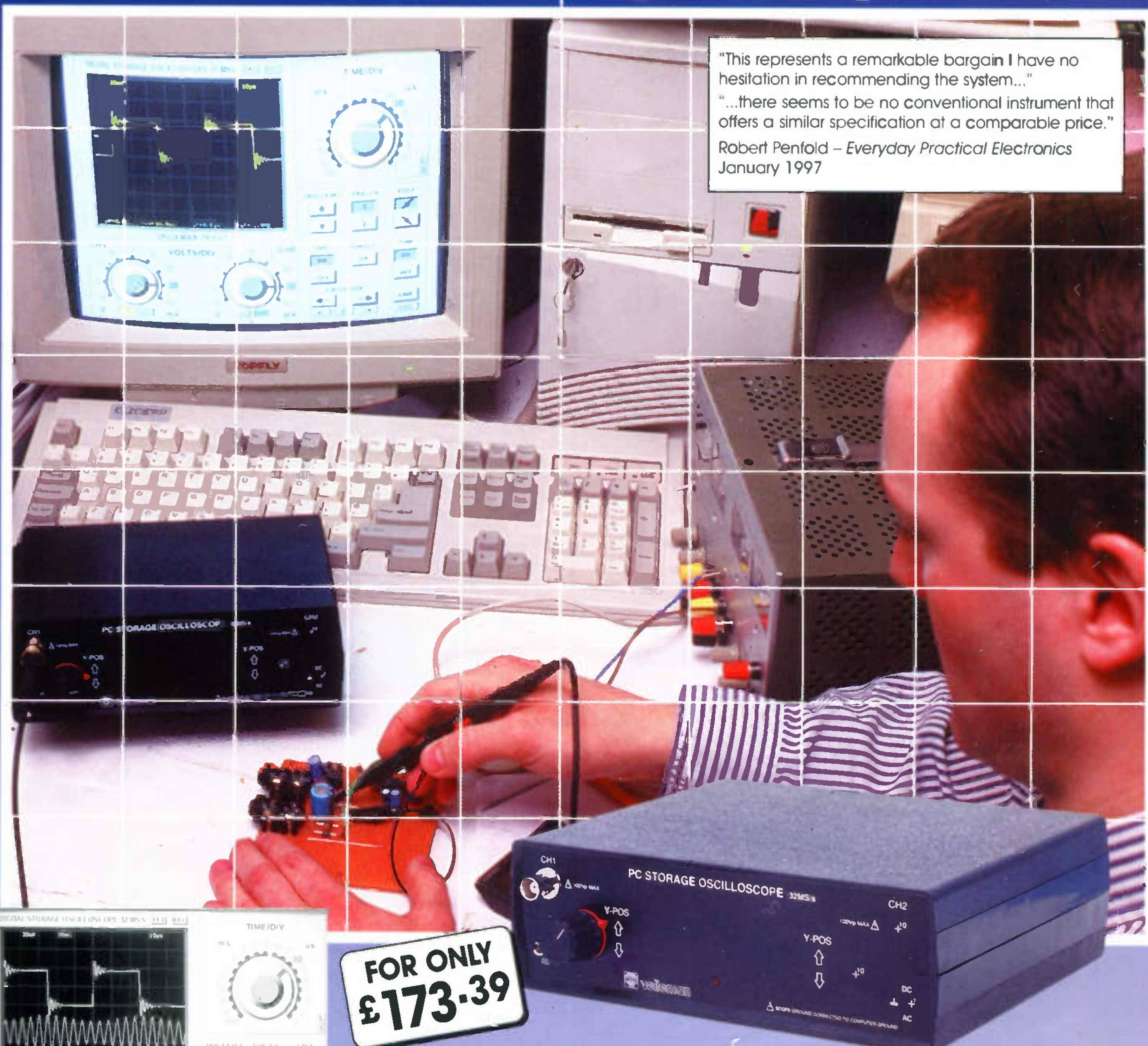

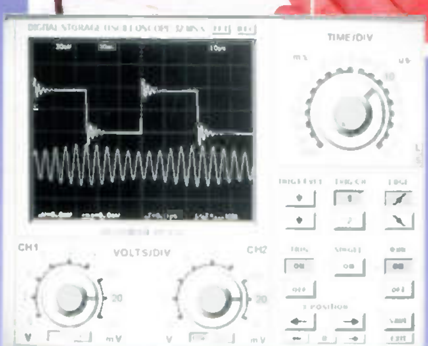

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