EVERYDAY

JANUARY 1996

PRACTICAL ELECTRONICS

£2.25

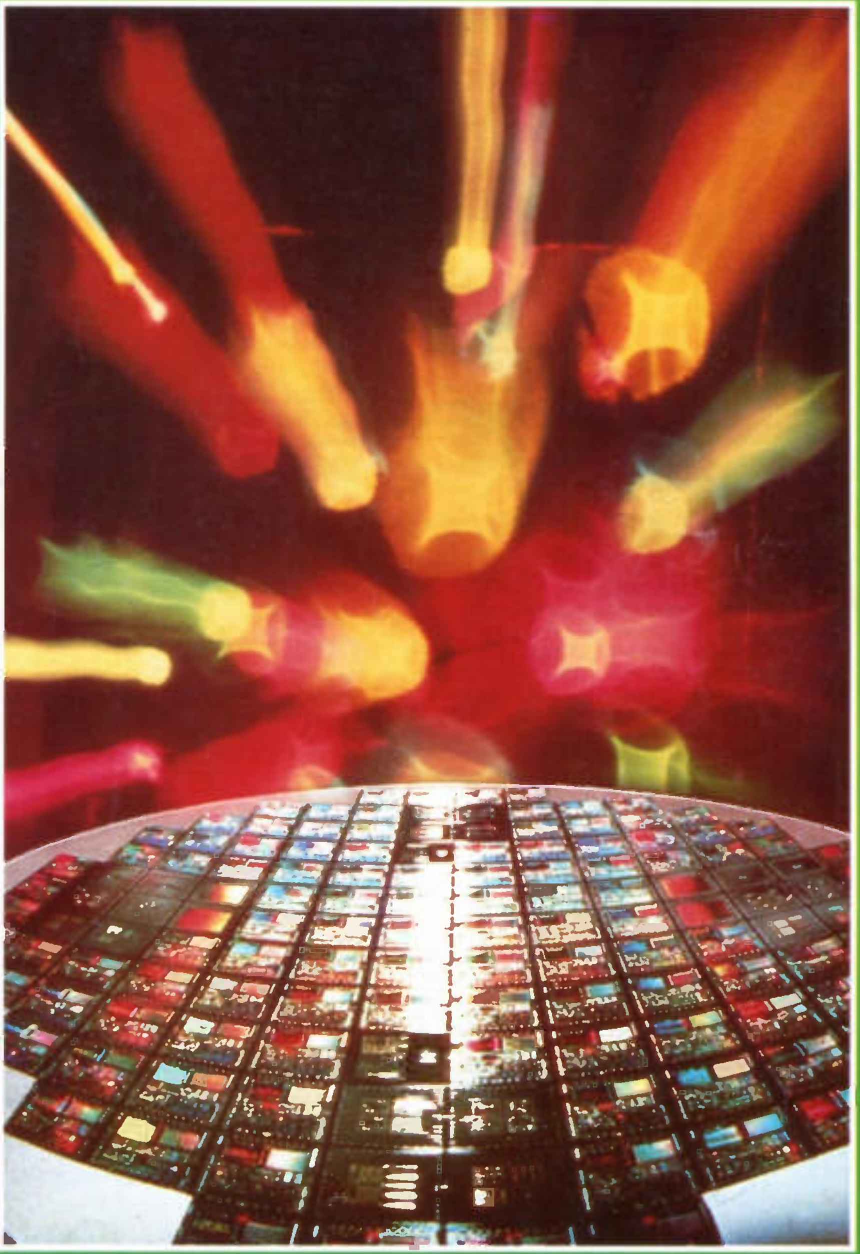
Printer Sharer for PCs

Automatic Camera Panning System

Teach-In'96

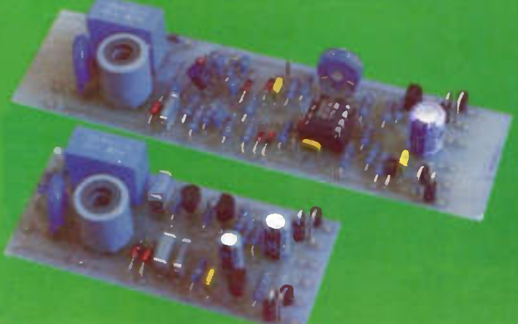
3- *Modular Circuit Design*

Decibels & The dBm Scale



Mains Signalling Unit

Through the mains remote control



The No. 1 Independent Magazine For Electronics Technology & Computer Projects

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Ingenuity Unlimited *Readers' Circuit Ideas*

SURVEILLANCE TELESCOPE Superb Russian zoom telescope adjustable from 15x to 60x! complete with metal tripod (imposible to use without this on the higher settings) 66mm lense, leather carrying case £149 ref BAR69

RADIATION DETECTOR SYSTEM Designed to be wall mounted and connected into a PC, ideal for remote monitoring, whole building coverage etc. Complete with detector, cable and software. £19.95 ref BAR75.

WIRELESS VIDEO BUG KIT Transmits video and audio signals from a minature CCTV camera (included) to any standard television! All the components including a PP3 battery will fit into a cigarette packet with the lens requiring a hole about 3mm diameter. Supplied with telescopic aerial but a piece of wire about 4" long will still give a range of up to 100 metres. A single PP3 will probably give less than 1 hours use. £99 REF EP79. (probably not licensable!)

CCTV CAMERA MODULES 46X70X29mm, 30 grams, 12v 100mA, auto electronic shutter, 3.6mm F2 lens, CCIR, 512x492 pixels, video output is 1v p-p (75 ohm). Works directly into a scart or video input on a tv or video. IR sensitive. £79.95 ref EF137

IR LAMP KIT Suitable for the above camera enables the camera to be used in total darkness! £5.99 ref EF138.

TANDATA TD1400 VIEWDATA Complete system comprising modem, infra red remote keyboard, psu, UHF and RGB output, phone lead, RS232 output, composite output. £9.95 ref BAR33.

MAGNETIC CARD READERS (Swipes) £9.95 Cased with flyleads, designed to read standard credit cards! they have 3 wires coming out of the head so they may write as well? complete with control elctronics PCB. just £9.95 ref BAR31

PANORAMIC CAMERA OFFER Takes double width photographs using standard 35mm film. Use in horizontal or vertical mode. Complete with strap £7.99 ref BAR1

COIN OPERATED TIMER KIT Complete with coinslot mechanism, adjustable time delay, relay output, put a coinslot on anything you like! TV.s, videos, fridges, drinks cupboards, HIFI, takes 50p's and £1 coins. DC operated. price just £7.99 ref BAR27.

ZENITH 900 X MAGNIFICATION MICROSCOPE Zoom, metal construction, built in light, shrimp farm, group viewing screen, lots of accessories. £29 ref ANAYLT.

LUBITEL 166U Twin lens Russian 2 1/4" sq reflex camera supplied with two free rolls of colour film, flip up magnifier, 3 element f 4.5 lens. £19.99 ref BAR36.

AA NICAD PACK Pack of 4 tagged AA nicads £2.99 ref BAR34

PLASMA SCREENS 222x310mm, no data hence £4.99 ref BAR67

NIGHTSIGHTS Model TZS4 with infra red illuminator, views up to 75 metres in full darkness in infrared mode, 150m range, 45mm lens, 13 deg angle of view, focussing range 1.5m to infinity. 2 AA batteries required. 950g weight. £210 ref BAR61. 1 years warranty

FILIN-1 150m range, 15 deg angle of view, focusing 10m-infinity. £179 ref BAR62. A separate infra red light is available at £30 ref BAR63.

WHITE NIGHT SIGHTS Excellent professional night sight, small, hand held with camoflaged carrying case £325. 1 years warranty.

MEGA AIR MOVERS 375 cubic feet per min!, 240v 200 watt, 2,800 rpm, reversable, 7"x7" UK made, new, Aluminium, current list price about £180 ours? £29.95 ref BAR35.

LIQUID CRYSTAL DISPLAYS Bargain prices,
16 character 2 line, 65x14mm £1.99 ref SM1612A
16 character 2 line, 99x24mm £2.99 ref SM1623A
20 character 2 line, 83x19mm £3.99 ref SM2020A
16 character 4 line, 62x25mm £5.99 ref SMC1640A

TAL-1 110MM NEWTONIAN REFLECTOR TELESCOPE Russian. Superb astronomical 'scope, everything you need for some serious star gazing! up to 169x magnification. Send or fax for further details £249 ref TAL-1

GOT AN EXPENSIVE BIKE? You need one of our bottle alarms, they look like a standard water bottle, but open the top, insert a key to activate a motion sensor alarm built inside. Fits all standard bottle carriers, supplied with two keys. SALE PRICE £7.99 REF SA32.

GOT AN EXPENSIVE ANYTHING? You need one of our cased vibration alarms, keyswitch operated, fully cased just fit it to anything from videos to caravans, provides a years protection from 1 PP3 battery, UK made. SALE PRICE £4.99 REF SA33.

DAMAGED ANSWER PHONES These are probably beyond repair so just £4.99 each. BT response 200 machines. REF SA30.

COMMODORE GAMES CONSOLES Just a few of these left to clear at £5 ref SA31. Condition unknown.

COMPUTER DISC CLEAROUT We are left with a lot of software packs that need clearing so we are selling at disc value only! 50 discs for £4, thats just 8p each!!(our choice of discs) £4 ref EP66

IBM PS2 MODEL 160Z CASE AND POWER SUPPLY Complete with fan etc and 200 watt power supply. £9.95 ref EP67

DELL PC POWER SUPPLIES 145 watt, +5,-5,+12,-12, 150x150x85mm complete with switch, flyleads and IEC socket. SALE PRICE £9.99 ref EP55

1.44 DISC DRIVES Standard PC 3.5" drives but returns so they will need attention SALE PRICE £4.99 ref EP68

1.2 DISC DRIVES Standard 5.25" drives but returns so they will need attention SALE PRICE £4.99 ref EP69

PP3 NICADS Unused but some storage marks. £4.99 ref EP52

DELL PC POWER SUPPLIES (Customer returns) Standard PC psu's complete with fly leads, case and fan, pack of two psus SALE PRICE £5 FOR TWO!! ref EP61

GAS HOBS AND OVENS Brand new gas appliances, perfect for small flats etc. Basic 3 burner hob SALE PRICE £24.99 ref EP72. Basic small built in oven SALE PRICE £79 ref EP73

BITS AND BOBS We have a quantity of cased modems, multiplexers etc different specs but ideal strippers. £4 each ref EP63

RED EYE SECURITY PROTECTOR 1,000 watt outdoor PIR switch SALE PRICE £9.99 ref EP57

ENERGY BANK KIT 100 6"x6" 6v 100mA panels, 100 diodes, connection details etc. £69.95 ref EF112.

PASTEL ACCOUNTS SOFTWARE, does everything for all sizes of businesses, includes wordprocessor, report writer, windowing, networkable up to 10 stations, multiple cash books etc. 200 page comprehensive manual. 90 days free technical support (0345-326009 try before you buy!) Current retail price is £129, SALE PRICE £9.95 ref SA12. SAVE £120!!!

WOLVERHAMPTON BRANCH NOW OPEN AT WORCESTER ST W'HAMPTON TEL 01902 22039

MINI MICRO FANS 12V 1.5" sq SALE PRICE £2. Ref SA13.

REUSEABLE HEAT PACKS. Ideal for fishermen, outdoor enthusiasts elderly or infirm, warming food, drinks etc, defrosting pipes etc.reuseable up to 10 times, lasts for up to 8 hours per go. 2,000wh energy, gets up to 90 degC. SALE PRICE £9.95 REF SA29

12V2AMP LAPTOP psu's 110x55x40mm (includes standard IEC socket) and 2m lead with plug. 100-240v IP. £6.99 REF SA15.

PC CONTROLLED 4 CHANNEL TIMER Control (on/off times etc) up to 4 items (8A 240v each) with this kit. Complete with Software, relays, PCB etc. £25.99 Ref 95/26

COMPLETE PC 300 WATT UPS SYSTEM Top of the range UPS system providing protection for your computer system and valuable software against mains power fluctuations and cuts. New and boxed, UK made Provides up to 5 mins running time in the event of complete power failure to allow you to run your system down correctly. SALE PRICE just £89.00.

SOLAR PATH LIGHTS Low energy walklights powered by the sun! built in PIR so they work when you walk past. Includes solar panel & rechargeable bat. SALE PRICE £19.95 REF EP62

BIG BROTHER PSU Cased PSU, 6v 2A output, 2m o/p lead, 1.5m input lead, UK made, 220v. SALE PRICE £4.99 REF EP7

WANT TO MAKE SOME MONEY? STUCK FOR AN IDEA? We have collated 140 business manuals that give you information on setting up different businesses, you peruse these at your leisure using the text editor on your PC. Also included is a certificate enabling you to reproduce the manuals as much as you like! SALE PRICE £14 REF EP74

RACAL MODEM BONANZA! 1 Racal MPS1223 1200/75 modem, telephone lead, mains lead, manual and comms software, the cheapest way onto the net! all this for just £13 ref DEC13.

4.5mw LASER POINTER. BRAND NEW MODEL NOW IN STOCK!, supplied in fully built form (looks like a nice pen) complete with handy pocket clip (which also acts as the on/off switch.) About 50 metres range! Runs on 2 AAA batteries. Produces thin red beam ideal for levels, gun sights, experiments etc. just £39.96 ref DEC49 TRADE PRICE £28 MIN 10 PIECES

BULL TENS UNIT Fully built and tested TENS (Transcutaneous Electrical Nerve Stimulation) unit, complete with electrodes and full instructions. TENS is used for the relief of pain etc in up to 70% of sufferers. Drug free pain relief, safe and easy to use, can be used in conjunction with analgesics etc. £49 Ref TEN/1

COMPUTER RS232 TERMINALS. (LIBERTY) Excellent quality modern units,(like wyse 50,s) 2xRS232, 20 function keys, 50 thro to 38,400 baud, menu driven port, screen, cursor, and keyboard setup menus (18 menu's). £29 REF NOV4.

RUSSIAN MONOCULARS Amazing 20 times magnification, coated lenses, carrying case and shoulder strap £29.95 REF BAR73

PC PAL VGA TO TV CONVERTER Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware.. Ideal for laptops or a cheap upgrade. Supplied in kit form for home assembly. SALE PRICE £25 REF SA34

EMERGENCY LIGHTING UNIT Complete unit with 2 double bulb floodlights, built in charger and auto switch. Fully cased. 6v 8AH lead acid req'd. (secondhand) £4 ref MAG4P11.

SWINGFIRE GUIDED MISSILE WIRE. 4,200 metre reel of ultra thin 4 core insulated cable, 28lbs breaking strain, less than 1mm thick! Ideal alarms, intercoms, dolls house's etc. £13.99 ref EP51

ELECTRIC CAR WINDOW DE-ICERS Complete with cable, plug etc SALE PRICE JUST £4.99 REF SA28

ASTEC SWITCHED MODE PSU BM41012 Gives +5 @ 3.75A, +12@1.5A, -12@.4A. 230/110, cased, BM41012. £5.99 ref AUG6P3.

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. £9.99 REF SA25.

TOP QUALITY CENTRIFUGAL MAINS MOTORS SALE PRICE2 FOR JUST £2.60 REF SA38

ECLATRON FLASH TUBE As used in police car flashing lights etc, full spec supplied, 60-100 flashes a min. £6.99 REF SA15.

24v AC 96WATT Cased power supply. New. £9.99 REF SA40

MILITARY SPEC GEIGER COUNTERS Unused anstraightfrom Her majesty's forces. SALE PRICE £44 REF SA16

MICRODRIVE STRIPPERS Small cased tape drives ideal for stripping, lots of useful goodies including a smart case, and lots of components. SALE PRICE JUST £4.99 FOR FIVE REF SA26

SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit SALE PRICE JUST £4.99 REF SA27

RGB/CGA/EGA/TTL COLOUR MONITORS 12" in good condition. Back anodised metal case. SALE PRICE £49 REF SA16

PLUG IN ACORN PSU 19v AC 14w, £2.99 REF MAG3P10

POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref MAG6P9

ACORN ARCHIMEDES PSU +5v @ 4.4A. on/off sw uncased, selectable mains input, 145x100x45mm £3.99 REF MAG7P2

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

BULL ELECTRICAL

250 PORTLAND ROAD, HOVE, SUSSEX, BN3 5QT. (ESTABLISHED 50 YEARS).

MAIL ORDER TERMS: CASH, PO OR CHEQUE WITH ORDER PLUS £3 P&P PLUS VAT.
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FAX 01273 323077

13.8V 1.9A PSU cased with leads. Just £9.99 REF MAG10P3

200 WATT INVERTER Converts 10-15v DC into either 110v or 240v AC. Fully cased 115x36x156mm, complete with heavy duty power lead, cigar plug, AC outlet socket. Auto overload shutdown, auto short circuit shut down, auto input over voltage shutdown, auto input under voltage shut down (with audible alarm), auto temp control, unit shuts down if overheated and sounds audible alarm. Fused reversed polarity protected, output frequency within 2%, voltage within 10%. A well built unit at an keen price. Just £64.99 ref AUG65.

UNIVERSAL SPEED CONTROLLER KIT Designed by us for the C5 motor but ok for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 REF: MAG17

COMPUTER COMMUNICATIONS PACK Kit contains 100m of 6 core cable, 100 cable clips, 2 line drivers with RS232 interfaces and all connectors etc. Ideal low cost method of communicating between PC's over a long distance. Complete kit £8.99.

VIEWDATA SYSTEMS made by Phillips, complete with internal 1200/75 modem, keyboard, psu etc RGB and composite outputs, menu driven, autodialler etc. SALE PRICE £12.99 REF SA18

AIR RIFLES .22 As used by the Chinese army for training puposes, so there is a lot about! £39.95 Ref EF78. 500 pellets £4.50 ref EF80.

PLUG IN POWER SUPPLY SALE FROM £1.50 Plugs in to 13A socket with output lead, three types available, 9vdc 150mA £1.50 ref SA19, 9vdc 200mA £2.00 ref SA20, 6.5vdc 500mA £2 ref SA21.

VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £15 REF: MAG15 12v psu is £5 extra REF: MAG5P2

***FM CORDLESS MICROPHONE** Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 9v battery. Tuneable to any FM receiver. Price is £15 REF: MAG15P1

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range up to 2km in open country. Units measure 22x52x155mm. Including cases and earp'ces. 2xPP3 req'd. £30.00 pr.REF: MAG30

***FM TRANSMITTER KIT** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £15 REF: EF62 (kit) Transmits to any FM radio.

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

TALKING COINBOX STRIPPER COMPLETE WITH COINSLOT MECHANISMS originally made to retail at £79 each, these units are designed to convert an ordinary phone into a payphone. The units have the locks missing and sometimes broken hinges. However they can be adapted for their original use or used for something else?? SALE PRICE JUST £2.50 REF SA23

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £12.95 Ref EF82B extra pellets (500) £4.50 ref EF80.

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. SALE PRICE £4.99 REF SA24.

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

MIXED GOODIES BOX OF MIXED COMPONENTS WEIGHING 2 KILOS YOURS FOR JUST £6.99

4X28 TELESCOPIC SIGHTS Suitable for all air rifles, ground lenses, good light gathering properties. £19.95 ref R/7.

RATTLE BACKS Interesting things these, small piece of solid perspex like material that it you try to spin it on the desk it only spins one way! in fact if you spin it the 'wrong' way it stops of its own accord and go's back the other way! £1.99 ref GI/J01.

GYROSCOPES Remember these? well we have found a company that still manufactures these popular scientific toys, perfect gift or for educational use etc. £6 ref EP70

HYPOTHERMIA SPACE BLANKET 215x150cm aluminised foil blanket, reflects more than 90% of body heat. Also suitable for the construction of two way mirrors! £3.99 each ref O/L041.

LENSTATIC RANGER COMPASS Oil filled capsule, strong metal case, large luminous points. Sight line with magnifying viewer. 50mm dia, 86gm. £10.99 ref O/K604.

RECHARGE ORDINARY BATTERIES UP TO 10 TIMES! With the Battery Wizard! Uses the latest pulse wave charge system to charge all popular brands of ordinary batteries AAA, AA, C, D, four at a time! Led system shows when batteries are charged, automatically rejects unsuitable cells, complete with mains adaptor. BS approved. Price is £21.95 ref EP31.

TALKING WATCH Yes, it actually tells you the time at the press of a button. Also features a voice alarm that wakes you up and tells you what the time is! Lithium cell included. £7.99 ref EP26.

PHOTOGRAPHIC RADAR TRAPS CAN COST YOU YOUR LICENCE! The new multiband 2000 radar detector can prevent even the most responsible of drivers from losing their licence! Adjustable audible alarm with 8 flashing leds gives instant warning of radar zones. Detects X, K, and Ka bands, 3 mile range, 'over the hill' 'around bends' and 'rear trap facilities. micro size just 4.25"x2.5"x.75". Can pay for itself in just one day! £79.95 ref EP3.

SANYO NICAD PACKS 120mmx14mm 4.8v 270 maH suitable for cordless phones etc. Pack of 2 just £5 ref EP78.

3" DISCS As used on older Amstrad machines, Spectrum plus3's etc £3 each ref BAR400.

STEREO MICROSOPES BACK IN STOCK Russian, 200x complete with lenses, lights, filters etc etc very comprehensive microscope that would normally be around the £700 mark, our price is just £299 (full money back guarantee) full details in catalogue. Ref 95/300.

SOLAR POWERED CAR VENTILATOR Simply fits along the top of the glass in a side window and provides a constant supply of fresh air in hot sunny conditions! keeps your car cool in summer. £19.95 ref s/vent.

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PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

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EVERYDAY PRACTICAL ELECTRONICS

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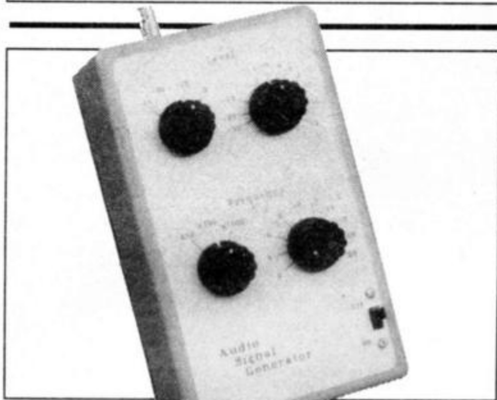
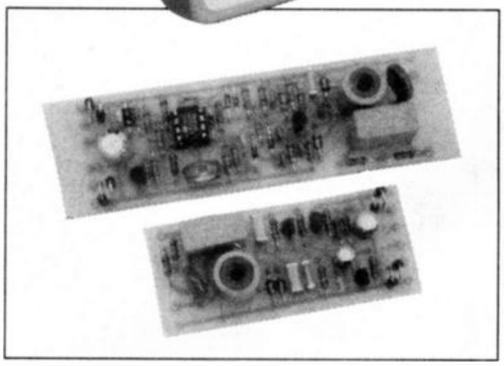
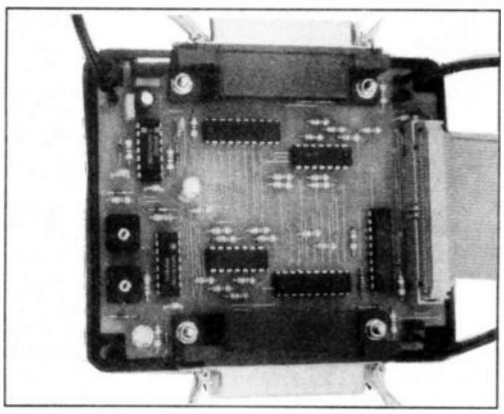
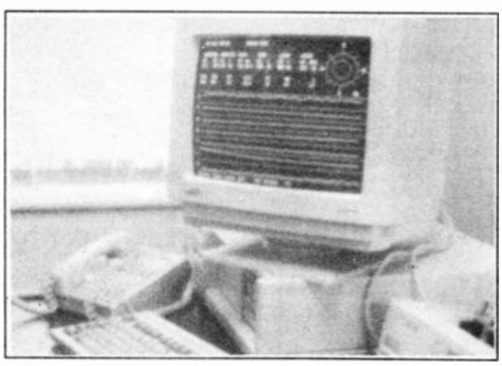








Projects

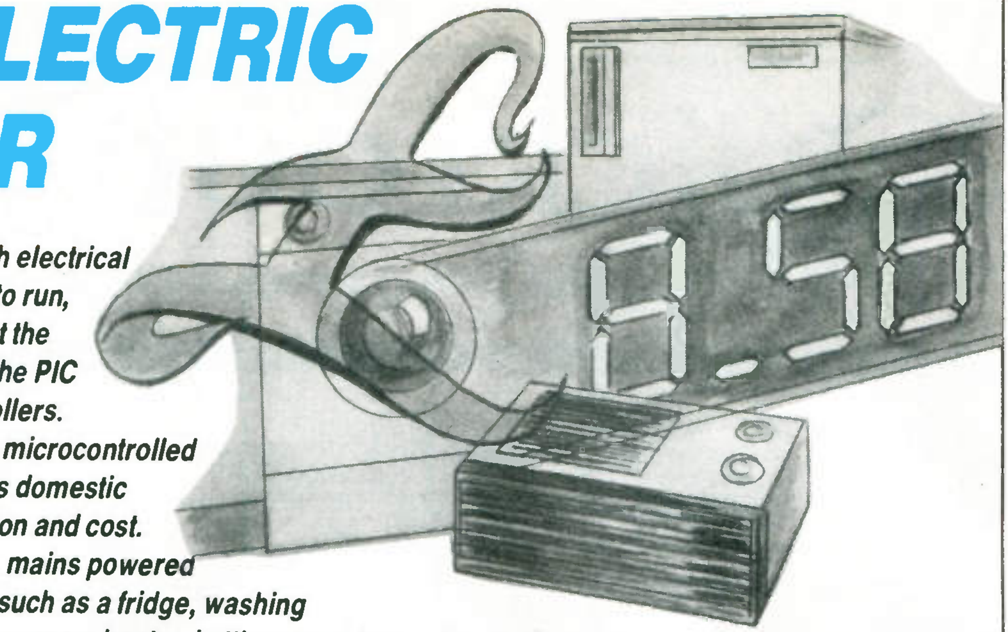
Series

Features

Our February '96 issue will be published on Friday, 5 January 1996. See page 3 for details.

NEXT MONTH

PIC-ELECTRIC METER



Know how much each electrical appliance is costing to run, and learn more about the EEPROM version of the PIC family of microcontrollers.

PIC-ELECTRIC is a microcontrolled meter which monitors domestic electricity consumption and cost. Any 230V to 240V a.c. mains powered electrical appliance, such as a fridge, washing machine, tumble dryer, room heater, kettle, computer, and so forth, can be plugged into the unit.

The digital meter will readout the cumulative cost of running the appliance in £'s and pence, the elapsed running time and the units of electricity used. In this way it is possible to evaluate the economical use of household equipment.

ANALOGUE FREQUENCY METER

The six-place accuracy of a digital meter is often unnecessary, whilst the procedure of setting the count period, decoding the decimal position and adjusting input and filtering levels are a hassle one could do without. By contrast the analogue meter is simply connected to the circuit and a suitable range selected to obtain a reading.

This easy to build instrument will read up to 1MHz and is quick and simple to use.

SIMPLE PIC PROGRAMMER

This article provides a minimalist approach to programming the PIC16C84 – the versatile EEPROM memory version of the PIC microcontroller. It uses about twenty-five components, plus a three wire PC connection. Get started simply, with minimal expense.

VARI-SPEED DICE

Developed from the modules described in Teach-In '96 *this project includes a simple l.e.d. display consisting of two rows of six l.e.d.s which chase before stopping at "random". A novel feature of the circuit is that instead of the display stopping abruptly it gently slows to a halt, rather like a roulette wheel, thereby adding to the excitement if a particular number is required.*

EVERYDAY PRACTICAL ELECTRONICS

FEBRUARY ISSUE ON SALE FRIDAY, JANUARY 5

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THE FEELGOOD FACTOR

The "feelgood factor" seems to be the latest in-phrase; we presently see it everywhere. It is what politics is based on at present, or so we are led to believe. However, politics has never been a part of *EPE* and I don't intend to introduce it now. So don't "switch over", this is not a Party Political Broadcast on behalf of the Technology Party. In fact, it is just the opposite.

Here on *EPE* we like straight talking; we like to be able to understand what people are telling us so, when we get a Press Release that waffles on about cutting edge technology and being at the forefront of an international integration path for companies, we simply put it down to the "feel-to-good, waffle-too-much-factor". Perhaps someone in PR thinks they have to write volumes to justify their fee. Or maybe they speak like that all the time!

For your further edification (I'm getting the habit – sorry) the same Press Release mentioned a "breathtaking 100MHz 4-wire LAN" – phew – and "opening evenings where new technology will be converted into simplified information" – now that trick might take my breath away!

DR. FEELGOOD

In my job I regularly get the "feelgood factor", it comes from appreciative readers' letters, or from PR companies who like to butter you up. The Press Release addressed to Dr. M. Kenward, which came in this morning, did the trick for me. I've just got to decide what I would like to be a doctor of – phlegmatism perhaps (I'll let you work it out!).

I know we are all capable of using three or eight words when one will do, but we do try to make *EPE* understandable! I suppose I have just shot myself in the foot – after all, none of this is essential, so I'll stop now before I put my cutting edge end-of-leg appendage further into my integrated higher frontal orifice.

By the way the rest of this issue is far better than this rubbish – try reading it!

Mike Kenward

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

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We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.

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

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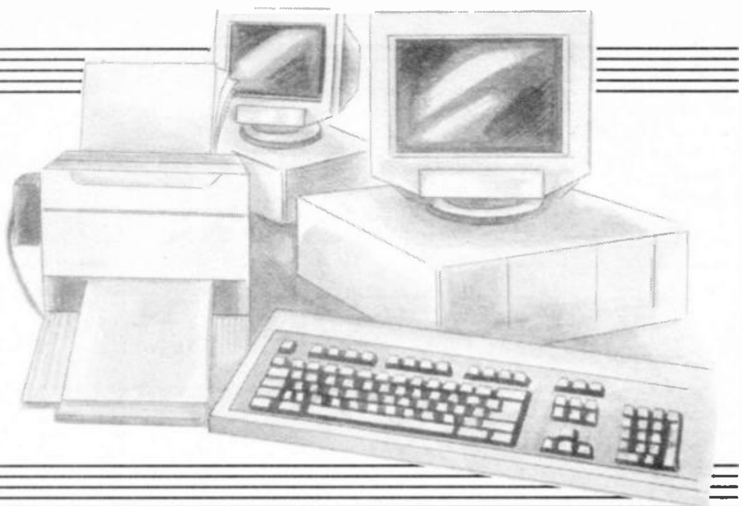
Constructional Project



PRINTER SHARER

PAUL STENNING

Allows two PCs to be permanently connected to the same printer, automatically polling which one should be allowed multiplexed access.

MANY households are now likely to have more than one PC-compatible computer. Ideally, it would be useful for each to have its own printer, though budgets might not stretch to this. In many cases, though, it may be rare for both computers needing access to the printer at the same time.

Since plugging and unplugging a printer between computers is tedious, a switch or a multiplexed printer sharing unit can provide a better solution.

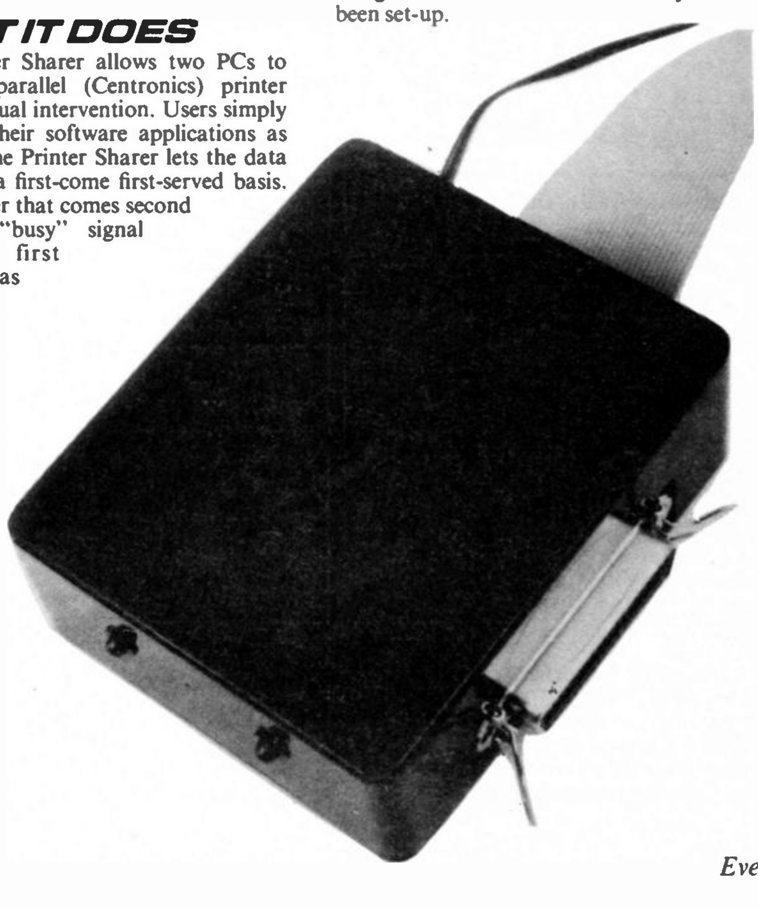
A switch would work fine, of course, but it is not ideal as it requires manual intervention – and inevitably there is the tendency to forget to operate it. The Printer Sharer described here does not need to be remembered!

WHAT IT DOES

The Printer Sharer allows two PCs to share one parallel (Centronics) printer without manual intervention. Users simply print from their software applications as usual, and the Printer Sharer lets the data through on a first-come first-served basis. The computer that comes second receives a "busy" signal until the first computer has finished. Most software, including Windows Print Manager, will happily wait for the printer to become available.

Unlike some commercial printer sharers, this one allows one of the computers to be turned off, yet still allowing the other to use the printer. The unit is designed to overcome the shortcomings of some commercial printer sharers tried by the author.

The timeout period is individually adjustable for each computer to allow for programs which print slowly and send data infrequently in bursts. Adjustment is by two internal presets and ranges from ten seconds to one minute, approximately. Two light emitting diodes indicate which computer has control – these can probably be ignored once the timeout delays have been set-up.



If one computer is off, the other computer can still access the printer. It is even possible to switch one computer on and off while the other is driving the printer, without affecting the printing.

Some printers, are "energy star compliant". In practice, this means that if the computer to which one is connected is switched off, the printer goes into standby mode. The Printer Sharer allows this feature to operate only when *both* computers are switched off.

In most cases, this unit can be powered directly by the printer it is controlling – using the +5V which is normally available on pin 18 of the Centronics connector. A few printers omit this, so a separate power supply will be needed for use with these printers.

A voltage regulator is included on the printed circuit board so the unit can be powered by nothing more fancy than a mains adaptor (battery eliminator) delivering around 9V d.c.

The Printer Sharer is designed for parallel printers only, and will *not* work with serial (RS232) printers. Also, it has only been tested with IBM PC-compatible computers. Although the Centronics Parallel Interface is supposed to be a standard, it cannot be stated for certain that this unit will work with other types of computer.

PARALLEL INTERFACE

Definitive information on the Centronics parallel interface is not easy to come by. The author has examined the manuals for several different printers, and found that various manufacturers interpret the standard in slightly different ways. However, by gleaning information from the manuals, it was possible to established a reasonable understanding of how the Centronics interface works, and its possible variations.

Every pin in the interface has its function detailed in Table 1. The first column gives the pin number on the 36-way Centronics connector (printer end) while the second column shows the matching pin number on the 25-way D-plug at the PC end. The asterisks show those functions which vary between different printers. The third column shows the signal name, and the fourth column gives the signal direction from the printer's point of view.

The following description of the operation of the interface is based on information in the Star SG10 printer manual:

Pin 1 ($\overline{\text{STROBE}}$). Carries the $\overline{\text{STROBE}}$ pulse signal from the computer to the

Table 1. Centronics Parallel Interface

Printer Pin	Computer Pin	Signal Name	Direction (Printer)	Function
1	1	$\overline{\text{STROBE}}$	IN	Data Ready (0·5µS Pulse)
2	2	DATA1	IN	Data Line
3	3	DATA2	IN	Data Line
4	4	DATA3	IN	Data Line
5	5	DATA4	IN	Data Line
6	6	DATA5	IN	Data Line
7	7	DATA6	IN	Data Line
8	8	DATA7	IN	Data Line
9	9	DATA8	IN	Data Line
10	10	$\overline{\text{ACK}}$	OUT	Data Received (9µS Pulse)
11	11	BUSY	OUT	Unable to Receive
12	12	PAPER OUT	OUT	Paper Empty
13	13	SELECT	OUT	Printer On-Line
14*	14	$\overline{\text{AUTO FEED}}$	IN	Extra Line Feed at End
15		Unused		
16		GND		Ground
17*		CHASSIS GND		Earth
18*		+5V D.C.	OUT	External 5V Supply
19-30	18-25	GND		Ground
31	16	$\overline{\text{RESET}}$	IN	Resets Printer
32	15	$\overline{\text{ERROR}}$	OUT	Printer Error
33		GND		Ground
34		Unused		
35*		Unknown	OUT	
36*	17	$\overline{\text{SELECT IN}}$	IN	Turns Printer On-Line

Signals marked "*" are not consistant on all equipment.

printer, this is normally held high by the computer. When the computer has data ready for the printer it sets this signal low for at least 0·5µS. When the printer sees this pulse on the strobe pin, it reads the data that the computer supplies on pins 2 through to 9 (DATA1 to DATA8).

The computer must maintain this data for a period beginning at least 0·5µS before the strobe pulse starts, and finishing at least 0.5µS after the strobe pulse ends. When the printer has successfully received the byte of data it sets pin 10 ($\overline{\text{ACK}}$) low for about 9µS.

Pin 2 to Pin 9 (DATA). See above.

Pin 10 ($\overline{\text{ACK}}$). See above.

Pin 11 (BUSY). Reports when the printer is unable to receive data. This signal will be high during data transfer, while the printer is actually printing rather than receiving, when the printer is off-line, and when an error condition exists.

Pin 12 (PAPER OUT). Reports when the printer is out of paper.

Pin 13 (SELECT). Indicates when the printer is on-line.

Pin 14 (AUTO FEED). This function is not supported on most printers. When this line is low, the printer does an extra line feed at the end of the data. Since the PC always holds this line high, its function is ignored on the Printer Sharer and the line is held high via a resistor.

Pins 16 and 17. Ground.

Pin 18 (Power supply output). Normally connected to the +5V supply inside the printer – the Epson Stylus 400 is the only exception found, the pin being unconnected. The line is normally used to power the Printer Sharer, providing it can deliver about 100mA.

Pins 19 to 30. Ground.

Pin 31 ($\overline{\text{RESET}}$). Can be used to reset the printer. The "energy star compliant" printers monitor this pin for its automatic shut-off function – the printer goes into standby mode if the voltage on the pin falls below about 1V for longer than about half a second.

Pin 32 ($\overline{\text{ERROR}}$). Used to report an error condition in the printer.

Pin 33. Ground.

Pin 35. One of life's mysteries! Most printer manuals describe it as unused, but one described it as an output and said it was pulled high via a 1k resistor. It is not connected through to the PC so it has been ignored!

Pin 36 ($\overline{\text{SELECT IN}}$). Unused on most printers. Only one printer has been found that uses it – the InfoRunner Riteman II, which does not print the data it receives when the line is high! This seemed utterly pointless and so this pin on the Printer Sharer has been held low.

In some cases, the various output lines from the printer are open-collector, so pull-up resistors are included within the Printer Sharer (R11 to R13, R29 to R32).

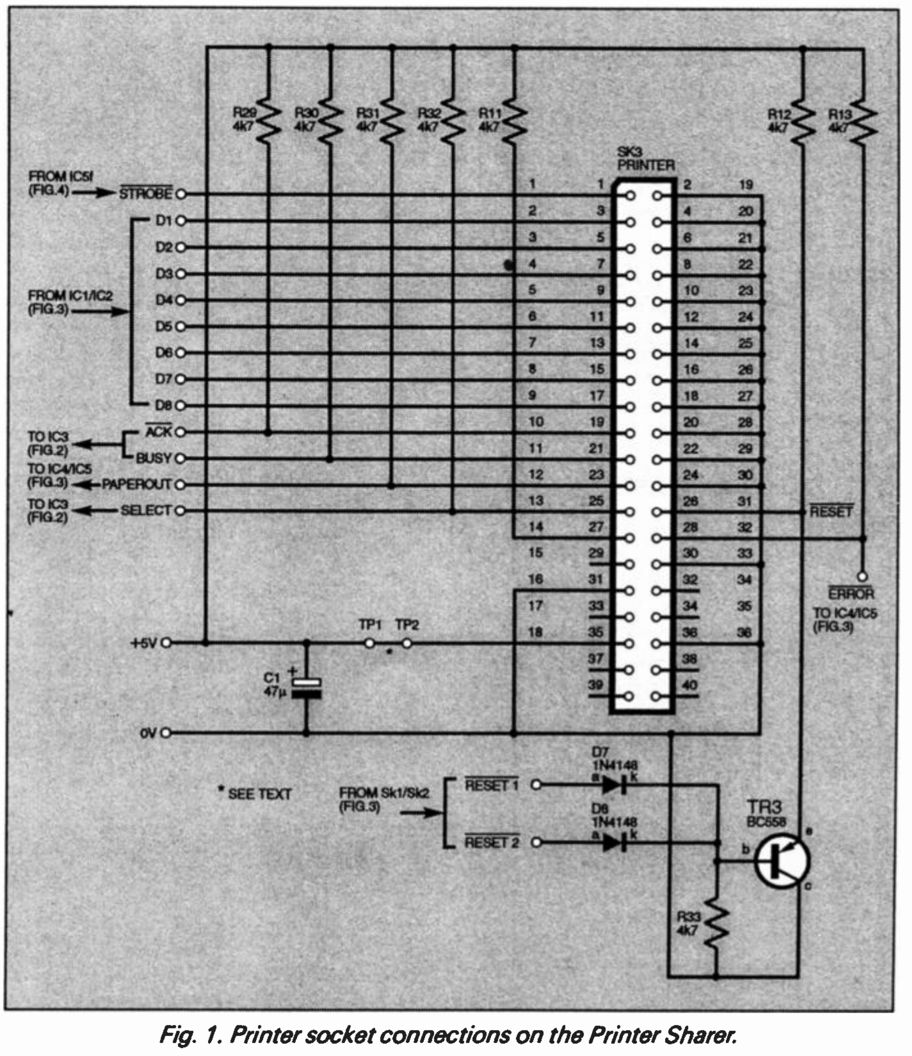


Fig. 1. Printer socket connections on the Printer Sharer.

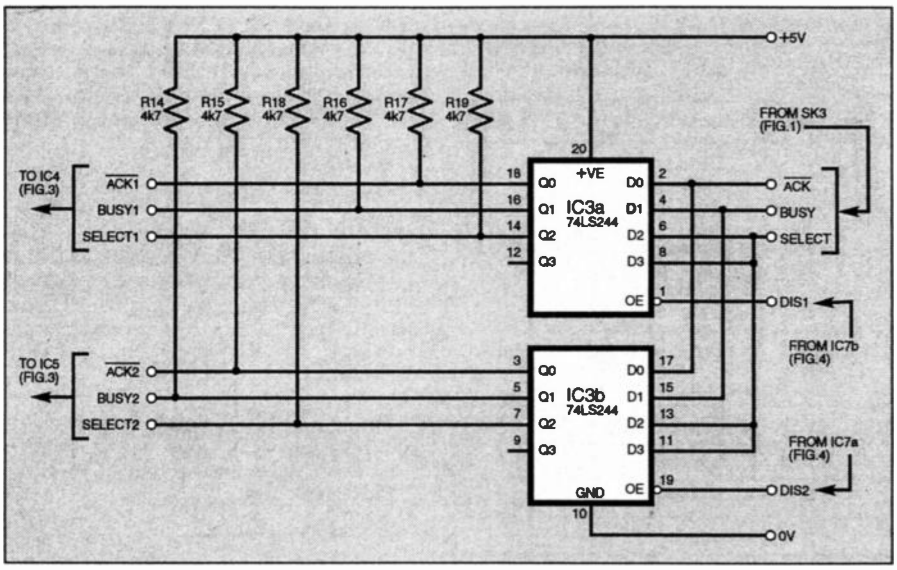


Fig. 2. Multiplexed distribution of control signals.

CIRCUIT OPERATION

Having compiled the Centronics information, the next stage was to decide which signals to and from the printer are connected directly to both computers regardless of which computer is active, and which have to be switched. The printer's connection socket details (as outlined) are shown in Fig. 1.

Signal lines notated $\overline{\text{ERROR}}$ and PAPER-OUT are required to be connected from the printer to both computers since they are relevant all the time (see Fig. 3).

Signal lines $\overline{\text{ACK}}$ (acknowledge), BUSY and SELECT, are connected to IC3a and IC3b (see Fig. 2), each being one half of a dual 4-bit tri-state buffer. When the Output Enable (OE) pin is low, data on the D inputs is passed through to the Q outputs. With OE high the outputs are set into tri-state (high impedance) mode.

When the Printer Sharer is idle (neither computer wanting to print), the control lines to IC3, DIS1 and DIS2 (Disable), are both low thereby allowing the three signals from the printer to reach both computers. When a computer is printing, the DIS line relating to the other computer goes high. The pull-up resistors R14 to R19 hold high the output lines from IC3a and IC3b when either of the devices is in tri-state mode.

For example, when Computer 1 starts sending data, the signals are switched off from Computer 2 by IC3b. Consequently, $\overline{\text{ACK2}}$ is held high (via R15) because this is its normal state, SELECT2 is held high (via R18) to tell the computer that the printer is on-line, and BUSY2 is also held high (via R14) to tell the computer that the printer is currently busy.

These levels mimic the signals sent when the printer is actually printing a line of text, rather than receiving data. In this state, the computer will not send data – most programs will simply wait for the printer, which is exactly what is wanted here.

As seen in Fig. 3, all five above-mentioned signals are coupled to the computers via open-collector buffers, IC4 and IC5, which have pull-up resistors (R1 to R10) on their outputs. This prevents conflict if the computer they are driving is switched off. Unfortunately, the 7407 (hex non-inverting open-collector buffer) is only available in standard TTL, there are no LS or HCT versions.

Both IC1 and IC2 are used to gate the data lines from the computers to the printer. In the idle state, the control lines $\overline{\text{EN1}}$ and $\overline{\text{EN2}}$ hold high the OE (output enable) pins of both chips, whose outputs (Q0 to Q7) are thus disabled (high impedance).

In this situation, the printer data lines (D1 to D8) to which the outputs of IC1 and IC2 are connected, will be high due to pull-up resistors within the printer. When a computer is sending data, the appropriate enable line ($\overline{\text{EN1}}$ or $\overline{\text{EN2}}$) goes low, coupling the relevant data lines to the printer.

The chips used for IC1 and IC2 are similar in function to IC3, except that the gates are controlled as one bank of eight instead of two banks of four. The pinouts are also in a more convenient order, with all the inputs down one side and the outputs down the other.

RETRIGGERING

In Fig. 4, IC7a and IC7b are two halves of a dual retriggerable monostable, type 74LS123. With a retriggerable monostable, the timing period will begin again if the device is retriggered during the timing period. Thus the monostable will time out a fixed period after the last trigger pulse received. With a non-retriggerable monostable (such as the type 74LS21), additional trigger pulses during that period will have no effect.

During the idle state, the Q outputs of IC7a and IC7b will be low and the $\overline{Q}$ outputs high. These provide the disable (DIS) signals to IC3 and the enable ($\overline{\text{EN}}$) signals to IC1 and IC2. Each monostable is triggered by the falling edge of one

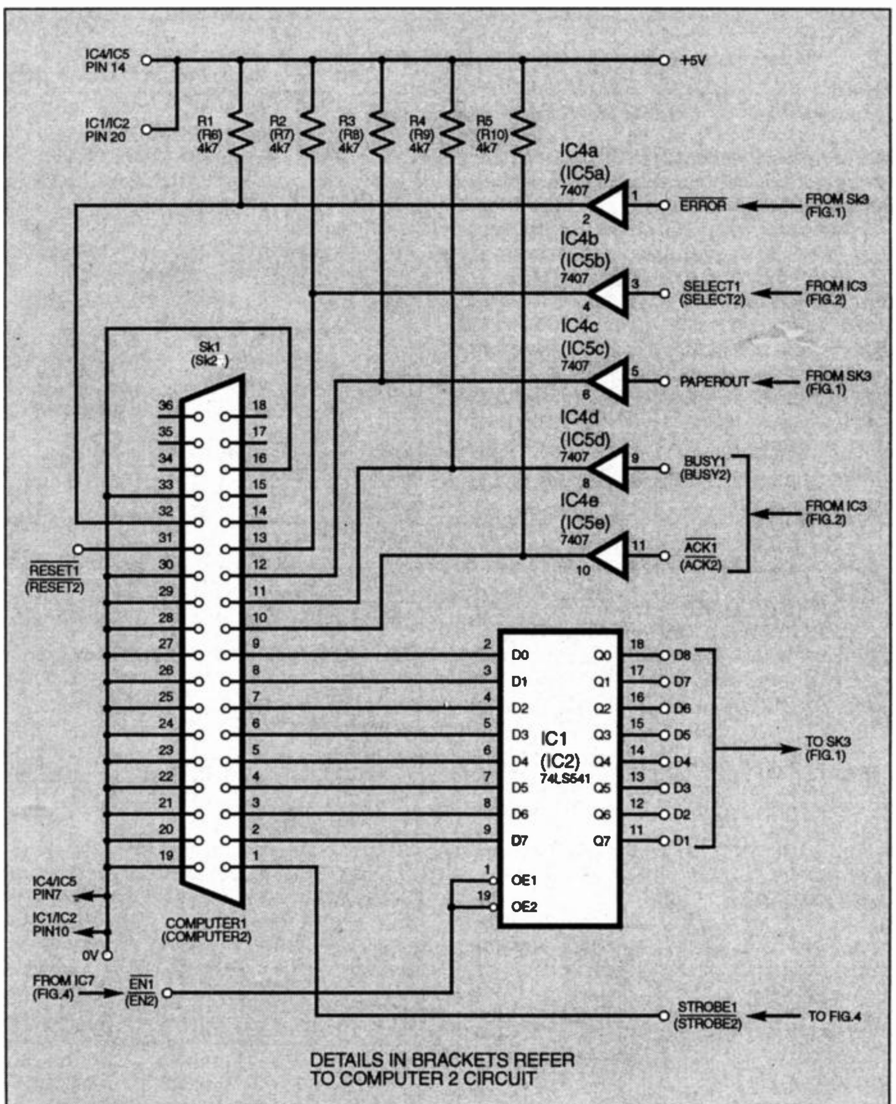


Fig. 3. Routing of data and control signals between the Printer Sharer and the computers. This section is repeated for the second computer.

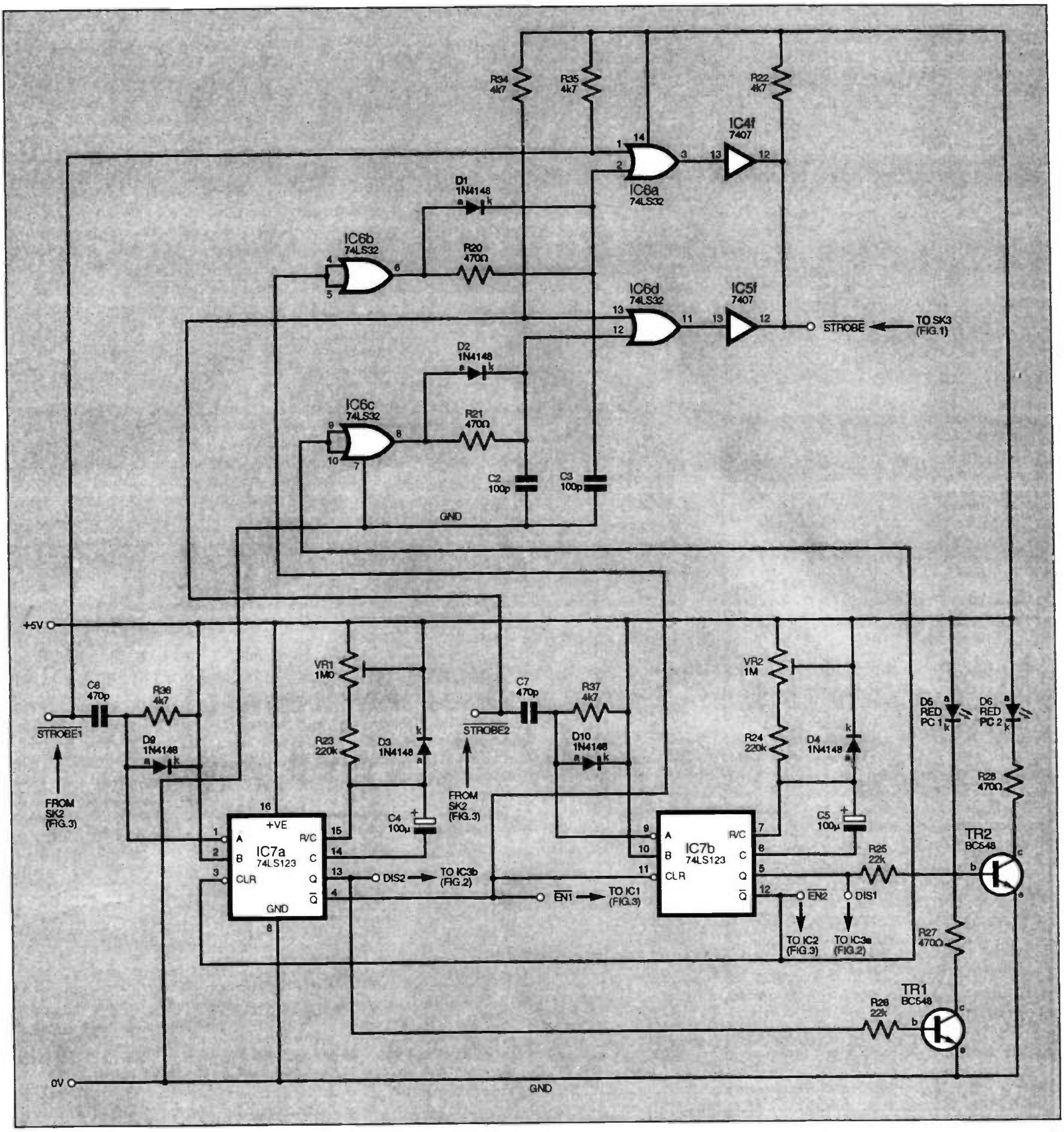


Fig. 4. Dual retriggerable timing period control circcuit.

strobe ($\overline{\text{STROBE1}}$ or $\overline{\text{STROBE2}}$) signal, and retriggered on each subsequent strobe signal. The $\overline{Q}$ line from each monostable is connected to the clear ($\overline{\text{CLR}}$) input of the other monostable, so when one is triggered the other is disabled.

The strobe signals are coupled to the monostables via capacitors C6 and C7, with resistors R36 and R37 tying the inputs high so that they will not be held in an indeterminate state when a computer is switched off. Preset potentiometers VR1 and VR2 set the monostable timeout periods. Diodes D3 and D4 give a discharge path for C4 and C5 when the power is switched off. The Q outputs from the monostables drive l.e.d.s D5 and D6 via transistors TR1 and TR2.

Strobe signals from the two computers are coupled to the strobe input ($\overline{\text{STROBE}}$) of the printer by an OR/AND selector circuit. The AND gate is formed by the remaining two open-collector drivers IC4f and IC5f in conjunction with resistor R22. When $\overline{\text{EN1}}$ is low $\overline{\text{STROBE1}}$ is coupled through, and when $\overline{\text{EN2}}$ is low $\overline{\text{STROBE2}}$ is coupled through.

The two R-C timing circuits (D1, R20, C3 and D2, R21, C2) between sections of IC6 are intended to slightly delay the start of the first strobe pulse to allow the data to settle. These may not be necessary; arbitrary values were fitted in the first prototype, which worked, so were left well alone!

The $\overline{\text{RESET}}$ signals from the two computers (see Fig. 3) are coupled to the printer by a simple diode OR gate (D7, D8 and R33), followed by an emitter follower buffer stage, TR3, as shown in Fig. 1. A proper logic gate was not used because the low level caused by an output from a switched-off computer is not at a low enough impedance to give a definite logic 0. When both computers are off, the printer's reset pin will be held low, switching the printer into standby mode if it is Energy Star Compliant.

POWER SUPPLY

In the majority of cases, the Printer Sharer can be powered at 5V by the printer, in which case track points TP1 and TP2 in Fig. 1 must be linked, and the voltage regulator IC8 in Fig. 5 omitted. If the printer does not have a +5V output, this link should be omitted, and the circuit powered by a separate supply input via socket SK4 and regulated down to +5V by IC8.

The power input to SK4 should be between 7·5V and 10V d.c. at about 150mA maximum. This does not need to be regulated, so a simple mains adaptor is ade-

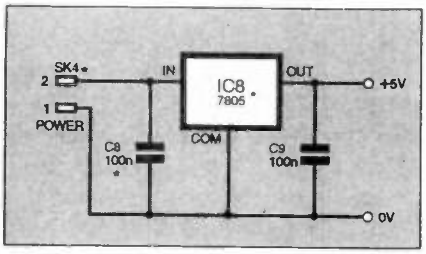


Fig. 5. Optional voltage regulator.

quate. The d.c. input is *not* protected against reverse polarity.

Note that printer socket, SK3 in Fig. 1, is a 40-way IDC connector on the printed circuit board. It is connected to a 36-way Centronics plug with an IDC ribbon cable. The inside numbers nearest to SK3 (as shown in Fig. 1) relate to the 40-way IDC connector, and the outside numbers to the 36-way Centronics plug.

CONSTRUCTION

All components, except l.e.d.s D5 and D6, are mounted on a single-sided p.c.b. This board is available from the *EPE PCB Service*, code number 973.

The p.c.b. component layout and track details are shown in Fig. 6. It is a fairly tightly packed board and has many closely spaced tracks, so take due care when assembling it. Thoroughly check the assembled board with a magnifying glass when completed.

There are a lot of wire links. These should be fitted first since many of them pass *underneath* other components. Thin tinned copper wire (about 28s.w.g.) is ideal. With thicker wire it may be more difficult to avoid short circuits unless it is sleeved.

The remaining components may now be fitted, in any convenient order. Sockets should be used for all i.c.s, except regulator IC8. None of the chips are CMOS devices but it is still best to treat them carefully. On the prototype, l.e.d.s D5 and D6 were mounted on the case, with their connecting wires soldered to terminal pins on the board.

COMPONENTS

See SHOP TALK Page

Resistors

R1 to R19, R22, R29 to R37	4k7 (29 off)
R20, R21, R27, R28	470Ω (4 off)
R23, R24	220k (2 off)
R25, R26	22k (2 off)

all 0.25W 5% carbon film, or better

Potentiometers

VR1, VR2	1M preset, horiz. (2 off)

Capacitors

C1	47µ radial elect. 16V
C2, C3	100p min. ceramic, 0·2in pitch (2 off)
C4, C5	100µ radial elect. 16V (2 off)
C6, C7	470p min. ceramic, 0·2in pitch (2 off)
C8, C9	100n min. ceramic, 0·2in pitch (2 off)

Semiconductors

D1 to D4, D7 to D10	1N4148 signal diode (8 off)
D5, D6	red l.e.d. plus mounting clip, 5mm (2 off)
TR1, TR2	BC548 *npn* transistor (2 off)
TR3	BC558 *pnp* transistor
IC1, IC2	74LS541 8-bit tri-state buffer (2 off)
IC3	74LS244 dual 4-bit tri-state buffer
IC4, IC5	7407 hex open-collector buffer (2 off)
IC6	74LS32 quad OR gate
IC7	74LS123 dual retriggerable monostable
IC8	7805 +5V regulator (see text)

Miscellaneous

SK1, SK2	36-way Centronics socket, right angled, p.c.b. mounting (2 off)
SK3	40-way IDC box header

printed circuit board, available from the *EPE PCB Service*, code 973; 40-way IDC ribbon cable socket; 40-way IDC ribbon cable (one metre); 36-way IDC Centronics plug; box type MB3 (117mm x 97mm x 44mm); M3 x 20mm countersunk bolt (4 off); M3 nut (8 off); 28s.w.g. tinned copper wire; connecting wire; solder, etc.

Approx cost guidance only **£29**

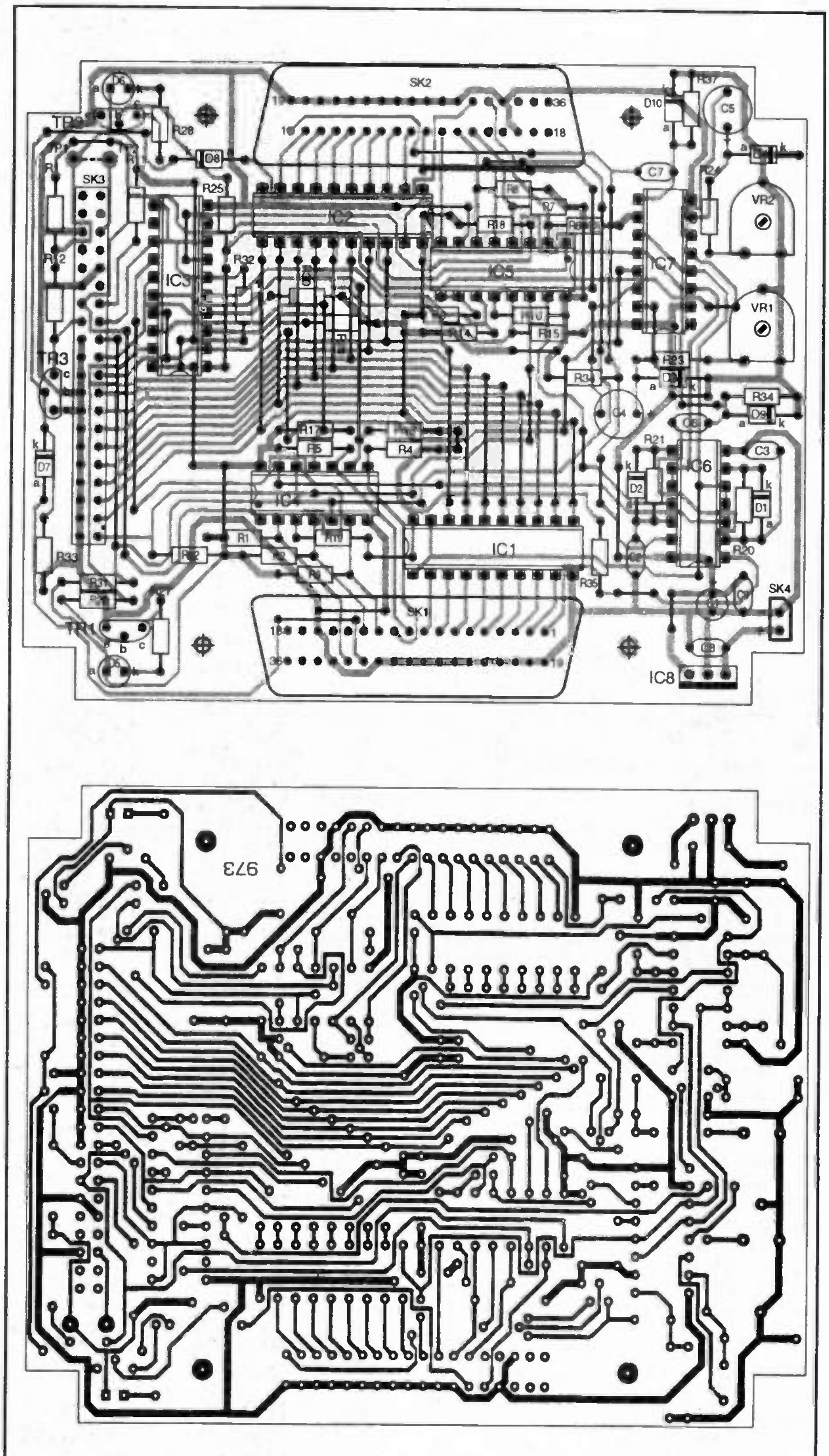


Fig. 6. P.C.B. layout and full size track master for the Printer Sharer.

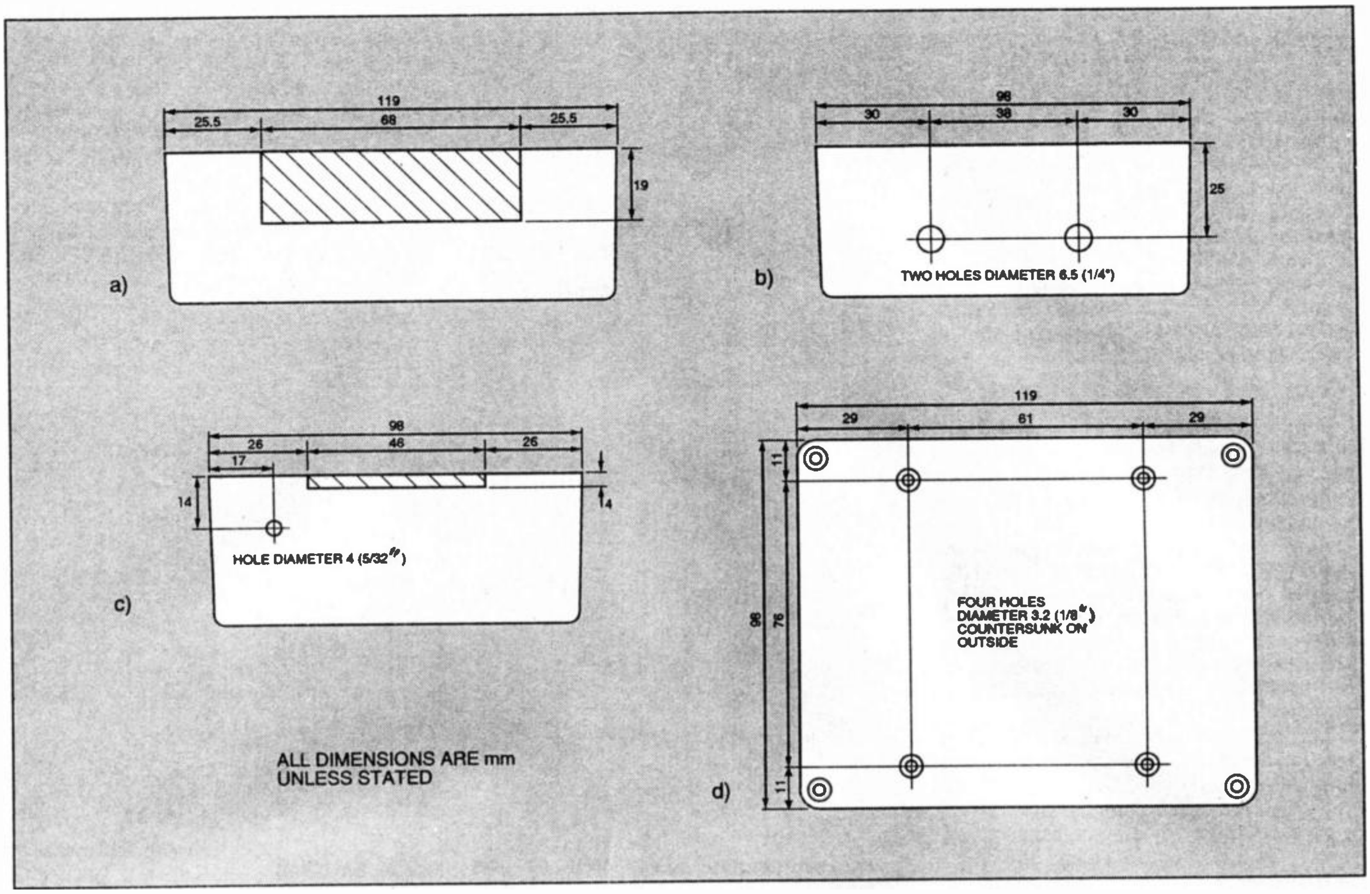


Fig. 7. Printer Sharer case drilling details.

Sockets SK1 and SK2 should be fitted facing towards the edge of the p.c.b. When fitting SK3, be sure to get the "V" indicator which marks pin 1 in the position shown. If in doubt, the large polarizing gap goes towards the centre of the p.c.b.

It is now necessary to establish whether the printer has a +5V output on pin 18 of its Centronics connector. If the printer manual is available, check the section towards the back that gives the interface connections. Otherwise you will have to get the test meter out!

If there is a +5V output, link track points TP1 to TP2, and omit C8, IC8 and SK4. If not, fit the above components and omit the link. Terminal pins should be fitted for SK4.

Regulator IC8 will not need a heatsink if an unregulated source supply has to be used and is below about 10V. If it is greater that +10V a suitable heatsink should used, fitting it rigidly.

RIBBON CABLE

Connection from the p.c.b. to the printer is via a length of 40-way IDC ribbon cable, no more than about one metre long. Fit the 40-way IDC socket to one end of the cable. The red stripe on the cable indicates pin 1 and should go to the "V" mark on the connector. Position the cable so that it emerges on the side of the connector with the polarizing bump. The strain relief clip should now be fitted, which reverses the cable direction.

Now separate wires 37, 38, 39 and 40 – these are the four furthest from the red wire. Cut off these four wires close to the 40-way IDC socket. Fit the 36-way Centronics plug to the other end of the cable, again with the red wire towards pin 1.

Ribbon cable is best cut with a sharp pair of scissors. Try to cut it square. It will probably be necessary to trim both ends to avoid stray strands causing short circuits. The connectors can be *carefully* pressed together using a WorkMate or vice. If using a metal vice, also use a couple of pieces of wood to protect the connector. Make sure the connector is squeezed evenly and the cable is square.

THE CASE

The p.c.b. is specifically designed to fit an MB3 type plastic case (see *Shop Talk*). Cutting and drilling details for the case and lid are shown in Fig. 7.

The board is bolted to the lid with the tracks towards the lid. A single M3 nut gives the correct spacing for the board, so that connectors SK1 and SK2 just clear the lip at the edge. Once the board is in place, a second nut on each bolt holds it and the connectors firmly in place.

The two 6·5mm holes in one end of the case are for the l.e.d.s. The 4mm hole in the other end is for the power cable to the mains adaptor. If the printer has a +5V output, this hole is not needed.

If a socket to match the plug on the mains adaptor is needed, it may be necessary to mount it lower down to clear the p.c.b. In the test unit, a cable emerging from the 4mm hole is connected to the mains adaptor by an in-line phono plug and socket.

The rectangular cut-outs shown should be carefully marked out with a steel rule, square and scriber. Drill a line of small holes along the bottom edge (inside the line), then cut down both sides with a junior hacksaw. It should now be possible to carefully break out the unwanted section and file the edges down to the lines.

Some of the p.c.b. mounting guides at the end of the case where the ribbon cable enters may have to be removed.

The l.e.d.s are fitted in standard clips and connected to the board with thin insulated wire. In each instance, the anode (a) of the l.e.d. goes to the pin closest to the corner of the p.c.b. Wire the l.e.d.s so that they are nearest the socket to which they relate.

An external power supply, if used, connects to socket SK4, with the positive closest to the corner of the board.

FIRST TESTING

If an external power supply is used, such as a 9V battery eliminator, check this out first. Do not connect the unit to the printer or computers at this stage. With the power supply connected and switched on, measure the voltage between pins 1 and 2 of SK4 (the power input). Ideally, it should be between 7·5V and 10V.

If the voltage is a little on the low side, this may be due to excessive ripple on the output from the power supply. The cheaper plug-in power supplies often have a low value smoothing capacitor, typically 470µF, which causes significant ripple when the output is loaded.

If an a.c. voltmeter reading shows the ripple to be over about 0·05V (0·15V pk-pk), connect a 1000µF or 2200µF capacitor of appropriate voltage rating across SK4.

Set presets VR1 and VR2 fully anticlockwise. Connect the unit to the computers and printer, and switch everything on (printer first). Watch the computer screens as they boot up, if any error messages appear switch off immediately. Now check the voltage on the power pins of one of the logic chips, e.g. between pins 7 and 14 of IC6. The reading should be 5V, ±0·25V.

Check that the printer has some paper loaded and is switched on-line. On one computer, type "COPY C:\CONFIG.SYS LPT1". It is easier to stick to using DOS commands to generate simple print jobs for now, rather than loading up applications.

The CONFIG.SYS file should be printed, and the appropriate l.e.d. on the Printer Sharer should light and remain on for about ten seconds after the C:\> DOS prompt reappears. Try this from the other computer too.

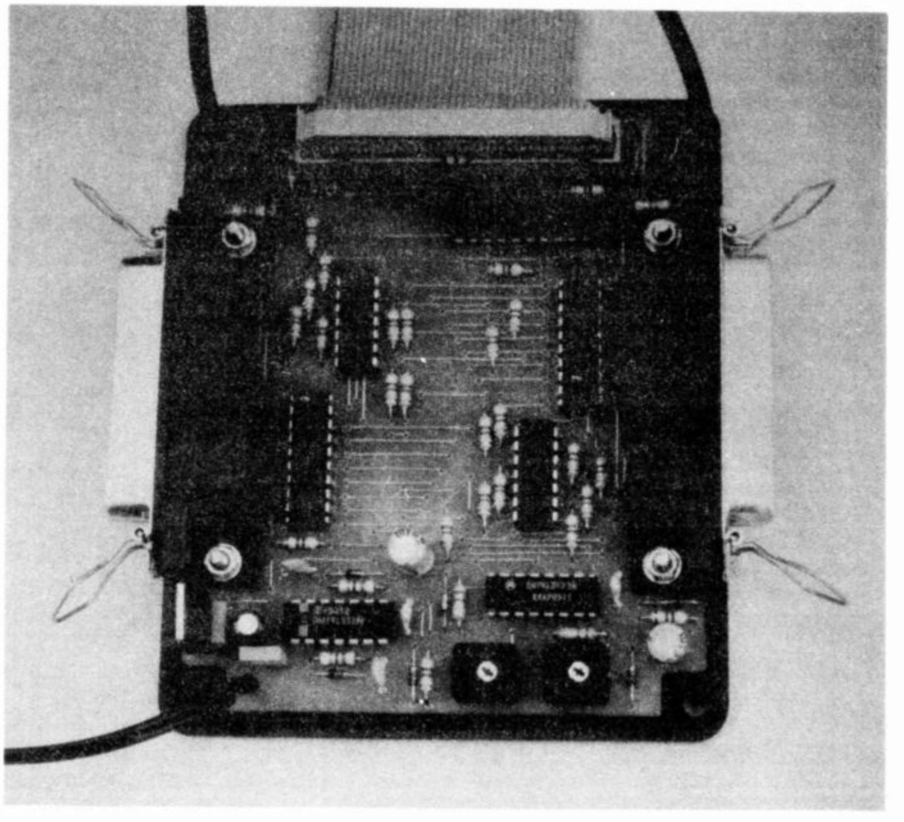
Now try switching one computer off and printing from the other. This too should work OK. It also should be possible to switch one computer off and on while the other is driving the printer, without affecting the printing. If the printer is Energy Star Compliant, switch both computers off – the printer should enter standby mode as usual.

FINAL TESTING

If both keyboards can be reached at the same time (or borrow an assistant!), try starting both print jobs at the same time by hitting both Enter keys simultaneously. One computer will inevitably get the printer first, and the other will have to wait. Both files should be printed correctly, and neither computer should give an error message. There should be a delay of about ten seconds after the first printout finishes. The l.e.d.s on the Printer Sharer show the state of progress.

The only job remaining is to set up the timeout delay. In many cases the ten seconds obtained with both presets fully anti-clockwise will be fine. However, with a slow computer or a slow application, it may be necessary to extend the delay to prevent the other computer getting in partway through a print job.

On the slower computer, load up the application that prints the slowest and start a large print job. If Windows is being used, try printing in the background while carrying out some disk-intensive activity, such as loading another application or sorting a large database.



Watch the appropriate l.e.d. on the Printer Sharer. If it goes off during the print job, increase the delay for that printer by turning the appropriate preset gradually clockwise until the l.e.d. remains on. Once the correct setting has been found, turn it up a fraction more (just to be sure). Now either set the other preset to the same position, or carry out the same test on the other computer.

IN USE

There really is not much to using the Printer Sharer – fit it and forget it! Since in normal use it is probably unnecessary to see the l.e.d.s.

Hopefully, the Printer Sharer should give years of reliable service, and make your life that little bit easier! Now all we need is some method of changing the paper automatically. . . □

SHOP TALK
with David Barrington

Printer Sharer

The Centronics plug and socket and other "computer link" connectors called for in the *Printer Sharer* project should be available from most of our component supplier advertisers. Likewise, they should also carry all the semiconductor devices and multi-way ribbon cable. Note the red stripe on the cable should go to pin one of the 40-way IDC socket.

A voltage regulator is included on the p.c.b., so if you opt for a separate supply then nothing more fancy than a cheap mains-plug type "battery eliminator" adaptor delivering around 9V d.c. should be OK here. Low voltage unregulated power supplies are frequently offered at "bargain prices" by both **Greenweld** and **Bull Electrical.**

The Sharer printed circuit board copper foil tracking is fairly complex and a ready-made p.c.b. is available from the *EPE PCB Service*, code 973 (see page 83).

Audio Signal Generator

Although the standard 7805 5V voltage regulator will operate in the *Audio Signal Generator* circuit, it is best if the LP2950CZ low current regulator is used. This device will work quite happily with as little as 100mV differential, allowing the battery to fall below 6V before replacement becomes necessary. If local suppliers are unable to supply the regulator, it is currently listed by **Maplin**, code AV35Q.

Looking through the components catalogues, it seems that most advertisers go for the 18-turn ceremet presets. There appears to be no reason why an 18 to 20 turn preset will not work in this circuit.

The printed circuit board is available from the *EPE PCB Service*, code 969.

Mains Signalling Unit

It is most important that the capacitor designated C1 in both the *Transmitter* and *Receiver* circuits for the *Mains Signalling Unit* be able to withstand the application of ***continuous*** 230V a.c. mains. The capacitors on the p.c.b.s are "high voltage interference suppression (IS)" types from **Maplin**, code JR34M. The transient suppressors also came from the same source, code HW13P.

Toko coils are a "speciality" of **Circkit** and they list the tank coil as code 707VXR042YUK. It is also listed as code FT55K (A042YUK) by Maplin.

The Receiver and Transmitter p.c.b.s are available as a pair from the *EPE PCB Service*, codes 970/971.

Automatic Camera Panning System (Teach-In '96)

Choosing a suitable motor and gearbox is the only problem confronting constructors of the *Automatic Camera Panning System*, this month's *Teach-In '96* project. The ideal motor and gearbox is an RS type available through **Electromail** (☎ *01536 204555*), codes: 12V motor 718-975 and gearbox (1250:1) 336-270. This will set you back about £60.

If the budget will not allow the use of the expensive motor and gearbox described above, much cheaper alternatives exist such as those supplied by **Magenta Electronics** (☎ *01283 565435*). This type of system may be noisy, but at a cost of about £5 complete does represent good value! Motors of this type are generally rated at around 4.5V. If such a motor is employed, the circuit should be operated from a supply of 6V.

Security cameras are now available in all shapes and sizes, and at very reasonable prices. Maplin supply camera modules that may be fitted inside a standard case which in turn could be fixed to the gearbox shaft. Also available are computer video cameras. If you really want to be professional, you could investigate the range being advertised by ***Direct CCTV Ltd.***

EPE Met Office

Sourcing for all the various sensors used in the *EPE Met Office* was fully covered in last month's Shoptalk. This month it's only the windspeed sensor spiral and software requirements that need covering.

A transparent version of the spiral comes free with the combined Sensor/Rainfall/Vane p.c.b.s (code 963/965), see page 83. The Interface board is also available, code 964.

The "working example" software is available as a disk (together with printout) for the sum of £2.50 from our Editorial Offices.

Christmas Offer

We have received news from **EPT Educational Software** that they are offering their Electronics Principles 2.1 package for £29.95 and an upgrade to Windows version 3.0 service for just £12.95. The full Windows version will be introduced in March '96. See their advertisement for details.

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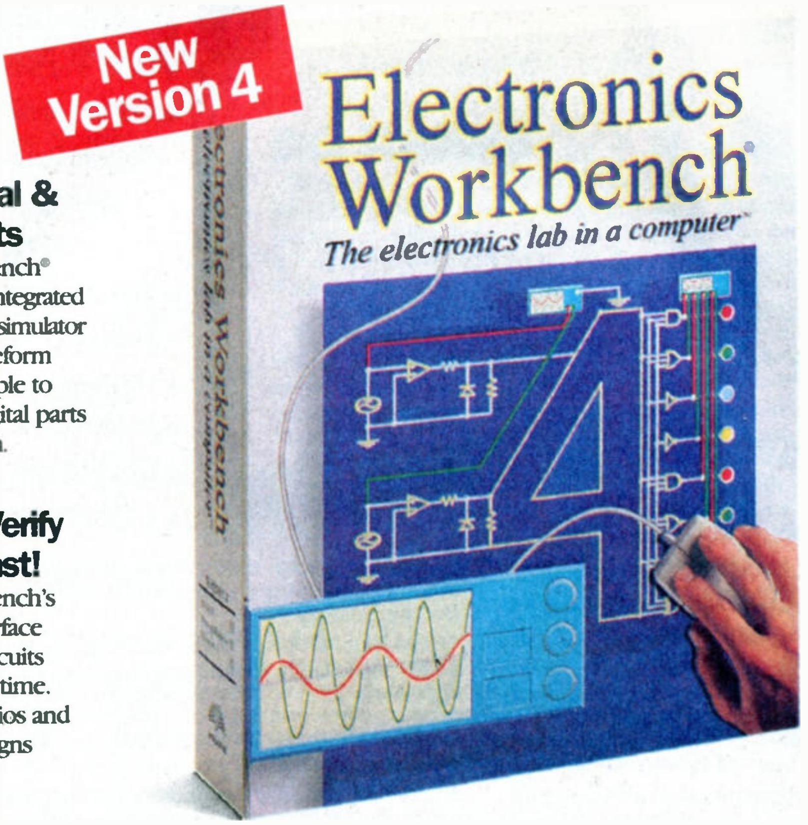

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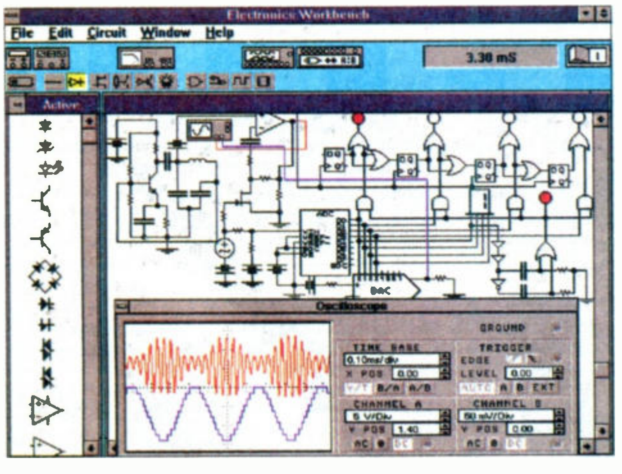

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INTERACTIVE

New Technology Update

Ian Poole goes "back-packing" to discover how i.c. manufacturers are using the latest "ball grid array" technology to cope with the dramatic increase in pin counts on today's i.c.s.

THE increased levels of integration in semiconductors today brings many advantages. Today's chips have far more functionality on them than anything which was available a few years ago.

The reduction in feature sizes also enables them to run much faster. Many top of the range processors like the Pentium can run at speeds of around 100MHz.

Pins and Needles

Naturally there is a downside as well. The increased levels of integration have also meant that the number of connections required to each i.c has risen.

Today, the quad flat-pack is the most popular package for these large pin count chips. The package has been refined over the years. Pin pitches have been reduced until they are now available with 0·5mm spacing.

Some chips with this spacing may have 200 pins and more. There are even some with 308 pins. All of these are delicate and very easy to damage in production.

The pins must not be bent because they cannot be returned exactly to their correct shape. With pin spacings of 0·5mm, accuracy is of paramount importance when the chips are being placed onto the board. Even a small error in the placement will mean that the pins can straddle the pads, shorting out the connections.

Even though the semiconductor manufacturers can make quad flat-packs with pitches down to 0·3mm without any real difficulty this is not done because of the difficulties encountered by the equipment manufacturers.

The problem is compounded by the fact that pin counts seem destined to increase even further. I.C.s become more sophisticated and require more connections to enable them to interface with the outside world. A.S.I.C.S (application specific i.c.s) are a particular example of this and manufacturers are becoming increasingly aware of the problem.

Ball Standard

Whilst not all chips will have these very large pin counts it is still obvious that new packaging technologies are needed. Within the industry it is now reckoned that the b.g.a. or "ball grid array" will become the next standard.

This is a surface mount package. Instead of having small pins around the outside, as with current i.c.s, the underneath of the package is covered with a matrix of solder "bumps" or "pimples" as shown in Fig. 1.

The pitch can vary from one package to another but the standard which is starting to emerge is 0·050 inches. For manufacturers this compares very favourably against 0·019 inches which is now common for quad flat-packs.

Even with the wider spacing of the solder bumps it is possible to have much higher pin counts because the connections can be placed all over the base of the package rather than just around the sides. It is anticipated that pin counts of in excess of a thousand could be handled with little difficulty.

A further advantage is that the solder bumps are far more robust and, unlike the pins on the quad flat-pack, they cannot be bent. As a result it is anticipated that far fewer of these chips will be damaged.

There are two main types of b.g.a. The one which will find most usage is the plastic or p.b.g.a. package. This type of package uses conventional bonding within the chip, enabling costs to be kept to a minimum. However, the disadvantage is that the pin count is limited to about 400. This will be adequate for 99 per cent of all current applications.

For the more demanding uses, possibly in large scale a.s.i.c.s, a second form of b.g.a. package is used. Called a "tape b.g.a." it was developed by IBM and instead of the wire bonds within the chip package, a metal connection frame is used to connect the metallised pads directly onto the chip itself.

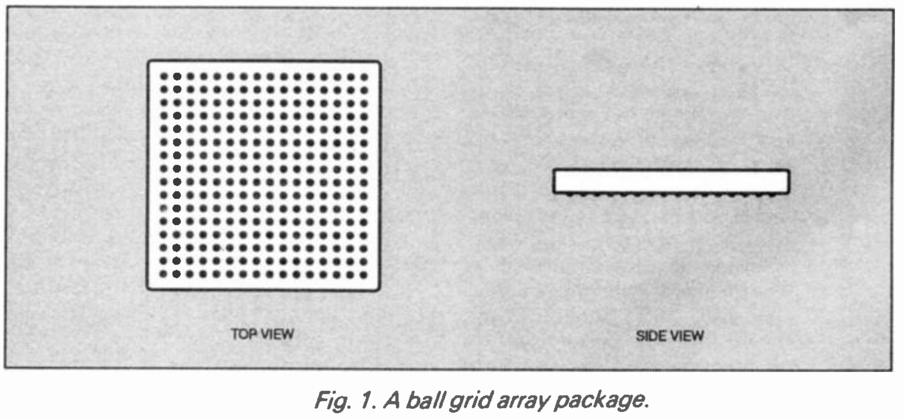


Fig. 1. A ball grid array package.

Manufacture

Many manufacturers are very sceptical about the use of b.g.a. packages. Care has to be taken in manufacture because the contacts are actually hidden below the package itself. This means there is no chance of being able to detect a poor joint visually.

When equipment is being manufactured the first step in the process is to place a small amount of solder paste onto the pads on the board. This is normally done very accurately using a screen printed board with the pattern through which solder paste can pass.

Once the solder paste is in place the components can be placed down onto the board. These days this is almost invariably done with an automatic "pick and place" machine. Occasionally some development boards may be hand placed, although even this is becoming more difficult.

Hot Line

To perform the soldering itself an infra-red, solder reflow machine must be used, this consists of a series of infra-red heaters.

The board is placed on a conveyor and passed into the machine. As it moves along the temperature of the whole board is raised in a number of carefully designed stages. In this way the whole of the board reaches the soldering temperature without receiving a sharp thermal shock.

To solder the b.g.a. chip heat passes through the whole assembly, including the board and the i.c. itself, so that the solder balls under the package melt and solder the chip to the board. When the solder has melted the surface tension tends to pull the i.c. perfectly into line with the pads. In this way small misalignments are permissible.

Obviously the main concern is that heat will not penetrate through to the inner pads properly and the connections will be open circuit or intermittent. Manufacturers will want to be able to inspect the joints to ensure that their processes are correct, even if they do not want to inspect all of the boards passing through.

The only way of looking at the joints is to use X-ray equipment. This is now beginning to appear on the market.

Despite all the concerns, the few people who have used b.g.a.s have reported that they have proved to give remarkably good results. Defects caused by handling were greatly reduced, and they indicate that if the joints on the outer edges of the package are correctly soldered then so are the ones further in. In total, they have found a significant improvement in quality when using b.g.a.s.

Innovations

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

BEING TALKED OUT OF A JAM

Throughout the motorway network, new automatic sensors assess traffic flow and offer avoidance advice.

– by Hazel Cavendish

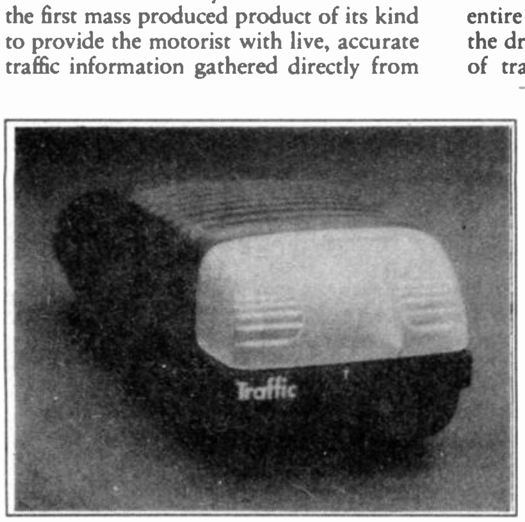
THE average driver who uses our motorways and trunk roads regularly will spend almost five full days each year stuck in traffic jams – according to a recent MORI survey. This statistic comes as no surprise to Britain's hard-pressed drivers; many would claim to spend an even longer period fretting at the wheel and wearing out a clutch in the course of a year.

It is heartening news, though, that the latest and most innovative technology is being used to examine the appalling congestion that bedevils our motorways. Britain has come up with the most advanced computer software for traffic simulation in the world, the brainchild of Edinburgh University's Parallel Computing Centre, which has produced the Paramics program. This is considered to be superior to any system produced by Germany's Institute for Automation and Communication in Magdeburg, or America's Los Alamos National Laboratories.

Paramics can simulate the movement around a complex network of roads by up to a quarter of a million individual vehicles with the use of a supercomputer. Smaller simulations can be carried out on PCs – both with the long-term aim of finding an in-car system to help drivers to navigate.

CHATTY TRAFFICMATE

Full credit, too, to the buoyant young company which has not only updated its highly successful Trafficmaster (described in *EPE* in August 1993), but has recently added Trafficmate. This ingenious device actually talks to the car driver, warning of delays within ten miles of his or her position on the motorway. It is claimed to be the first mass produced product of its kind to provide the motorist with live, accurate traffic information gathered directly from the sensors on the entire motorway network.



A neat solution to avoiding jams.

Trafficmate is fully automatic and only requires the driver to touch the front panel to switch it on at the beginning of a journey. It is designed in the UK, but built in Spain, using surface mount techniques which allow a high functional specification at low cost.

Priced realistically at £49.99 to put it within reach of the average motorist, it uses speech technology to provide audible messages on traffic flow. Data is gathered from a network of over 2,400 infra-red bridge-mounted sensors, which monitor the speed of the traffic passing below. When the speed drops below 30 m.p.h. the system alerts the National Traffic Data centre in Milton Keynes via radio. This information is instantly sent out to over 1,500 local transmitter stations.

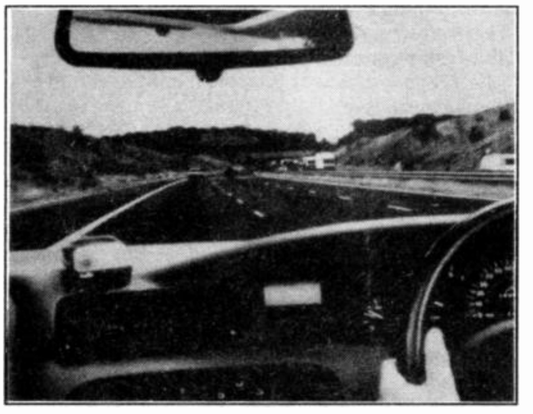
PERSONALISED

Each transmitter station has a unique ID code and is capable of "filtering" all motorway traffic information relevant to that particular site (to within a 10 mile range or two junctions of the vehicle's position) and translates it into coded messages.

Traffic information is sent "live" to the Trafficmate unit using a low-power 433MHz transmission. Trafficmate's microprocessor converts the message into speech using a human (lady's) voice. As the unit "remembers" the last transmission and contains a "map" of the entire motorway network, it not only tells the driver's position, but also the direction of travel. Each transmission is repeated approximately twice per second, assisting the reliability of signal reception.

The driver is told whether traffic is flowing freely, and if there is slow traffic within the horizon. If the latter is reported the driver is told the length of the tailback and whether it is stationary or slow moving. It also calculates the actual delay that the motorist can expect through the problem area.

An advantage of Trafficmate is that the driver will receive information on traffic flow in all directions *as he or she approaches the motorway*, so if there is a warning of a real snarl-up, the motorway can be avoided at that junction and joined at another point.



Sitting unobtrusively on the dashboard, Trafficmate helps you find the clearest route.

Trafficmate is a portable unit that can be used in the office and transferred to the car for use en-route.

WHY QUEUE?

The updated Trafficmaster YQ system is larger and is aimed at the control rooms of major distributing companies, senior business people who are frequent users of the entire motorway system, and chauffeurs who need to plan a journey in advance.

When the YQ is switched on it displays a map of the national motorway network and, by moving a cursor to the area of interest, the driver can then zoom in on a specific section of the motorway. It also features a personal messaging system and users gain access to live traffic information via a special key which slots into the back of the unit. Information is updated on screen every three minutes.

FULLY NETWORKED

When the parent Trafficmaster unit was reported on in 1993 only a part of the motorway was covered by its sensors. Now the entire national motorway network is included, with the Scottish motorway stretch and the M4 into Wales from the Severn bridge currently being added.

Trafficmaster plc is now based at Milton Keynes, at the centre of the UK motorway network. The company is currently piloting new technology designed to monitor traffic flow in urban areas, called Passive Target Flow Measurement. This uses CCTV camera equipment and recognition software to record number plates and calculate the time taken to travel the distance between two cameras.

BEGINNERS' PIC GUIDE

The fast-selling *Beginners Guide to the Microchip PIC* has gone to a new, and much updated edition, published again by the Polar Group. The new edition has been upgraded, but not up-priced, and is available at £19.95 through the major component suppliers, including Maplin, Farnell, R.S. and Rapid.

The most obvious aspect of the book to change is its appearance. The text is now spiral-bound, to lie open flat on the bench, and features a full-colour front cover. Sections inside detail what is involved in hardware design, software design, assembly and debugging. A disk (3.5in) of useful design software is included in the price.

Those who have already read version 1.0 will find much that is new. Most of this relates to applications of the 16Cxx family, with on-chip A/D, EEPROM and other features.

For details on how to obtain single copies of this recommended publication, please ring Farnell (0113 263 6311), Maplin (01702 554161), R.S. (01536 201201), or Rapid (01206 751166). For volume or trade enquiries, contact Ian Ewin or Peter Greenslade, Resource, Polar Group plc, tel: 01525 858200.

NEW MIRACLES

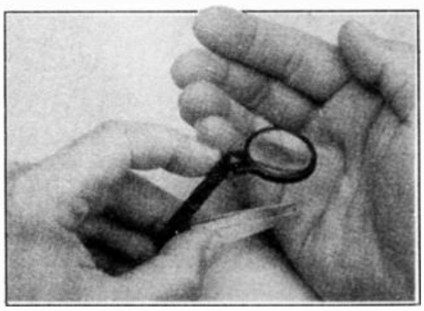
The new Miracle Point range of hand tools is now available from Minicraft. Miracle Point is a range of high precision stainless steel pliers and tweezers which are ideal for all fine work, whether in electronics, modelling, or even general household repairs.

Minicraft are a long established company whose name will be familiar to many readers. They have an excellent reputation as producers of high precision tools. The introduction of the Miracle Point range, which is manufactured in America, follows the takeover of Minicraft last year by Macford Products Ltd. The company are actively pursuing the policy of launching new and unique products.

One interesting product in the range is the pin-point precision tweezer which has a x5 magnifying glass attached to it on a third arm. Just the job for removing splinters from a finger (or for fine electronics work) – what a useful tool!

Another product newly introduced is a 12V d.c. variable speed fretsaw with a 5mm safety stroke, available with or without its own power supply.

For further information, contact Minicraft Macford Products Ltd., Dept. *EPE*, Units 1 & 2, Enterprise City, Meadowfield Avenue, Spennymoor, Co. Durham, DL16 6JF. Tel: 01388 420 535.



ELECTRONICS SHAREWARE CD

Equinox Technologies are launching an Electronics and Microcontroller Shareware CD. The CD contents include a wealth of PC and microcontroller shareware programs, demonstration versions of many popular CAD packages and a comprehensive collection of PC based Internet utilities.

The CD is aimed at both the professional engineer and keen enthusiast alike and features contributions from many major silicon manufacturers.

This shareware CD contains over 250MB of data, divided into five sections:

- PC Shareware – general DOS utilities, editors, compression programs, etc.
- Demonstrations of many commercial CAD packages, including Schematic and p.c.b. design with demos from Protel, Tsien, etc., plus Circuit Simulation with Spice for Windows, Geseca, Superfilter and Circuit Maker, etc.
- Microcontroller shareware utilities and applications software for a wide variety of microcontrollers, such as Atmel, Microchip, Intel, Zilog, Motorola, etc.
- Internet newsgroups, with over 2500 articles from them.
- PC Internet utilities, such as news readers, mail readers, web-browsers, plus many other useful utilities, all running under Windows.

Other contributors include Hitex UK and Hitex GmbH, Keil Software, Motorola, Philips, Protel Technology Inc., Seimens, Those Engineers, and Tie Pie.

Equinox also supply a range of microcontroller programmers and development modules.

The cost of the shareware CD is £30 plus P&P and VAT. For further information contact: John Marriott, Equinox Technologies, Dept. *EPE*, 229 Greenmount Lane, Heaton, Bolton, Lancs, BL1 5JB. Tel: 01204 492010.

SMARTEN-UP YOUR PC'S SECURITY

Apparently, last year over £100 million worth of computer and office equipment was stolen in London and the South East. You may rightly conclude that if you have a PC you too could be a target for theft.

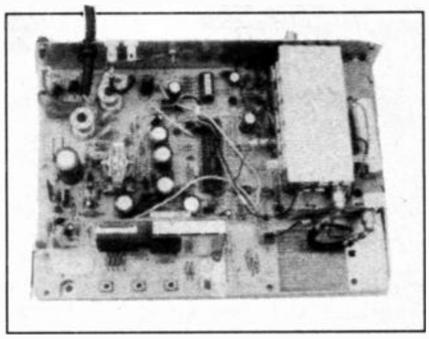
To help combat this problem, the Smart Technology Group has announced the first model in its range of alarms specially built for computer equipment. Their Smart *PC* Protector is an anti-theft alarm system which can detect unauthorised attempts to remove any IBM-compatible PC from the premises.

Once installed, its operation is automatic and it has battery back-up to protect your machine even when it is disconnected.

The system is inserted within the spare expansion slot on the PC. Once inserted and turned on by a high-security switch, if the computer is lifted the alarm will sound for 20 minutes, and then rearm itself for activation again. The alarm allows free movement around the desk while in normal use.

The Smart *PC* Protector is available at only £45 plus VAT.

For further information, contact Smart Technology Group, Dept. *EPE*, Unit 8, Ross Business Centre, Cambell Street, Pemberton, Wigan, WN5 9HT. Tel: 01942 621600.



CRAZY CABLE

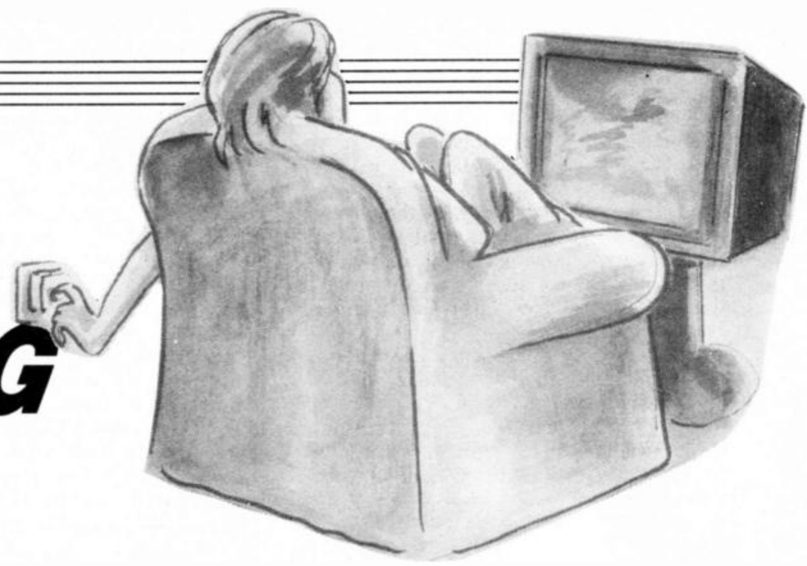
Regular readers will know that some quite complex bits of kit can often be picked up from advertisers for a fraction of their original cost. They are often unusable in their original form but contain all sorts of salvageable items which are often worth well over the asking price of the unit.

Just such an item has landed in our office from Greenweld. It's a cable vision control box, together with remote control, which was made by Zenith. In addition to plenty of useful passive components, the complete IR remote control system with digital readout could be put to various uses. There is a small switch mode power supply and even an AA NiCad battery.

These units are said to be in working order, so if you enjoy experimenting and fancy a challenge, the price is just £6.95, plus postage.

For more information, contact Greenweld Electronics, Dept. *EPE*, 27 Park Road, Southampton SO15 3UR. Tel: 01703 236363.

Constructional Project



MAINS SIGNALLING UNIT

ANDY FLIND

Part 1

Get rid of those unsightly wires with this versatile "through-the-mains" Transmitter/Receiver link. We also add a plug-in Alarm Sounder (next month) for the household wiring.

THIS project was designed to eliminate the need for wiring to extend a doorbell to an outbuilding. The site of the new bell would have been difficult to run new cables to, but it was already connected by mains power wiring so it made sense to use this for signal transmission.

Although an integrated circuit designed especially for mains wiring communications is available, there are one or two minor snags with this. The first is expense. The chip costs around £7.00 and two are required, one at either end of the circuit.

Both need to be powered continuously by supplies that can only be provided by separate transformers. Together with the other necessary components, the cost of implementing the link with these would easily have topped £30 and this was felt excessive for simply extending the Doorbell.

POWERFUL APPROACH

By contrast, the present design uses cheap and readily available parts and can be built for much less. The Transmitter only needs power whilst actually transmitting and will accept a wide range of supply voltages, so battery power can be used or it may be powered from the same supply as the doorbell itself. The Receiver needs continuous power, but with careful design to minimise current consumption it has proved possible to run this from a simple mains supply using a capacitor instead of the transformer.

Although the circuit can only transfer a simple "on-off" signal, *not* data or speech, there will be many applications where this is all that is required and a cheap and simple solution is therefore welcome. To widen the range of uses as far as possible a number of options have been provided on the printed circuit boards (p.c.b.s) so that constructors can configure the system to suit their own specific needs.

The system works by impressing a sinewave signal of about 120kHz directly across the "Live" and "Neutral" wires of the mains wiring. This is detected at the other end, its presence or absence indicating "on" or "off".

TRANSMITTER

The full circuit diagram for the mains carrier Transmitter is shown in Fig. 1. T1 is a "tank coil" designed especially for this type of circuit.

One side of the coil is tuned to the required frequency by capacitors C2 and C3 to form the frequency determining element of an oscillator constructed with transistor TR1. The output of this oscillator is a reasonably clean sinewave, which should minimise problems of interference with other mains-powered equipment.

The output from the oscillator is stepped down by T1 and applied to the live (L) and neutral (N) lines through the blocking capacitor C1. This capacitor is an "IS" type, designed especially for use in suppression circuits and capable of withstanding the application of *continuous* 230V a.c.

Additional protection is also provided to guard against the transient voltage spikes which sometimes occur on the mains. VDR1 is a transient suppressor which conducts if the voltage exceeds normal levels to clip such spikes, whilst on the other side of T1, Zener diodes D1 and D2 similarly protect the low-voltage side of the circuit.

Resistors R1 and R2 ensure rapid discharge of C1 when the circuit is disconnected from the mains to remove the risk of shock from stored charge.

TAKE CARE

The coil T1 is manufactured by Toko and, although intended for mains use, has recently been supplied with a warning stating that the insulation is not guaranteed beyond 100V! Although the supplier states that a large number have been sold without any problems, designers obviously have to consider this advice seriously.

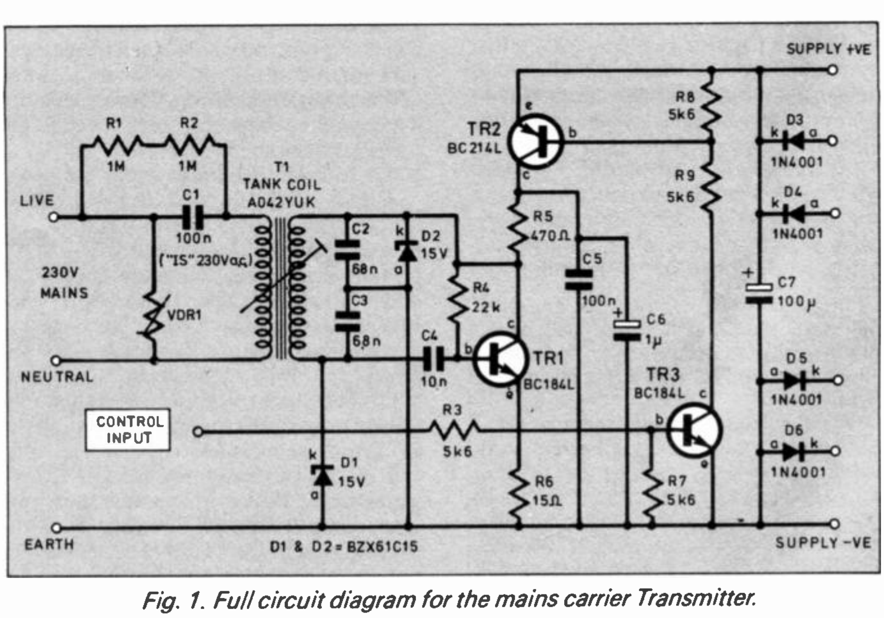


Fig. 1. Full circuit diagram for the mains carrier Transmitter.

In this circuit one side of the coil is connected directly to "neutral" and the other is isolated from "live" by capacitor C1, which passes only a small current at mains-frequency. The inductance and resistance of the coil at 50Hz are virtually insignificant so the whole of the low-voltage side of the coil may be thought of as being at neutral potential. "Earth" should always be within a volt or two of this, so the voltage across the coil insulation will be very low, easily meeting the safety requirements.

As a matter of interest, the characteristics of T1 are such that at 50Hz there is minimal coupling across it. As a result, the amount of 50Hz voltage induced into the low-voltage side, despite the "step-up" ratio in this direction, is so small as to be almost unmeasurable.

The circuit will then transmit whenever power is supplied.

The average household mains wiring system is not a communication engineer's ideal transmission line. Its impedance is very low and also varies considerably according to the various loads connected to it at any given time.

Some, such as heaters, are resistive but many loads also have capacitance. Fluorescent lights are an obvious example, but a major source of signal attenuation in the author's house is the central heating pump which has a "capacitor-start" motor.

Fortunately, most of these capacitors have a fair amount of inductance at high frequencies so some of the 120kHz signal survives. All the same, a sensitive Receiver is the key to the success of this design.

Again a "tank coil" transformer T1 couples to the mains through a blocking capacitor C1. The low-voltage side is tuned to 120kHz by capacitor C2 and transient protection is provided by Zener diodes D1 and D2.

A transistor amplifier stage TR1 follows, with a voltage gain of about fifteen and a frequency response tailored to eliminate signals well outside the required band such as r.f. and 50Hz or 100Hz interference. A simple diode detector made from D3 and D4 with capacitors C5, C8 and resistor R11 allow the signal amplitude to be monitored with a meter for tuning adjustment.

The signal from transistor TR1 passes level clamping diodes D5 and D6 to the comparator IC1a, where the circuit sensitivity is set by adjusting the reference voltage from preset potentiometer VR1.

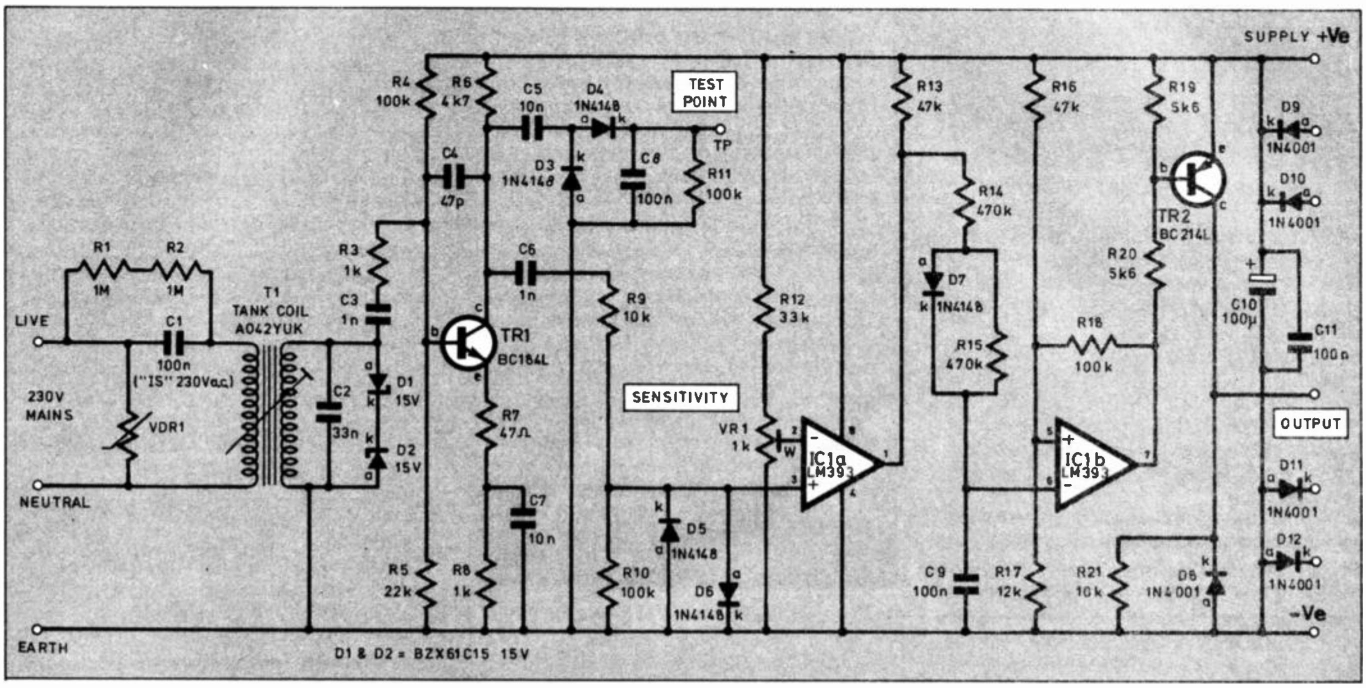


Fig. 2. Complete circuit diagram for the mains carrier Receiver. For power supply options and connections see Fig. 7.

ON SUPPLY

Power for the Transmitter may be supplied in various ways. The intended supply voltage is 9V to 12V, but during tests the prototype operated happily over the entire length of the household wiring with a supply of just two volts!

A direct d.c. supply such as a battery may be used, placed across the supply positive and negative, or two of the diodes may be used with a centre-tapped transformer, or all four diodes (D3-D6) can be connected to form a bridge for a two-wire a.c. supply such as a bell transformer. More details of this will be given later.

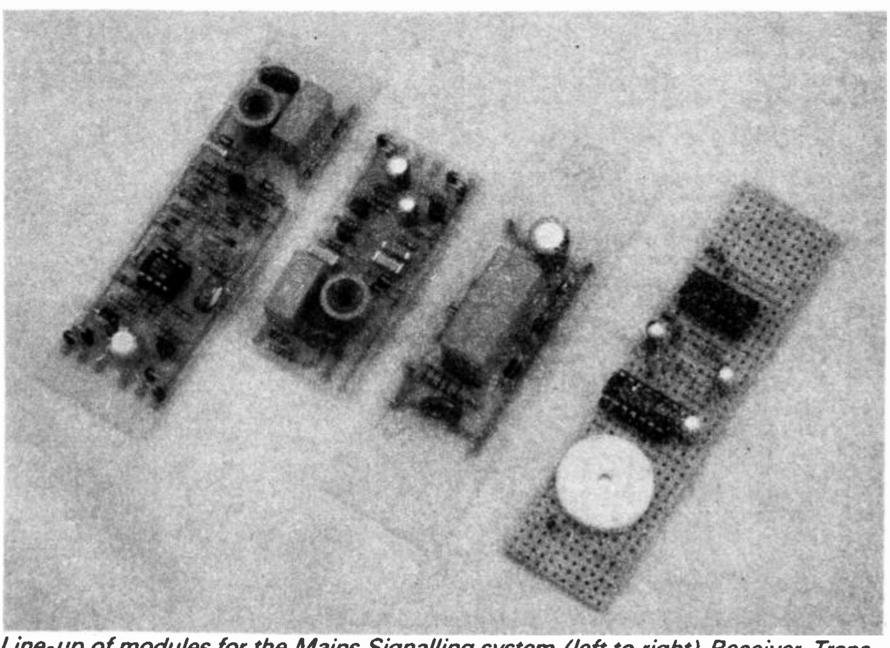
In applications such as alarm systems it might be necessary to operate the Transmitter with an electrical signal. Transistors TR2 and TR3 make this possible. A positive input anywhere between 2V and 20V applied to the Control Input will cause both these transistors to turn on and power will then be supplied from TR2 collector to the oscillator.

When the "control input" is not present, the circuit will not draw any current so it may be powered for long periods with a battery if required. If electrical control is not required these two transistors and their associated four resistors (R3, R7 to R9) may be omitted and a link fitted across TR2 collector (c) and emitter (e) points.

RECEIVER

The complete circuit diagram for the mains carrier Receiver is shown in Fig 2.

The outputs of IC1 are open collector transistors, they can sink current to ground but cannot source it.



Line-up of modules for the Mains Signalling system (left to right) Receiver, Transmitter, Power Supply and Two-Tone Sounder.

When the signal amplitude is sufficient IC1a's output transistor will turn off during positive half-cycles, allowing current from resistor R13 to flow through R14 and D7 to charge capacitor C9. The time necessary for C9 to charge prevents brief noise spikes from causing spurious output.

When the voltage across capacitor C9 becomes high enough, the output of IC1b (pin 7) goes low and turns on TR2 which provides the output from its collector (c). Resistor R18 introduces hysteresis for a clean switching action.

The output from TR2 is sufficient to drive a small relay so diode D8 is provided to handle back e.m.f. should one be connected. Alternatively, the output may be used as a control signal or may directly power small items such as a piezo bleeper.

As with the Transmitter, the Receiver circuit can be powered from d.c. of nominally 9V to 12V, or a.c., where the four diodes D9 to D12 allow the use of centre-tapped or untapped transformer supplies.

CONSTRUCTION - TRANSMITTER

Construction of the Transmitter is straightforward, the p.c.b. topside layout of all components and full size underside copper foil master being shown in Fig. 3. This board, together with the Receiver p.c.b., is available from the *EPE PCB Service*, code 970 (Trans.).

If the electronic control facility is not required transistors TR2 and TR3 may be omitted along with resistors R3, R7, R8 and R9 and a link placed across the emitter and collector points for transistor TR2, these being the top and middle connections.

If a d.c. (battery) supply is used diodes D3 to D6 can be omitted. If a centre-tapped transformer is to supply the unit, D3 and D4 will be required, but for operation from a single-ended a.c. supply such as an a.c. doorbell supply all four will be needed. Their polarities should be noted carefully; D3 and D5 have their marked or banded cathode (k) ends facing upwards, D4 and D6 have them facing down.

The connections for the tank coil transformer T1 are shown in Fig. 4. This should be the right way round if the "markings" on its side are facing capacitor C1, but it would be sensible to check this with a meter; set to the Ohms range to check "continuity". It should be ensured that the two connections on the right, nearest to diodes D1 and D2, are *not* electrically in contact with the other four in any way.

COMPONENTS

MAINS CARRIER TRANSMITTER

Resistors

R1, R2	1M (2 off)
R3, R7, R8, R9	5k6 (4 off)
R4	22k
R5	470Ω
R6	15Ω

All 0·6W 1% metal film.

See SHOP TALK Page

Capacitors

C1	100n suppression cap "IS" 230 volt
C2, C3	68n polyester layer (2 off)
C4	10n polyester layer
C5	100n resin-dipped ceramic
C6	1µ radial elect. 50V
C7	100µ radial elect. 50V

Semiconductors

D1, D2	BZX61C15, 15V 1·3W Zener diode (2 off)
D3 to D6	1N4001 1A 50V silicon rect. diode (4 off)
TR1, TR3	BC184L *npn* silicon transistor (2 off)
TR2	BC214L *pnp* silicon transistor

Miscellaneous

VDR1	250V mains transient suppressor
T1	"Tank coil" transformer, Toko A042YUK.

Printed circuit board available from *EPE PCB Service*, code 970 (Trans.); plastic case, size as required; multistrand connecting wire; solder terminal pins; solder etc.

Approx cost guidance only **£12** excluding case

When construction is complete a quick check can be made by powering the circuit from 12V d.c. (*without connecting to the mains!*) and noting the current consumption which should be about 18mA. If the "Control" option has been constructed the input to this will have to be connected to positive before the circuit will operate.

CONSTRUCTION - RECEIVER

Construction of the Receiver printed circuit board is similar to that of the Transmitter although there are a few more components in this. This board is available from the *EPE PCB Service*, code 971 (Rec). The positions of all parts and p.c.b. master are shown in Fig. 5.

For ease of construction low-profile items such as horizontal resistors and diodes should be fitted first. A socket is advised for IC1, though this is not essential. Checking and fitting of transformer T1 should be carried out as for the Transmitter, and the same comments apply to the fitting of the power diodes D9 to D12.

If the completed Receiver circuit is powered with a 12V supply, the voltage at the collector (c) of TR1 should be around

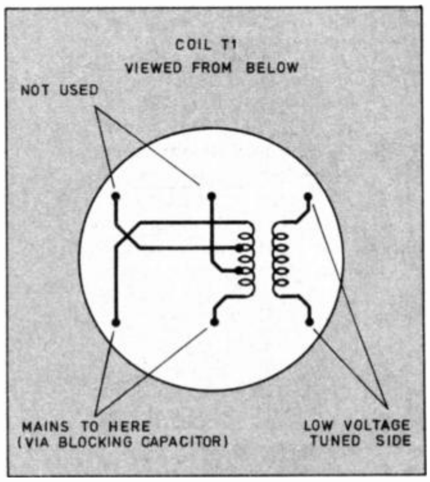


Fig. 4. Tank coil T1 internal pin connections details.

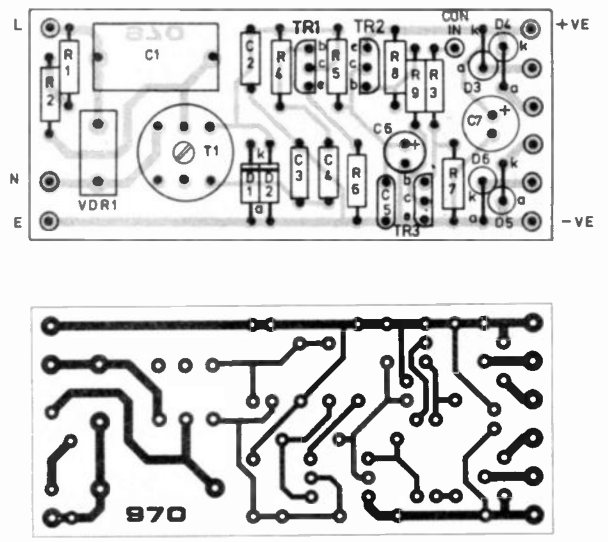
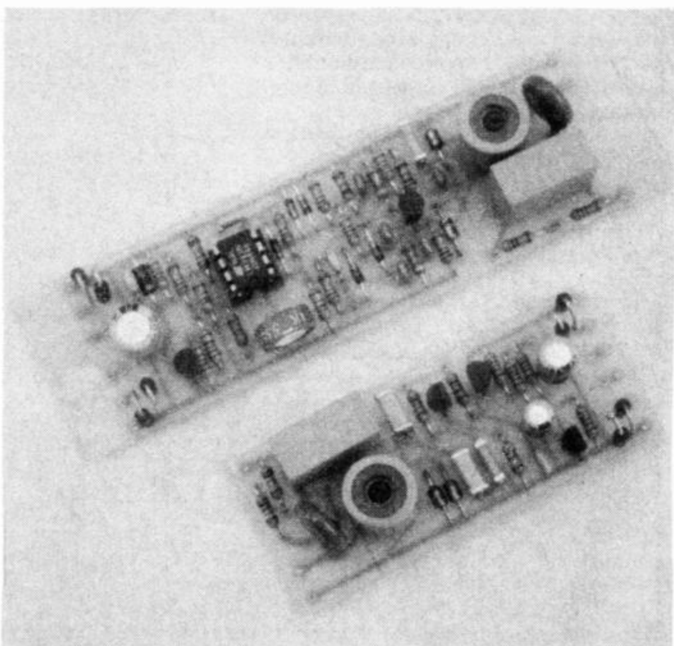


Fig. 3. Printed circuit board component layout and full size copper foil master for the Transmitter.



The completed mains carrier Transmitter and Receiver (top) printed circuit boards.

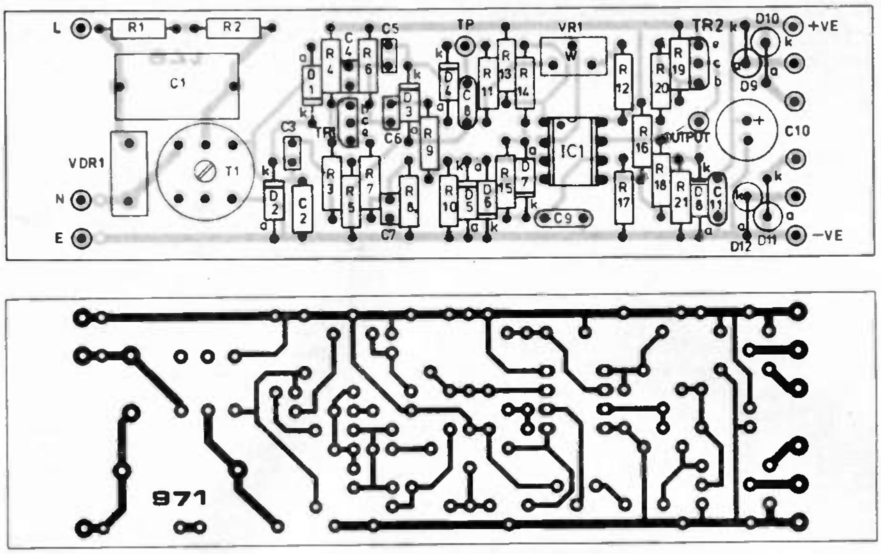


Fig. 5. Receiver p.c.b. component layout and full size copper foil master pattern.

5·5V. With IC1 inserted and preset VR1 set to about half-travel, pin 1 of IC1 should be at zero volts and pin 7 at almost full supply voltage. Current drain from the supply should be a mere 3mA or so.

TESTING AND SETTING-UP

A safe and simple method of checking and tuning the two units without the necessity of connection to the mains is shown in Fig. 6. The two 10 ohm resistors simulate (roughly!) the mains wiring impedance, whilst the 1 kilohm potentiometer (pot) and 220 ohm resistor allow adjustment of the amount of signal reaching the Receiver. A voltmeter connected between negative and the test point, situated just above C8, will give an indication of relative signal strength.

The pot should be adjusted for a reading of about 0·2V to 0·5V, then the ferrite core of T1 on the Receiver can be adjusted for the highest obtainable (peak) reading. It is also possible to alter the core of the Transmitter transformer if necessary, but sufficient adjustment will usually be obtained without resorting to this. Care is needed when adjusting these cores as they are fragile.

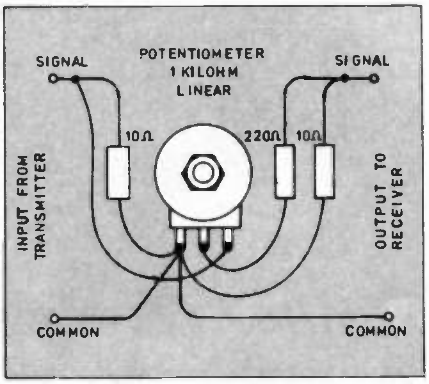


Fig. 6. Simulating connections for testing and setting-up.

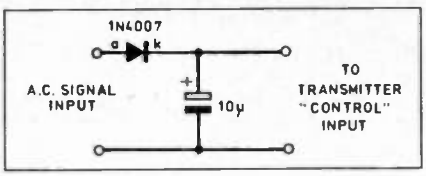


Fig. 8. Operating the Control input from an a.c. signal.

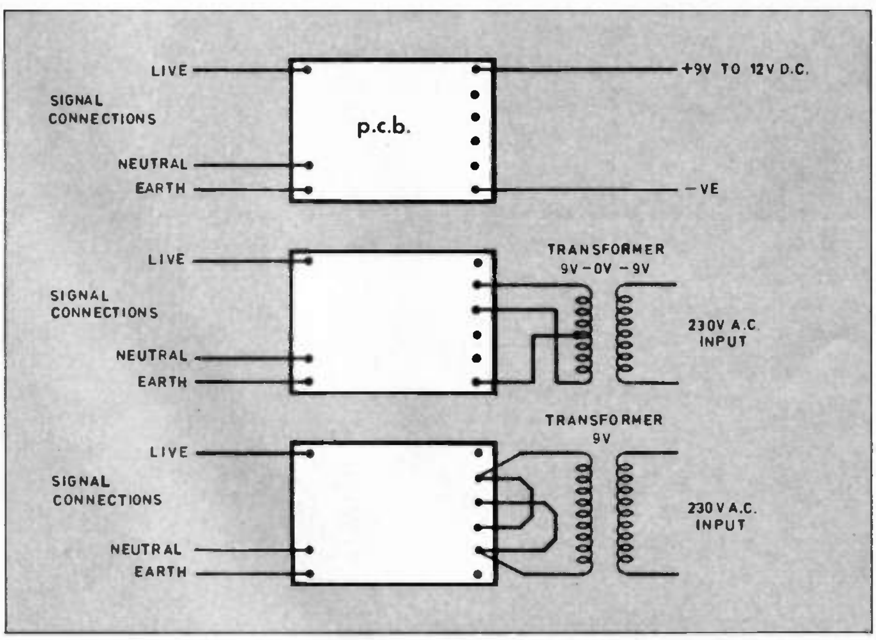


Fig. 7. Various methods of powering the Transmitter and Receiver boards. ***Extreme care must be taken when installing boards due to to the presence of mains voltages.***

Following this, with preset VR1 adjusted at half-travel, the output from TR2 in the Receiver can be monitored with a meter for correct operation with the presence and absence of signal.

The two units can now be installed and tested for operation through the mains wiring. Connections for the various types of power supply are shown in Fig. 7, along with a simple half wave circuit (Fig. 8) for operating the "Control" input from an a.c. signal should this be needed.

Connections to the mains carry obvious hazards, so this should only be done by constructors with sufficient knowledge to recognise and avoid the dangers. The Live and Neutral connections *must* be the correct way round and an Earth connection should be made, but study the following comments on connection to a doorbell circuit regarding this.

COMPONENTS

Mains Carrier Receiver

Resistors

R1, R2	1M (2 off)
R3, R8	1k (2 off)
R4, R10, R11, R18	100k (4 off)
R5	22k
R6	4k7
R7	47Ω
R9, R21	10k (2 off)
R12	33k
R13, R16	47k (2 off)
R14, R15	470k (2 off)
R17	12k
R19, R20	5k6 (2 off)

All 0·6W 1% metal film

See SHOP TALK Page

Potentiometer

VR1	1k carbon preset, vertical

Capacitors

C1	100n suppression cap "IS" 230 volt
C2	33n polyester layer
C3, C5, C7	10n resin-dipped ceramic (3 off)
C4	47p resin-dipped ceramic
C6	1n resin-dipped ceramic
C8, C9, C11	100n resin-dipped ceramic
C10	100µ radial elect. 50V

Semiconductors

D1, D2	BZX61C15, 15V 1·3W Zener diode (2 off)
D3, D4, D5, D6, D7	1N4148 signal diode (5 off)
D8, D9, D10, D11, D12	1N4001 1A 50V silicon rect. diode (5 off)
TR1	BC184L *npn* silicon transistor
TR2	BC214L *pnp* silicon transistor
IC1	LM393 dual voltage comparator

Miscellaneous

VDR1	250V mains transient suppressor
T1	"Tank coil" transformer, Toko A042YUK.

Printed circuit board available from *EPE PCB Service*, code 971 (Rec.); plastic case, size as required; 8-pin d.i.l. socket; multistrand connecting wire; solder terminal pins; solder etc.

Approx cost guidance only **£13** *excluding case*

The preset VR1 in the Receiver should be set to a point some way above operation threshold with the Transmitter off, and this setting may subsequently need to be increased if it is found to be triggered by noise. A common source of noise that might give rise to spurious operation is switch-mode power supplies; the author's computer proved a strong producer of this. Other noise sources usually produce only brief spikes which will be rejected by the time-constant of R14 and C9.

WARNING BELL

Some words of caution apply where the Transmitter is to be connected to a Doorbell. The prototype, without the "control input" option, was plonked on the wall next to the bell transformer, connections made to the mains and the low voltage power input hooked across the leads going off to the bell using the "bridge" diode arrangement.

The bell supply was nominally 8V a.c. An earth connection was present at the transformer, so the Transmitter earth was connected to this. Result: *continuous transmitter output and two of the supply diodes became hot!*

Subsequent investigation revealed two unexpected features. First, the bell transformer secondary was tapped for 3V or 5V and the "earth" was internally connected to this. This provided the unexpected extra circuit that caused the diode heating and output, so the Transmitter earth was removed, leaving it to obtain this through the a.c. supply.

The second unexpected feature was a lamp in the bellpush! This is wired across the switch so that it lights when the switch is open, the return path being through the bell. A low-current lamp is used so the bell does not receive enough current to operate but a small voltage is still developed across its leads.

This was not enough to power the Transmitter so did not prove a problem. In an installation where it does, the Control Input can be fitted and operated by the input arrangement shown in Fig. 7 with the Transmitter circuit powered continuously from the transformer or a battery.

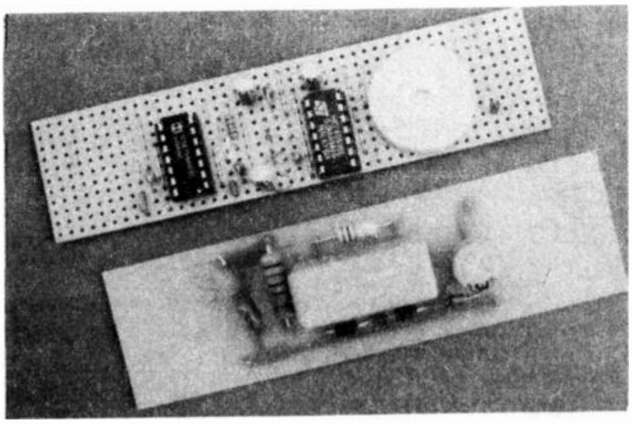
Another point which may be of relevance concerns what might happen if a neighbour builds one of these and happens to be on the same phase! The signal level drops quite rapidly with distance so by the time it reaches the house next door it is likely to be at a low level, so changing the Transmitter tuning and readjusting the Receiver to a new frequency may eliminate the problem.

A more drastic tuning shift can be effected by replacing capacitors C2 and C3 in the Transmitter with 100n components, and C2 in the receiver with a 47n type. This lowers the operating frequency to 100kHz. The circuit works just as well at this lower frequency, indeed much of the prototype development was carried out using these values.

However, even this much retuning may not guarantee independent operation of two units within the same building. Only a much tighter bandwidth would ensure this and that could only be done at the loss of the inherent simplicity of this circuit. □

NEXT MONTH

Details of a simple Capacitive Mains Power Supply and a Two-Tone Alarm Sounder for the Receiver will be given, allowing construction of a complete stand-alone Portable Doorbell or Alarm Repeater that can be plugged in anywhere on the household wiring.



Special Show Report

Internationale
Funkausstellung
Berlin

world
of consumer
electronics

EUROPEAN INTERNATIONAL CONSUMER ELECTRONICS SHOW

BARRY FOX

Barry dons his Batman, or is it Robin, disguise to track down all the latest developments that may, or may not, be about to hit the High Street stores. Even changing their title, once again, did not put him of the scent of the latest moves to use plasma techniques and micromirror chip technology to produce a new kind of TV screen.

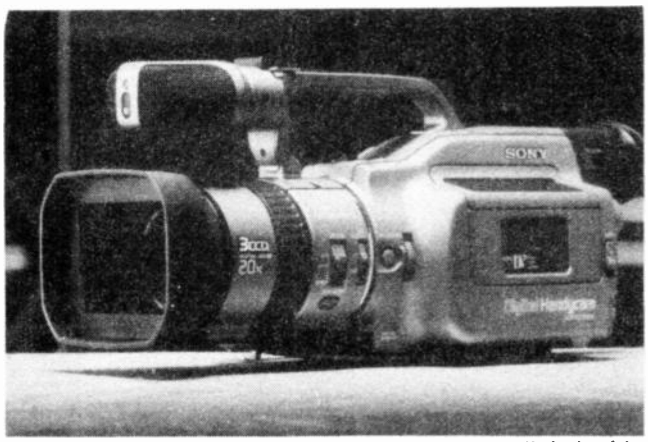
BERLIN'S *Internationale Funkausstellung (IFA)*, is now subtitled the "World of Consumer Electronics", and held every two years. Last year's, the fortieth since 1924, notched up 758 exhibitors from 30 countries with around 100,000 trade visitors and half a million consumers willing to pay nearly £10 each to swelter in the thirty or so halls, and pack like sardines in the garden area where live TV shows are the big draw.

This time we had a visit from Robbie of *Take That*, real snow imported by satellite channel Eurosport, bungee jumping from the top of a tower crane, a simulated rock face for abseiling and, probably a world's first, a Batman flying machine. An enormous fan, surrounded by inflatable cushions generates such a devastatingly powerful updraft that anyone who dons a Caped Crusader suit and dives into the slipstream gets carried ten metres into the air to hover in flapping suspension.

Inside the exhibition halls, the over-riding impression was one of complete confusion. If the trade and press cannot get a clear fix on what is going on in the industry, then what hope has the consumer?

World Firsts

Both Sony and Panasonic showed their "world first" digital video camcorders, using the standard DVC format agreed by 55 manufacturers worldwide. Sony plans two models for the European market and first sales began in October with prices at 4,500DM and 7,000DM. That's several thousand pounds each. Sony plans a deck, but says it must "first agree copyright issues".



The very latest Mini DV DigitalHandycam digital video cassette camcorder from Sony.

The deck will record PAL-Plus in its transmitted form, i.e. with the analogue helper information still coded in the letterbox dark areas. The TV set will do the decoding.

The Sony DV camcorders will record indexing information in a 4 kilobit memory housed inside the cassette, for access without the need to run the tape. Sony plays down the likely impact of DV on Hi 8. Panasonic also plays down the impact on S-VHS. Asked why Sony and Panasonic are using different serial digital connectors on their DV camcorders and different time code formats, Panasonic claimed it was "not familiar" with what Sony was doing within the standard.

Panasonic engineers were moving from Berlin to Paris for a DVC standards conference scheduled to coincide with *IFA* week. There they would talk about standardizing an interface. Surely this should have been done before the products were ready for launch?

Meanwhile JVC also showed a Mini DV, "the world's smallest camcorder". This hand-held version of DVC is similar in size to a compact 35mm camera, but with the lens and view finder in the side. Pulling the view finder out switches the unit to record mode. Maximum recording time on all DV camcorders is one hour. The JVC unit will dock with a connector which looks unlikely to match the connectors used by either Panasonic or Sony.

Mini DV is still an "engineering prototype" and will be launched in Europe in 1996 at around 4,500DM. JVC is also launching a modified S-VHS recorder which tapes full PAL-Plus signals for decoding by a TV set.

Says Hiroki Shimizu, General Manager of JVC's video and audio sectors, "It is time for JVC to be more aggressive".

With all DVC products, picture quality is limited by the CCD and lens which will usually be far outstripped by the potential of the tape.

Says Shimizu, when asked about the future of VHS, "We cannot stay with one system for ever, we are showing JVC's direction in the future, the digital age of the 21st century".

Flash Terminal

Finish company Nokia has moved from deep loss in the early 90s to break even between 1992-94 and is now a world leader in digital cellphone technology. Nokia has watched the mess of confusion over digital TV and multimedia standards and developed the "multimedia terminal". The heart of the terminal is an MPEG-2 decoder to which cable, satellite or terrestrial TV receiver circuitry can be added, even a CD-ROM drive to play Video CD. It handles any data rate between one and 50 megabit/second and there is no operating system software on ROM chip. Everything is in flash memory, and thus instantly upgradeable, if necessary by broadcast transmission.

"The most important feature though", says Helmut Stein, Nokia's Vice-President in charge of technology, "is that it exists".

Working boxes were receiving digital broadcasts transmitted by the German Kirch Group, which had taken five transponders on *Astra 1D* satellite to transmit 27 digital streams during the *IFA* show. Some streams were carrying near video on demand, the same movie broadcast at 15 minute intervals. Others were delivering five different views of an international motor car racing event; so viewers could choose which view of which car to watch.

Helmut Stein supports Europe's stance on digital TV and HDTV. This is that future DDTV broadcasts will be simulcast alongside standard definition transmissions. Europe's Digital Video Broadcasting Group has rejected the idea of a scaleable signal, which can be received either in HD or SD. It puts a 20 per cent data burden on all channels. So it wastes more digits than simulcasting selected programmes.

Panasonic has launched 3DO in Germany at a street price of 649DM. The system, says Panasonic, "is very successful in the US, selling 20,000 players per month". Visting journalists from the USA were surprised to hear about the success of the system back home. It brought back memories of Commodore, and the ill-fated CDTV system. At European events CDTV was branded a success in the USA, and at North American events it was branded a success in Europe.

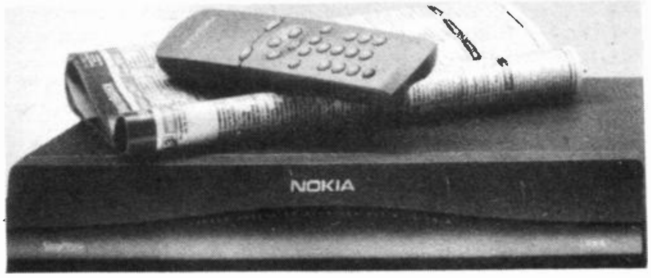
SD Alliance claim cinema-quality movies in the home and exciting multmedia on personal computers for their SD Discs and video tapes.

Strong Alliance

Both sides in the DVD (digital video disc) standards battle, Philips and Sony with MultiMedia CD (MMCD) and Toshiba, Panasonic, Time-Warner and Thomson with Super Density (SD) made their pitches to the press, trade and public. Philips and Sony made news with a statement by Henk Bodt, Executive Vice-President of Philips Electronics, that Philips and Sony had "expressed our desire to work towards creating a single format that ideally combines the best features of the currently proposed MMCD and SD formats". Both Philips and Sony, he added, were "in discussions with the SD Alliance regarding this goal". Immediately before the *IFA* show Philips people had been in Japan for discussions.

Guy Johnson, Senior Vice-President of Thomson in charge of DVD worldwide, made it clear that "any agreement would have to involve agreement to a product launch in mid-1996. That is when we will launch players and discs".

Alain Prestat, Chairman and CEO of Thomson Multimedia, is clearly the driving force behind the French company's commitment to the SD digital video disc, rather than the Dutch Philips's MMCD. Prestat has promised a launch for "the second half of 1996".



The 8002 Twin ShowView satellite receiver from Nokia boasts two tuners, with a possible 500 pre-programmed channels.

So, now that the two sides are finally talking about a single common standard, is Thomson prepared to sacrifice that chance simply to avoid missing the mid-1996 launch date promised by the SD Alliance?

"SD has acquired a strong momentum and we must not lose it. If we miss mid-96, we lose the year's season. Yes, it would be possible to make a player that plays both disc densities (3·7 Gbyte for Philips/Sony, 5Gb for SD). Everything is possible, but at what cost? The player has to be simple and at low price.

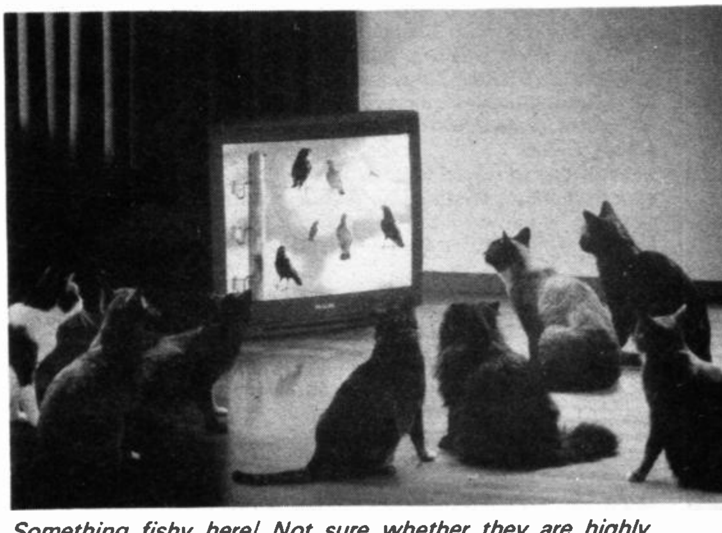
"I strongly believe that DVD will be a success, after all the various failures, like DCC, Mini Disc, MAC and Muse. DVD will be like CD, or the Walkman. It will be the next major consumer electronic (CE) product. We have taken the leadership and it is important not to lose the momentum".

Most of the questions on DVD were fielded by Toshio Yajima, Toshiba's Deputy General Manager in charge of the Multimedia Division. He confirmed that there will be two major and deliberate differences between discs sold in the US and Europe, to maintain the current situation whereby movies are released in the US earlier than elsewhere. There will be a distinction between PAL and NTSC video formats; also whereas the NTSC format will use Dolby AC-3 multichannel surround-sound, the PAL format will use MPEG-2 sound.

Yajima says the SD Alliance also "thinks there will be copy protection" that will prevent users making either analogue or digital dubs of DVD discs. Although it is easy to block digital dubbing, simply by providing no digital video output on the player, preventing analogue dubbing, e.g. onto a VCR, is far more difficult. The DVD player must incorporate an encoder which adds a spoiler signal, for instance Macrovision, to the output signal so that will play through a TV set but not copy onto tape. This will inevitably put up the price of the player.

The consumer player will not record. Yajima says this is because the phase change on the erasable disc has a capacity of only 2·8 Gigabyte per side, which is not enough for recording. Subsequently Thomson expanded on the reasoning. To use the DVD player as a VCR, it would have to incorporate an MPEG encoder as well as phase change optics. Although MPEG decoding is relatively cheap, MPEG coding is still an industrial process.

Although the DVD deck could serve as a bitstream recorder, for instance capturing broadcast data already encoded for transmission, the Alliance sees digital video cassette or digital VHS as a far better option.



Something fishy here! Not sure whether they are highly impressed with the latest Philips "Crystalclear" TV set or awaiting the latest weather report from the EPE Met Office.

Says Guy Johnson, "DVD was intended as a new home player, not a replacement for existing products". The SD player will however be backwards compatible with existing audio discs. The extra cost of the double lens needed to focus both on half thickness SD discs and full thickness CDs is claimed to add only around one per cent to the price of the optical pick-up.

Warren Lieberfarb of Time-Warner, repeated the SD pledge that there would be "250 titles available at launch".

Screen Images

Sanyo as a company continues to puzzle. In Japan Sanyo has a high profile for innovation. In Europe, especially the UK, the company is known mainly as a name on TV sets and camcorders, and the name is fading from view. In Berlin Sanyo drew crowds with a TV set that uses an LCD screen to produce 3-dimensional pictures without the need to wear spectacles.

Of course there is a catch. The screen displays sliced left and right images, with an aperture grille, like a Venetian blind, in front. When the viewer stands at just the right distance from the screen, and keeps absolutely still, there is a quite reasonable 3-D effect. But the image becomes a double jumble as soon the viewer's head moves and the effect cannot be seen by two viewers at the same time.

One spectator inadvertently summed it up nicely. Unable to get the two images to lock into a single 3-D picture, he just put his hand over one eye and said, "That's a lot better".

Philips is working with all the major TV and VCR manufacturers in Europe, along with the European Association of Consumer Electronics Manufacturers, to agree a standard for a new use of Teletext. This delivers programme information to a TV set which then displays it in whatever format the viewer chooses. For instance, the TV screen can list every programme due to be transmitted that evening which covers sport. The main object of the exercise is unashamedly to establish a non-proprietory standard, and so block plans by Californian company Gemstar to launch Showlist, its own proprietory system.

Philips plans to bring the Internet into the living-room, with a £100 hardware and software kit that adds a 14·4Kb/s modem to a standard CD-I player. To make searching easier, the index of favourite sites is stored on a standard CD-I disc. Subscribers to the service will get a new disc every three months through the mail.

Around *IFA* there were so many wide screen TV sets on display that the format no longer looks particularly new. Despite the rush to digital, the PAL-Plus group of European broadcasters still believes there is life left in analogue TV. But most of the interest in PAL-Plus remains in Germany where viewers expect to see programmes in letterbox format.

In the UK, *Channel 4* has recently shelved plans to transmit horse-racing in PAL-Plus because tests with letterbox transmissions produced an unprecedented number of complaints. This is despite the fact that *Channel 4* now gets complaints if it transmits movies in 4:3 instead of letterbox format.

At the PAL-Plus conference Mick Gleave of the BBC, confirmed that the BBC still regards PAL-Plus as an "insurance policy". Although it has no plans to broadcast in PAL-Plus, the door is "still open".

Gas-Light

One of the oddest demonstrations at Berlin was on the Schneider stand. Working with Daimler-Benz, Schneider has developed a video projector which uses three gas lasers, one red (with a wavelength of 630nm), one green (532nm) and one blue (450nm). By deflecting the laser beams with a mirror so that they scan a projection screen in a raster of lines, the traces blend to paint a full colour picture.

According to Jurgen Kranert, Schneider's scientific assistant for laser technology, the three lasers and ancillary equipment together consume 80 kilowatts of power, to put a sum total of less than 3 watts of white light on the screen. The aim is to reduce consumption to 3kW.

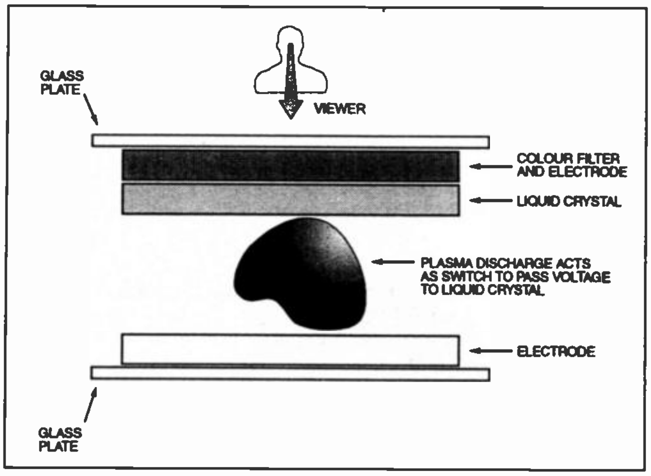
The effect on screen is nowhere near as bright as might be expected, with quite poor contrast and some unnatural colours. Although Schneider's publicity material claims that "functional assemblies are available", the company confirms that the demonstration kit is still a prototype and that nothing will be available for sale for two years yet. The price, says Kranert, will be "comparable to an Eidophor projector".

The long-term plan is to replace the gas lasers with solid state diodes, and build something approaching a consumer device. It seems highly unlikely that health and safety regulations will ever leave Schneider free to sell a consumer projector that beams raw laser light onto a screen; there will be too much risk of a family member looking into the beam and suffering eye damage.

Music Service

DMX of America used *IFA* as the launch pad for its digital music service for Europe from the *Astra* satellite. All music is uplinked from Denver, Colorado, coded in Musicam for Europe, AC-3 for the USA and a proprietary system for cable. Jerry Rubinstein played numerous excerpts of music, as if the audience had never before heard music of different styles before. Coding is at 48kHz, data rate 192 kilobit/s.

The system launches in Germany, Austria and Switzerland with hardware decoders selling for between 600DM and 700DM. The UK launch has been delayed again, to March, with receivers at £225 to £275. DMX blames chip delays. Subscription costs will be 19·8DM or £7 a month.



Greatly simplified diagram of the Sony Plasmatron system.

Plasmatronics

Sony recently claimed success with a modified l.c.d. screen, called Plasmatron which uses plasma gas discharge instead of transistors to switch the crystal cells. But when the company demonstrated two screens at *IFA*, both had dark spot blemishes caused by unswitched cells. The demonstration also revealed that, because the picture is formed by light from a lamp behind the l.c.d. cells, it looks poor when viewed from the side.

French company Thomson has built a 56cm plasma size screen which uses a different approach. Two glass plates, 100 micrometres apart, trap Xenon gas. A criss-cross of wires on the plates carry pulses of 350 volt a.c. When a pulse jumps through the gas from one plate to the other it creates a brief electrical discharge which generates a flash of ultra-violet light.

One of the plates has a pattern of red, green and blue phosphor spots on its surface. The phosphors glow when they are excited by a nearby flash. Ribs serve the dual purpose of spacing the plates apart and shielding the phosphor dots from stray u.v. light.

The wire matrix is built from 512 horizontal lines, each with 480 red, 480 blue and 480 green phosphors. When a TV signal is fed to the wires the screen displays a colour picture. Because the phosphors emit light like a c.r.t., the picture looks almost as good from the extreme side as from the front.

Thomson admits that mass production is not yet planned. The screen shown at Berlin had several visible blemishes.

Although Sony promises TV sets with Plasmatron screens by the end of 1996 at "less than twice equivalent tube price", Nokia of Finland believes that none of the plasma technologies will be ready as early as promised and will cost up to twenty times as much as a c.r.t. of similar size. Several companies in Japan are now offering sample plasma screens to TV set-makers. The samples cost $10,000 each!

Plasma screens will degrade faster than c.r.t.s, with their light intensity halving after 10,000 hours of use, or less if the screen brightness is turned up. Also, because plasma displays emit high voltage pulses they may fall foul of Europe's new EMC regulations, which control electromagnetic interference.

Mirror Image

This, says Nokia, is why it is the first consumer electronics company to back the Digital Micromirror Device developed by Texas Instruments. A microchip, measuring 1·5cm x 1cm carries half a million mirrors, each individually hinged to a silicon wafer. Transistor switches under the mirrors create an electrostatic force which flips the mirrors between reflecting and non-reflecting positions. When a TV signal is fed to the transistor array, and a bright light shone on the surface, it beams a TV picture through a lens and onto a screen.

TI initially developed the device to project images across a large room onto a wall screen. In the UK Rank Brimar is making large screen mirror projectors for industrial use. Nokia has built the same device into a TV set, behind a transluscent screen. This lets a cabinet, 40cm deep, display a 1·3 metre picture which looks like a flat screen panel.

It is being claimed that DMD is the first truly digital TV display device. Each mirror is either on or off. They are switched at high speed (around a thousand times a second) to create a grey scale. The longer the mirrors are switched into an "on" position, the brighter their light spots appear on screen.

The full TV picture is refreshed at around 75 times a second, so there is no flicker, even though the PAL field rate is 50Hz.

Colour is generated by a new application of an old principle. Colour filters spin in front of a 120 watt metal halide lamp, so that as the mirror array displays the red content of the image, the reflected light shines through a red filter; then the mirror array shows the blue content just as the blue mirror passes; and the green filter passes as the array is showing the green content.

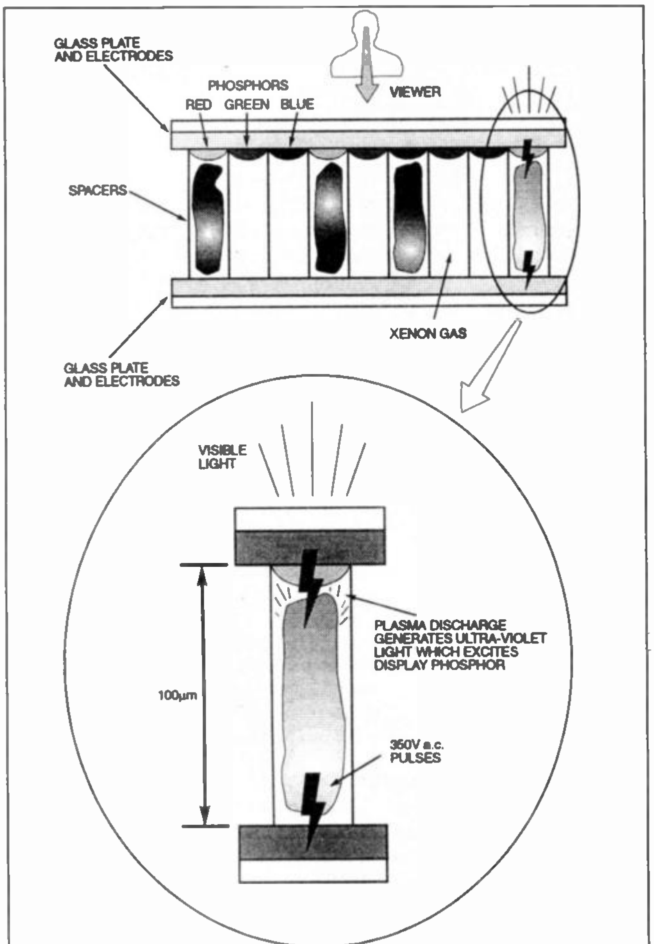
The system compensates for the fact that metal halide lamps are usually deficient in red light content. There are two mirror devices, and two filter sets, one red and blue and one red and green. This doubles the amount of red light that reaches the screen. The final picture is extremely bright and clear.

Texas has converted one of its existing microchip production lines, in Dallas, Texas, for DMD production. The line is now capable of producing mirrors with no visible defects. Nokia will buy mirror units from TI and build them into back projection TV cabinets. Sales are promised for early 1997 and Nokia is very realistic about the price.

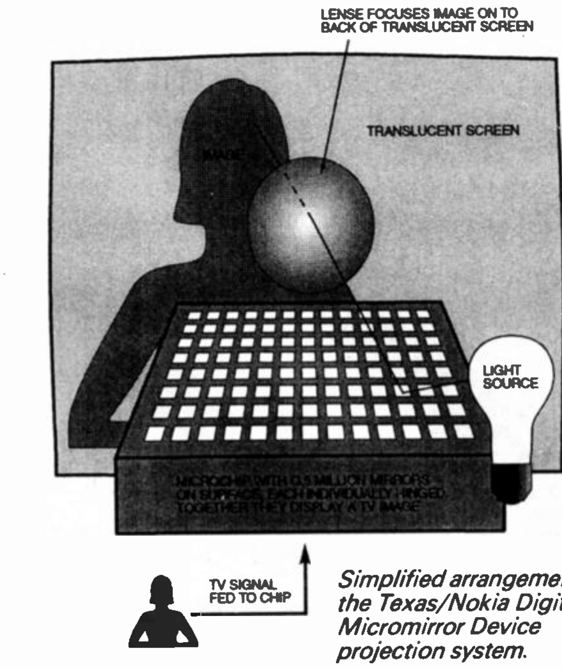
"For every product there is always a market price", says Goran Whalberg, Nokia's Director in charge of the DMD project. "We will follow that market price. Otherwise there is no market chance".

Because the scanning rate is easily varied, the projector can display NTSC, PAL or computer graphics.

But TI is hedging bets. Along with several other companies including Motorola and Raytheon, TI has signed a licence deal with French company PixTech to make a flat panel display that uses field-emission technology called "microtips". The panel works like a flattened cathode ray tube, but without a heated cathode.



Simplified representation of Thomson's Pure Plasma system.



Simplified arrangement of the Texas/Nokia Digital Micromirror Device projection system.

A sandwich of two panels has phosphor spots on the top panel, and a matrix of cone shaped electrodes on the lower panel. When a high voltage is fed to the cones, their tips concentrate the charge and emit electrons even though they are cold. The electrons hit the phosphors which emit light.

PixTech has done the basic research. The large companies will now try to manufacture products.

Ferguson Lives

Thomson launched its own brand TV and video equipment in the UK in time for Christmas. But this will not mean the end of the Ferguson brand name. Alain Prestat, Chairman and CEO of Thomson Multimedia, pledged that the two brands will run in parallel. UK MD Craig Smart was due in Berlin, to gauge the reaction from a party of British dealers.

In stark contrast to the "gung ho" reassurances from Ferguson in the UK over recent years, Prestat admits that things have not been going well.

"When you take over a brand you must have a strategy," he says. "You must manage. But we have managed only a decrease in business. There has been no clear strategy".

The UK decline has been allowed to continue only because Thomson's first priority was the USA, where RCA has now rebuilt its market share from 16 per cent to over 20 per cent.

"Now we can focus on the UK" says Prestat. "We will now have good clear positioning. We shall launch Thomson alongside Ferguson,". There will be no more cluttering of the Ferguson brand name with subtext like "Thomson Technology".

"That was crazy" says Prestat. "Crazy. Ferguson is Ferguson. Full Stop."

At *IFA*, Thomson set out to present a clear market picture of three very different brands (Saba, Telefunken and Nordmende/Thomson), all under the same corporate wing. The Ferguson brand will roughly equate with the Saba range. The UK Thomson range will match Nordmende.

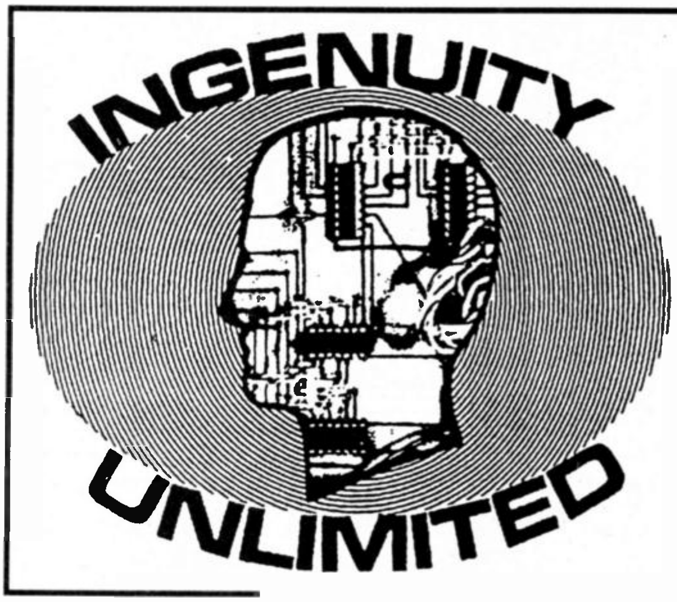
The Ferguson name will continue "for ever", pledges Prestat. "We didn't take over Ferguson just to forget it".

DAB Service

The Berlin show closed as the BBC was getting ready to "switch on" the first Digital Audio Broadcasting service in the world. Now operational, five DAB transmitters inside the M25 motorway ring deliver six digital radio programmes to a claimed 20 per cent of the population. But members of the public who want to listen in will be disappointed, or have to pay around £2000 pounds for a prototype receiver.

The prototypes, made by Philips, and its subsidiary Grundig, are so bulky that half the circuitry is stowed in the car boot. They will be used mainly by engineers for testing reception.

Lauri Klomp, of Philips Car Systems division, said at Berlin "The consumer will want a one-box dashboard receiver and this should be ready for the next show in 1997". □



Our regular round-up of readers' own circuits. We pay between £10-£50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit tips, not simply mechanical or electrical ideas. Ideas *must be the reader's own work* and **not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should preferably be typed or word-processed, with a brief circuit description showing all relevant component values. Please draw all circuit schematics as clearly as possible.

Send your circuit ideas to: Alan Winstanley, *Ingenuity Unlimited,* Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF. They could earn you some real cash!

Using LM317 with high voltages

– high power squeeze

THE LM317 voltage regulator is characterised by a very low output noise level making it popular in audio circuits. However, its maximum input-output voltage differential is limited to 40V. Most capacitor microphone supplies, for example, are 48V but it is possible to use the LM317 at these higher voltages provided you ensure that *no more than* 40V appears across the device.

In the circuit diagram of Fig. 1, the input voltage should be in excess of 50V to overcome the dropout voltage of the regulator, and the regulated output voltage is set to 48V d.c. by resistors R1 and R2. Zener diode D2 ensures that the regulator IC1 never sees more than 18V across it and it also provides a discharge path for capacitor C2 when power is disconnected.

Similarly, the Zener D1 ensures that the voltage between the input and adjustment pins never exceeds 18V, and it charges/discharges C1. The diodes also protect against transients on the supply.

Jake Rothman,
Bristol.

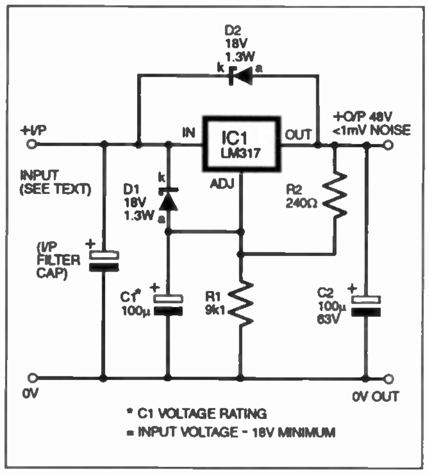


Fig. 1 (right). High voltage regulator.

Dog Yap Inhibitor - The Yap Trap!

A CIRCUIT diagram which provides an electronic means of inhibiting a dog's yapping is shown in Fig. 2. It has been shown that dogs tend to stop their yapping when they are made aware of it through a strong ultrasonic signal. This circuit is triggered by the sound of the yapping and generates such an ultrasonic signal.

A low-impedance dynamic microphone connects, via socket SK1, to IC1 and the sounds of amplified "yaps" are coupled via C3 into a diode pump consisting of D1, D2 and capacitor C4. The voltage across C4 gradually rises until the astable timer chip IC2 is enabled at its reset pin (pin 4).

The frequency of this oscillator should be trimmed by preset VR1 to run at 23kHz, the resonant frequency of ultrasonic transducer X1 which is driven by the output of the timer IC2. This may be carried out by adjusting VR1 to about 30 kilohms, then "fine tuning" VR1 for maximum d.c. current through X1.

The Dog Yap Inhibitor can be attached to a dog's collar and, with some care, may be enclosed in a small case. It gives up to a fortnight's continuous use on an alkaline PP3 battery.

Sensitivity of the circuit may be lessened by reducing the value of resistor R4. A piezo disc may possibly be used for the microphone with equal results.

Rev. Thomas Scarborough,
Cape Town,
South Africa.

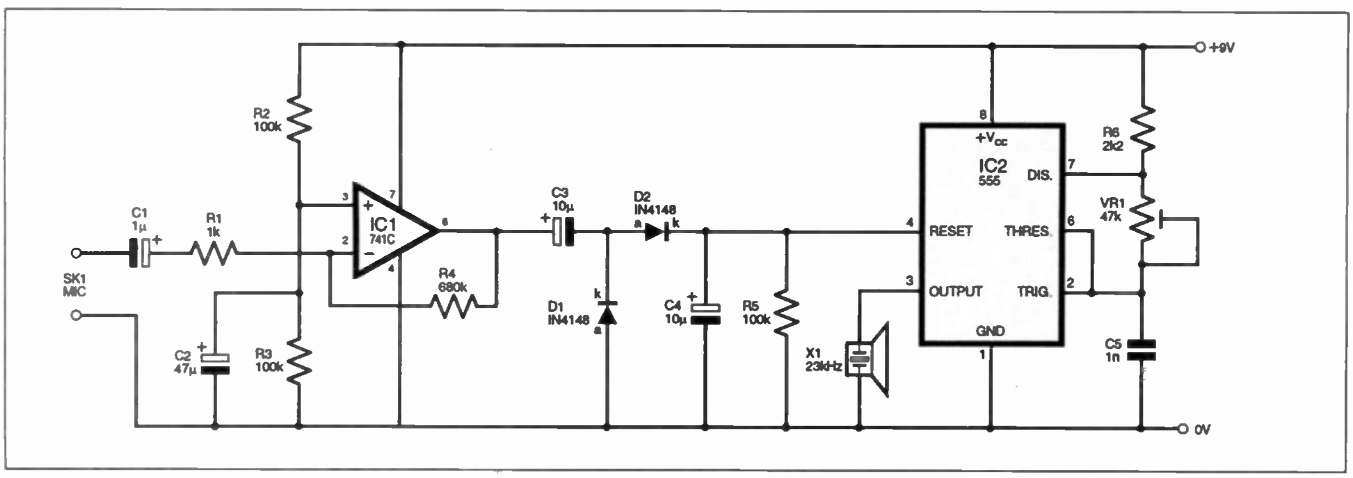


Fig. 2. Ultrasonic Dog Yap Inhibitor.

Programmable Sequence Driver

– for controllers, simulators etc.

SEQUENTIAL operations of devices are often controlled by hard-wired sequence drivers. My circuit diagram shown in Fig. 3 will generate a sequence of bits which can be programmed by entering data on a keypad. Hence it can be applied to many applications including traffic light simulation, automation, industrial models, etc.

Data from a 12-button keypad is encoded by IC2, which demands a high frequency clock (IC1a and IC1b). Here I have wired four 64-stage static registers, IC3 to IC6, in parallel thereby making a single 4-bit wide 64-word long "First-In"/"First-Out" recirculating register. The keypad encoder IC2 also provides a strobe pulse (pin 14) to transfer and store the data rippled at its outputs to the register's succeeding stages.

This register is the main component for storing up to 64 BCD's, and the circuit uses these BCD's by converting their respective decimal equivalents via the BCD to decimal decoder IC7. This subsequently generates a sequence through the driver transistors TR1 to TR9. The transistor type shown is not critical and any general purpose *npn* type would be fine.

Table 1 gives a sample of the programming pattern.

With Selector switch S1 set in "Program Mode" the numbers 1 to 9 in the keypad represent outputs Q1 to Q9 respectively, and key "0" introduces a pause between any sequence cycle if necessary. In "Normal Mode" the stored function is played at the outputs repeatedly.

The time taken to dump the data in the registers depends on the second clock generator IC1c and IC1d. Long intervals can be obtained by feeding the clock through, say, a decade counter.

Fawad Hafeez,
Karachi,
Pakistan.

Table 1: Sequence Driver Program Pattern

No. of Register Stages	Program Key pressed	Outputs with Clock Transition					
		Q1	Q2	Q3	Q4	Q5....	....Q9
1	1	1	0	0	0	0	0
2	2	0	1	0	0	0	0
3	3	0	0	1	0	0	0
4	4	0	0	0	1	0	0
5	4	0	0	0	1	0	0
6	5	0	0	0	0	1	0
7	2	0	1	0	0	0	0
8....	2	0	0	0	0	0	0
....64	etc.						

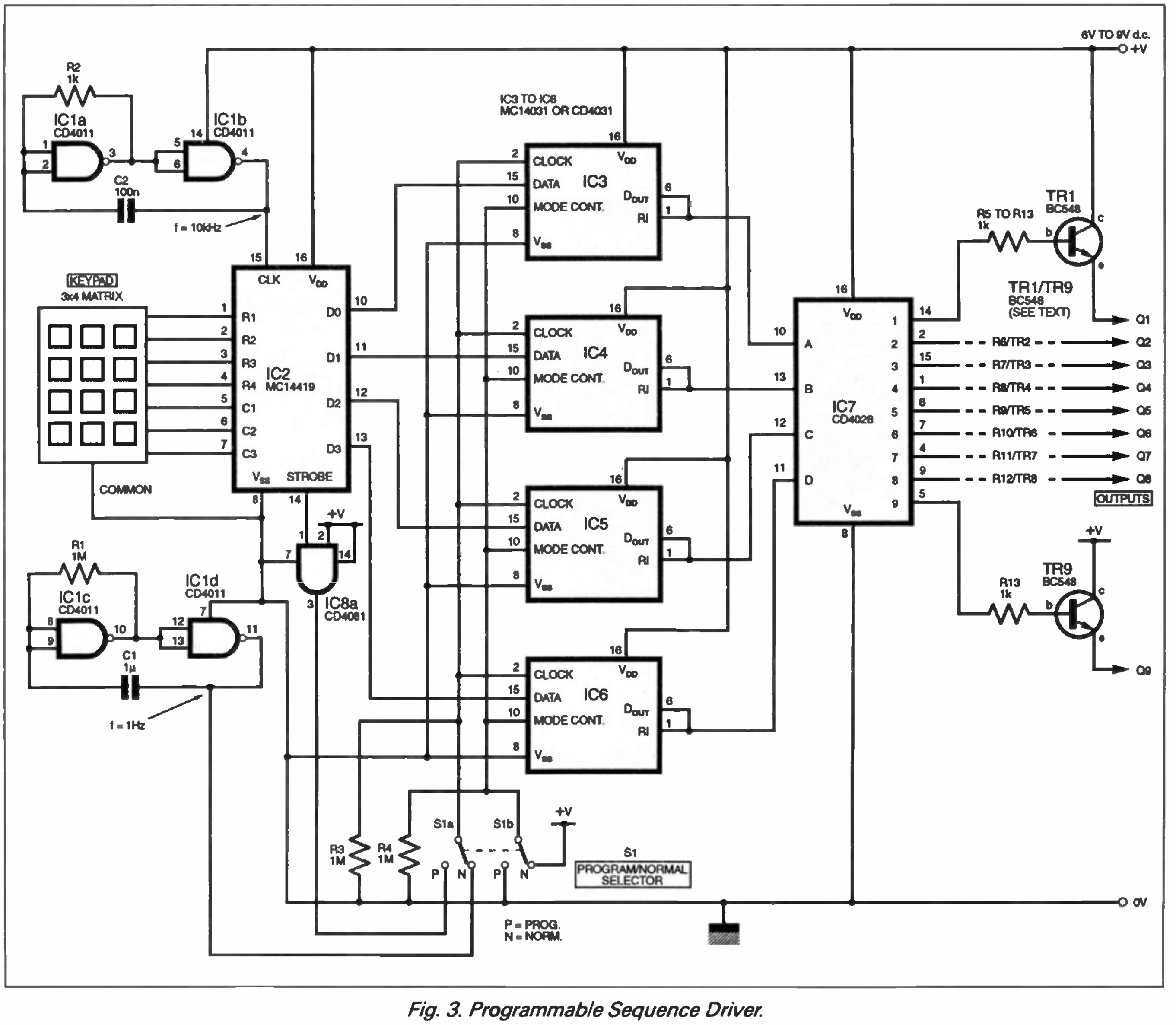


Fig. 3. Programmable Sequence Driver.

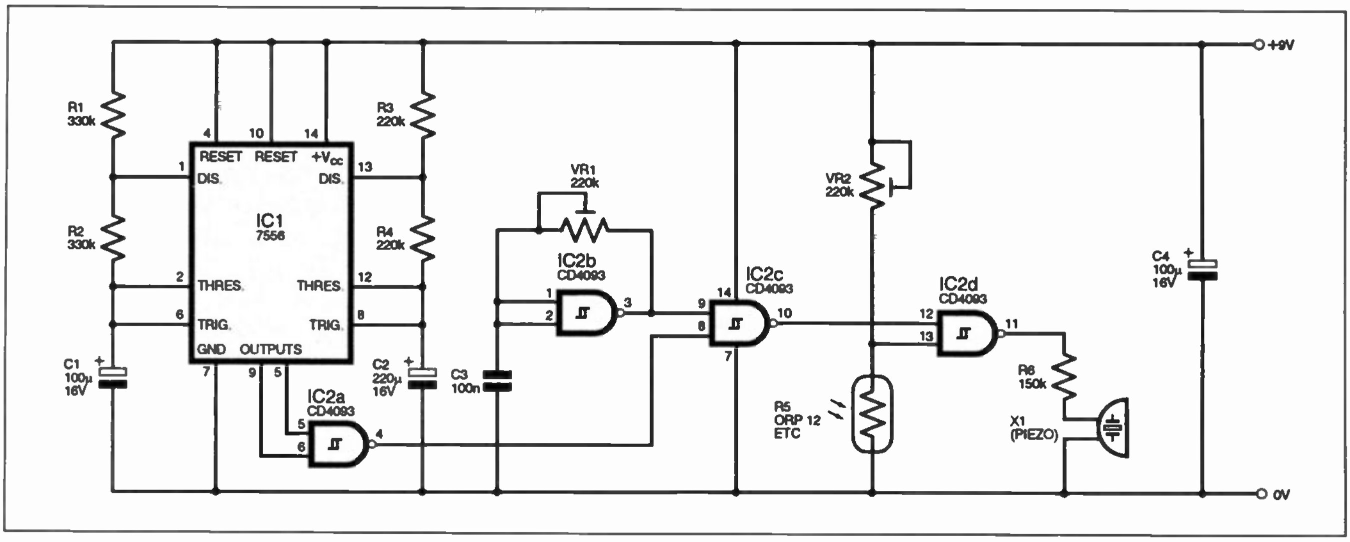


Fig. 4. Simple Mosquito Emulator with light sensitivity.

Mosquito Emulator – a gnatty design

WHILST there seems to be a glut of mosquito repellers in electronics magazines today, there is, alas, a dearth of mosquito *emulators* with which to impress (or annoy) your friends. (*Yes, we've got a Mosquito Repeller too, lined up for a future* Ingenuity Unlimited . . . *! A.R.W.*)

The novel design in Fig. 4 mimics the action of mosquitoes in every way – apart from their bite! My Mosquito Emulator reproduces the familiar "whine" of this pesky pest. Also, real mosquitoes tend to land as soon as a light is switched on – this circuit design imitates this frustrating habit, too!

In Fig. 4, IC1 is a dual CMOS version of the 555 timer, whilst IC2 is a 4-gate NAND Schmitt trigger. IC1 produces two slow square waves at pins 5 and 9, which are mixed through IC2a to produce a pseudo-random "beat" timing for the mosquito's pattern of hovering and rest. IC2b oscillates to reproduce the mosquito's "whine", the pitch of which may be tuned by adjustment of preset VR1. The whine is mixed with the beat timer output by gating it with IC2c.

The sound effect is generated by X1, a piezo sounder with resistor R6 reducing the volume. Finally, IC2d acts as a light-sensitive switch which gates the mosquito whine effect. When light falls on the light dependent resistor (l.d.r.) R5, this silences the mosquito. Preset VR2 adjusts the sensitivity of the photocell circuit.

Note that following switch-on, there will be about a minute's silence, after which the Mosquito Emulator is ready for deployment to the eternal frustration of any nearby victims: it was used to great effect on my poor aged father, who hunted in vain for this elusive electronic mosquito! (*I wonder if it will work on Ed . . . ? A.R.W.)*

Rev. Thomas Scarborough,
Cape Town, South Africa.

Switchable Sub-Woofer – cross talk

THE circuit diagram shown in Fig. 5 allows simple in and out switching of a "sub-woofer" loudspeaker in a studio monitoring situation. A standard d.p.d.t. switch is used for S1. (One channel only is shown.) Note the *polarity* of the speakers plus the fact that *non-polarised* capacitors are used.

The combination of the crossover slopes with the unit's roll-offs gives an approximate response of 18dB per octave. The crossover frequency is approximately 100Hz with the values shown.

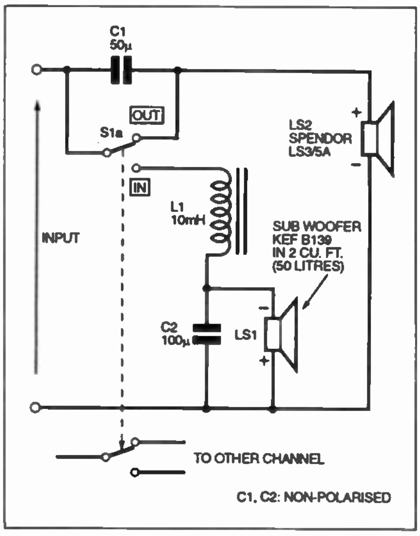


Fig. 5. Sub-woofer switching.

Fuse protection of speakers – speaking out

AN ACCEPTED method of protecting a loudspeaker is to insert a fuse in the amplifier output. The problem with doing this is that the resistance of the fuse is modulated by a combination of high currents and low frequencies. Secondly, the fuse can only protect the "bass driver" because most "tweeters" (high frequency speakers) blow at around 200mA.

The circuit of Fig. 6 eliminates the problems by inserting protection fuses *after* the crossover network. Putting the bass fuse FS1 *before* the low-pass filter means that the distortion harmonics are filtered out. The mechanical roll-off of the woofer also helps.

The additional 200mA "quick-blow" fuse FS2 for the tweeter is placed *after* the high-pass filter so that there are no low frequencies present to cause thermal modulation.

Jake Rothman
Bristol

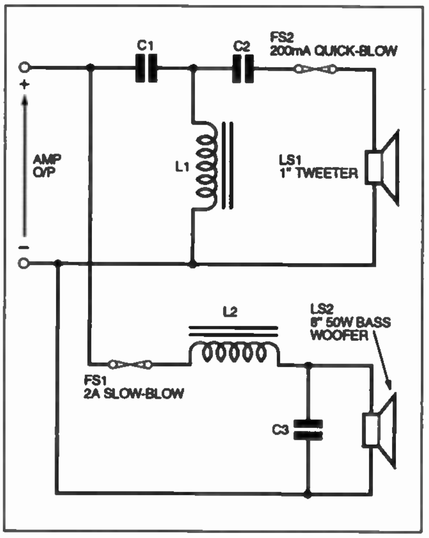
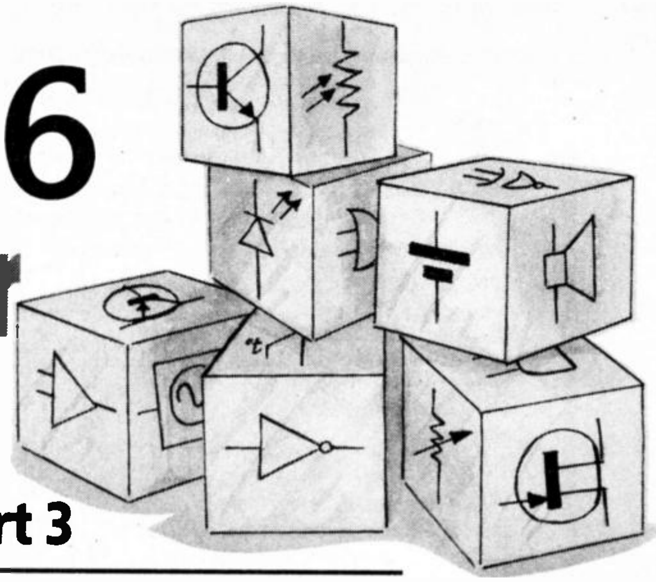


Fig. 6. Fuse protection of loudspeakers.

TEACH-IN '96

A Guide to Modular Circuit Design



Max Horsey

Part 3

DURING this series of articles, a range of circuit modules is examined, divided into Input, Processor and Output sections. Where possible a choice of module is offered within each section.

Each of the ten Parts of the Series is accompanied by a constructional article explaining how a complete project may be devised by employing the modules described, together with a p.c.b. design. Each project will be one of many possible ideas that could be implemented and it is hoped that readers will design for themselves a variety of circuits by combining modules provided in the whole series.

The proposed range of modules covered by the Series is detailed in Part 1, Table 1.1. Each module is chosen to link easily with adjacent modules in the same Part, but modules may also be linked with modules in other Parts of the Series.

Max Horsey is Head of Electronics at Radley College.

Here in Part Three, the modules to be examined are:

INPUT MODULES: Switches, touch sensors, moisture sensors

PROCESSOR MODULES: Latching circuits based on: relays, thyristors, and logic gates

OUTPUT MODULES: Motor speed control, motor direction control

The example project based around a selection of these modules is the Automatic Camera Panning System, designed to cause a security camera to pan continuously, the speed and extent of pan being controlled by the circuit.

CIRCUIT DIVISION

First, a reminder of how modules are combined to make a complete circuit:

Each module can be considered as a block, as shown in *Teach-In* Part 1, Fig. 1.1.

Select the modules required, join their positive rails together, join their 0V rails together, and link the output of one module to the input of the next to make the finished circuit diagram.

SWITCH INPUT MODULE

Two circuit examples of using a normally-open switch are shown in Fig. 3.1:

a. When switch is pressed, output changes from 0V to positive
b. When switch is pressed, output changes from positive to 0V

Any type of normally-open switch can be used, e.g. a normal pushswitch with push-to-make contacts, under carpet pressure mat, tilt switch, vibration switch etc.

Note: Several normally-open switches may be connected in parallel.

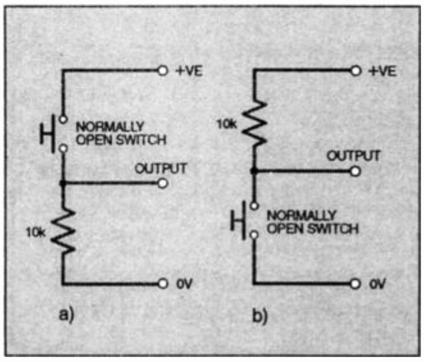


Fig. 3.1. Two ways normally-open switches can be used as triggers.

Two circuit examples of using a normally-closed switch are shown in Fig. 3.2:

a. When switch is pressed, output changes from 0V to positive
b. When switch is pressed, output changes from positive to 0V.

Note: Several normally-closed switches may be connected in series.

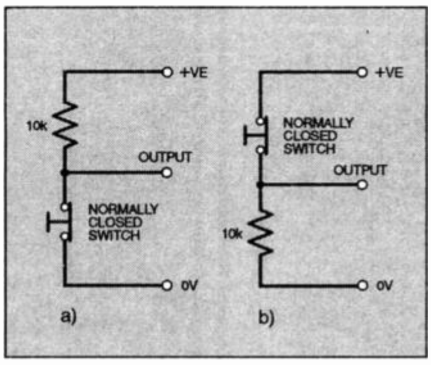


Fig. 3.2. Two ways normally-closed switches can be used as triggers.

TOUCH SENSING INPUT MODULE

Two examples of touch-pad switches are shown in Fig. 3.3. Their operation is similar to the circuits in Fig. 3.1.

a. When touch pads are bridged by a finger, output voltage rises
b. When touch pads are bridged by a finger, output voltage falls

The touch contacts can be produced using a pair of drawing pins, or by drilling small holes in the case and twisting a pair of bare tinned copper wires through the holes. It is important that the contacts do not become wet, and they should not be sprayed with silicon polish etc. A small piece of stripboard (Veroboard) may also be used, although in time the copper surface will corrode.

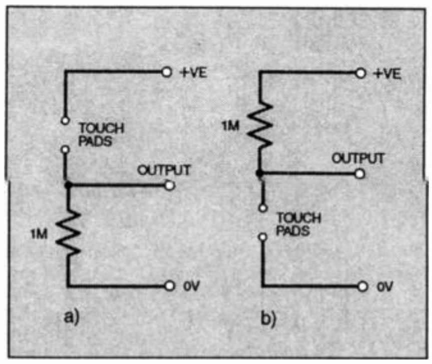


Fig. 3.3. Using touch pads in place of normally-open switches.

WATER SENSING INPUT MODULE

Two circuits which sense the presence of water are shown in Fig. 3.4.

a. When water is added to container, output voltage rises
b. When water is added to container, output voltage falls

The sensitivity of the circuit is adjusted by means of the variable resistor.

The diagrams imply that a pair of wires is used to sense the water. In practice, one wire can be placed at the bottom of the container and the other wire used to detect the correct level. The sensing wire may be fastened inside an empty ballpoint pen casing for a neater finish.

Soil moisture sensing may be achieved by pushing a pair of nails into the soil. If

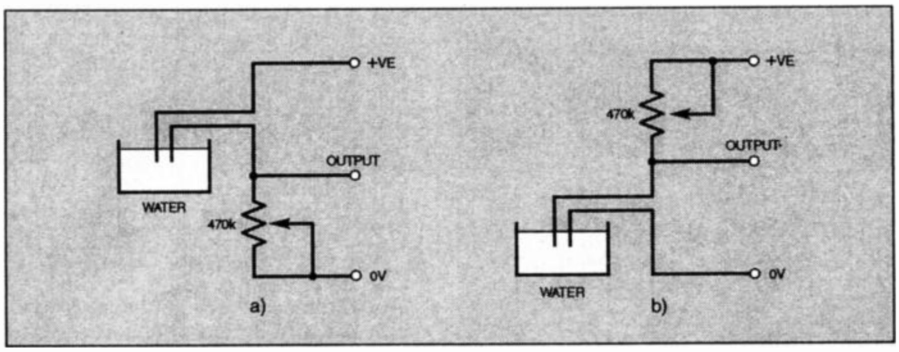


Fig. 3.4. Two circuits which sense the presence of water.

trying to solder wires to the nails, note that a very large amount of heat will be required to ensure a sound joint. Most ordinary soldering irons will not cope.

A piece of stripboard (Veroboard) may be used for rain detection, since the drops of water will bridge the gaps between the copper strips, so allowing current to flow. This idea is not recommended for general water sensing, since the gaps remain wet for a long time afterwards.

After a long period of time the process of electrolysis will cause a transfer of copper from one wire (or probe) to the other. The problem can be reduced by ensuring that the current flowing is small, and by using reasonably thick wires.

An integrated circuit (i.c.) type LM1830N is available which produces an alternating current for the sensing probes. The alternating current ensures that there is no longer a flow of copper in one single direction from probe to probe.

The i.c. represents a much more expensive option and is not particularly straightforward when compared with the method above. However, it should be considered if the probes are under water for most of the time (for example, if required to detect low water level) and are in use for a very long period.

LATCHING PROCESSORS

Four types of Processor Module are offered, all providing a latching action:

1. Relay
2. Thyristor
3. Logic OR gate
4. Logic gate bistable

RELAY LATCHING CIRCUIT

The relay as an Output device was met in Part 1 of this Series. In the latching context here in Part 3, the relay may be used both as a Processor and Output device.

Electronics has progressed so rapidly that some readers will not have used relays as processors, yet not long ago many telephone exchanges were packed with relays, sorting and directing the calls. Many people will still remember telephone calls with an irritating background of crackling sounds caused by dust in the relay contacts.

Modern sealed relays work very well, and if a single latching circuit is required with a high output current, a relay may well provide the solution. Note that in this application as described here, a relay with two sets of contacts is required.

How a relay coil (represented by the rectangular box) is energised by a push-to-make switch is shown in Fig. 3.5a. Once energised the two sets of contacts close. One set of contacts is connected in parallel with the push-to-make switch. If the switch is released, current can still flow via the first set of contacts – in other words the relay is now latched on. The second set of contacts can be used to switch on a lamp, motor etc.

The relay may be unlatched by simply switching off the power supply. Alternatively, a push-to-break switch may be connected as shown in Fig. 3.5b. This is one of several positions at which the push-to-break switch may be placed. Try to spot the others!

TRANSISTOR DRIVER CIRCUIT

In Part 1 of the Series, a transistor/relay combination was discussed and illustrated as an output module (Fig. 1.13c). The circuit diagram in Fig. 3.5c shows how the combination can be modified so that the relay can be latched. The first pair of relay contacts are connected across the collector (c) and emitter (e) of the transistor. The

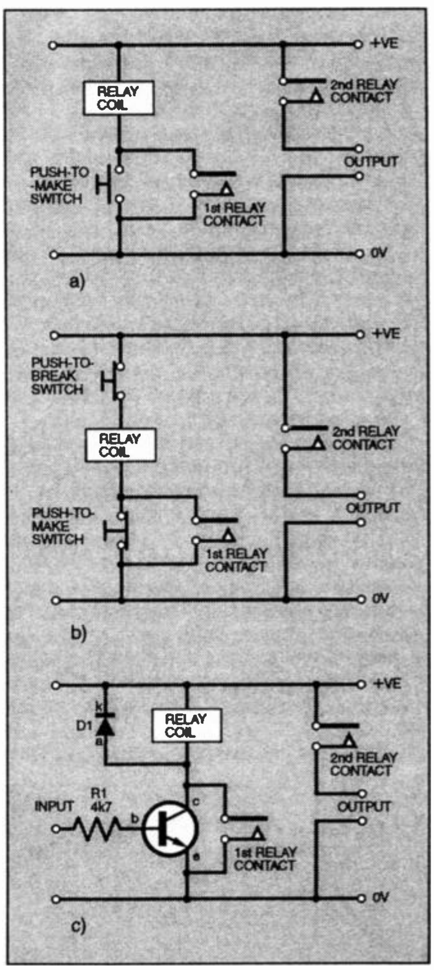


Fig. 3.5. Latching relay circuits (a) basic circuit; (b) with unlatching switch; (c) with transistor.

series resistor R1 should be in the region of 2k to 5k (kilohms), and a typical transistor would be a BC108, BC184L, BC549 or similar.

Check that the current required by the relay coil does not exceed the maximum allowed via the collector of the transistor. If in doubt, use a Darlington transistor such as type TIP121 or TIP122, as discussed in Part 1 (Fig. 1.13b).

Note the inclusion of the diode, D1, required to reduce the back-e.m.f. (high voltage spikes) produced by the relay coil, which might otherwise damage the transistor.

The circuit may be unlatched by the push-to-break switch method shown in Fig. 3.5b.

To sum up the three latching relay circuits in Fig. 3.5:

ADVANTAGES:

Positive clear switching action
Involves little electronics
Combines the latching process with a high current output

DISADVANTAGES:

Not easy to unlatch electronically
The smallest relays are large when compared with other devices
Relays are relatively expensive
Relay contacts may eventually wear out
Not an elegant option if complex setting/resetting is required

THYRISTOR LATCHING CIRCUIT

The circuit diagram shown in Fig. 3.6 is particularly straightforward, since it is based on a single device – a thyristor, sometimes called a silicon controlled rectifier (SCR). Like a transistor, a thyristor has three connections, the anode (a) (equivalent of the collector), the cathode (k) (equivalent of the emitter), and the gate (g) (equivalent of the base).

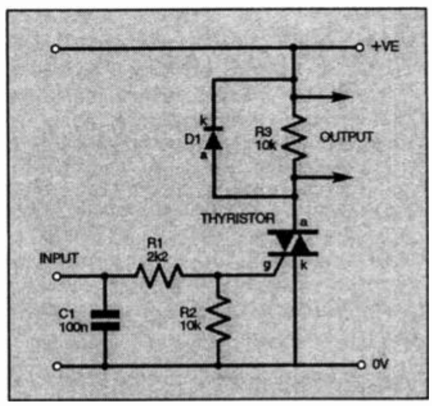


Fig. 3.6. Thyristor latching circuit.

A small current starting to flow into the gate will cause the thyristor to switch on, but unlike a transistor, once triggered the thyristor remains switched on, i.e. it remains latched.

It can be unlatched by interrupting the flow of current through its anode/cathode path, e.g. by switching off the power supply, or by inserting a push-to-break switch between its anode and the positive power supply, equivalent to the technique shown in Fig. 3.5b. The circuit can therefore be thought of as a latching output circuit (i.e. Processor and Output combined).

The type of thyristor suggested is a C106 (or C106D) which, typically, can switch about 1·7 amps.

Thyristors can be triggered accidentally if suitable precautions are not taken, consequently capacitor C1 and resistor R2 are included to ensure that the thyristor is only triggered when the input is made positive deliberately.

Resistor R3 across the output ensures that once triggered, a minimum current always flows into the anode even if the output device (e.g. a motor) causes the output current to fluctuate. Such fluctuations can make the thyristor unlatch accidentally.

Diode D1 removes high voltages which electromagnetic devices such as motors and relays generate. It can be omitted if the output load consists only of lamps or light emitting diodes (l.e.d.s).

To sum up the thyristor latching circuit in Fig. 3.6:

ADVANTAGE:
Simple and inexpensive

DISADVANTAGES:
Not easy to unlatch electronically
A rather crude device in this context

It would be doing the thyristor an injustice to imply that the module provided in Fig. 3.6 represents its main application. In fact the thyristor and its close relative, the triac, are used mainly in a.c. power control, such as in mains lighting dimmers, for example.

LOGIC GATE LATCHING CIRCUITS

The circuits described in this section are based on the CMOS 4000 series and use logic gates which have two inputs and one output.

The first is an OR gate (e.g. type 4071B). Note that the i.c. contains four gates, but only one is required in this circuit. All unused inputs must be connected to 0V (or positive if more convenient). The pin layout is shown in Part 1, Fig. 1.14.

CMOS logic NOR gates were examined in Part 1 (Fig. 1.9 to Fig. 1.11), but both inputs were connected together, making the gates behave as simple buffers or inverters. To understand how the output depends upon the two inputs controlled separately, a truth table may be used.

For simplicity here, logic 1 is taken to mean that the voltage is "high", i.e. close to the positive supply voltage, and logic 0 is taken to mean that the voltage is "low", i.e. close to 0V. (Logic-level voltages were discussed in more detail in Part 1.)

The truth table for an OR gate is shown in Fig. 3.7.

INPUT A	INPUT B	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	1

Fig. 3.7. OR gate truth table.

The table shows all possible combinations of input logic levels (i.e. 00, 01, 10, 11), and that if *both* inputs are at logic 0, the output is also at logic 0, but if *either* input is changed to logic 1, so does the output. In other words, a logic 1 at input A, OR at input B produces a logic 1 at the output.

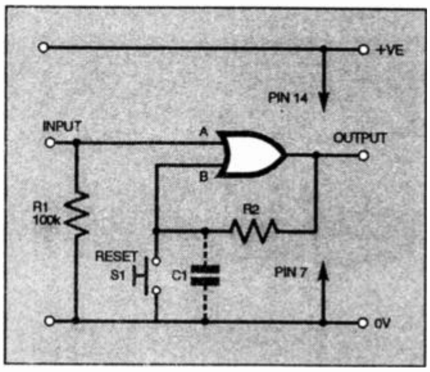


Fig. 3.8. Latching OR gate circuit.

LATCHING OR GATE

The circuit diagram for a latching OR gate is shown in Fig. 3.8. Resistor R2 connected from the output back to input B causes the latching action.

If input A is set to Logic 1 (by a switch connected to the positive rail, for example) then the output will switch to Logic 1, so setting input B to Logic 1. Even if input A returns to Logic 0, the gate will remain latched with its output at Logic 1.

Note that CMOS i.c. inputs must never be left "floating", i.e. not connected to anything. In this instance, it is input A which must be protected against being unconnected. Consequently, the "tie down" resistor R1 is included. It holds the input at Logic 0 unless a Logic 1 signal is received.

If the input is *directly* connected to another module (without a capacitor in series with the signal path between the two modules), or to the output of another gate, then R1 may be omitted.

The value of the feedback resistor R2 is not critical and any value from say 10k to 1M ohms is suitable. The resistor can be replaced by a wire link if the "reset" facility is not required. Pressing the push-to-make reset switch S1 forces a Logic 0 level onto input B. Providing that input A is also low at the same time that S1 is pressed, the output will return to Logic 0.

When power is first connected to the circuit, the outputs may latch positive, even if input A is at 0V. This can be avoided by adding a small value capacitor (C1) in parallel with the reset switch, S1. The capacitor will ensure that the circuit always starts up with the output at Logic 0. A typical value would be 100nF (0·1µF).

The reset switch can be omitted if not required, in which case capacitor C1 *must* be included for correct operation of the circuit.

LATCHING NOR GATE

An OR gate makes an effective simple latch, but sometimes it may be more convenient to use two NOR gates for the purpose. (There are i.c.s specifically designed for latching purposes, but this will not be discussed here.) A NOR gate truth table is shown in Fig. 3.9.

Note that the output logic of the truth table is the exact opposite of that for the OR gate. Note also that if both inputs are connected together, then they are either both at Logic 0, producing an output of Logic 1, or both at Logic 1, producing an output of Logic 0. In other words, the gate acts as an inverter (or NOT gate).

INPUT A	INPUT B	OUTPUT
0	0	1
0	1	0
1	0	0
1	1	0

Fig. 3.9. NOR gate truth table.

The latching circuit which can be produced by using two NOR gates is shown in Fig. 3.10.

Note that the second NOR gate, IC1b, is used as an inverter and the whole circuit acts in the same way as the latching OR gate of Fig. 3.8. Again, the value of feedback resistor R2 is not critical and any value from 10k to 1M ohms is suitable.

The use of capacitor C1 is the same for the circuit of Fig. 3.8.

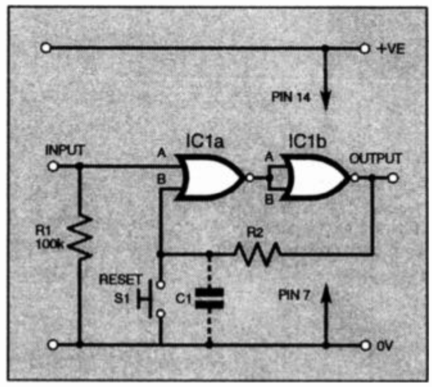


Fig. 3.10 Latching NOR gate circuit.

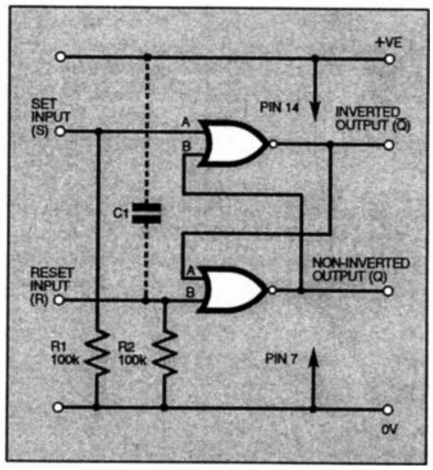


Fig. 3.11 Bistable latch circuit.

BISTABLE LATCH

An alternative latching circuit using two NOR gates is shown in Fig. 3.11. Its latching action is less obvious than in the previous design of Fig. 3.10, but it is generally considered to be a more professional arrangement. Its action is as follows:

When Logic 1 is briefly applied to the Set input, the non-inverted output switches from Logic 0 to Logic 1.

When Logic 1 is briefly applied to the Reset input, the normal output switches back to Logic 0.

The inverted output does the exact opposite of the non-inverted output.

Note that the Set and Reset inputs are connected to 0V via resistors R1 and R2. In practice, their values are not important and can range between 10k and 1M ohms. The resistors may be omitted if the Set/Reset inputs are directly connected to another module.

When the power supply is first connected the circuit may start up with the outputs in either state. To ensure that the circuit always starts up with the non-inverted output at Logic 0, capacitor C1 may be connected between the positive rail and the Reset input. A typical value would 100nF (0.1µF).

This will cause a positive pulse to be applied to the Reset input at the moment when power is first connected. This is another example of "a.c. coupling" which was discussed in Part 2 (Fig. 2.5).

MOTOR DIRECTION OUTPUT MODULES

Two Output modules are offered for controlling the direction of d.c. motors:

a. Based on a relay
b. Based on transistors

RELAY MOTOR CONTROL

Any d.p.d.t. (double-pole, double-throw) switch may be connected as shown in Fig. 3.12 to control a motor or any device where the polarity of the supply needs to be reversed. With the relay coil "off" the motor will rotate in one direction, and in the other when the relay coil is "on". Whatever the state of the coil, the motor will always be in motion since no master switch is included.

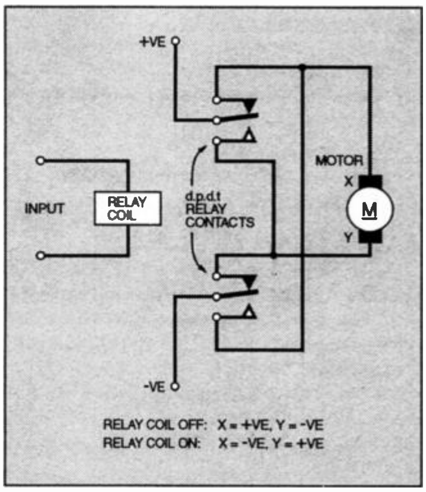


Fig. 3.12. Relay controlled motor.

It should be appreciated that the use of this simple circuit in a practical situation is not really desirable since switching the relay whilst the motor is in motion will cause undue wear and also waste current.

Another relay or a Darlington pair (see Part 1, Fig. 1.13c and Fig. 1.13b, respectively) could be used in addition to the relay reversing circuit of Fig. 3.12 to switch the motor on and off.

Note that the connection labelled as −VE in Fig. 3.12 could be the 0V rail as usual. Alternatively, if the Darlington pair of Fig. 1.13b was used then the −VE point would be connected to the collector (c) of the Darlington.

When selecting the relay, ensure that it has d.p.d.t. contacts, and that they are capable of carrying the current used by the motor. The relay coil must have a voltage rating roughly equal to the circuit supply voltage.

To sum up the relay motor control circuit of Fig. 3.12:

ADVANTAGES:

Straightforward circuit
No p.c.b. or stripboard required

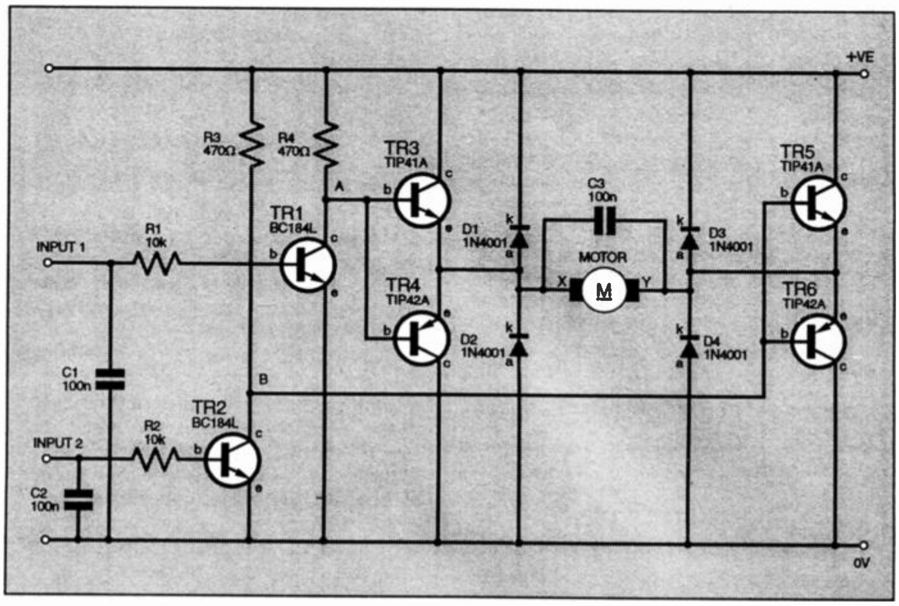


Fig. 3.13. Transistorised motor direction control circuit.

DISADVANTAGES:

Contacts may wear, particularly if the relay is switched whilst the motor is running
Needs a separate motor on/off circuit
Wastes current if relay remains energised when motor is off

TRANSISTORISED MOTOR CONTROL

The circuit in Fig. 3.13 shows how transistors may used to change the rotational direction of a motor. Control of the circuit may be by switches or from the outputs of logic i.c.s.

To understand this circuit it is necessary to understand the difference between *npn* and *pnp* transistors. Transistors TR1, TR2, TR3 and TR5 are *npn* types. Each acts like a switch in this circuit, and conducts (i.e. current flows from collector to emitter) when its base is raised to about 0·7V *above* its emitter voltage. Transistors TR4 and TR6 are *pnp* types, and each switches on when its base is held at about 0·7V *below* its emitter voltage.

If Input 1 is held at Logic 1 and Input 2 held at Logic 0, transistor TR1 is switched on, causing the voltage at point A to fall to 0V. Therefore the bases of TR3 and TR4 are held at 0V, making TR3 switch off, and TR4 switch on. The voltage at point X is therefore at 0V.

Meanwhile, TR2 is switched off (remember that Input 2 is at 0V), therefore the voltage at point B is positive due to the action of resistor R3. Since the bases of TR5 and TR6 are connected to point B, TR5 is switched on, and TR6 switched off. Hence current flows via TR5 to point Y, through the motor and down to 0V via TR4.

With Input 1 at Logic 0 and Input 2 at Logic 1, the result is that point X is positive and point Y is at 0V.

The control logic is thus:

Both inputs at Logic 0 – motor stops (X = +VE, Y = +VE)

Input 1 only is at Logic 1 – motor moves forward (X = 0V, Y = +VE)

Input 2 only is at Logic 1 – motor reverses (X = +VE, Y = 0V)

Both inputs at Logic 1 – motor stops (X = 0V, Y = 0V)

Transistors TR1 and TR2 both have base resistors (R1 and R2) to limit the flow of current into each base. The capacitors, C1 and C2, at the inputs help to remove any minor voltage spikes which may cause trouble. The four diodes, D1 to D4, remove back-e.m.f. generated by the motor, which could otherwise destroy the transistors.

Capacitor C3 connected in parallel with the motor removes voltage spikes which may be generated across the motor. In many cases the motor will be connected via long wires, in which case it is helpful to connect a second capacitor (say 100nF) across the motor connections, as close to the motor as possible.

Any high gain *npn* transistors may be used for TR1 and TR2. The power transistors suggested will allow the use of motors requiring an amp or more. They may require heatsinks (i.e. pieces of metal attached to their metal tabs and designed to prevent overheating); if in doubt experiment.

To sum up the motor control circuit of Fig. 3.13:

ADVANTAGES:

Provides on/off and reversing action
Requires little control current
Easy to drive from logic i.c.s
A more professional approach

DISADVANTAGE:

More complicated than the relay alternative

VARIABLE RESISTANCE

The variable resistance circuit shown in Fig. 3.14 shows a simple way of controlling a voltage or current, and hence the speed of a motor or the brightness of a lamp. It is a circuit which beginners are often tempted to use because of its apparent simplicity.

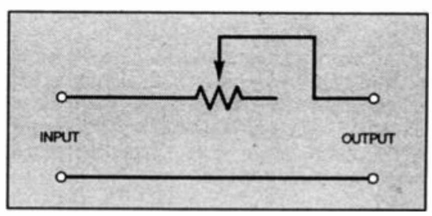


Fig. 3.14. Variable resistance circuit.

Indeed, before the introduction of power transistors, triacs, regulators etc., this arrangement was used regularly for voltage and current control, such as in stage light dimmers. The problem was that at low brightness settings, the power not used by the lights had to be dissipated in the variable resistor. Hence the resistor was very large and became very hot.

A second problem is that the output voltage depends upon the amount of resistance and the current flowing (remember Ohm's Law?). Therefore the actual voltage at the output is fairly unpredictable unless the variable resistor is used only with a particular lamp or motor.

To sum up the variable resistance control circuit in Fig. 3.14:

ADVANTAGE:
Simple

DISADVANTAGES:
High power variable resistors are required, making them large and expensive
Unpredictable voltage output
The output cannot be reduced to 0V

POTENTIOMETRIC CONTROL

In the circuit diagram of Fig. 3.15 is shown a potentiometer with all three terminals in active use. In this configuration the output voltage will vary from 0V to the full input voltage as the wiper (represented by the arrow) is moved up (as seen in the circuit).

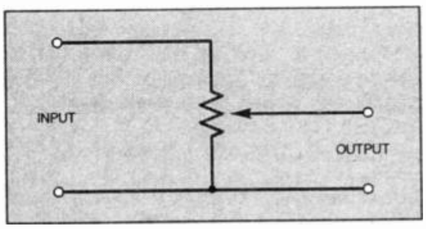


Fig. 3.15. Potentiometer circuit.

In theory, for a given input voltage, the output voltage is precisely related to the position of the wiper. In other words, if the potentiometer has a linear action (as opposed to a logarithmic action) and the wiper is exactly half way up, the output voltage will be half that of the input voltage – *providing no current is allowed to flow from the wiper!*

Since the whole purpose of the circuit is to provide voltage *and* current, a compromise is adopted whereby current *can* be drawn via the wiper, providing it is ten times less than the current flowing from one end of the potentiometer to the other. The output voltage will then be roughly the expected value.

Unfortunately, a motor or lamp will require an appreciable current. For example, if it requires a current of 0·5A there would be a need for a potentiometer with a total resistance allowing a current of 5A to flow through it. Not only would an enormous and expensive potentiometer be required, but the continuous flow of current would represent an unacceptable waste of energy.

The potentiometer control method is therefore only suitable for small current work, such as a tone control in an amplifier.

To sum up the potentiometric control circuit of Fig. 3.15:

ADVANTAGES:
Provides a more stable, predictable output voltage
The output can be reduced to 0V

DISADVANTAGE:
Suitable for small currents only

PERFECT SOLUTION

The potentiometer circuit of Fig. 3.15 would provide the perfect solution to the problem of motor speed (or lamp brightness) control if only the available current could be increased. Modern transistors make this relatively easy!

The circuit diagram in Fig. 3.16 shows how an *npn* transistor can be used to amplify the current available from the wiper of the potentiometer. In this circuit, the output voltage is controlled by the position of the potentiometer's wiper, and there is an output current available at the transistor's emitter (e) equal to the current flowing from the wiper into the transistor base (b) times the transistor's gain factor.

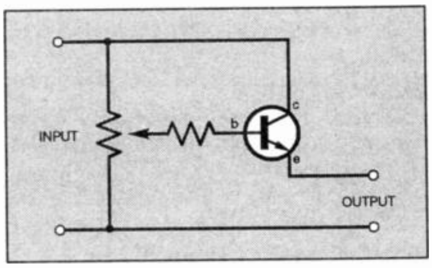


Fig. 3.16. Transistor-buffered potentiometer control circuit.

Note, though, that the base of an *npn* transistor always tries to be 0·7V above its emitter. Or to put it another way, if the base voltage is controlled as in Fig. 3.16, the emitter always tries be 0·7V less. Consequently, the output voltage can only range from 0V to the maximum of the input voltage, less 0·7V.

The fixed resistor in series with the transistor's base limits the current to a safe maximum when the potentiometer wiper is moved up towards the full input voltage position.

Problems may still be posed by the circuit, however. A transistor with a large enough power and current capability will have a rather low gain. What is needed is a transistor with a high current capability and a high gain.

The solution was discussed in Part 1 – the Darlington pair (Fig. 1.13b). In other words, two transistors, the first to provide high gain, the second to provide high current. It is more convenient to purchase the transistors housed in a single package, which looks like a single power transistor.

It is important, though, to remember that two transistors are involved in a Darlington package, since the emitter (of the second transistor) will try to be 1·4V less than the voltage at the base of the first transistor.

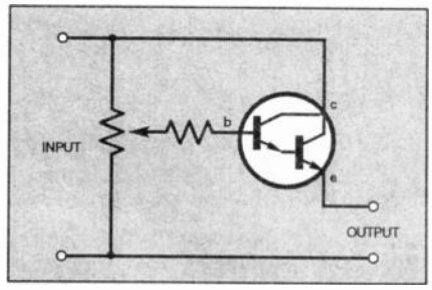


Fig. 3.17. Using a Darlington transistor to buffer a potentiometer output.

The circuit arrangement using a Darlington pair is shown in Fig. 3.17. Typical component values are a 10k linear potentiometer, 1k fixed resistor and a TIP121 or TIP122 Darlington transistor. If separate transistors are preferred, these could be a type BC184L or similar small signal high gain transistor, followed by a TIP41A power transistor.

To sum up the voltage control circuits of Fig. 3.16 and Fig. 3.17:

ADVANTAGES:
Output voltage is set precisely by the potentiometer
Output voltage can be reduced to 0V
Output voltage does not vary appreciably with the output current
Output current can be several amps – depending on the chosen transistors
A small inexpensive potentiometer is used

DISADVANTAGE:
Maximum output voltage is less than the input voltage

ALTERNATIVES

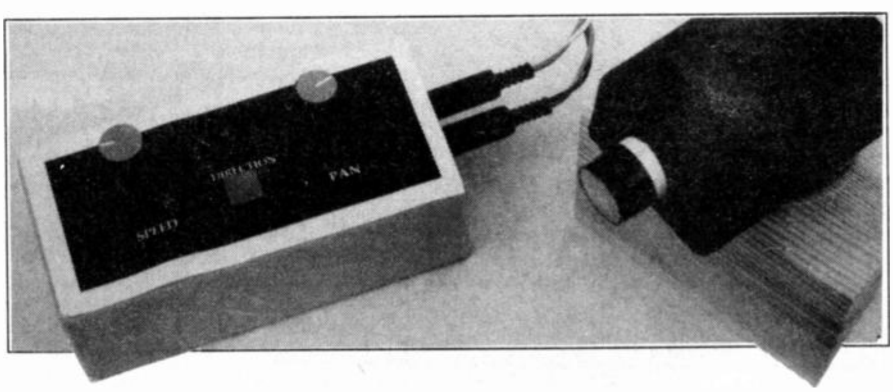
Even more precise control of voltage is possible using modem voltage regulator i.c.s. The range is so wide that readers are advised to browse through a good catalogue if this type of control is necessary. However, most variable voltage i.c.s will not allow the output to be reduced to 0V. This can be a considerable disadvantage in motor or lamp brightness control.

PART FOUR

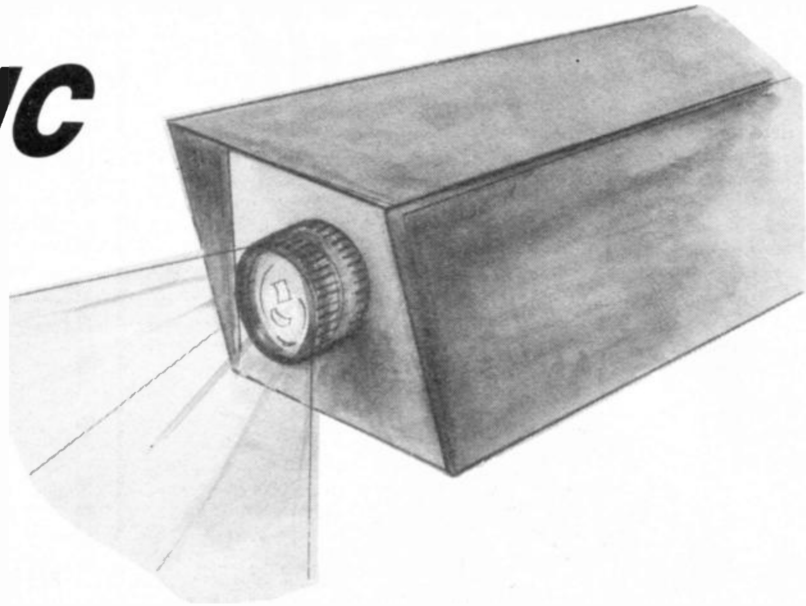
The modules to be examined in *Teach-In* Part 4 are astables, decade counter and chaser, l.e.d. series resistance, and the example project is a Vari-speed Dice.

EXAMPLE PROJECT

The Automatic Camera Panning System is the example project (elsewhere in these pages) which shows how the modules in *Teach-In* Part 3 can be combined in a practical application.



AUTOMATIC CAMERA PANNING SYSTEM



MAX HORSEY
PCB DESIGN BY ALEX SIMM

Build an automatic panning circuit and increase your surveillance range. Illustrates how Teach-In Part Three might be applied.

BASED on the information provided in *Teach-In* Part 3, this article shows how modules may be selected and combined to produce a working project.

The project described enables a security camera to pan automatically. The speed and extent of pan are both controllable from the circuit, making it particularly suitable for remote operation. Only one switch is required to sense the camera position.

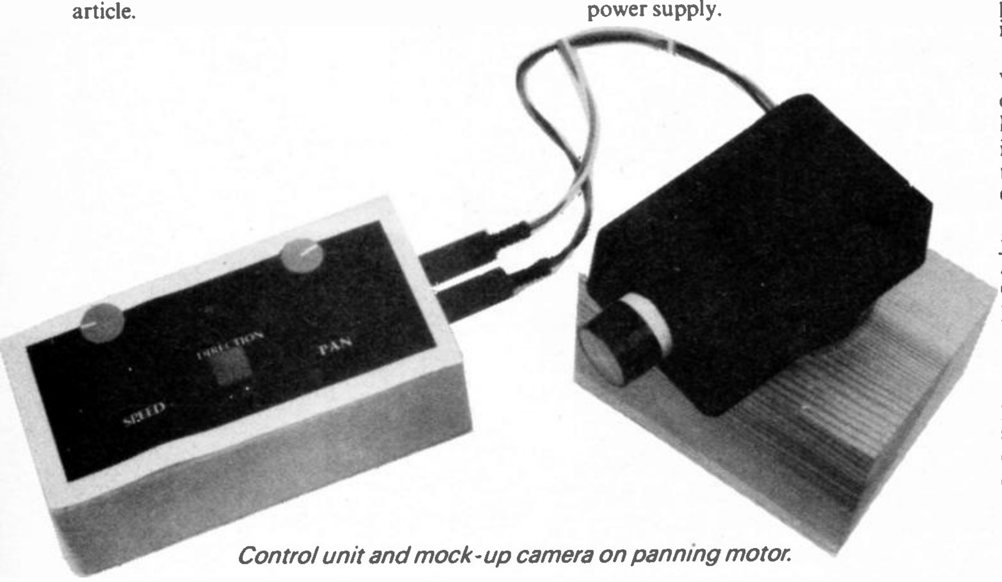
It is a circuit suitable for use with many devices which require a controlled reciprocal movement.

Throughout this article, figure numbers of the style Fig. 3.1, Fig. 3.2 etc., refer to drawings having the same number in *Teach-In* Part 3. Other figure numbers, e.g. Fig. 1, Fig. 2, etc., refer to drawings in this article.

DESIGNER SPECS

As always, before beginning the design of a project, it is necessary to define its specification. In this camera panning application there are five essential design requirements:

1. A geared motor will control the camera position
2. The camera will pan continuously between limits set by the circuit
3. Both the panning angle and the speed are controlled by the circuit
4. A single microswitch will detect the centre of the pan
5. The system will operate on a 12V d.c. power supply.



Control unit and mock-up camera on panning motor.

BLOCK DIAGRAM

Once the design requirements have been listed, the block diagram for the system can be drawn, as shown in Fig. 1. To understand this particular block diagram, consider first the requirements of the motor and work backwards:

A d.c. motor is used since its rotation direction can easily be reversed by swapping over its power supply connections. The positive power rail of the motor direction circuit is supplied via the speed control module.

It is important that the motor is not reversed too quickly and a delay module allows the system to pause for a second or so before reversing. The delay module is buffered so that a clean logic level is supplied to the motor direction circuit.

The motor direction is determined by the status of a bistable. Feedback from each output of the delay unit is applied to its respective bistable input via an AND gate.

Examination of the NOR gate bistable in Fig. 3.11 shows that a positive pulse applied at the Set input (S) will cause the non-inverted output (Q) to latch high. A positive pulse at the Reset input (R) will cause the inverted output (NOT-Q) to latch high.

If output NOT-Q is fed back to input S via a two-input AND gate, then input S can only be triggered if output NOT-Q is high. Similarly, if output Q is fed back to input R via another two-input AND gate, then input R can only be triggered if output Q is high.

Consequently, each positive-going pulse jointly applied to the second inputs of both AND gates will cause outputs Q and NOT-Q to alternately switch between high and low.

TRIGGER PULSE

The system depends upon the trigger pulse at the joint input being brief, and the series capacitor Cx in Fig. 1 (a.c. coupling) ensures that this condition is met. Since the change of logic level at the outputs must not be reacted upon too quickly, feedback to the AND gates is taken after the delay module.

In the block diagram of Fig. 1, the monostable provides overall timing and hence the extent of the pan. At set points in the camera panning movement the microswitch is triggered, which in turn triggers the monostable. A description of various monostable modules was given in *Teach-In* Part 2.

The pulse length set by the monostable determines the time for which panning continues after the microswitch has been triggered. A longer pulse results in a wider pan, as shown in Fig. 2. This means that the width of pan is controlled entirely by the circuit and not by the more obvious method of using two fixed switches mounted on the camera support.

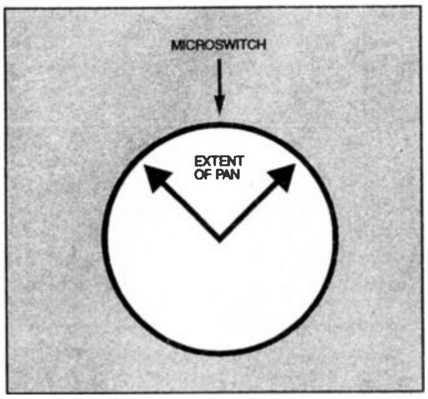


Fig. 2. Extent of pan in relation to microswitch position.

MAIN CIRCUIT

The full circuit diagram as expanded from the block diagram is shown in Fig. 3. The monostable is formed around two NOR gates, IC1a and IC1b. Its principle was discussed in *Teach-In* Part 2, Fig. 2.8.

IC1a input pin 1 is normally held at 0V via resistor R1, but if the microswitch S1 is pressed, pin 1 is switched to positive. Capacitor C1 removes any noise which may be induced into the (possibly long) leads which connect S1 to the circuit.

The monostable pulse length is set by capacitor C2 and the combination of potentiometer VR1 and resistor R2. The latter ensures that there is always some resistance even if VR1 is reduced to zero. The values shown provide a maximum time of about 33 seconds.

The "normal" output from the monostable (IC1b pin 4) goes high immediately the input is triggered, switching back to 0V after the timed period. However, for this application it is desirable to take the output from the first NOR gate of the pair, IC1a pin 3, which goes high at the end of the timed period.

In other words, the monostable is triggered by the microswitch, but a positive pulse is delivered to the bistable only after the monostable's timed period has elapsed.

At the end of the timed period, IC1a pin 3 switches high, and a positive-going pulse is generated across capacitor C3 and fed into the two AND gates IC2a and IC2b, at pin 1 and pin 6, respectively.

The principle of this type of pulse generation was discussed in *Teach-In* Part 2 (a.c. coupling – Fig. 2.5). Resistor R3 sets the pulse decay rate, and ensures that IC2 pins 1 and 6 are normally held at 0V. Diode D1 prevents the pins from becoming negative – a problem which could arise when IC1a output pin 3 switches from high back to 0V at the start of the timed period.

BISTABLE AND DELAY

The bistable consists of two cross-coupled NOR gates, IC1c and IC1d. The full description of the bistable and of the AND gates IC2a and IC2b was given in the discussion of the block diagram.

Following the bistable are the two delay circuits, formed around resistors R4 to R7, diodes D2 and D3, and capacitors C4 and C5. The circuits are identical, thus, for example, when IC1c output pin 10 switches from low (0V) to high, this change of voltage is delayed as C4 charges up via R4. The delay may be altered as required by substituting another value for C4.

The AND gate IC2c acts as a buffer and only changes its output state from low to high when the voltage on C4 reaches a threshold trigger level, about half the positive rail voltage (as discussed in *Teach-In* Parts 1 and 2). Using a buffer provides a cleaner output voltage swing, via current limiting resistor R8, for the base of transistor TR2.

When IC1c output pin 10 switches back to 0V, the charge on C4 decays as current flows via R4 and via D2 and R5. Since the value of R5 is much less than that of R4, the capacitor discharges much more quickly than it charged.

The operation of the delay circuit between IC1d and TR3 is identical and the net effect is that when the bistable outputs change state, the motor is switched off quickly. There is then a short pause before the motor starts rotating in the opposite direction.

MOTOR CONTROL

Basically, the motor direction control circuit is identical to that discussed for Fig. 3.13. However, the two input-smoothing capacitors in that circuit, C1 and C2, are not needed in this application and have been omitted.

If the camera is housed a long distance from the circuit, it may be helpful to include the optional light emitting diode (l.e.d. D8) to indicate which way the camera is panning. A bicolour l.e.d. is ideal, since it becomes red when the current flows in one direction, and green when colour flows the opposite way. When the motor is stationary, the l.e.d. is off. Resistor R13 limits the l.e.d. current and must be included.

Speed control for the motor is provided by the circuit around Darlington transistor TR1, potentiometer VR2 and resistor R10. This circuit is identical to that in Fig. 3.13.

Power supply decoupling is provided by capacitors C7 and C8. Both are essential in this type of circuit, where sensitive logic gates are working with an electrically noisy motor.

MANUAL DIRECTION CONTROL

The circuit is designed to operate unattended. However, there are occasions when manual control is useful. For example, when power is first applied this simple circuit has no way of knowing in which direction to drive the motor relative to the microswitch.

Consequently, pushbutton switch S2 has been included. Wired in parallel with microswitch S1, it provides manual control of the reversing action via the monostable. If S1 is disconnected, either by unplugging it, or by fitting another switch in series with S1, S2 can be used for full direction control

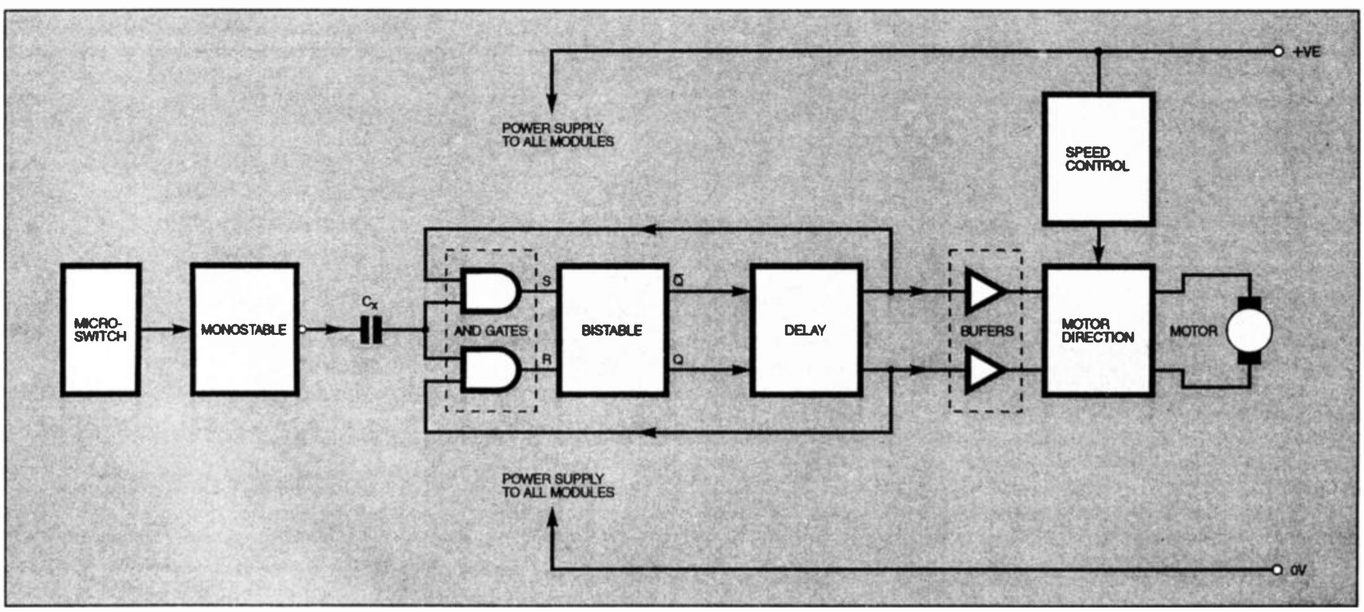


Fig. 1. Block diagram for the Automatic Camera Panning System.

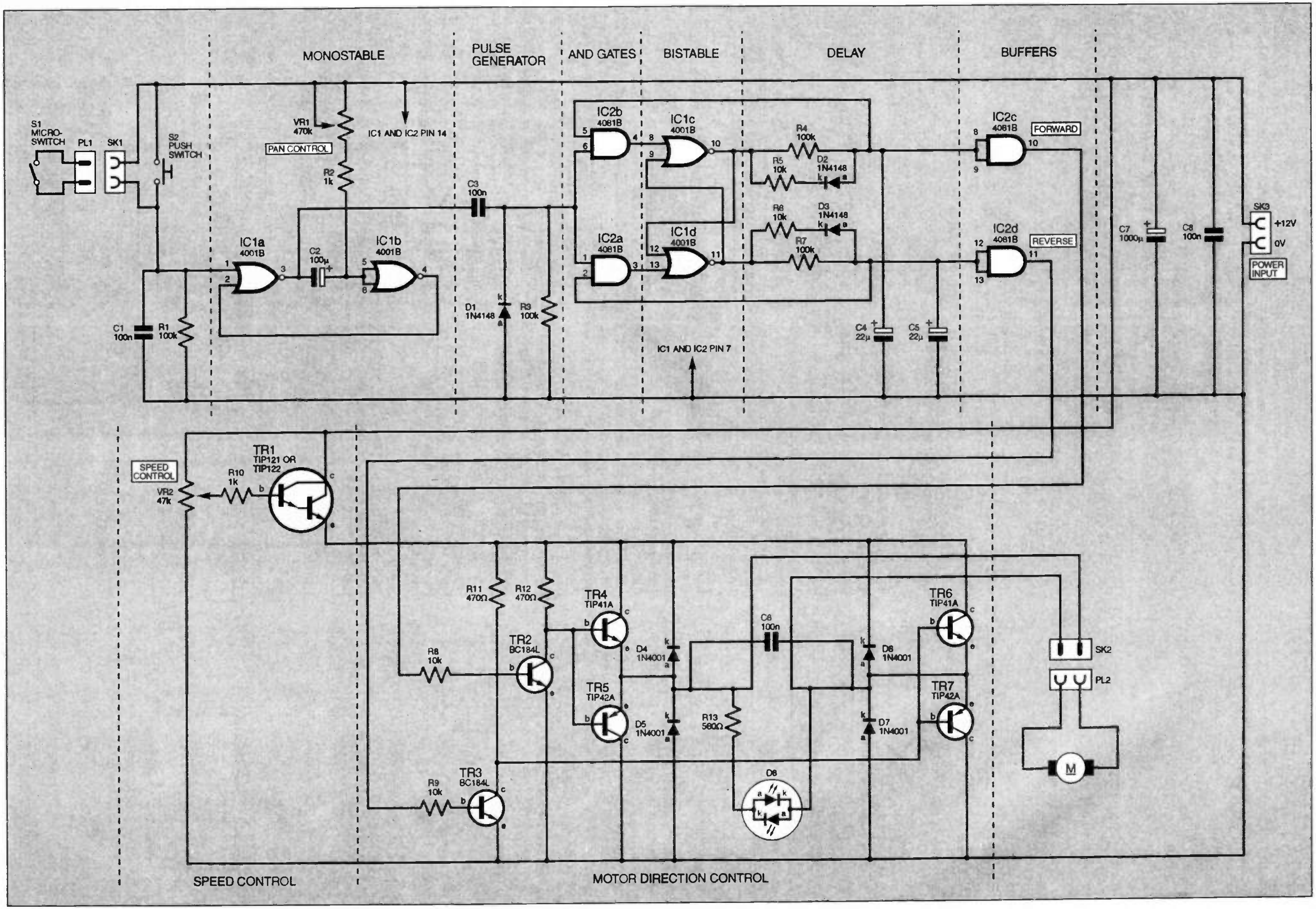


Fig. 3. Complete circuit diagram for the Automatic Camera Panning System.

COMPONENTS

See SHOP TALK Page

Resistors

R1, R3, R4, R7	100k (4 off)
R2, R10	1k (2 off)
R5, R6, R8, R9	10k (4 off)
R11, R12	470Ω (2 off)
R13	560Ω (see text)

Potentiometers

VR1	470k lin. rotary
VR2	47k lin. (see text)

Capacitors

C1, C3, C6, C8	100n disc ceramic (4 off)
C2	100μ elect. radial, 16V
C4, C5	22μ elect. radial, 16V (2 off)
C7	1000μ elect. radial, 16V

Semiconductors

D1 to D3	1N4148 signal diode (3 off)
D4 to D7	1N4001 rectifier diode (4 off)
D8	bicolour l.e.d. with mounting clip (see text)
TR1	TIP121 or TIP122 *npn* Darlington transistor
TR2, TR3	BC184L *npn* transistor (2 off)
TR4, TR6	TIP41A *npn* transistor (2 off)
TR5, TR7	TIP42A *pnp* transistor (2 off)
IC1	4001B quad 2-input NOR gate
IC2	4081B quad 2-input AND gate

Miscellaneous

S1	s.p. normally-open micro-switch
S2	s.p. pushmake switch, square profile (see text)
SK1, PL1	2.5mm jack plug and socket
SK2, PL2	3.5mm jack plug and socket
SK3	power input socket

Printed circuit board, available from the *EPE PCB Service*, code 972; plastic case 127mm x 63mm x 44mm; motor and gearbox (see text); self-adhesive p.c.b. supports (3 off); connecting wire; solder, etc.

Approx cost guidance only **£19** *excl. motor and gearbox*

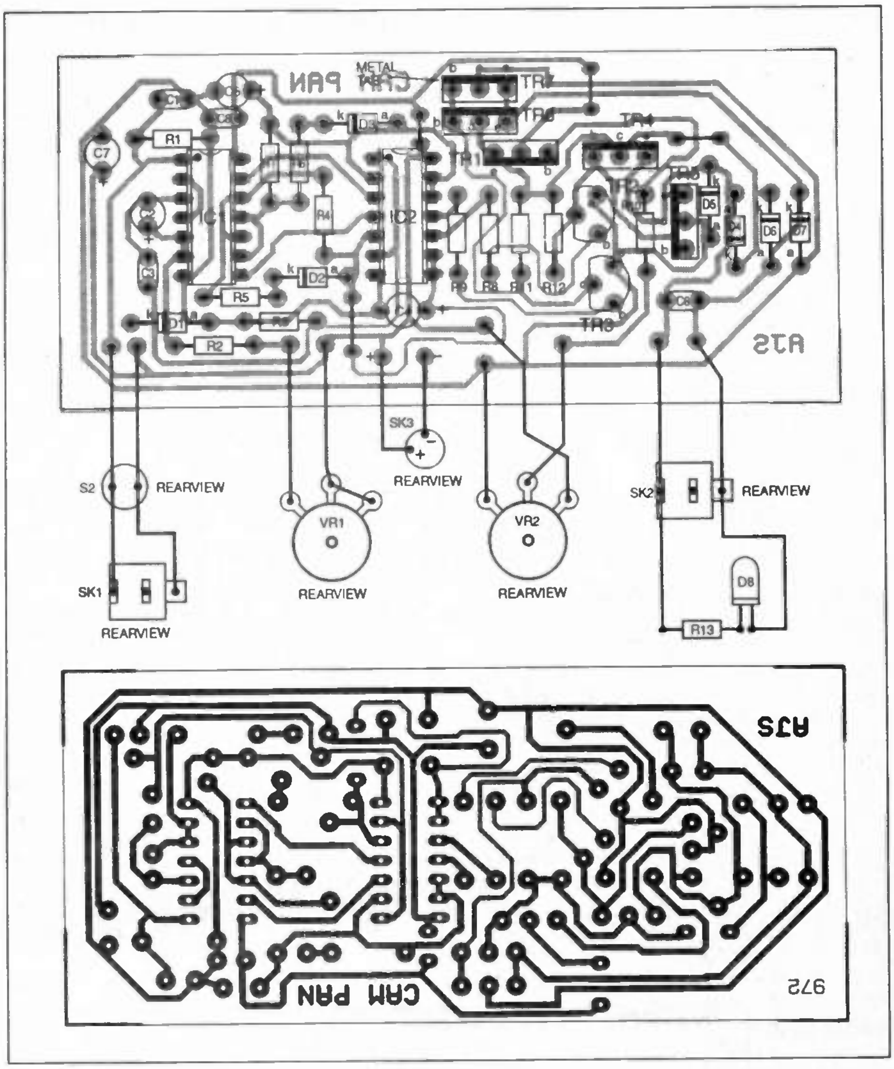
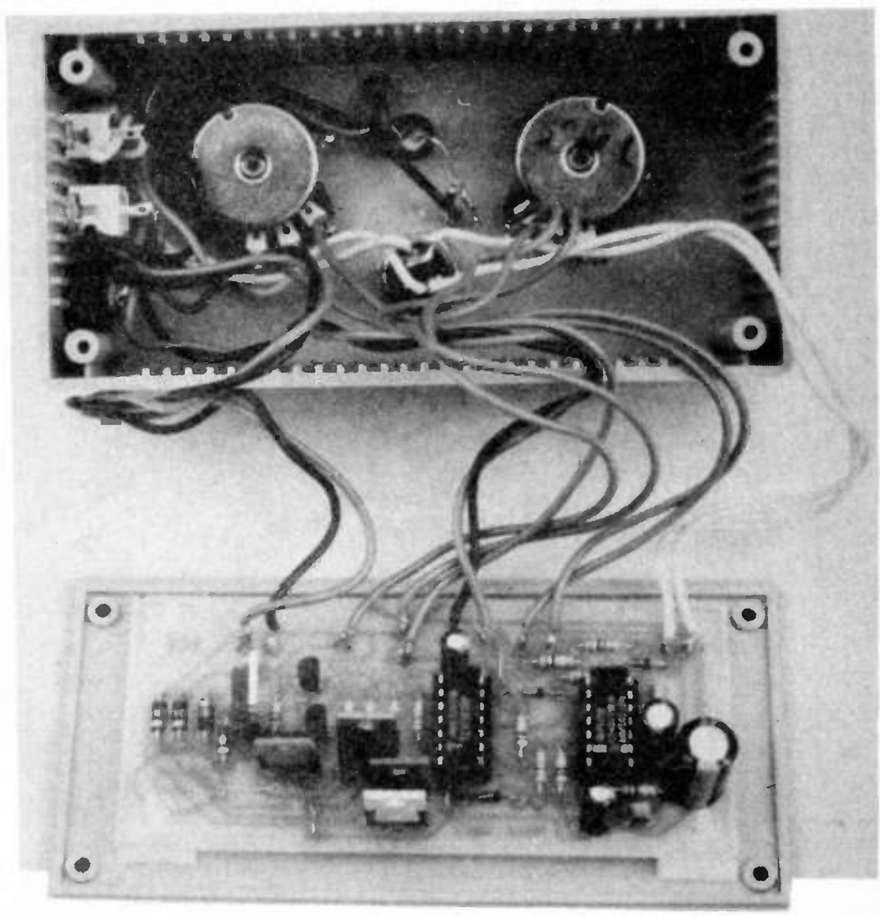


Fig. 4. Printed circuit board component layout and full size underside copper foil master track pattern.



and will be particularly effective if potentiometer VR1 is set for a short monostable time delay.

This, combined with the speed control provided by VR2, could be very valuable in tracking an object via the camera. An extra switch could also be added in series with the motor connections to provide instant "freeze".

CONSTRUCTION

Details of the printed circuit board (p.c.b.) tracking and component layout are shown in Fig. 4. The board is available ready-made from the *EPE PCB Service*, code 972.

Begin construction by inserting the i.c. sockets into the board, followed by the wire links and smaller components, ensuring that the diodes are fitted with their polarity bands facing the correct way as shown.

Resistors and the 100n capacitors (C6 and C8) can be fitted either way round, but the electrolytic capacitors and transistors must be the way shown. Be careful not to confuse the power transistors: types TIP121, TIP41A and TIP42A all look very similar.

Panel-mounting rotary potentiometer VR1, the Pan Controller, is connected via a pair of wires as shown. The Speed Control, VR2, may be either another panel mounting rotary potentiometer, wired as shown, or a horizontal skeleton preset mounted on the p.c.b. using the same holes.

The switches, motor and power supply connections are joined to the p.c.b. via terminal pins. A plug and socket arrangement provides a neat method of connecting the motor, switch and power supply to the circuit.

In the prototype, a power socket, 3·5mm jack socket and 2·5mm jack socket were used to ensure that the connections could not be mixed up. Other types of socket could be used instead.

If preferred, the manual direction-change switch S2 may be connected in parallel (i.e. across the connections) with microswitch S1.

Finally, the i.c.s should be inserted into their sockets, taking special care to earth your fingers (by briefly touching an earthed metal object) before removing them from their protective package or foam. Ensure that they are fitted with the notch as indicated in Fig. 4.

The power transistors are unlikely to require heat sinks unless a very inefficient motor is used. During testing, carefully feel the transistors at regular intervals. They are allowed to become *a bit* too hot for comfort, but should not be hot enough to cause a burn!

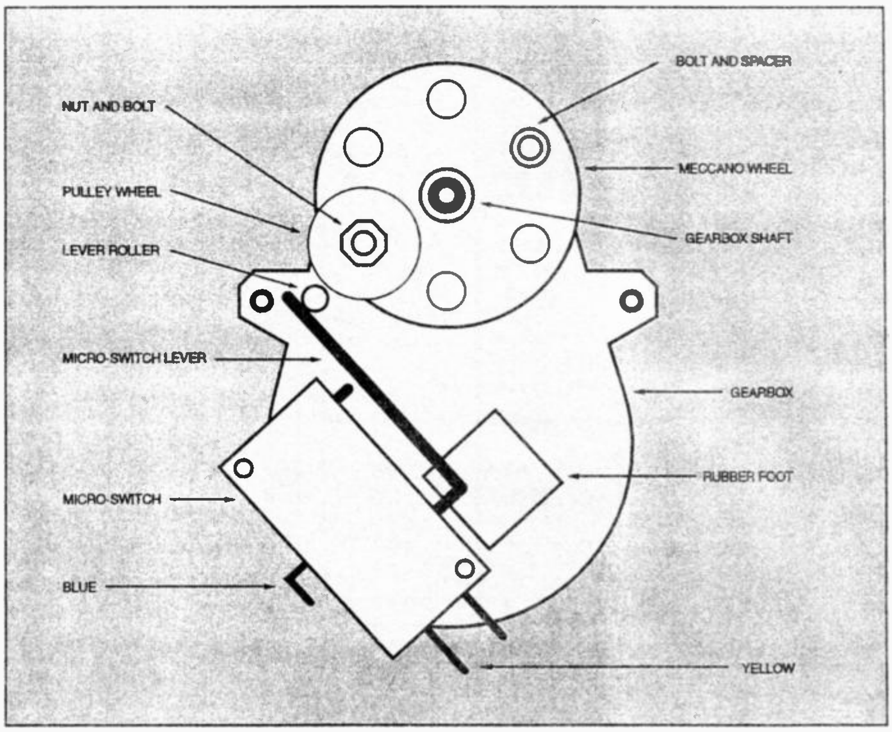


Fig. 5. How the gearbox triggers the microswitch in the test model.

TESTING

Ideally, the circuit should be tested using a 12V 100mA regulated power supply. In this case, the motor should be disconnected and a digital voltmeter used in place of the motor (beware that an analogue meter may not like the ensuing voltage reversal). Set potentiometers VR1 and VR2 about midway and switch on. The voltmeter should show that a voltage is present between the motor output points, either positive or negative.

Trigger the microswitch. After a pause determined by the setting of VR1, the output voltage should switch to zero, then reverse its polarity. Trigger the microswitch again. Check that after the same delay, the output voltage returns to its previous value.

Note that if VR1 is set to zero, the microswitch must be triggered for a very short time to reverse the voltage polarity. If this time is not sufficiently short the polarity will not be reversed.

Adjusting the Speed Control potentiometer VR2, it should be possible to vary the output from 0V to a little less than 12V.

Connect the motor and use a 12V power supply having enough output current to drive it. Check that the circuit behaves correctly. Again note that if VR1 is set to a low value, making the monostable time shorter than the time for which the switch is triggered, the motor will not reverse.

FAULT FINDING

Basic fault finding techniques were discussed in *Teach-In* Part 1. Once the recommended visual checks are complete, use a voltmeter as described. Ideal test points are:

IC1a input pin 1.
IC1a output pin 3.
IC1c output pin 10.
IC1d output pin 11.

Note that it will be difficult to detect a pulse via C3. If the monostable is working correctly, yet the motor refuses to reverse, try joining (briefly) a wire from the junction of R3 and C3 to the positive rail. This should make the motor reverse if the AND gates and bistable are working correctly.

If the motor fails to work at all, check the outputs from the AND gate (IC2 pins 10 and 11). One or other should be positive. If both are positive, though, both connections to the motor will be at 0V and the motor will not turn.

If all is well, check the base voltage of TR1 and TR2. One should be near 0V, the other at about 0·7V. If in doubt, try connecting a 1k resistor between the positive rail and one transistor base lead. This test should make the motor work. If not, check the voltage from the emitter of TR1. This is the main supply voltage to the output module, and it should be possible to vary it by turning VR2.

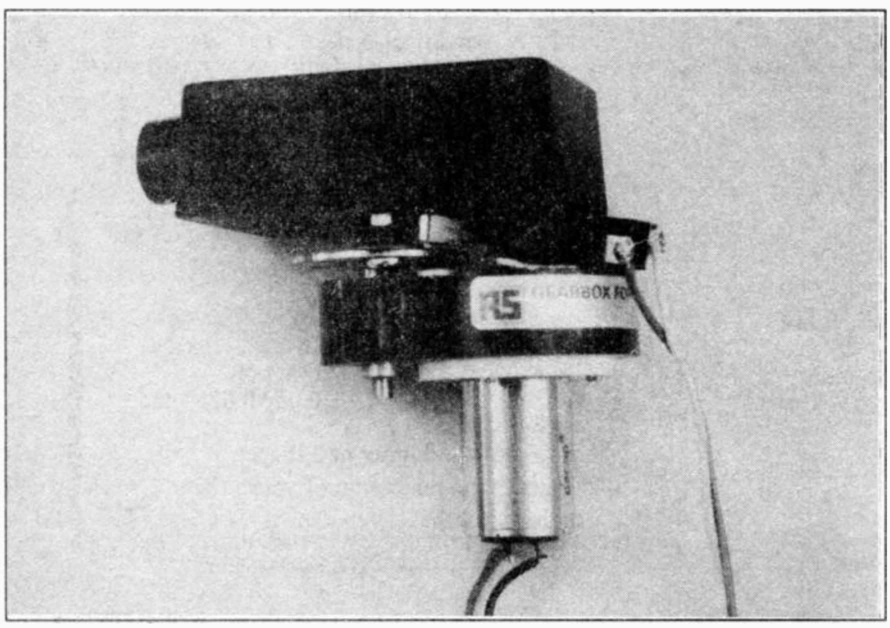
THE CASE

A small plastic case houses the p.c.b. and the controls. Referring to the photographs, begin by drilling holes for the potentiometers (or one hole if a preset is used for VR2), and the main switch S3 together with any other switches required for optional manual control. Drill holes in the side for the power connector, motor and microswitch connectors.

The p.c.b. may be mounted on the lid of the box using short self-adhesive supports.

MOTOR AND GEARBOX

The ideal motor and gearbox will be almost silent in operation and be capable



Although a mock-up camera is shown on the panning motor and gearbox mount, the power available is great enough to steer very much larger surveillance cameras.

of operating continuously for a very long period. Such assemblies are available from RS Components/Electromail, but at about £60 are not cheap.

However, if the budget will not allow the use of the RS motor and gearbox, much cheaper alternatives exist (see *Shop Talk*). This type of system may be noisy, but at a cost of about £5 complete does represent good value!

Motors of this latter type are generally rated at around 4·5V and if one is used the circuit should be operated from a power supply of 6V.

The shaft from the RS gearbox fitted a standard Meccano wheel, and this was used to trigger the microswitch as shown in Fig. 5. Be aware, though, that Meccano wheels may not fit other types of gearbox.

It is important that the microswitch is not held closed for too long by the mechanism since this will prevent the monostable operating properly. In other words, the monostable period must be longer than the time for which the microswitch is closed.

CAMERAS

Security cameras are now available in all shapes and sizes, and at very reasonable prices. Some *EPE* advertisers supply camera modules that may be fitted inside a standard case, which in turn could be fixed to the gearbox shaft. Also available are computer video cameras; for example Macintosh supply a camera not much larger than a golf ball which provides a video image on the computer screen. The *CCD TV Camera* published in *EPE* issues of March and April 1994 could also readily be panned by this unit.

It is beyond the scope of this article, though, to give advice on what camera to use. Study the adverts if you want Big Brother (or even Little Brother) to watch over you! □

PART FOUR

A Vari-speed Auto Dice unit is the project described in *Teach-In* Part 4.

Techniques
ACTUALLY DOING IT!
by Robert Penfold

FOR the experienced constructor, soldering the components onto a printed circuit board is usually a fairly routine matter. There may be the occasional awkward component to deal with, and some boards represent a major challenge due to their sheer size, but probably most "old hands" build circuit boards without too much conscious effort.

For beginners the situation is very different, and the task is likely to be approached with a certain amount of trepidation. Self-doubt is then likely to result in endless checking and rechecking as the job progresses.

It would be misleading to advise newcomers that "there is nothing to it", but if you go about the task conscientiously there is every chance that your first few circuit boards will work perfectly first time. They should also go on working properly for many years.

It is probably no bad thing if a slight lack of confidence leads to much checking and rechecking, since a few errors are likely to creep in when you first undertake any new task. Proceeding in a mad rush is a sure-fire recipe for failure in practically any creative hobby, and electronic project construction is certainly no exception.

ERROR CHECKING

While it is probably true to say that beginners make more errors than experienced constructors, errors are still made by even the most accomplished project builders. However, most of these errors fail to prevent the finished project from working as they are spotted almost as soon as they are made.

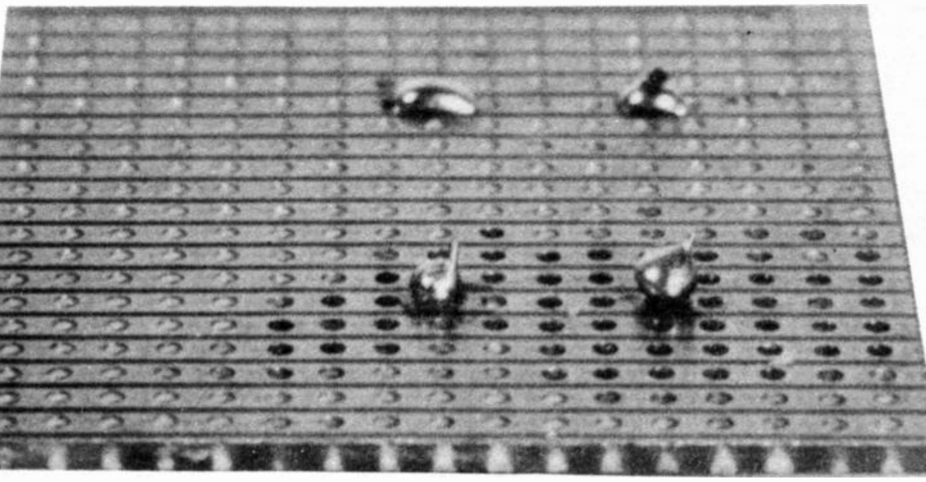
When assembling circuit boards you need to be on the constant lookout for problems. Just what errors should you be looking for while constructing circuit boards?

Modern printed circuit boards (p.c.b.s) tend to be quite small with masses of tiny copper tracks and pads packed close together. In the case of stripboard the tracks, by necessity, have very close spacing.

When soldering components onto a circuit board you should obviously try to orient the iron to avoid excess solder producing short circuits between tracks and pads. Not being too heavy handed with the solder also helps in this respect. However skilfully and carefully you proceed, it is probably best to regard the odd short circuit here and there as inevitable.

Provided you look carefully at what you are doing, most solder "blobs" and "trails" will be spotted immediately. The offending solder can then be removed with the aid of even the simplest of desoldering equipment. In fact it can be coaxed onto the bit of the soldering iron in most cases, and then cleaned off the bit using a moist sponge or bit cleaning block.

Circuit boards tend to become increasingly contaminated with half-burned flux as construction progresses. This can result in small solder trails being hidden under the flux. It is a good idea to clean the underside of a newly completed board, and then carefully check for short circuits.



These two "dry" joints have the characteristic blob-like appearance.

Special printed circuit cleaning fluids can be obtained, but vigourous brushing with something like an old toothbrush or nailbrush does the job very well. Such is the intricacy of modern circuit boards, that some form of magnifier greatly increases your chances of locating any short circuits.

JOINT LIKE THIS

In the past, "dry" joints were a major problem when assembling circuit boards. Improvements in electrical solders and the components themselves have greatly reduced this problem, but have not totally eliminated it.

The circuit board itself will only cause problems if there is corrosion or a lot of dirt on some of the copper pads. If a circuit board shows *any* signs of dirt or corrosion, always clean the affected parts of the board *before* fitting any of the components. Printed circuit cleaning blocks, etc. are available from the larger electronic component suppliers, but wirewool or a piece of scouring pad (such as "Brillo-Pad") will do the job just as well.

Dirty component leadout wires are a more likely cause of trouble. Many components come off the production line with their leadout wires secured in bandoleers.

In this context a bandoleer is two thin strips of gummed paper, with the leadout wires sandwiched between the two strips. Some of this gum is often left on the leadout wires when they are removed from the bandoleer, but in most cases only those parts of the leads that will be trimmed off are affected.

However, with some radial components such as printed circuit mounting electrolytic capacitors, there can be some gum left on the sections of the leadout wires that the solder will be applied to. It is virtually impossible to make a good quality soldered joint on a leadout wire which is contaminated in this way.

With components that have this problem, always clean the leadout wires before trying to solder them in place. Indeed, always clean *any* leadout wire that is obviously dirty or corroded.

Gum and most other dirt can be cleaned away by firmly wiping the lead a few times with a cloth. Scraping the lead with the blade of a penknife should soon remove even severe corrosion. Provided the leadout wires and copper tracks are all reasonably clean it is highly unlikely that a bad soldered joint will occur.

SOLDERING ON REGARDLESS

If an unseen contaminant should cause problems, or you fail to notice some dirt or corrosion, an adequate joint may well be produced anyway. Modern solders are very good at producing viable joints regardless of a certain amount of contamination on one or both of the surfaces to be joined. If there is too much contamination for the flux in the solder to tackle, the resultant joint will almost certainly look completely wrong.

A good soldered joint has a sort of "mountain shape", as in the cross-section of Fig. 1. The solder has a quite *bright* and *shiny* finish, and the joint has good symmetry.

If you use too little solder it will be fairly obvious, since the joint will be very flat with much of the leadout wire still visible. Such a joint will probably provide a perfectly good electrical connection, but it will be physically quite weak.

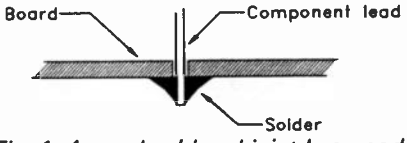


Fig. 1. A good soldered joint has good symmetry, and is a sort of mountain shape.

A slight knock or pressure on the body of the component is then likely to break the leadout wire free from the joint. It is advisable to top-up with solder any joint of this type, so that a physically strong joint is produced.

If dirt or corrosion cause problems, the solder will not flow properly over the two surfaces to be joined. In some cases it will be impossible to get the solder to flow onto the joint at all, and it will simply stick on the end of the soldering iron bit.

If the solder can be persuaded to leave the iron, it will either just fall as a solder splash on the surface of the board, or go into a blob on the end of the leadout wire. In either case the problem should be self-apparent, although the joint can sometimes look reasonably plausible if the solder forms in a blob on the end of the leadout wire.

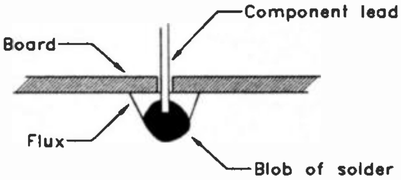


Fig. 2. A "dry" joint is usually large and blob-like in appearance.

What seems to happen is that excess flux fills in the gap between the solder and the pad, as in Fig. 2. This may anchor the leadout in place, but it gives a physically weak joint, and in most cases there will be no electrical connection between the leadout wire and the pad.

A joint of this type is usually quite easy to spot, as it is slightly larger and more rounded than a good quality joint. Also, there is usually a fair amount of burned and blackened flux in the vicinity of the joint, and the solder has a dull grey finish, often with obvious cracking and crazing on the surface.

If any soldered joint looks at all suspect it is as well to clean away all the solder. If necessary, clean the two surfaces, and then resolder the joint.

HANDS ON

Soldering components onto circuit boards is one of those jobs that is tailor made for people with three hands! You need one hand to hold the soldering iron, the other hand to feed in the solder, and an extra hand to hold the board and components in position. Most constructors soon devise their own ways around this problem.

My usual method is to hold the soldering iron in my right hand, and the board plus components in my left hand. I position the reel of solder on the edge of the workbench, with about 200mm to 300mm of solder protruding out over the edge of the bench.

I then apply the iron to the joint, and move the joint into position at the end of the solder. The joint is fed into the solder, rather than the solder being fed into the joint. This may seem like a rather cumbersome way of doing things, but many find it to be quite easy and reliable in practice.

A popular alternative is to use something like a large blob of "Plasticine" or Bostik "Blue-Tack" to hold a few components in place, and to fix the board to the workbench with the copper side uppermost. This leaves both hands free to deal with the solder and the iron.

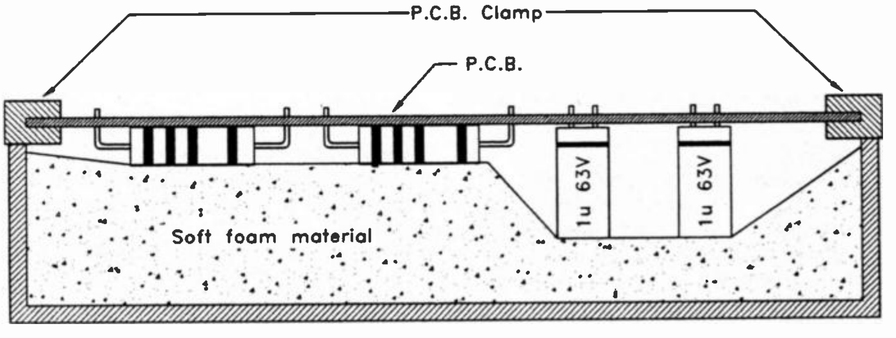


Fig. 3. A printed circuit construction frame can hold large numbers of components in place while they are soldered to the board.

IN THE FRAME

The up-market approach to the problem is to use a printed circuit construction frame. These differ in their exact appearance, but basically they all consist of a large piece of soft foam material in the base section, plus an adjustable frame into which the board is clamped.

With the components slotted in place, the board is mounted with the copper side facing upwards, and the component side pressed down into the piece of foam. Fig. 3 illustrates this basic scheme of things.

In theory it is possible to deal with all the components in one go. In practice it is usually better to deal with the small components first, and then progress to the larger ones that protrude further above the board. Otherwise there is a risk that the smaller components will not be pressed flush with the board.

ON THE LEVEL

It is very important that the components are always fitted right up against the board, as in Fig. 4a. If they are mounted at an angle, or simply spaced off the board, as in Fig. 4b and Fig. 4c respectively, any pressure on the component tends to tear the pads away from the board. The small pads of most modern p.c.b.s makes them very vulnerable to this kind of damage.

It is particularly important that radial electrolytic capacitors and inductors are mounted flush with the board. These vertically mounted components usually get knocked over slightly before too long. This will almost certainly cause some damage if they are not fitted tight against the board.

Problems are also likely if the components are flush with the board when the leadout wires are trimmed, but are then allowed to fall slightly out of place before being soldered. Apart from the trouble mentioned previously, it is likely that the leadout wires will barely reach the soldered joints. This will give physically weak joints, with the likelihood of a few leadout wires pulling free from the board before too long.

When building circuit boards try to work to high standards, producing finished boards that look neat and tidy. This is not just a matter of trying to impress people by producing boards that "look pretty".

In general, if a board looks immaculate it will probably work well, and go on functioning efficiently for many years. If a circuit board looks a complete mess it will probably be difficult to get it working in the first place, and it may well be problematic thereafter.

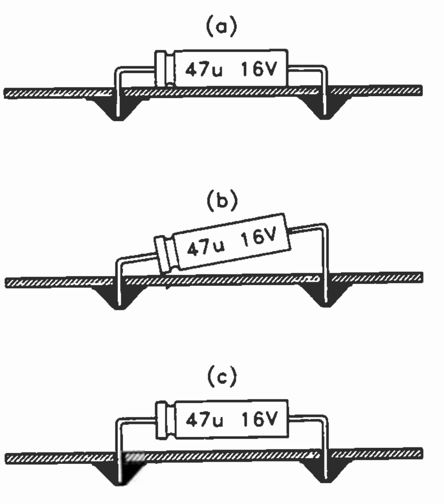


Fig. 4. Components should be fitted tight against the board, as in (a), and not spaced off it slightly as in (b) and (c).

DECIBELS AND dBm SCALES

ANDY FLIND

There is no need to be confused by decibels, they're really as easy as falling off a log.

DECIBELS are very useful units for many electronic measurements, especially those connected with audio circuits. However, some confusion seems to surround them, so this article will attempt to explain decibels and their use in plain English, and provide a simple method of conversion between "dBm" and other units.

In electronics, it is frequently necessary to express values of quantities which cover a huge range. Sometimes these are described in linear terms. For example, voltage values may be expressed in microvolts, millivolts, volts or kilovolts. Similarly, current values may be expressed in quantities of amps, microamps or milliamps.

LOGGING ON

In other areas, though, values are expressed in logarithmic (log) form, the decibel being a good example. Most readers will know that the decibel is a logarithmic unit. They may also have heard that it is a ratio, not an absolute value, which adds to the impression that it is difficult to understand. In fact, very simple calculations are involved, well within the capabilities of most *EPE* readers.

The logarithmic "Bel" scale was originally introduced by Alexander Graham Bell as a method of measuring sound levels. It was particularly appropriate for this as evolution has given the human ear a logarithmic response to cope with the vast range of sound levels encountered naturally.

Later, though, the Bel was found to be a rather large unit so the decibel (dB), a tenth of its value, was adopted for general use. This also began to be used in the measurement of electrical signals, particularly in telegraphy.

RELATIVELY REAL

Whilst the textbooks state that the decibel is a "relative" power measurement or ratio and not a "real" unit, so long as a reference or "starting point" is clearly defined, it can be used to describe actual values as easily as anything else.

Since the human ear and most volume controls have a logarithmic response, working with decibel scales can seem more natural since the readings appear to correspond better with control settings and perceived volume levels. A little familiarity is all that is required.

BASE LOGGING

On the mathematical side, the most complicated bit is conversion to and from logarithmic values. The log of a number to "base" ten is that number expressed as a power of ten. Other "bases" exist, but are not used in decibel calculations.

A simple example is the number "100". This is 10 × 10, or ten raised to the power of 2, so the logarithm of 100 is "2". In the same way the log of 1000 is 3, the log of 10000 is 4, and so on. The log of 10 itself is 1, and the log of 1 is zero.

Logs of numbers smaller than 1, representing losses in analogue signal systems, are negative numbers. For example, a tenth is −1, a hundredth is −2.

IT ALL ADDS UP

To multiply values, their logs are added. For example, the log of 100 is 2, and 2 + 2 is 4 which, as we have seen, is the log of 10000. This is useful in systems with lots of sections all having their own loss or gain figures in dB, as these are simply added together to obtain the overall value.

Most scientific calculators (and every electronics enthusiast should have one!) can convert to and from logs. There will usually be a button labelled "log" which, when pressed in combination with the number to be converted, will produce its logarithmic value. This can be tested with something obvious, like 1000, which should return "3".

To convert back again, sometimes an "antilog" function is provided, perhaps by combining "shift" with the "log" button. It may be marked "10^x".

Alternatively, the function for raising numbers to various powers can be used to raise 10 to the power of the log value. This too can be tried, using "3" as the input which should produce the answer "1000".

WHAT A DODDLE

Once this process has been mastered, the rest of decibel calculation is a doddle, requiring nothing more than simple formula manipulation, secondary school stuff. It can be broken down to a simple step-by-step process, as will be shown. The standard formula for conversion of a power ratio to a dB measurement is:

$$\text{dB} = 10\log_{10}\frac{P_{out}}{P_{in}}$$

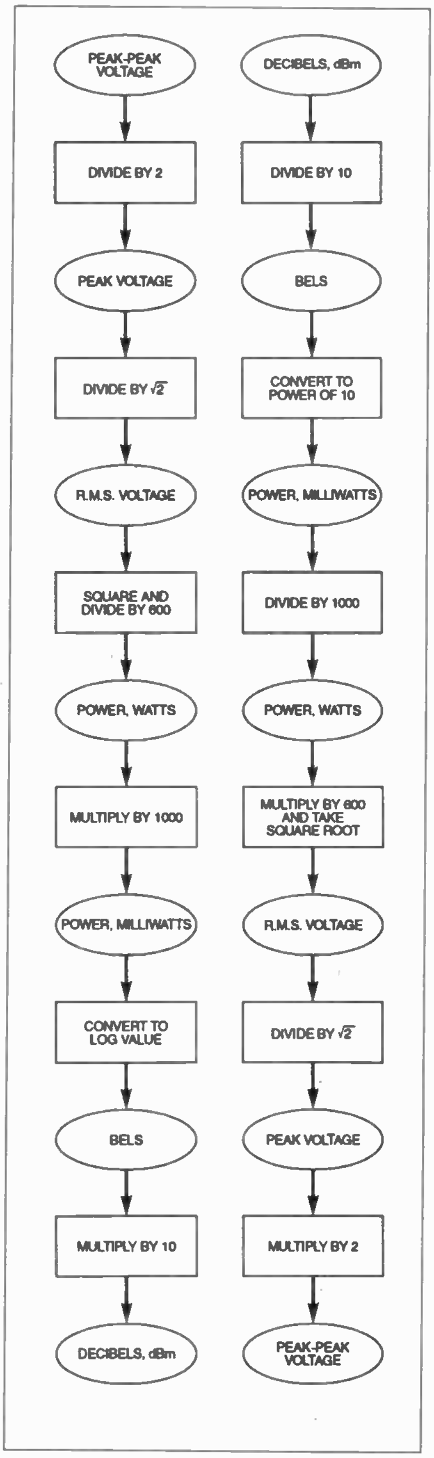


Fig. 1. Conversion steps to and from dBm values.

In this equation, P_{out}/P_{in} (output power divided by input power) is the power ratio, which is then converted to its logarithmic value and multiplied by 10 to turn it into decibels.

For example, if a system has a power input of one watt and a power output of 100 watts, then the ratio P_{out}/P_{in} is 100 and the log of this is 2, which when multiplied by ten becomes 20, so the system has a gain of 20dB. Simple!

POWERFUL REFERENCE

Notice, though, that for a true dB gain the input and output figures have to be in "power". To talk of signal levels in terms of dB, it is necessary first to specify just what they are related to. Various reference values are used in decibel measurement, but the most widely accepted is that of one milliwatt into a 600-ohm load.

This again originates from telephony and is known as the "zero dBm" level. The scale is referred to as the "dBm" scale, the "m" standing for "milliwatt". Levels higher than a milliwatt have corresponding positive dBm values, whilst lower ones are negative, and telephone engineers can often be heard saying something like "The level's *neg thirteen* here".

Usually, they will be using an instrument that is scaled in dBm but which is actually measuring signal voltage, with an assumption that this voltage is connected to a known load so that the power is proportional to it.

To convert a signal voltage to a dBm level, it is first assumed that it is connected to a 600-ohm load. With simple average-value voltage detectors it must also be assumed that the signal is a pure sinewave tone. The procedure which is then used is to convert the voltage into a power level, in milliwatts, which represents the ratio to the one milliwatt reference. This is converted to its log value and multiplied by ten, giving the level in dBm.

The assumption that the signal is a pure sinewave into 600 ohms is not always rigidly adhered to, however. In fact a dBm-scaled meter is often used to take a reading with the instrument simply placed across an audio signal path, perhaps carrying music or speech. This is still useful, especially where the user is concerned mainly with system gain or loss, or has experience of what the reading in these conditions should be.

CHARTED

To simplify conversion as far as possible, two flow charts are shown in Fig.1., for converting dBm values to and from other units. The first chart, Fig.1a, shows the steps for converting from any a.c. voltage or power level to the corresponding dBm value and includes the procedures for handling peak-to-peak and r.m.s. voltages. Simply following the steps from whichever value is already available will produce the corresponding dBm value.

Where it is necessary to convert back again, from dBm to the r.m.s. reading expected on a meter, or to the peak-to-peak value that would be seen on an oscilloscope, the procedure shown in Fig.1b can be used. This will convert a dBm input value back to its power and voltage equivalents.

With both these charts, it should be remembered that assumptions are being made about circuit loading and signal waveform. Use of these two flowcharts and a pocket calculator should make conversion a simple matter. They will also be found useful by anyone wishing to create a conversion program or formulae for a spreadsheet if required. □

Ohm Sweet Ohm

Max Fidling

Christmas Spirit

DECEMBER is a month which sees a plethora of activity in the *Fidling* household. I generally find it best to keep a low profile while the Boss busies herself around the house bringing in the Christmas spirit. Up go the decorations, the strings from which we'll hang our Christmas cards, the Christmas tree, and – best of all – the Christmas tree lights!

On a reluctant shopping expedition I'd spotted in the window of a local store a particular set of lights which I thought would look terrific on our new "plastic" Christmas tree. The tree, contrary to the picture on the box it came in, resembled something approaching a green lavatory brush – so I thought it would be enhanced tastefully by forty plastic candles each with a bulb stuffed in its tip at a precarious angle.

Not content with the usual array of tinsel and baubles, though, I intended to liven things up by adding some effects to said plastic tree in the form of an electronic flasher circuit for the new lights. This, I reckoned, would be a piece of (Christmas) cake.

A simple circuit using a 555 timer, which drives a mains-relay, was soon contrived. (I had a box load of surplus Octal-based relays which I'd bought in a "mystery" parcel. I soon discovered that the mystery was in trying to guess the coil voltage ratings....) Hence, I mused, the relay would flash the lights accordingly and we would be in business. Las Vegas would have nothing on this, I reckoned.

Paw Piddles

The flashing device was quickly assembled in the workshop and hooked up to the new set of Christmas lights, which I'd disentangled from its carton while Piddles looked on. Throwing the instruction leaflet away (as usual) I hooked the illuminations up to the relay contacts and then flicked the switch. The relay clattered into life and the chain of lights flashed rhythmically.

Piddles seemed fascinated by this palaver and started nosing the lamp at the end of the chain, pawing it with a furry foot. I likened this to his fascination with moving lights, since more than once, for light relief, I had driven him mad by shining my Woolworth's plastic torch at the sitting room wall, which made him pounce at the pool of light, only he'd nearly collide with the wall just as I moved the torch, if I timed it right! So Piddles was always entranced by moving lights – cat owners will know what I mean.

Glory Be!

Back at the ranch, the new plastic horticultural horror stood there resplendent in its polythene glory, and was soon throttled Boa Constrictor-like with the string of lights. The green flex led to my box of tricks which I plugged into the wall socket nearby.

By now the Boss had decided to join in the fun. She had been busily cooking in the kitchen as always, and the house was filled with the fragrance of delicious brandy-laced Christmas treats.

After some rummaging in the attic I'd found the box of decorations and these appeared in the sitting room, ready for deployment with military precision by the Boss, whilst I stood to attention, proudly pointing to the clattering and ticking gadget which I'd assembled with zeal earlier. The fact that the lights flickered periodically – I suspected a dicky bulb connection – did not instil any confidence in the Boss who eyed it all suspiciously. Piddles started playing about with the tissue papers with which the baubles had been wrapped, whilst the relay continued to chatter away to itself in staccato Morse.

Illuminating Experience

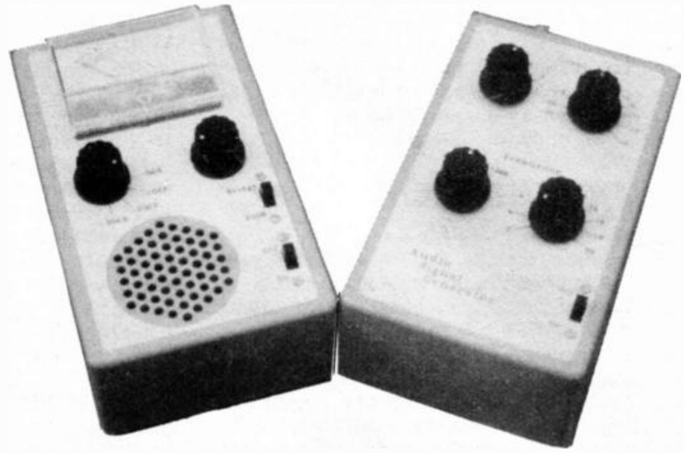
Gradually the plastic tree filled with an impressive array of tinsel and glass balls, finishing triumphantly with the Christmas fairy which was perched adroitly on top. The Boss having returned to the kitchen to check out the latest batch of scrummy cooking, I popped back to the workshop to switch off the lights and lock up, now that the mission was accomplished.

Two minutes later I returned, and there in the sitting room was the Boss, staring in horror at the Christmas tree! Had my new invention gone awry, I asked myself?

Not likely! Instead, Piddles' curiosity with moving lights had finally got the better of him it seems, as he'd launched himself straight at the illuminations and had brought the whole lot down with a feline wail, in a heap!

Baubles crashed onto the floor as Piddles emerged sheepishly from under some tinsel. I started munching a warm mince pie and sidled out workshop-wards, in a low profile sort of way. The moggie followed, pausing to munch on a morsel of mince pie which I'd dropped in my eagerness to escape.

AUDIO SIGNAL GENERATOR



ANDY FLIND

A compact, low cost, signal generator that will prove an invaluable addition to the workshop test equipment. Three-switched ranges from 20Hz to 20kHz.

THIS simple, compact signal generator should find numerous applications in the repair, testing and setting up of any type of audio equipment, and will probably be found very useful for general electronic experimenting.

The output is a sinewave with a reasonably low harmonic content and a virtually constant level over the frequency range 20Hz to 20kHz, in three decade ranges. The output level is calibrated in voltages corresponding to dBm levels to match the Audio Level Meter and Amplifier project (shown above) in last month's issue, but other units could easily be used instead.

SIGNAL GENERATION

For the design of a sinewave oscillator, several methods of signal generation are possible. One is the classic "Wien Bridge" circuit, but this can be difficult to control. Simultaneous alteration of two component values is usually necessary for frequency adjustment and automatic gain control is invariably required to stabilise amplitude.

A frequently used alternative is a dedicated "waveform generator" i.e., usually the 8038. The snag with this is that a minimum supply of 10V is required at moderate current, which makes a design using a single 9V battery particularly difficult to implement.

A third method is to start with an oscillator producing a triangle wave and then shape this into something approaching a sinewave. Surprisingly good results can be achieved with this from relatively uncomplicated circuits having the advantage of simple frequency control and constant output amplitude, so it is the method chosen for this design.

CIRCUIT DESCRIPTION

The full circuit diagram for the Audio Signal Generator is shown in Fig. 1. A stable reference voltage is required by the circuit and is provided by the regulator IC1. This is an LP2950 device, a three-terminal 5V regulator similar to the popular 78L05 but with the advantages of very low quiescent current and a low "drop-out" voltage.

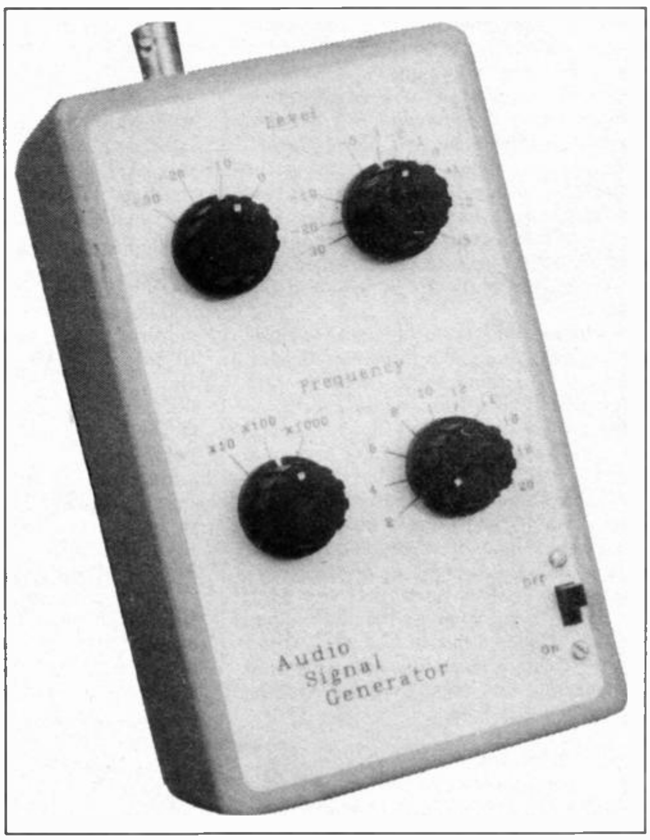
"Drop-out" is the minimum difference between input and output voltages at which the device will still work properly. For the "78" series regulators it is over two volts, so a 9V battery has to be discarded at about 7·5V.

The LP2950 operates happily with as little as 100mV differential, allowing the battery to fall below 6V before replacement becomes necessary. With this, plus the additional benefit of micropower operation, the small extra cost of the device is soon recovered in savings on battery replacement.

The signal is generated by IC2, a TL072 dual op.amp, and IC3, a 3130 CMOS op.amp. This part of the circuit requires a "ground" voltage of half the supply, or 2·5V which is provided by buffering the voltage divider formed by resistors R1 and R2 with IC2a. IC2b is connected as an integrator.

The rate of change of output voltage for a given input voltage is set by the value of input resistors R3 and R4, and of the capacitors C7/C8, C9 and C10. These are selected by the switch S2 to provide three ranges. Output from the integrator IC2b goes to a comparator IC3, which has hysteresis fixed at about plus and minus one volt to set the high and low points of the triangle waveform from IC2b.

A proportion of the output voltage from IC3 is fed back to the integrator by "Frequency" control VR1 and the amount of this feedback determines the rate of integration and thus the output frequency. With the values shown the ranges have a



Layout of controls on the completed Audio Signal Generator.

high-to-low ratio of a little over ten-to-one and cover 20Hz to 200Hz, 200Hz to 2kHz, and 2kHz to 20kHz. The highest frequency range uses two 100pF capacitors in place of the expected value of 220pF, as it was found that this compensated for the stray capacitance of the switch, leads etc. which become significant with this range.

A CMOS 3130 op.amp is used for IC3 as it has rail-to-rail output voltage capability, giving a precise and symmetrical input to the Frequency control VR1. This ensures a linear and symmetrical triangle wave output from IC2b, with a constant amplitude at all frequencies.

WAVEFORM SHAPING

The shaping of the triangle wave into a sine is accomplished by IC5, a CA3080 "transconductance" op.amp. A feature of this device is that distortion caused by overloading the inputs can convert a triangle wave into something very close to a sinewave. The optimum amount of overloading is set by VR2 whilst VR3 is used to cancel any input offsets to ensure symmetry.

Unlike ordinary op.amps, the output of the 3080 is a current proportional to both input voltage and to a control current applied to pin 5. To convert the output back to a voltage signal a fixed load and a buffer is required.

The load in this case consists of the resistor network around switch S3, followed by IC4b. The resistors are chosen to have a total value of about 10 kilohms and to provide the switch with logarithmic steps equivalent to 0dBm, −10dBm, −20dBm and −30dBm. Other step values can be used if preferred but the total value of the network should still remain at about 10 kilohms.

This part of the circuit also requires a "ground" of half the supply voltage, which is provided by resistors R9 and R10 and op.amp IC4a. IC4b is a unity-gain buffer to prevent loading of the resistor network by the Output Level control VR5.

From VR5 the signal passes to the output amplifier IC7 which has a voltage gain of two, and is supplied with an auxiliary "negative" rail generated by IC6, a 7660 negative rail generator i.c. There are two reasons for the auxiliary negative rail. One is that the output can reliably reach an a.c. voltage level equivalent to +3dBm, and the other is that it can use the negative rail as "ground" without the need for a series capacitor.

This avoids the drop in level that such a series capacitor would cause at low frequencies. The 270 ohm output resistor R24 prevents overloading of the output of IC7, this particular value being chosen so that a 330 ohm resistor placed in series with it will turn it into a 600 ohm source if required. More will be said about this later.

COMPONENTS

Approx cost guidance only **£28** excluding batts

Resistors

R1, R2, R4, R9, R10, R14	22k (6 off)
R3, R17	120k (2 off)
R5	820Ω
R6, R22, R23	10k (3 off)
R7, R12	4k7 (2 off)
R8	27k
R11, R13	100Ω (2 off)
R15	6k8
R16	2k2
R18	680Ω
R19	330Ω
R20	8k2
R21	1M
R24	270Ω

All 0·6W 1% metal film.

See SHOP TALK Page

Potentiometers

VR1, VR5	10k rotary carbon, lin (2 off)
VR2	1k enclosed cermet preset
VR3	10k enclosed cermet preset
VR4	47k 22-turn cermet preset

Capacitors

C1	470µ radial elect. 16V
C2, C3	10n resin dipped ceramic (2 off)
C4, C5, C6, C11, C12, C14	10µ radial elect. 50V (6 off)
C7, C8	100p polystyrene, 1% (2off)
C9	2n2 polystyrene, 1%
C10	22n polystyrene, 1%
C13	100µ radial elect. 10V
C15	220µ radial elect. 16V
C16	470n resin dipped ceramic
C17	100p resin dipped ceramic

Semiconductors

IC1	LP2950CZ 5V regulator (or 78L05, see text)
IC2, IC4	TL072CN dual low noise op.amp (2 off)
IC3	CA3130E CMOS op.amp
IC5	CA3080E transconductance op.amp
IC6	ICM7660 negative voltage generator
IC7	TL071 low noise op.amp

Miscellaneous

S1	s.p.s.t. slide switch
S2, S3	2-pole 6-way rotary switch (2 off)
SK1	50 ohm, chassis mounting, BNC socket
B1	9V (6 x AA cells)

Printed circuit board available from *EPE PCB Service*, code 969; plastic case, size 90mm x 149·5mm x 52·5mm; 8-pin d.i.l. socket (6 off); knobs (4 off); battery clip; battery holder (6 x AA); connecting wire (ribbon cable); solder pins; solder etc.

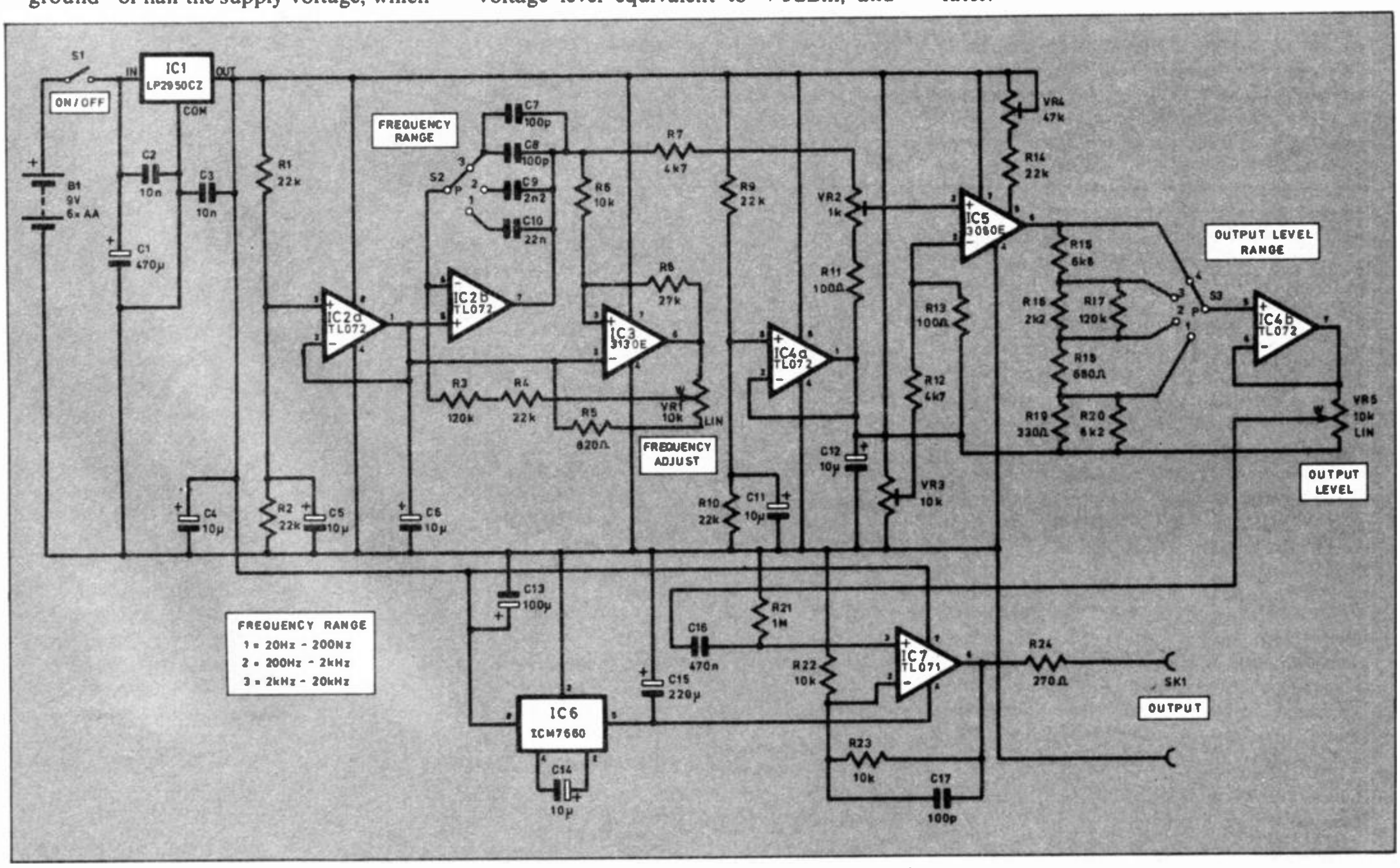


Fig. 1. Complete circuit diagram for the Audio Signal Generator.

CONSTRUCTION

Most of the components for this project are mounted on a small printed circuit board, the topside component layout and full size underside copper foil master being shown in Fig. 2. This board is available from the *EPE PCB Service*, code 969.

The following construction procedure is recommended to minimise the possibility of error, and to assist with easy location of any problems. First, all the resistors should be fitted with the exception of those soldered directly across switch S3 connecting tags. Then the small ceramic capacitors C2, C3, C16 and C17 should be fitted, followed by the i.c. sockets for IC2 to IC7. Using d.i.l. sockets helps to simplify testing.

Preset potentiometers VR2, VR3 and VR4 should be fitted next, taking care with VR2 and VR3 markings as one is 1k (kilohm) and the other 10k. Note also that VR4 is a multi-turn "in-line" cermet type.

Following this, the 10µF miniature electrolytic capacitors can be fitted, followed by the larger electrolytics C1, C13, and C15. All the electrolytics should be fitted with their positive sides facing the top edge of the board, see Fig. 2.

The +5V voltage regulator IC1 should now be soldered in place, taking care to insert it the correct way round, and leads for the power supply can also be connected. If a 9V supply is now applied to the board the current drawn should settle to about 1mA, following a brief surge as the capacitors charge. The presence of the 5V regulated supply should be checked across capacitor C4.

Incidentally, it is possible to use a 78L05 regulator for IC1 if the increased battery costs are not a disadvantage. If this is done it will increase all the quoted supply currents by about 3mA to 4mA.

PRELIMINARY TESTING

The following preliminary test readings should be taken as the final components are mounted on the p.c.b. Wiring from the p.c.b. to some off-board components, together with some temporary "test components," is also made as board testing progresses.

The negative rail generator IC6 can be plugged into its socket next, and the negative 5V supply across capacitor C15 checked as being present. IC6 is another micropower device and will add less than 100µA to the supply current.

Leads for Range switch S2 and rotary control VR1 can now be connected and IC2 inserted into its socket. This will raise the drain to about 3·25mA. Pin 1 of IC2, the output of IC2a, should be at half the supply or around 2·5V.

Following this VR1 should be connected to its leads, a 2·2nF capacitor soldered across the leads for switch S2, and IC3 fitted into its socket. VR1 should be set to about half-travel.

When powered up the board will now draw about 3·5mA. IC2 pin 7, IC2b output, should now measure about 2·5V d.c. as an average value if the oscillator is operating correctly. If an oscilloscope is available the signal can be checked, it should be a triangle wave with a peak-to-peak value fractionally less than 2V. A square wave of about 4·5V peak-to-peak should be present on the output of IC3, pin 6.

An alternative would be to listen to the output from IC2 pin 7 with an amplifier. With either of these methods, the operation

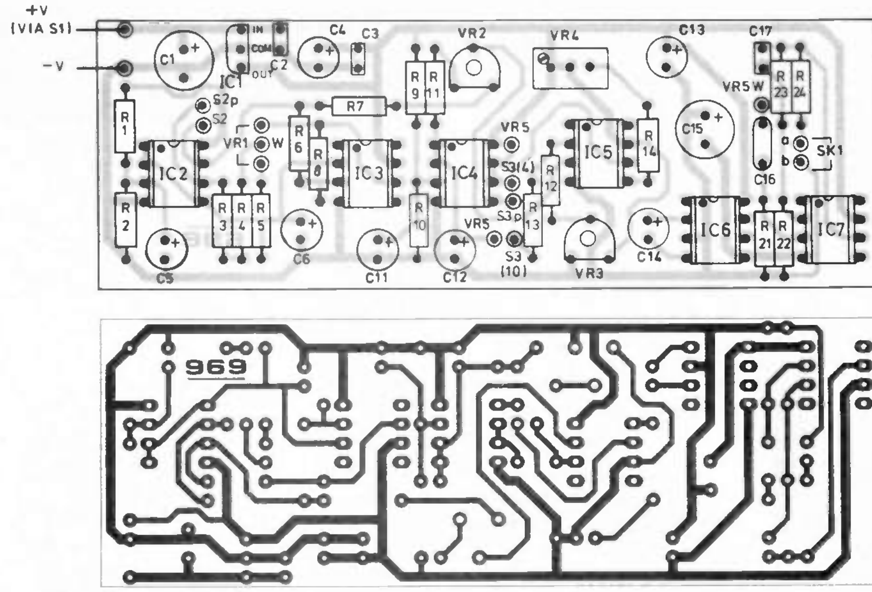
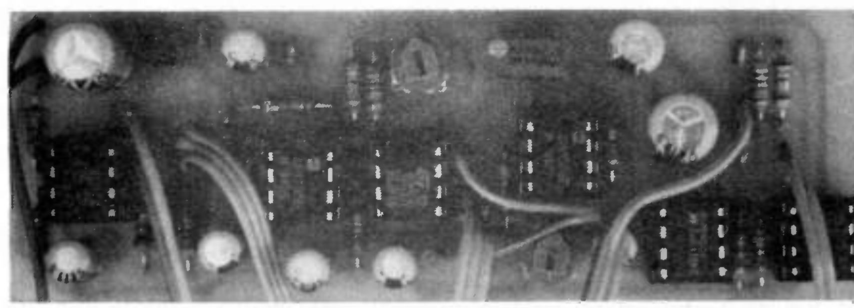


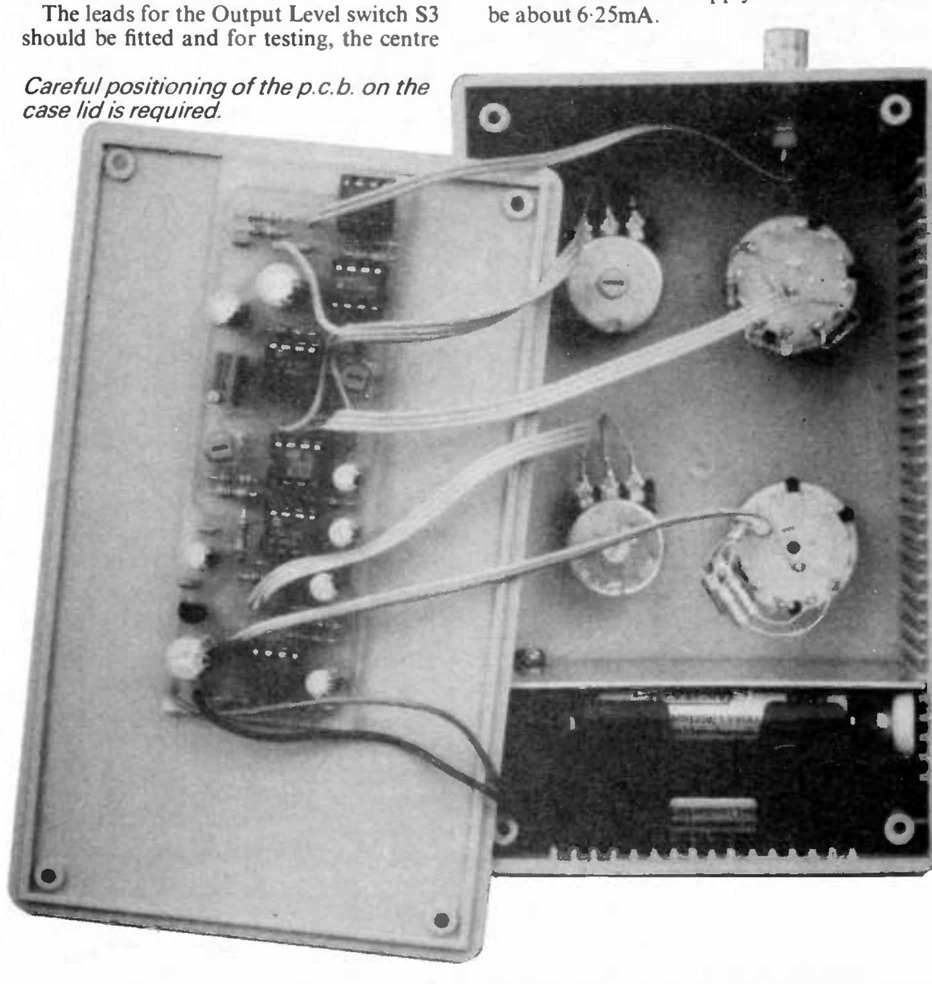
Fig. 2. Printed circuit board component layout and full size copper track master pattern. The completed board is shown below.



of VR1 can be tried and it should vary the frequency from below 200Hz to over 2kHz.

Next, IC4 can be inserted which will raise the supply drain to about 6mA. Pin 4, IC4a output, should be at half the supply voltage or 2·5V.

The leads for the Output Level switch S3 should be fitted and for testing, the centre lead shorted to the top one (looking at the p.c.b. – see Fig. 3) with a 10kilohm resistor between these two and the bottom lead to provide a load for IC5. The presets VR2, VR3 and VR4 should be set to mid-travel and IC5 fitted. The supply drain will now be about 6·25mA.



Careful positioning of the p.c.b. on the case lid is required.

The output of IC4 pin 7 should have an average d.c. level of around half the supply, and if a means of viewing or listening to the signal at this point is available the effect of the presets can be tried. Presets VR2 and VR3 alter the wave shape, though VR2 will also vary amplitude. VR4 adjusts the output level.

Leads for the Level control VR5 and the output should now be fitted, and the two wires for top and wiper of VR5 shorted together. IC7 can be inserted and the unit powered again, the drain now being about 9·5mA to 10mA. The average d.c. voltage at the output of IC7, measurable at pin 6 or either end of resistor R24, should be zero. Again the signal can be viewed or heard with suitable equipment.

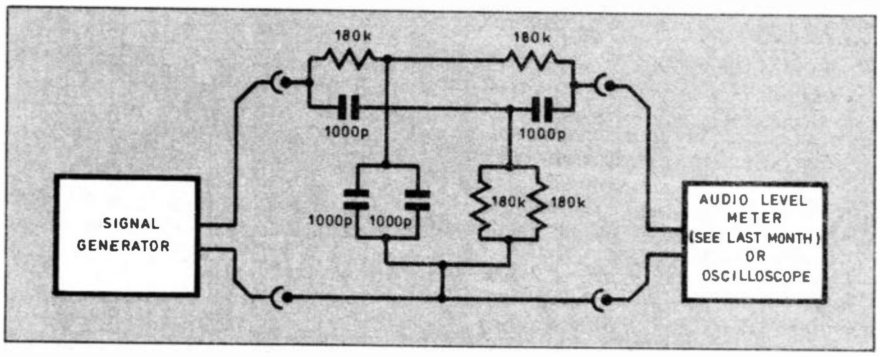


Fig. 4. A "twin-T" notch filter arrangement is used for adjusting waveform.

INTERWIRING

Connections between the board, controls, battery, On/Off switch and the output socket SK1 are shown in Fig. 3. As usual ribbon cable is advised for a neat job, though this is not essential.

The fitting of the components directly to the rotary switches S2 and S3 is also shown in this drawing. The tags marked "10" are in both cases unused switch positions, employed as convenient anchor points for the component leads and a connection.

The prototype was fitted into a plastic box 90mm x 149·5mm x 52·5mm in size, see photographs. With careful positioning of the p.c.b., controls and On/Off slide switch S1, plenty of room was found for a pack of six AA batteries to provide power.

A PP3 could be used but many signal generator applications require long periods of use, both in fault-finding and other work, so the AA battery pack is recommended for a reasonable lifespan. Rechargeable AA cells would also be ideal for this project or it could be fitted with a socket for an external 9V power supply.

FINAL SETTING UP

With the project finally assembled in its case, the presets require setting up. The waveform could be set by ear using presets VR2 and VR3 as it is possible to hear the harmonics increase either side of the optimum point, but the simple filter network shown in Fig. 4. offers a much improved method. This is a "twin-T" notch filter, capable of removing nearly all of the fundamental signal at a fixed frequency just below 900Hz leaving only the harmonics and distortion.

Connected as shown, with a meter or scope monitoring the output, the frequency is first set with control VR1 for minimum output and then presets VR2 and VR3 adjusted carefully, also for minimum output. The Audio Level Meter and Amplifier project described last month is ideal for making this adjustment.

Finally, the filter should be removed and a DVM used to set the output level to slightly above 1·094V r.m.s., the value corresponding to +3dBm. It was originally intended that this level should be set exactly, but in practice it was found better to leave it a little higher and mark the +3dBm point a little lower on the control.

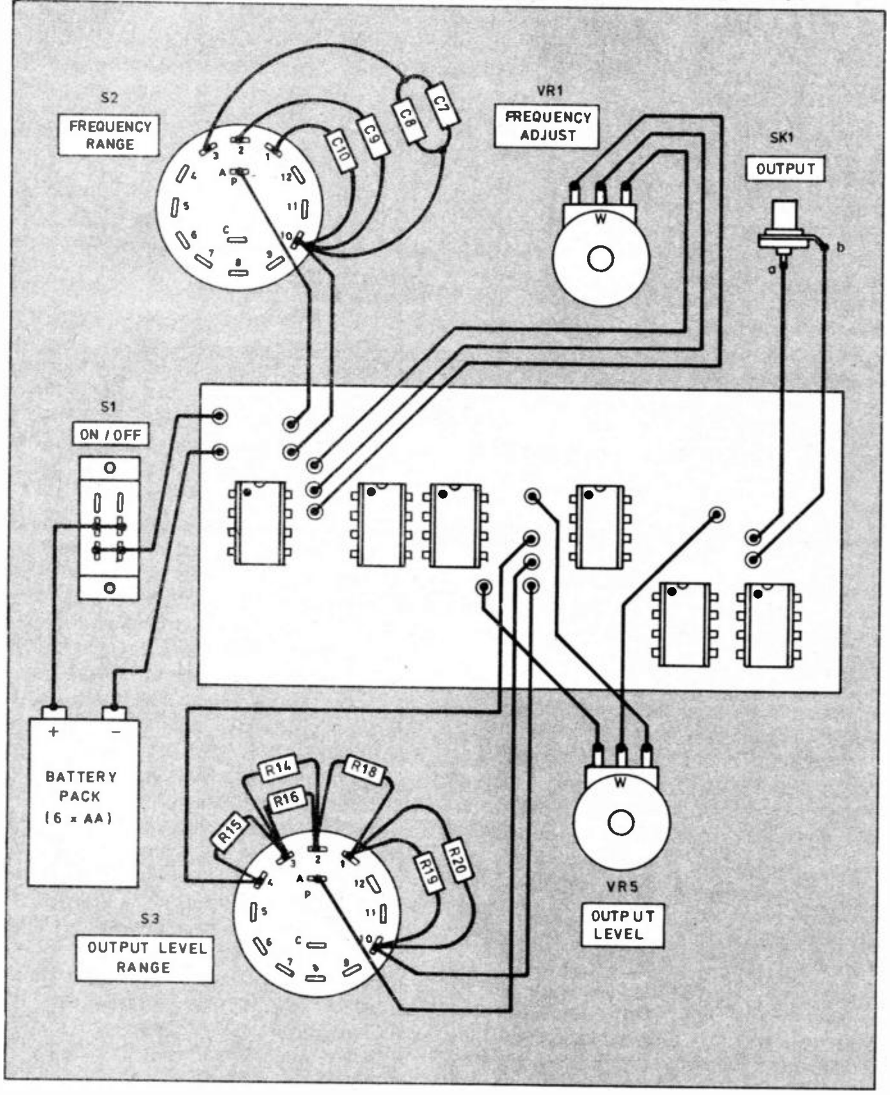


Fig. 3. Interwiring to all off-board components.

BE PATIENT

Calibration of the Frequency control VR1 and the Level control VR5 requires patience and a marker pen, with suitable instruments indicating the output values. The Audio Level Meter (last month) and Analogue Frequency Meter (next month) projects are eminently suitable for this task.

The calibration will be found more of a guide than an exact indication anyway, though they are quite good enough for most test purposes. The level, from VR5 and switch S3, was calibrated as a voltage corresponding to dBm values, although volts r.m.s. or peak-to-peak could be used as an alternative.

Whilst not an absolutely pure sinewave, the output of this generator will be found adequate for most test, maintenance and adjustment tasks. When viewed on an oscilloscope the most noticeable distortion is slight "points" at the high and low points of each cycle.

However, these actually constitute quite a low harmonic content, a fact borne out by the quality of the sound which appears quite pure to the ear. The output level varies very little over the entire frequency range from 20Hz to 20kHz, allowing rapid and easy testing of most audio equipment.

Most constructors will probably not require a true "600 ohm" dBm calibrated source, but if this is needed a 330 ohm resistor should be placed in series with the output and level settings used should be 6dBm higher than the actual level required. For instance, for a −10dBm signal, the output should be set at −4dBm.

When loaded with 600 ohms, the line level will then be found to be −10dBm or half the unloaded level, which is correct for this type of measurement. Most users will probably not need to do this however, but will find the unit a simple and convenient signal source for general purpose testing. □

FOX REPORT

by Barry Fox

English – Britain's Most Successful Export

How do the Japanese use a word processor? How can a simple keyboard generate the many thousands of pictorial characters or "ideograms" which the Japanese language uses?

Many businesses now use Western languages, just as the Japanese military had to use Western words for their Morse code messages. Later businesses used Western text for telex. English, or more accurately American English, is already the international language used by the airline industry, for all communication including air traffic control.

There are 6,500 languages spoken round the world. No-one can master more than few. American English is quickly becoming the international business language. So English, Britain's most successful export, is now succeeding where Esperanto failed.

But that is not the full story. Japanese newspapers still publish in ideograms, Japanese companies use them for correspondence and press releases. If you go into an electronics store in Japan, all the word processors and computers have Japanese characters on the keys, as well as Western alphanumerics.

The Japanese only learned to write around 1500 years ago, using picture characters borrowed from the Chinese and Korean languages. But as well as using ideograms, called kanji, to represent whole words, they also used simplified characters to represent phonetic symbols. These are called kana. There are two types, katakana and hiragana.

Katakana are abbreviated symbols, which are quicker to write, and used mainly for imported words. Hiragana are full symbols, rounded for easier writing. As a result the Japanese language ended up with around 60,000 different characters.

Modern Japanese writing is a mixture of kanji, and both types of kana. This is why Japanese, Chinese and Koreans are usually able to read each other's literature, while not understanding each other's speech.

Legal Limit

After World War II the Japanese Government tried to rationalise the messy situation by putting a legal limit on the number of ideograms that can be used in newspapers. They set the ceiling at 1,850. Obviously the 256 characters that can be written in 8-bit ASCII computer code cannot cope with Oriental ideograms.

The keys of a Japanese computer carry ordinary Western characters, as well as around 50 katakana or hiragana phonetic characters. The word is built up by keying in several kana to make a string, like entering the phonetic sounds "com", "pu" and "ter" . The computer then hunts through its memory for any corresponding kanji character e.g. for "computer" , and displays it on the screen or prints it onto paper.

If there is no single kanji equivalent to the phonetic spelling, for instance if the word is modern or technical, the system displays and prints the string of kana to give a phonetic spelling. So the final text becomes a logical mix of kanji (with one character representing a complete word) and kana (with several characters phonetically spelling the word). This is the only way that 8-bit ASCII can hope to cope.

Pound/Hash

Of course it is absurd that in these days of 32-bit computing, and the promise of 64-bit processing, we are still stuck with 8-bit ASCII code and all the restrictions and confusion it brings. The best everyday example is the mess over pound signs. The companies who sell computer printers seem completely oblivious to the very real practical problems this causes business. And it stems from old telex keyboards that have three keys that varied from country to country. One is labelled pounds in the UK and hash in North America, where hashes are often called pounds.

I still get many business letters with hash signs, instead of pounds. My own laser printer, a Hewlett-Packard 4L, has the infuriating habit of re-setting to a North American character set at every possible opportunity. It then tries to print hashes instead of pounds. So I then have to re-set it to ISO-4 for the UK.

Hewlett-Packard works on the daft principle that everyone now uses Windows (which drives a printer according to the local country code), so there is no need for a printer to default to the local country's character set. In reality, many businesses still use DOS programs, often quite old programs because staff feel comfortable with them. If there are no modern printer software drivers available, these programs will print hash signs instead of pounds.

I recently visited a small business whose complete computer system and printer stand idle because, as the owner put it, "We bought it to do our accounts, but have never been able to get it to print pound signs. So we just go on using a typewriter and ledger book" .

I am assured by a helpful correspondent that there is now a move inside the computer industry to set a new standard, called Unicode, which uses 16-bit words to generate 65,536 character codes. This should be enough to cope with the 3,500 characters common in Western languages, and the 27,000 ideograms common in the Japanese, Korean and Chinese languages. At the same time it will finally let PC users print pounds onto paper instead of hash marks.

GPS Car Navigation

The Motor Show generated a lot of interest in GPS car navigation, with promises of a full system for £1000. This needs putting into perspective.

The Global Postioning Satellite system has been built over the last ten years by the US Department of Defence. There are 24 satellites circling the Earth in six low orbits, with four back-up spares also in orbit. Each satellite is continually transmitting a very accurate time code signal. A receiver locks onto three, or preferably four, of them to read and compare their time codes; three satellites give longitude and latitude, four give altitiude as well.

A relatively inexpensive hand held device can tell you where you are, with map co-ordinates. This is very useful for yacht crews, but not so much use on the ground unless you genuinely don't know whether you are on Exmoor, Dartmoor or the Yorkshire Moors.

The car systems tell you which roads to take to get from city A to city B. Civilian GPS cannot accurately know which way a car is travelling or at what speed. So in addition to the GPS receiver, a compass, speed sensor and gyro sensor dead-reckon turns and progress. Even the type of tyres can affect the reckoning.

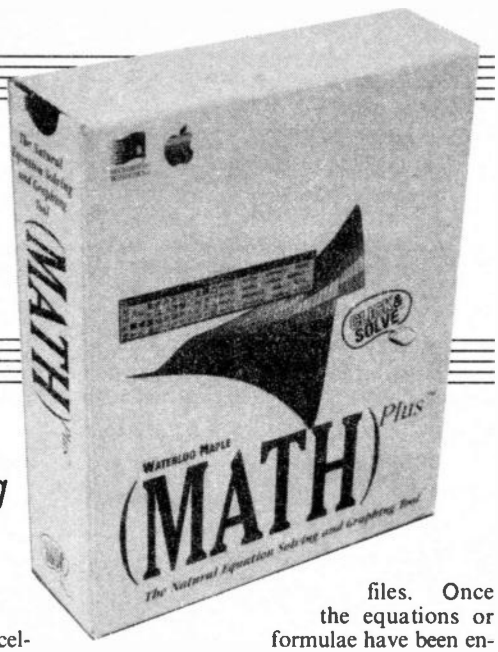
Accurate maps are stored on CD-ROM. Ordnance Survey's high royalties put up the price of wide coverage. A computer uses the GPS and sensor data to work out the best route and speech synthesis gives the driver directions.

The only way the car maker can charge £1000 for the full system is to factory-fit GPS as a loss leader on flagship new cars. There is no firm prospect yet of a DIY kit. It would be too expensive and too difficult to fit.

Special Review

MATHPLUS

JOHN BECKER



Reviewing the interesting new Waterloo Maple equation solving and graphing software for PCs and Macs.

MATHPLUS 2.02 is a new mathematics package from Waterloo Maple Software. Designed for use with a PC-compatible computer running Windows 3.1 or later, or a Macintosh Plus and above, it is a most interesting package with two well presented manuals, the Learning Guide and the Reference Manual, each having well over 300 pages.

ORIGINATION

It is an improved Windows version of Theorist, a computer algebra package that has been available for the Macintosh for several years. Waterloo Maple describe it as a unique and revolutionary mathematical program with algebra and graphing, which combines the power of advanced maths with a simple yet powerful graphical user interface.

It is claimed to have all the tools needed for Mathematics, Engineering and Science, yet with sufficient simplicity to suit any student of the subjects.

Introduced in the UK as a teaching and learning mathematical tool for secondary school, college and university education, it covers a large portion of attainment levels within the National Curriculum, specifically Keystages 3 and 4.

Many of the course requirements within Advanced Supplementary and Advanced Level mathematics courses are also covered, paying particular attention to Pure and Mechanical disciplines.

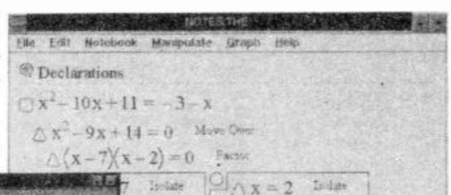
MathPlus is distributed in the UK by Robinson Marshall (Europe) PLC, the same company who distribute the excellent Electronics Workbench software which was so well received when featured in the *Electronics from the Ground Up* series published in *EPE* October '94 to June '95. It was supplied for me to assess its potential usefulness in electronics.

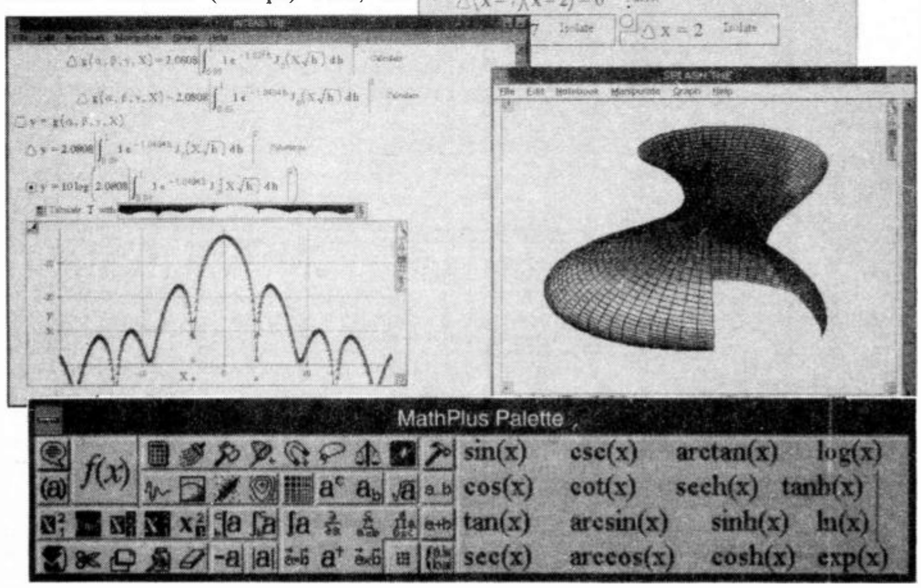
FORMULATION

Whilst maths was a major subject for me during school days (not long after Pythagoras got the hang of angles!), I am not well steeped in its higher use.

Even so, from having played around with MathPlus during several intriguing sessions, despite a few problems, it appears that the software, with its simplicity of equation and parameter entering, and clear display of answers as text, tables and colour graphics, offers good opportunities for enhancing the problem solving capabilities of any user, however limited or advanced their experience with maths.

Users of this software can quickly and accurately explore mathematics numerically, algebraically and graphically. The facilities include more than 250 maths functions, 2D and 3D graphics, animation, symbolic algebra, 15-digit arithmetic precision, remanipulation, and notebook files. Once the equations or formulae have been entered, their data values can easily be changed. New answers are rapidly and accurately recalculated and displayed.





Colourful graphs can be generated quickly and can be manipulated on screen, simply by clicking and dragging the mouse in order to explore different aspects of their construction. Running the software on a 25MHz machine, most graphical movements were found to be satisfactorily fast.

Everything you write or display through the MathPlus "notebook" files in which you work, texts, tables and graphs, can be saved on disk or output to a printer.

SPECIFIC FACTORS

The maths facilities include:

- Powers, factorials, roots
- Integers, fractions, decimal numbers
- Standard mathematical constants of π, e, i, and ∞
- Trig and hyperbolic trig functions
- Natural and base 10 logarithms
- Polynomials: factor, expand, collect
- Equation systems solving
- Trigonometric identity application
- Vector and matrix manipulation
- Series, differentiation, integration
- Automatic remanipulation precise to 15 digits

Notebooks have the following features:

- Icon based access
- Mouse and menu manipulation
- Built-in outliner for organising documents
- High quality printouts
- Type-set mathematical equations in input, results and text
- E-mail and exchange notebook files between platforms

Plotting and graphics features include:

- Lines, curves and surfaces
- 2D and 3D animation
- Animate directly in notebook
- Smooth rotation of 3D graphs
- Smooth scrolling of 2D graphs
- Cartesian, polar, log, complex, parametric, cylindrical and spherical coordinates

REQUIREMENTS

The minimum system requirements for running MathPlus are:

For a PC:

- 386 processor
- 4MB RAM
- 3MB hard disk space
- Windows 3.1 and later (including Windows 95), or NT

For Macintosh and Power Mac:

- Mac Plus and above, including Quadras
- 2MB RAM
- 2MB hard disk space
- System 6, 7 and A/UX compatible
- Maths co-processor support version included

INSTALLATION

MathPlus was supplied on three 3.5in disks. Two of them comprised the software for version 2.01. The third was a Windows Patch disk which upgraded it to version 2.02 and "addresses problems with the program quitting unexpectedly as well as some printing and display difficulties".

The disk space requirements for using MathPlus with a PC were found to be not quite as simple as implied by the specification. With 6MB free on a 170MB hard disk, the program would not install. Only after deleting some unwanted hard disk files and running the DOS routine DEFRAG, making about 8MB free, did it install successfully.

A small irritation arose at the end of installation. MathPlus requires that a registration routine is completed in which the rightful user's name is recorded. It was not immediately obvious that the data could only be entered after the mouse cursor had been clicked over the relevant boxes.

Having figured that out, though, it was now possible to start examining MathPlus with the aid of its Learning Guide. Often, the temptation is to try and get new software to work *before* reading its manuals. With MathPlus, don't! Work your way through at least some of the Learning Guide since some aspects of its use are not instinctive.

For example, the <ESC> key is not used for escaping from a particular situation as is commonly the case. It is used as a command key. Additionally, the two <ENTER> keys on the keyboard have separate uses depending on the data entry mode required – Propositions or Declarations (basically, equation data or comments). Some other keys, such as <TAB> and <DELETE> also have operational significance.

TUTORIALS

The tutorials in the Learning Guide follow a progression from simple to complex. In general, each tutorial describes how to solve example problems. The Guide points out that you don't need to *entirely* follow this structured approach. Once the basic concepts have been grasped, it is perfectly feasible to experiment, whether problems are specifically mathematical, or simply related to how to manipulate a graph for different coloured displays, for example.

Regrettably, the first tutorial presented an unexpected problem at its conclusion. The manipulation of an equation and subsequent rotation of a 3D graph had been easily achieved. The problem was how to stop the graph rotating and move on to something else. No mention of this was made in the manual. As it turns out, the answer is simple, but at the time, the computer had to be reset.

After this, though, several other tutorials were worked through without too much difficulty.

EASY EQUATING

Amongst other things during these trials, it was discovered how to enter an equation with several algebraic terms to either side of the equality sign, and then click the mouse to isolate individual terms to the left of the equality sign with the remainder of the equation rearranged on the right.

For example, although not part of tutorial exercises, Ohm's Law stating that voltage equals current times resistance can be simply entered as the equation V = I × R. Then the mouse can be clicked to isolate R. The program copies and rearranges the equation on another line so that:

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

Later it was found that another Ohm's Law, stating that watts equals voltage squared divided by resistance, can be entered in the same context as the first and from the two basic statements the other ten derivative Ohm's Law equations can be quickly extracted.

There is no need to try to remember how to *mathematically* isolate a term to one side of an equation when it is embodied in a statement on the other. Just select the required term with the mouse and the program does it for you.

Even equations with numerous brackets, powers and roots can have their separate terms isolated and the equality rearranged and acted upon accordingly. Numerical values for various terms can then be played around with and the calculation results for any of the derivative equations displayed.

CONCEPTS

Those who are more familiar with computer programming than maths may find it necessary to reprogram themselves to the concept of equality as related to *mathematics* rather than to *computing*.

In programming, the statement that A = A + 1 is perfectly legitimate. The variable A has a value of one added to it and the result is stored back into A. In conventional mathematics, the statement A = A + 1 is nonsensical since logically it could mean that 0 = 1; equality *means* equality!

A mathematical convention perhaps unfamiliar to UK readers is the use by MathPlus of the raised point (·) in place of the multiplication sign. Thus, if you type 5 × 5, MathPlus converts the statement and displays it as 5·5.

Consequently, you have to be in tune to the possibility that when, for example, you see 5·5 displayed, it means five *times* five and not five *point* five, which is displayed as 5.5. (In *EPE*, the convention is that the *decimal* point is raised, i.e. 5·5.)

Conversion of equational keyboard entries into simpler formats is a design feature with MathPlus. It has the benefit that complex statements can be keyboard entered with as many brackets, powers and roots as the user feels content with, and the program will automatically convert the entry into a simpler mathematical form.

The software also allows these simplified expressions to be converted to a more "conventional" format, although not necessarily the same as the original format entered from the keyboard.

GRAPHS

The ability to create 2D and 3D graphs in colour proved to be an acute fascination! The use of 2D (linear) graphs will be familiar to almost everyone. They are commonplace in such applications as, for example, displaying amplitude as a product of time. Sine waves, square waves and other waveforms displayed by oscilloscopes are examples of typical 2D graphs.

The practical use of 3D graphs, though, will probably be less familiar to many readers, as it is to myself. All that I can realistically comment about the ability to generate them from equations is that they are visually appealing. As to how information is derived from them I don't know.

Not only can graphs be produced easily, they can be rotated and viewed from every conceivable angle and in as many colours as the screen can be told to produce. Their orientation can be related to any of the three axes plotted against any of the terms within the equation.

With all the graph formats, 2D and 3D, a "knife" facility is available with which to select sections of the graph for enhance-

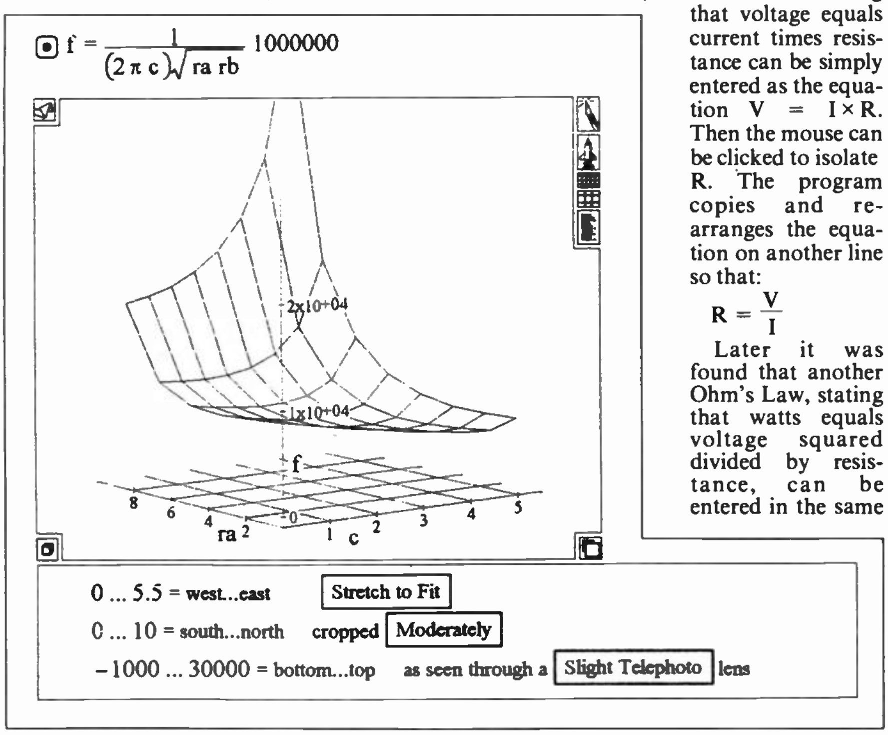


Fig. 1. Graph production from an equation is simple and all of the parameters can be readily changed, allowing rotation, zooming, ranges and colouring to be modified on screen.

Tabulate f(c) with

Save	Load	Copy	Paste
domain:	0	...	100
points:	11	inc:	10
range:	112.54	...	1125.4

0	f =	∞
10	f =	1125.4
20	f =	562.7
30	f =	375.13
40	f =	281.35
50	f =	225.08
60	f =	187.57
70	f =	160.77
80	f =	140.67
90	f =	125.04
100	f =	112.54

Fig. 2. Tabulating data from any graph is easy and highly flexible regarding all parameters.

ment, further assisted by a zoom option. Once a graph has been created, it is very easy to change its parameter values and immediately see it redrawn accordingly. All graphs can be "animated".

ICONOGRAPHY

Continuing to work through the Learning Guide, I was struck by how much work the authors seemed to have put into MathPlus. There are nice little touches and areas where extra facilities have been included which do not seem to be strictly necessary from a functional point of view, but which might have been added purely because the programmer enjoyed the idea of doing so. (That enjoyment is also obvious in the way some of the disk reference files have been written!)

A larger example is, perhaps, the inclusion of the Palette at the top of the screen. This is comprised of two windows of icons and regularly used maths statements, any of which can be called up by clicking on them with the mouse.

When selected, the maths statements are automatically copied into the working screen area for use as part of equational expressions, saving the task of actually typing them in from the keyboard.

The icons call up specific manipulations. For example, selecting the calculator icon commences the Calculate routine for a selected equation; a brush icon performs Simplify; a butterfly net selects Collect; a horizontal squiggle selects Graph mode; and so on.

Icon functions can also be accessed via the pop-down menus available from the top of the screen. Some pop-downs have other pop-downs accessible from them. "Help" facilities are available through the menus.

GOING SOLO

At times, it became slightly tedious to be asked to do some things in the tutorials without the reasons for doing so being made clear. When there is a need to use a manual to establish how to do something which is not instinctively apparent, it is nice to be led by the hand and have the what-fors and why-fors spelt out. There are areas which could have been explained more fully, and the indexes occasionally do not cover some key words.

Moving on stage by stage, though, earlier puzzlements became clarified.

Eventually, after working about half way through the Learning Guide, which probably took about four or five hours, I felt confident enough to put it to one side and start to "do my own thing".

First, I took Ohm's Law and messed around performing all manner of manipulations and displays. Well encouraged by success, and occasionally referring back to the Learning Guide, I moved on to see what could be done with a more complex formula, one of those related to frequency filters.

Accurate textual answers were again easy to produce, and generation of graphs from the data was, by and large, simple.

TABULATIONS

Extremely useful is the fact that numerical tables can be generated through the 2D and 3D graph functions, tables which can include extrapolated data which has not actually been programmed in as specific term values. The tables can be output to disk files for future use.

Similarly, tables can be imported from other sources and used to generate graphs. You could, for example, monitor an electronic circuit from Basic or machine code, input regular readings of various voltages or changing digital codes, output the data to disk, load up MathPlus, call in the data file and examine its graphical representation on screen, manipulating it to see how the electronic design might be improved.

PRINTING OUT

Notebook files can be output to a printer complete with all texts, tables and graphs. As with a sophisticated word processing package, numerous options are available for modifying the printout presentation – including different typeface styles and sizes. Naturally, the quality of the print will depend on that of the printer. The example printouts in Fig. 1 and Fig. 2 were made on an Epson LQ-550 24-pin printer.

Be aware that when outputting to a printer, the program first formats the data into a disk file, and prints from the file and not from memory. This can result in a bit of a wait between giving the command to print and the printer actually starting to work.

However, it does allow other work to be continued once the printer has started to print, although there can be an occasional slight inconvenience in that printing is interrupted (but not terminated) if what you are doing on screen requires access to the disk.

In this context, it would have been desirable for the screen "wait" symbol, the hourglass, to appear immediately the print command is given. The cursor arrow, implying that other keyboard work can be continued, remains on screen longer than desirable. Instances of this behaviour have also been found in other parts of the program.

REFERENCES

The Reference Manual states that it "assumes that you have a basic understanding of mathematics and want to use MathPlus to pursue scientific or engineering research, or you are studying mathematics, and want to improve your grasp of mathematical relationships in your field . . . (it) is not designed to teach mathematics but to describe how MathPlus works so that you can explore, and gain new insight and understanding in any mathematical subject."

Although the *manual* may not teach mathematics, in fact, amongst the disk files are many whose purpose apparently *is* to teach maths. They are from the original Theorist software and state that they are for "High School" use. Subjects relevant to both maths and physics are included. They are interactive and their presentation style is very chatty!

There are also several lengthy files which give definitions of various commonly (and less commonly) encountered terms and units, such as SI units, for example.

The files are accessed via the Notebook icon in the Open File window (a facility not covered in the Index).

Do not expect MathPlus to provide you with its own library of useful equations or formulae. It would be nice if did, but it doesn't!

Through its notebook structure, what MathPlus does allow, though, is the creation of your own libraries of equations, formulae and expressions to suit what you want to do. The act of saving each notebook file automatically saves all equations, values, graphs and tables created within them.

HOW USEFUL?

The facilities offered by MathPlus and the *general* ease with which they can be used are impressive. Readers who need to make many electronics calculations during their designing will find MathPlus a great assistance. The ability to input tabular data generated when using test equipment with other software is also of enormous value.

Despite not being a mathematician, I recall a bit of what was taught years ago and feel confident that those who *are* mathematicians will benefit from what seems to be well thought out software. MathPlus also has a broad range of other facilities to which I have not referred. Judging from the examples given in some of the reference files, *extremely* complex equations can be manipulated.

Although a few problems have come to light, I believe that MathPlus is definitely a software package which deserves to be examined if you are seriously involved in electronics or mathematics. Faraday, Ike Newton and Uncle Albert would have loved it!

OBTAINING MATHPLUS

For individual users, MathPlus costs £199.00, plus VAT and shipping charges. Site licences are available for group users, starting at £1000.00 for ten users.

MathPlus, and more information about it, is available from Robinson Marshall (Europe) PLC, Dept. *EPE*, Nadella Building, Progress Close, Leofric Business Park, Coventry CV3 2TF. Tel: 01203 233216.

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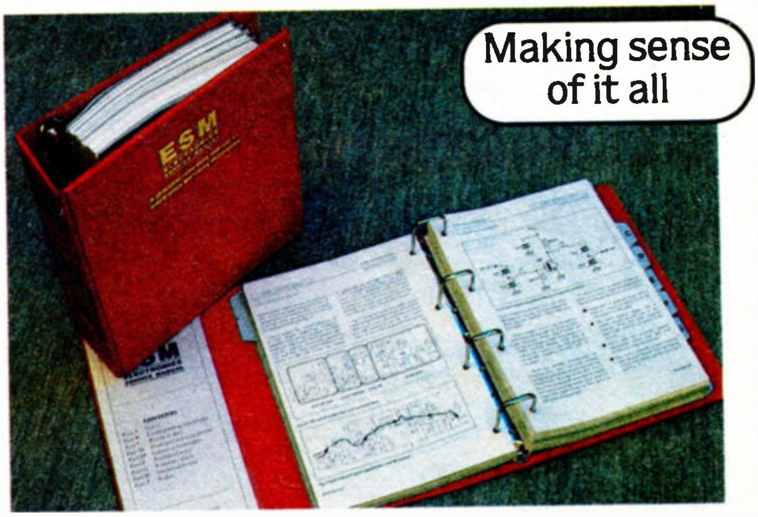

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EPE MET OFFICE

JOHN BECKER

Part Two

Whatever weather changes might befall, this seven-sensed centre computes them all.

LAST month the circuits for the *EPE* Met Office sensors and output multiplexer were described. This month we conclude the project by describing the PC-compatible Computer Interface circuit, the construction of the wind speed and direction mechanics, the example software listing, and the final testing and setting up.

COMPUTER INTERFACE

The circuit diagram for the PC-compatible computer interface is shown in Fig. 15. It consists of an interface address decoder around IC19 and IC20, a tri-state signal output gate IC21, and an additional data latch IC18 which is used for function control purposes.

All PC-compatible computers have one or more expansion sockets into which customised peripheral circuit boards can be plugged. Data can be read from or written to the expansion ports at any one of 32 addresses, from &h300 to &h31f. The function of the address decoder is to allow the circuit plugged into the port to respond only to the correct address calls made from software.

Between them, OR gate IC19a and data selector IC20 respond to any address call made to the block &H300 to &H307. On detection of read or write calls to these addresses, IC20 pin Y1 (14) goes low. This output is connected to OR gates IC19b and IC19c. If a read call is made to the addresses, the computer's $\overline{RD}$ line goes low, and so does the output of IC19c pin 6, which in turn allows tri-state buffer IC21 to connect data on its input pins D0 to D7 (pins 2 to 9) through to outputs Q0 to Q7 (12 to 19).

The data input D0 of IC21 is connected the frequency output of the v.c.o. IC91 in Fig. 11 (last month). The other inputs are not used and so are grounded. Software repeatedly reads the status of IC21 output Q0 over a period of time which allows the data output frequency to be calculated.

The computer data lines are also connected to the data input lines D0 to D5 of the 6-bit latch IC18. When a write call is made by the computer, the output of OR gate IC19b goes low, an action which causes IC18 to latch the presented data through to its Q0 to Q5 outputs (pins 2, 5, 7, 10, 12, 15).

Example screen display. Graph lines show : D – Wind direction gusts fluctuating around NW. P – Barometric pressure slightly falling. H – Humidity slightly rising. R – Rain starts about third way across. T – Temperature falling slightly. L – Light level dropping from near max. to half level as rain starts. S – Wind speed fluctuating.

Output Q1 of IC18 pin 5 is routed through resistor R30 to the clock input pin 1 of IC7 in Fig. 11 and to IC3b pin 4 in Fig. 3 (last month). Any write call in which data bit 1 is toggled automatically sends a clock pulse to these two destinations.

Counter IC7 in Fig. 11 counts each of these clock pulses, setting the binary code on its QA0 to QA3 outputs accordingly. As discussed last month, this code determines which data source is routed through IC8 to its output pin 3.

Referring to Fig. 3, (last month) the same clock pulses are also used to read the rotation sensor data held by shift register IC4. This action can only take place when the change-over gate around IC3b to IC3d is appropriately set by IC2, as also discussed in Part One.

Referring jointly to Fig. 11 (last month) and Fig. 15, synchronisation of counter IC7a is achieved by periodically resetting it by making write calls to IC18 which set the latter's Q0 output high. This latter output is connected via resistor R29 to IC7 pin 2 and IC7 pin 13. The former is the reset input of counter IC7a, and the latter is the clock input of counter IC7b.

Repeated toggling of IC7b's clock input pin causes the counter's QB0 output to toggle high and low at half the clocking rate. Connected to IC8 output pin X1, the output level from IC7 pin QB0 provides high and low reference voltages which are used by the software to compensate for temperature dependent frequency shifts of the v.c.o. IC9a.

The Interface circuit is powered by the computer at +5V.

INTERFACE BOARD

The printed circuit board (p.c.b.) component layout and full size copper foil master patterns for the double-sided *EPE Met Office* Computer Interface board are shown in Fig. 16. This board is available from the *EPE PCB Service*, code 964.

With the computer switched off, insert the Interface p.c.b. into one of the expansion card sockets to check alignment. The computer manual will show the correct orientation of the board. If necessary, file down the sides of the board until it fits in snugly and all the socket tags line up with the p.c.b. connection tracks. Remove the p.c.b. from the socket.

Although the p.c.b. is double-sided, it is not through-hole-plated, consequently all the on-board wire links have to be soldered in. This should be done first, preferably using 24s.w.g. tinned copper wire.

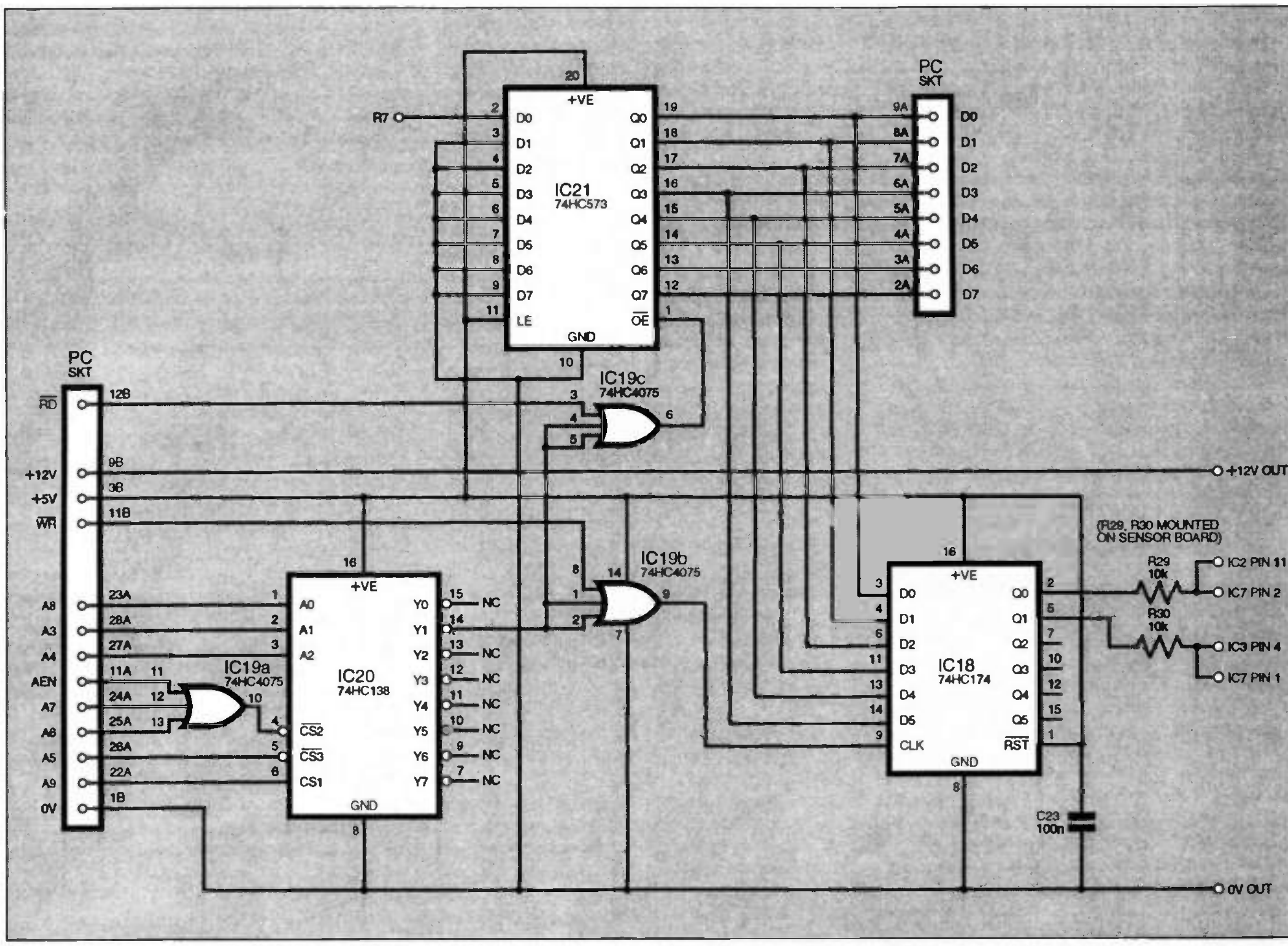
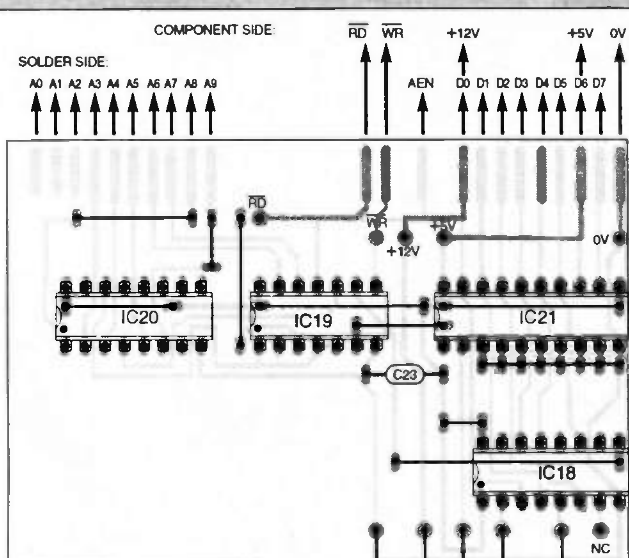
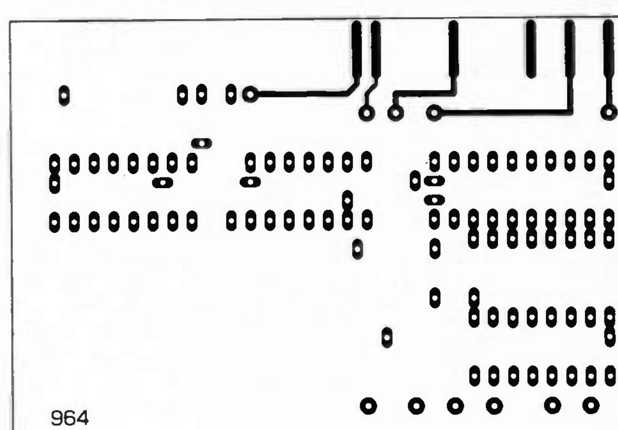


Fig. 15. Circuit diagram for the PC-compatible Interface.





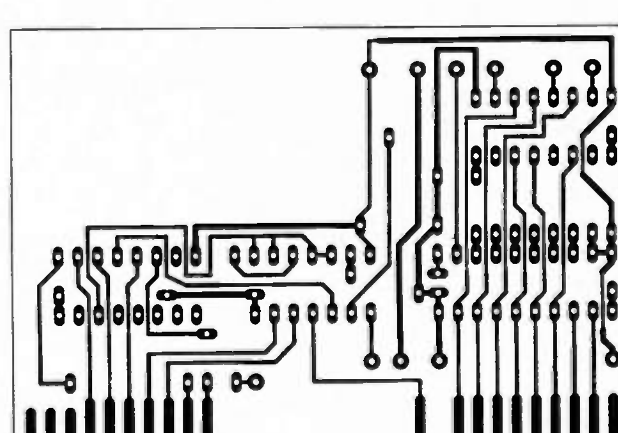
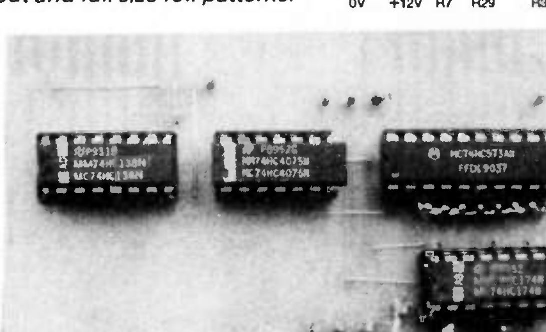


Fig. 16. Interface p.c.b. component layout and full size foil patterns.



First, single-sided prototype board.

Note, though, that the link shown immediately below IC21 has to have terminal pins inserted first into the relevant holes, and then the link wire is soldered across all of them. Next solder in the i.c. sockets, followed by terminal pins into all the remaining holes. Do *not* insert the i.c.s into their sockets at this stage.

Once assembled, check the p.c.b. for inadequate soldering, and for solder shorts across the tracks. Plug the board into the computer and switch on. If at any stage during testing the computer does not respond as normal immediately switch off and recheck the p.c.b. assembly and component insertion correctness.

Remembering that all the i.c.s are CMOS devices and observing the usual anti-static handling precautions (briefly referred to in Part One last month), switch off, insert the i.c.s and again switch on to check that the computer still behaves as usual.

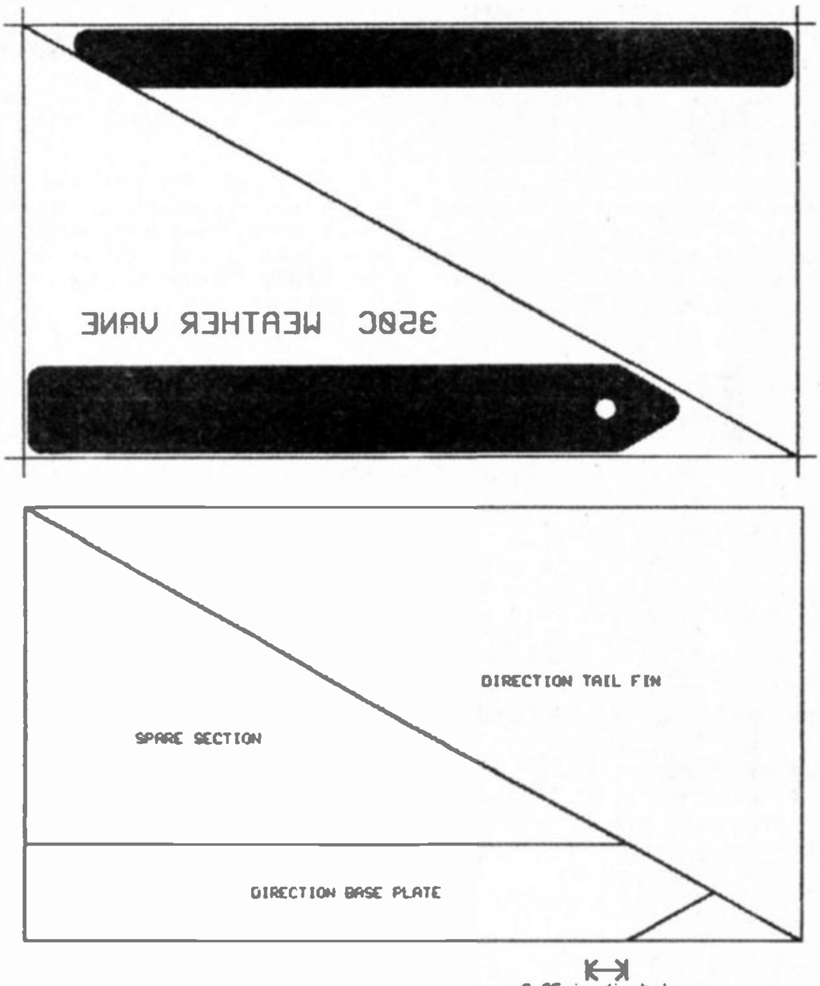


Fig. 17. Full size foil pattern and cutting details for the Vane p.c.b.

SOFTWARE EXAMPLE

An example of how software can monitor the *EPE Met Office* is given in a seperate disk/prinout listing. The example working and test program discussed here is available on disk, together with a printout copy, from the *EPE Editorial Office* (see page 13) for the sum of £2.50, including p&p. Orders should be sent to "Back Numbers" Dept.

It is written in GW-Basic but can optionally use a short machine code routine which is held in data statements at the end of the listing. It is likely that the program can be used with other Basic dialects, such as QuickBasic, but without the optional machine code routine.

If the machine code is not to be used then in line 50 "MC=1" should be amended to read "MC=0". This zero value automatically causes the program to use an equivalent Basic routine commencing at line 1270. QuickBasic will not like the statement "CALL CODE" in line 1290 so this line should be deleted accordingly.

Since the Basic equivalent of the machine code runs much slower, it may be necessary to reduce the frequency range of the v.c.o. in Fig. 11 (last month). Increasing the value of capacitor C3 will achieve this.

Doubling the value of C3 is a good starting point. Note, though, that some computers may run fast enough in Basic to make adjustment of C3 unnecessary. From Basic, the Amstrad 1640 with which the prototype is used can sample the *EPE Met Office* output at frequencies up to about 50Hz.

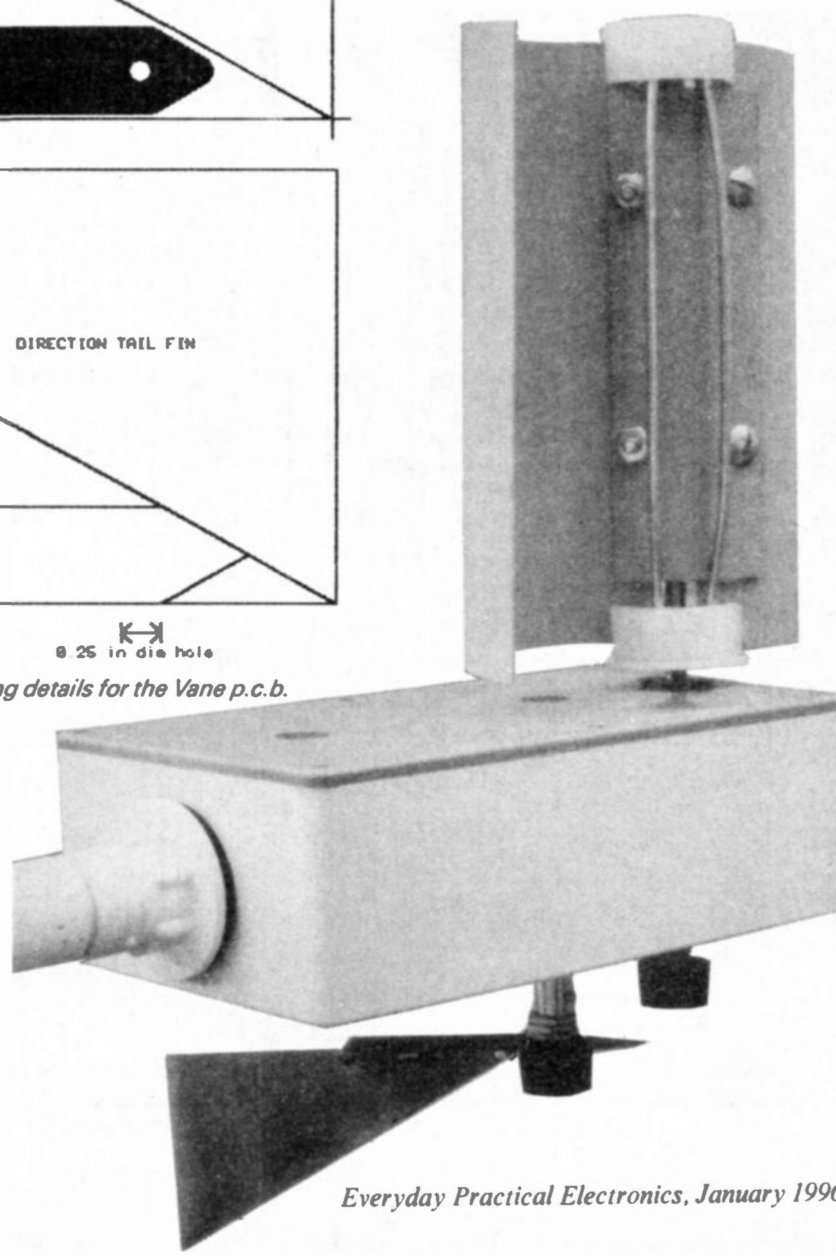
The software has been written so that it samples all of the sensors in a repeatedly looped routine. During each loop, minimum and maximum v.c.o. frequencies, as biased by IC7 output QB0, are calculated and used as reference levels against which the frequencies caused by the sensor outputs are compared. This helps to compensate for temperature induced changes to the VCO's frequency stability.

Temperature induced changes in the basic output voltages from the sensors can be compensated for by including correction factors in the individual sensor sampling routines within the loop. Examples of some correction factors will be seen near the head of the listing. The values given to the correction variables shown may be changed and other correction variables introduced to suit individual conditions.

The printer routine listed was written for use with an Epson LQ550 24-pin printer. It is believed that the codes used are compatible with the majority of Epson printers.

No provision has been made for outputting data to disk, but experienced programmers should have no difficulty in including disk storage and recall routines. There are good examples of such routines in the software for the *EPE Seismograph* of September and October 1994. They will, of course, need modifying to suit the *EPE Met Office*, although the data acquisition principles have much in common.

Type in and save the software program, and make a back-up copy.



BOX PREPARATION

The next task in the construction process is to select and prepare the control case. Drilling details for the box are not given since the hole sizes and positions are likely to vary between different units. The photograph shows the approximate positions of the vane, rotor and vertical stand holes.

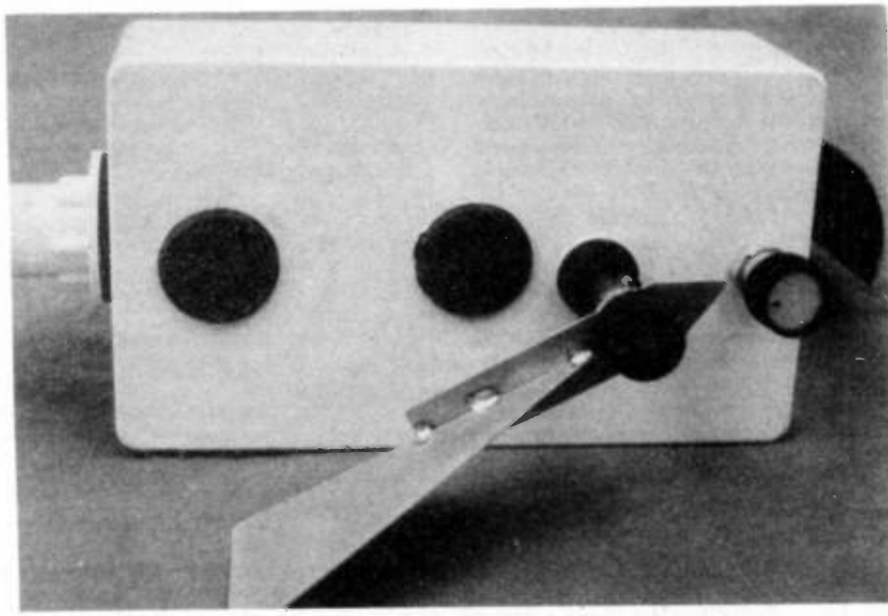
A hole of about 25mm should be drilled below the LDR (R43) position. A plumbing "tank-connector" is inserted into a hole drilled in the box end nearest the power supply end of the p.c.b. This forms the stand fixing point and the outlet for the cables from the box back to the computer.

VANE AND ROTOR

Most of the parts for the Wind Speed and Direction Indicator mechanics are derived or modified from normal electronic components, such as rotary potentiometers, knobs and so forth. The weather vane wind direction pointer is made from the p.c.b. whose details are shown in Fig. 17. This board is available from the *EPE PCB Service* and is supplied as part of the Main Board whose details were shown last month, code number EPE 963.

The p.c.b. in Fig. 17 should be carefully cut into its separate sections using a fine-toothed hacksaw, after which its edges should be smoothed with a fine file. Drill out the hole in the base plate pointer to allow a potentiometer shaft to pass through.

Now solder the triangular vane tail fin at right angles to the base plate pointer, as shown in Fig. 18. The same figure also shows how the vane and spiral pattern disc are mounted on the Main Board within the box. The potentiometer bush mounting called for is obtained by carefully dismantling any standard potentiometer assembly.



Early prototype control case showing the wind direction vane mounting, light sensor "window" (left) and vertical stand fixing, far left edge. Note the centre hole was a "mistake!"

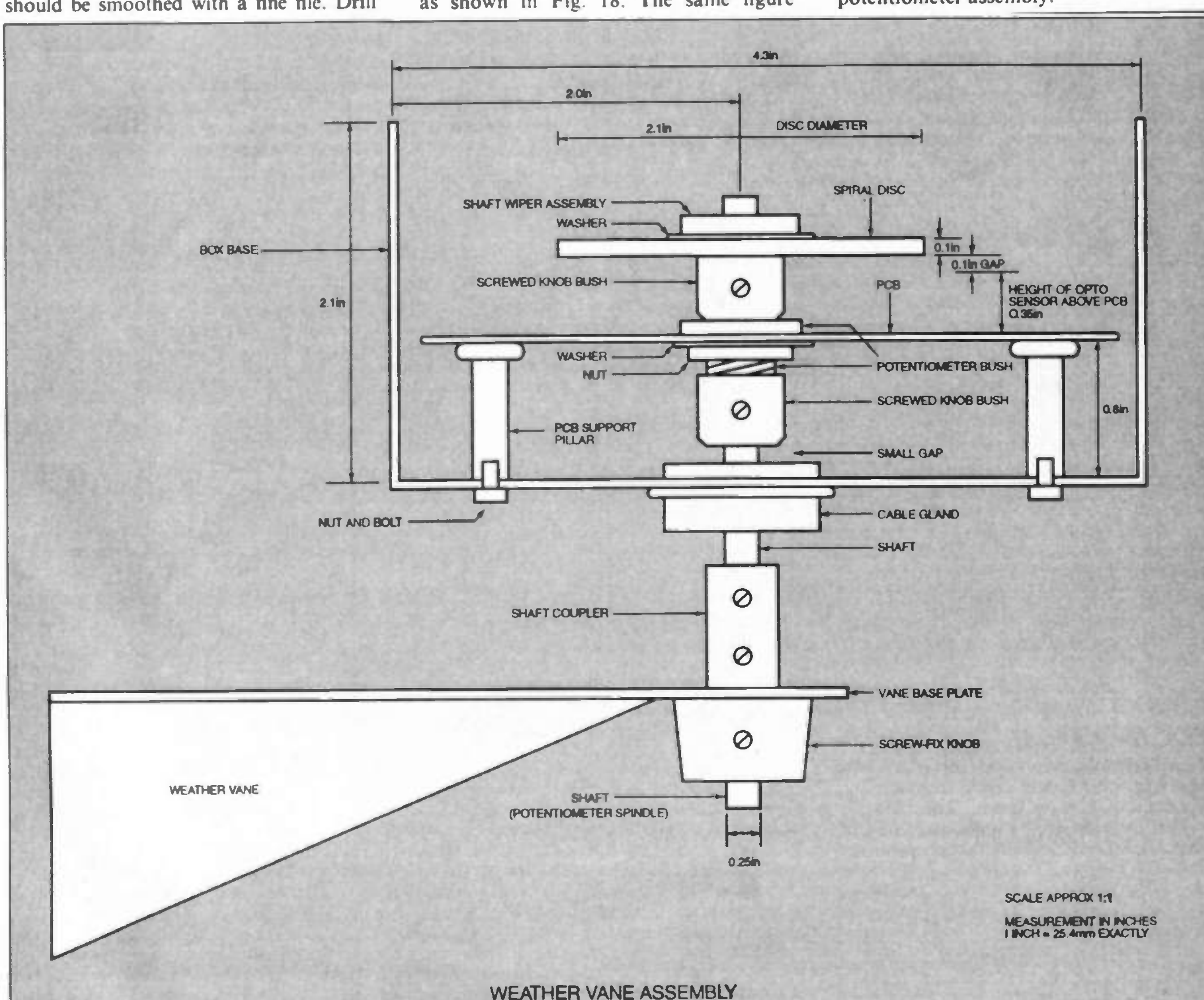


Fig. 18. Constructional details and mechanical assembly of the wind direction vane.

SPIRAL DISC

The spiral pattern used for the rotation sensor is shown in Fig. 19. A life-size transparent film print of the pattern is available from the *EPE PCB Service*, code 963. It can, alternatively, be photocopied onto transparent film by many photocopy service shops. The image density may not be as dense as that from the *EPE* film image, but carefully mounting two copies together should provide a sufficiently dense image from which the linear sensor can detect the pattern.

It is also possible to use p.c.b. black drafting tape to duplicate the image direct onto a clear film base. In fact, this technique was used in the prototype, though patience was needed to achieve the tracking precision needed.

However, transparentising a paper-based photocopy is not recommended as it may prove to be unsatisfactory since the image might not have sufficient contrast and transparency to allow the sensor to detect the track to non-track separation.

With the prototype, the spiral image film was secured to a perspex disc which had been cut from a small off-cut sheet. Double-sided self-adhesive tape (Selotape or similar) was used as the securing medium.

The disc should be positioned above and as close to the opto-sensor IC1 as possible, allowing for satisfactory rotation. The spiral track surface should point downwards at the sensor to increase the image definition, though the direction of rotation is unimportant since this can be corrected for from software.

The l.e.d. is then positioned about 25mm above the disc, facing downwards to the centre of the opto-sensor's line of pixels. Its height may eventually need adjusting in order to obtain the best signals across the full rotation of the spiral. A data-bit bargraph is displayed on the computer screen which will help in this alignment.

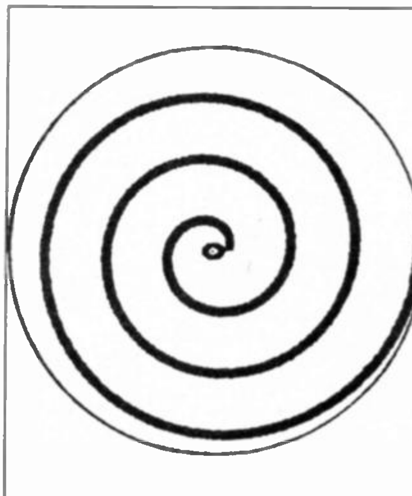


Fig. 19. Full size "blanking" pattern for the wind direction spiral disc.

WIND SPEED ROTOR

The Wind Speed rotor design was inspired by those on some of the ships in Poole Harbour! It takes the form of an "S" shape rotating about a central point, as shown in Fig. 20 and Fig. 21.

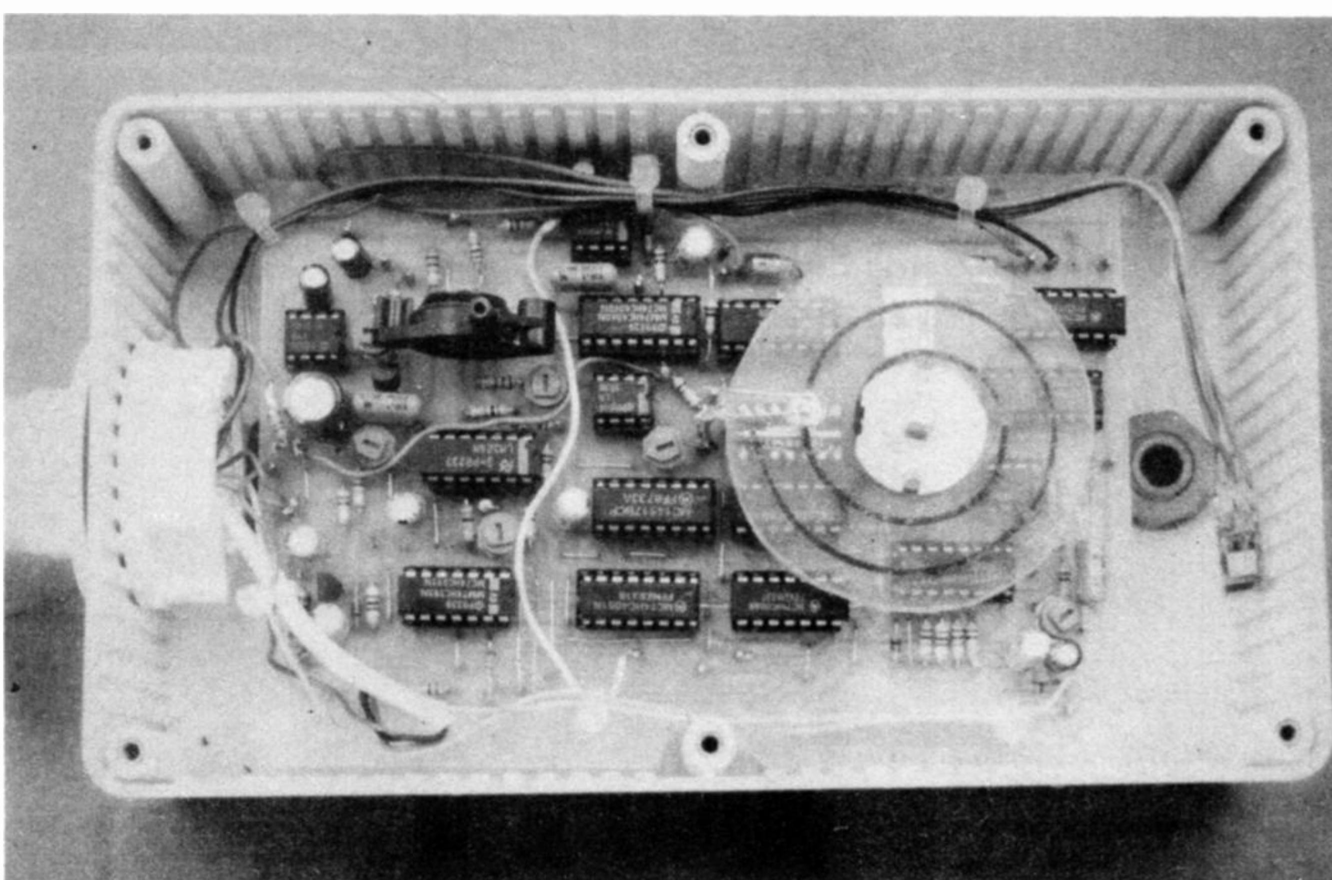
The two halves of the "S" are made from two "U" sections of thin plastic guttering obtained from a d.i.y. store. They are mounted on a small cheap paint roller framework (sold without cylindrical painting foam attached), obtained from the same store.

The guttering was cut to a length to suit the framework and pushed into slots cut into the cupped ends of the frame. Another section of the gutter was then cut to provide a rectangular plate which was bolted to the two "U" sections to hold them together. The potentiometer bush mounting called for in Fig. 21 is also obtained by carefully dismantling any standard potentiometer assembly.

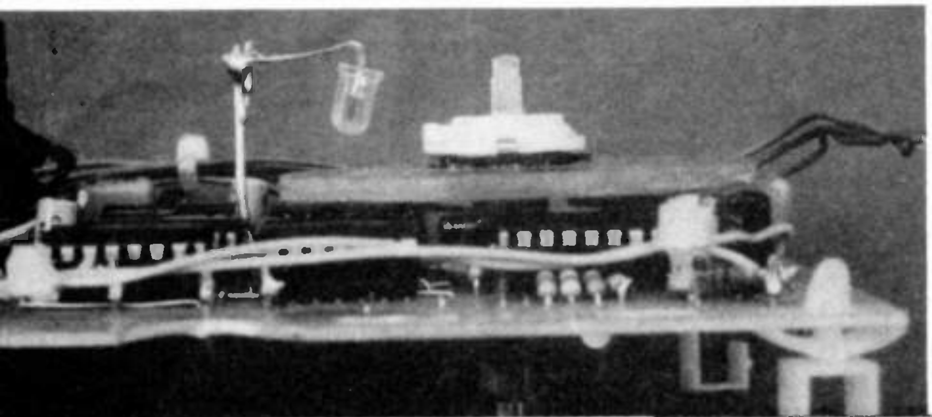
Before the guttering was attached, the shaft handle of the "paint roller" assembly was straighted using a hammer and a vice. It was then cut to a length which would just pass through the *EPE Met Office's* box from top to bottom, allowing for the height of the mounting bushes. The lower mounting bush is a cable gland which can be tightened onto the shaft to hold it in position. It is not necessary for the shaft to rotate.

Into the lower cup of the roller a small magnet was inserted with one of its poles pointing downwards (either of the poles may be used). The magnet may be glued into position. The Hall effect sensor TX5 is secured to the box's inner lid surface directly below the magnet's rotational path.

This d.i.y. assembly has been found to be extremely responsive to even very slight breezes. Road tests were carried out to establish the rotational rate to wind speed conversion factors. The example software listing calculates wind speeds according to the results of these tests, though the correction data shown may need changing to suit other rotor assemblies.



Layout of components inside the Sensor control unit. The pressure transducer is located towards the top left of the board, the wind direction spiral and l.e.d. above the opto-sensor. Finally, the wind speed Hall-effect transducer, which will normally be secured to the underside of the case lid below the "speed paddle", can also be seen to the right of the p.c.b.



Close-up of the l.e.d. above the wind direction spiral which masks the "pixels" of the opto-sensor IC1.

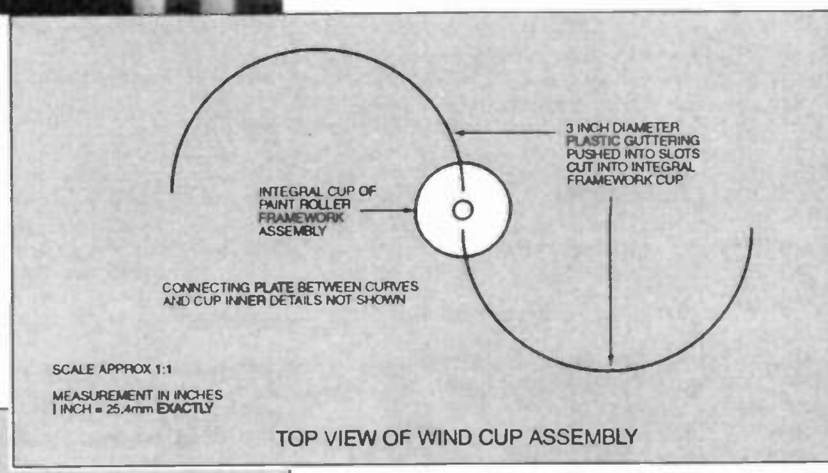
With both the rotor and the vane, it is important that the moving parts rotate smoothly and that they are kept well lubricated. Adequate lubrication should also serve as a barrier to rain trying to seep into the vane and rotor mountings.

SETTING UP

Initial setting up of all but the Wind Speed Sensor should be carried out indoors. Connect the Sensor and Interface boards together via three or four metres of unscreened signal cable. Plug the Interface into the computer.

The computer screen displays a variety of facts about the data read from the sensors, including voltages and their functionally converted values, such as millibars, k.p.h., compass bearing, etc. These figures will help in the setting up and in the choice of correction factors written into the software.

There are four preset potentiometers which need to be adjusted, VR1, VR2, VR4 and VR5. Adjust VR2 first. This preset, as shown in Fig. 11 (last month), provides a bias voltage for the v.c.o.-controlling op.amp IC17a and optimises its output voltage swing in response to the minimum and maximum input voltages from multiplexer IC8.



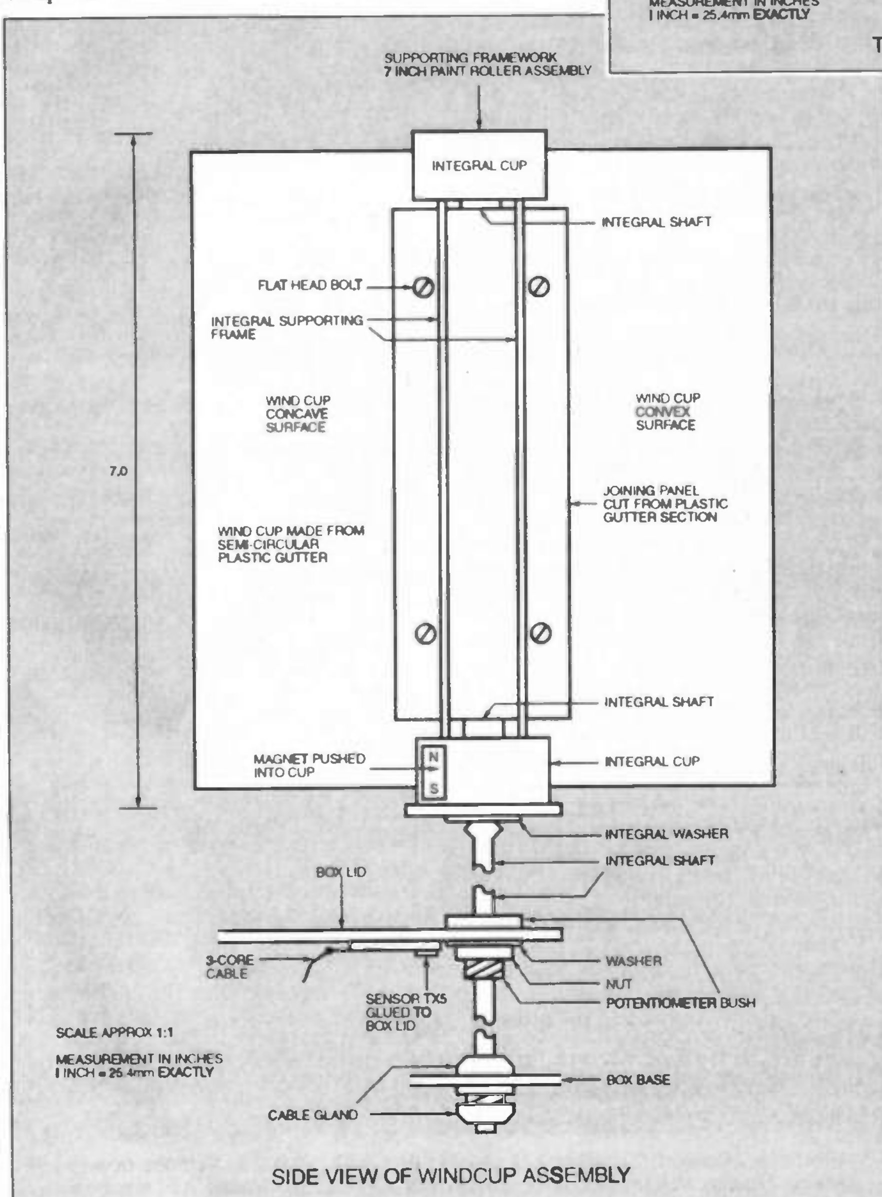
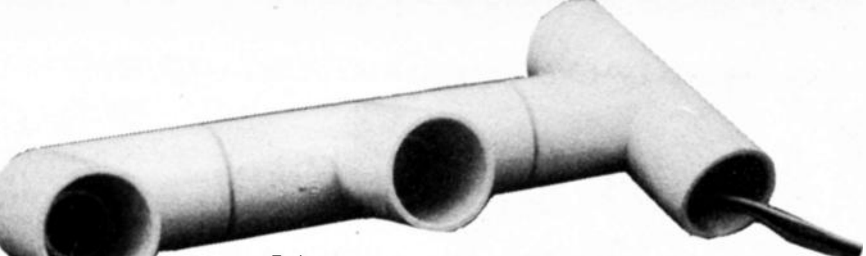


Fig. 20 (above). Top view of the wind speed paddle assembly.

Fig. 21 (left). Side view showing the mechanical assembly of the wind speed rotor and below the completed paddle assembly mounted in the control case.



Rain sensor transducers mounted inside some plastic plumbing which is placed over the rain collector.

Load the software and temporarily reinstate the "STOP" commands in lines 400 and 410 by deleting the word "REM" from each of them. Monitor the voltage at IC8 pin 3 and run the program.

When the program stops at line 400, the meter reading should be about 0V. If, instead it's about +5V, continue the program, which will then stop at line 410.

When the meter reading is showing 0V, monitor IC9 pin 9 (the VCO input pin) and adjust preset VR2 until the meter reading shows about 1·8V. This is about the minimum voltage to which the v.c.o. will linearly respond.

Towards the head of the Listing set VMIN to the actual voltage reading. Press the <CONT> key. Set VMAX to the new voltage at IC9 pin 9 (about 3·85V).

Reinstate the word "REM" back into both lines 400 and 410. Resave the program and then run it again. Adjustment of the other presets can be made whilst the program is running.

PRESSURE AND HUMIDITY BIAS

Preset potentiometers VR4 of the Pressure Sensor (Fig. 5) and VR5 of the Humidity Sensor (Fig. 6) simply set the minimum d.c. bias voltage output from these two sensor circuits. These and should be adjusted until their screen displayed readings make sense when compared against known pressure and humidity values.

Current barometric pressure can be ascertained by watching the weather forecasts on BBC TV, although it should be noted that this is quoted relative to sea level and should be adjusted to suit the altitude at which the sensor is situated. (The *EPE Altimeter* discussed this in greater detail.)

On a normal dry day when its not too dusty and there is no sign of rain, it can probably be assumed that the relative humidity will be about 50 per cent. Exceptionally dry days should produce a humidity reading of about 30 per cent, whereas if the washing machine has been on and the house atmosphere is damp a reading of between 70 and 90 per cent might be expected.

WIND DIRECTION BIAS

Adjustment of preset potentiometer VR1 of the Wind Direction Sensor (Fig. 3 – last month) should be made whilst watching the screen's bargraph display towards the top. VR1 needs to be adjusted so that the sensor's detection of the spiral pattern position results in a series of 0s and 1s in the display. It is likely that a midway position of VR1's wiper should allow the sensor's voltage steps to trigger the comparator IC17a correctly, but it may be found that adjustment of the wiper's position may be necessary.

Changing the rotary position of the vane should cause the relative positions of the 0s and 1s of the display to change. Adjust the height of the l.e.d. so that the sharpest definition of the spiral pattern is shown in the display.

It is important that the sensor is only illuminated by the l.e.d. otherwise it will respond to other light sources. It is acknowledged that this fact makes life a bit difficult at the time of setting up!

RAIN SENSOR

To check the Rain Level Sensor, position the ultrasonic transducer p.c.b. above a bucket, with the transducers facing into it. Gently pour water into the bucket whilst observing the screen display.

The increasing water level will cause a phase shift between the transmitted and received ultrasonic signals. Software calculates the change in water level height and displays the result on screen.

In practical use, the sensors could be positioned over the garden water barrel, via a long cable. The calculation routine could take into account the surface area over which the rain falls before draining into barrel.

The sensitivity of the sensor phase shift detection is such that ripples on the water surface can be detected, so indicating the presence of rain.

WIND SPEED

The only way that can be suggested to ascertain the true rotor speed to wind speed relationship is to carry out road tests. For this the complete *EPE Met Office* control box (disconnected from the computer!) should be temporarily mounted outside a car.

A voltmeter should then be connected to IC22 pin 4 or pin 7 and the voltages produced noted against the speed of the car. Returning the unit to its normal home, software correction factors can then be set according to the trial data.

If any reader can suggest a better method, other than hiring a wind tunnel from a military or commercial establishment, the author would be pleased to hear from them! Using mathematics to calculate the theoretical rotation rate to wind speed conversion is unlikely to be accurate because of the unknown friction and inertia values of the assembly.

TEST VOLTAGE

Provision has been made for "test voltages" to be fed to multiplexer IC8. Referring to the p.c.b. component layout chart of Fig. 13 (last month), disconnect the connecting wire at the point marked (SPEED) and connect it to the point marked "TEST V". This couples the wiper (w) of test voltage preset VR6 to multiplexer IC8 (it also disconnects the wind speed signal).

Adjust VR6 whilst running the program and monitoring the voltage on the preset's wiper with a multimeter. The true voltage and the screen displayed value can be compared and, if necessary, compensated for in software.

Alterations to any of the correctional factors written into the software should be made in the light of experience, having observed the readouts and assessed them intelligently or compared them with other data sources. Remember to Save the program each time corrections are made.

GARDEN MOUNTING

The author's complete *EPE Met Office* unit was mounted in the garden on a support, about one and a half metres high, made from plastic plumbing pipes of about 21mm diameter. The use of copper piping is advised, however, in order to provide greater stability.

The piping is attached to the box via the tank connector referred to earlier. Cabling may be run through the piping.

The maximum length of cable between the *EPE Met Office* and the computer is not known, but using about 20 metres of 5-core unscreened signal cable with the prototype no adverse results were apparent.

PROGRAM NOTES

The following notes are those referred to in the test program listing/disk.

NOTE 1:
AV – Sets the sample quantity for averaging. Must be greater than 1. MC=1 – Set MC=0 if machine code is not used. PC=&H300 – Computer address which accesses Interface.

NOTE 2: See "Setting Up" text.

NOTE 3: Output of Pressure Sensor is approximately 0·06mV per mb. IC13b multiplies by about 50, IC13c is unity gain, therefore output at IC13c pin 14 is about 3MV per mb, hence PRESSMULT = 1/3.

NOTE 4: HUMIDTEMP is temperature factor change of 0·5 per cent per one degree Celcius (manufacturer's quotation). Set HUMIDMULT to 1 and HUMIDADD to 0.

On a normal dry day assume humidity is actually 50 per cent. Note screen reading. Place damp cloth at ambient temperature around sensor. Wait several minutes. Assume new reading represent 90 per cent humidity.

Multiply first reading by 8/5, divide this answer by 2nd reading. The new answer is the factor to which HUMIDMULT should be set. Then set HUMIDADD to value which results in screen readout of correct percentage values. DO NOT WET SENSOR.

NOTE 5: SPEEDADD subtracts the minimum offset voltage present at the output of the tachometer chip when input is nil Hertz. Following road tests, work out the number of revs which would represent 100mph.

Set signal generator to this rate. Feed sig. gen. into test point. Run prog. Read the millivolts that this rate produces, set MPH100 to this mV value.

NOTE 6: MINRAIN and MAXRAIN are the screen displayed voltages (in mV) when the ultrasonic signal phases are at minimum and maximum shift respectively.

NOTE 7: VOLTS=VOLTS/1·45 corrects for gain of buffer op.amp. First set VOLTS=VOLTS/1 then observe Test voltage and meter reading. Divide Test voltage reading by meter voltage reading, then set VOLTS=VOLTS divided by resulting answer.

NOTE 8: Observe light per cent reading when light is at its strongest. Set LIGHTMULT to factor which results in a reading of 100 per cent. □

INTERFACE

Robert Penfold

FROM time to time an *Interface* article is devoted to the popular subject of using computers with model railways. With the aid of a computer it is often possible to endow a model railway with quite advanced features using a minimal amount of add-on hardware.

The simple pulsed controller described in this feature a few months ago is a good example of this. The hardware was basically just a buffer amplifier, with the computer and software routines being used to generate the complex pulse signal which controlled the train in the desired manner.

Seeing the Light

In this month's article we turn our attention to automatic signalling. Getting a computer to drive a few signal lights is very simple, provided a few latching output lines are available. A PC printer port is used in the example system described here, but the general principles apply to any computer port that has similar facilities.

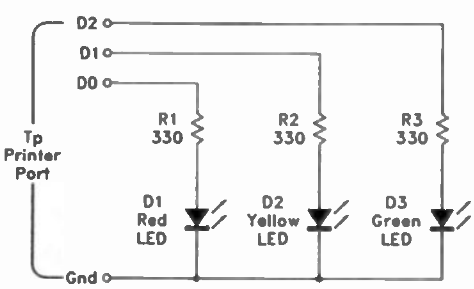


Fig. 1. Driving three signal l.e.d.s from a PC printer port. High brightness l.e.d.s should be used here.

Most output ports, including the PC printer ports, provide TTL compatible outputs that can provide quite respectable output currents. The current available certainly seems to be high enough to drive l.e.d.s at good brightness, although it is advisable to use "high brightness" types. A current limiting resistor should be included in series with each l.e.d., as shown in Fig. 1.

This circuit is for a "three aspect signal" having the red, yellow, and green l.e.d.s driven from data lines D0 to D2 respectively. These are at address &H378 for printer port one, and &H278 for port two.

Outputting values of one, two and four to the printer port therefore selects the red, yellow, and green l.e.d.s respectively. You may prefer to use an orange l.e.d. instead of the suggested yellow type, but to my eyes at least, yellow l.e.d.s look more like the "real thing."

Drivers

Experience shows that TTL compatible ports are unable to drive small filament bulbs directly, but can do so via a simple driver circuit. Fig. 2 shows the circuit for a suitable driver stage.

This is basically just a simple common emitter switch which drives the signal bulb. Of course, in order to drive three bulbs, three of these circuits are needed, with each one being controlled via a separate output line.

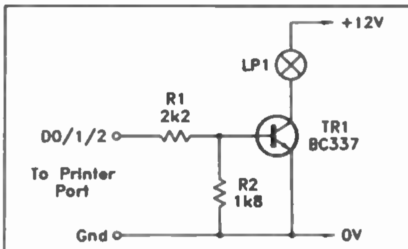


Fig. 2. Driving a 12V filament bulb from the PC printer port.

Output currents of up to 100mA or so can be accommodated. Note that the circuit will only work properly with a d.c. supply.

The same circuit can also be used to drive an l.e.d. in cases where the output current from the port itself is inadequate. Simply replace the bulb with the l.e.d. and its series resistor. For a l.e.d. current of about 20mA the resistor should have a value of 560 ohms for a 12V supply, or 150 ohms for a 5V supply.

One way of using a signal of this type is to have the computer take the signal through a repeated sequence. In other words, the signal would be set at "red" for X seconds, then at "amber" for Y, seconds, then at "green" for Z seconds, and so on.

A more interesting approach is to have the signal partially controlled by the computer, and partially controlled by feedback from the train. This is a system which has similarities to the way in which a real train signalling system operates.

Seeing Red

With the "real thing" the signals are to some extent automatic, with each signal being set to "red" as it is passed by a train. When the train has progressed a certain distance along the track it operates a sensor which sets the signal to "amber". Once the train has progressed further along the track it operates another sensor, and the signal is then set to "green."

The point of this system is that it sets a minimum distance between trains, and avoids the possibility of one train ramming into the back of another. Of course, the signals can be overridden by the signalman at any time.

It is possible to implement a model railway equivalent to this system, but it is obviously necessary to have some form of feedback from the tracks to the computer. Probably the most popular method of providing this feedback is to use a magnet on the train, and reed switches mounted beneath the track.

This is a subject which has been covered in at least one previous *Interface* article, and it is a technique which is fairly well known in model railway circles. Consequently, it is not something we will consider in detail here.

Listing 1: Automatic Model Train Signalling

```
10 REM Automatic Train Signal
   Program
20 CLS
30 PRINT "press 's' key to end
   program"
40 LOOPS = 0
50 LIGHTS = &H378
60 SENSORS = &H379
70 OUT LIGHTS,4
80 IF (INP(SENSORS) AND 16)
   = 16 THEN GOSUB 180
90 IF (INP(SENSORS) AND 32)
   = 32 THEN GOSUB 260
100 IF (INP(SENSORS) AND 64)
   = 64 THEN GOSUB 300
110 IF LOOPS = 5 THEN GOSUB
   340
120 A$ = INKEY$
130 IF A$ = "s" THEN END
140 IF A$ = "r" THEN OUT
   LIGHTS,1
150 IF A$ = "a" THEN OUT
   LIGHTS,2
160 IF A$ = "g" THEN OUT
   LIGHTS,4
170 GOTO 80
180 OUT LIGHTS,1
190 LOOPS = LOOPS + 1
200 CLS
210 PRINT "Press 's' key to end
   program"
220 PRINT "On loop "LOOPS
230 FOR DELAY = 1 TO 5000
240 NEXT DELAY
250 RETURN
260 OUT LIGHTS,2
270 FOR DELAY = 1 TO 5000
280 NEXT DELAY
290 RETURN
300 OUT LIGHTS,4
310 FOR DELAY = 1 TO 5000
320 NEXT DELAY
330 RETURN
340 FOR DELAY = 1 TO 32000
350 LOOPS = 0
360 NEXT DELAY
370 OUT LIGHTS,4
380 RETURN
```

The Maplin "large" magnet (which is actually only 25mm long) works well in this application, particularly when used with their inexpensive "miniature" reed switches. Microswitches offer an alternative method which can work well, but everything must be set up carefully if reliable results are to be obtained.

Also, you must design a system that will not cause frequent derailments! One slight problem with reed and microswitches in this application is that they will probably only be activated for a few milliseconds each time the train passes.

The software will normally be monitoring the sensors at a reasonably high frequency, but unless you have the latest "state of the art" PC it is quite possible that the signals from the sensor switches will be missed occasionally. This possibility can be avoided by using pulse stretchers to slightly elongate the signals from the sensor switches.

Pulse Stretcher

A suitable circuit diagram for pulse stretching is shown in Fig. 3, and this just consists of three 555 timer i.c.s used in the conventional monostable mode. The duration of the output pulse is the same in each case, at about 110 milliseconds.

This should give reliable results provided the sensors are checked at least ten times per second. In practice the sensors are likely to be checked about ten or more times this rate, even if the software is written using a slow computer language.

Low power 555s were used in the prototype circuit as they happened to be to hand, but the circuit should work just as well using standard 555s. The current consumption is under one milliamp using low power 555s such as the TS555CN, or about 18mA using the standard type.

Train "position" sensor switches S1 to S3 are the reed or microswitches. S1 is the switch *just past* the 3-light signal housing, S2 is the switch positioned further along the track, and S3 is the sensor switch positioned furthest away from the signals.

The monostables (IC1 to IC3) drive three of the printer port handshake inputs, and these are at bits four to six of address &H379 (printer port 1) or &H279 (printer port 2). Fig. 4 provides connection details for the printer port plug, which is a 25-way male D-type connector.

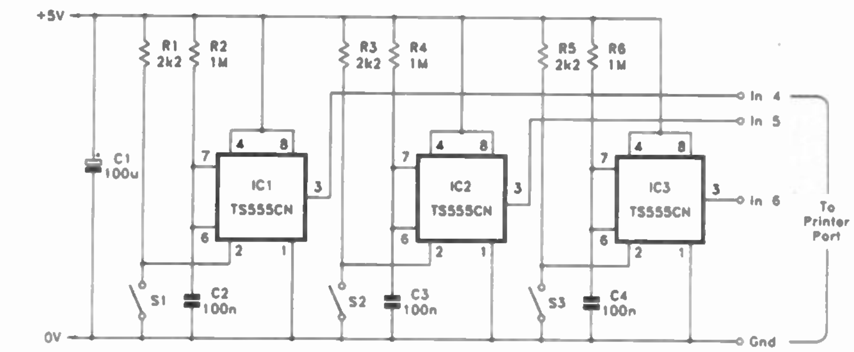


Fig. 3 (above). Circuit diagram for the pulse stretchers.

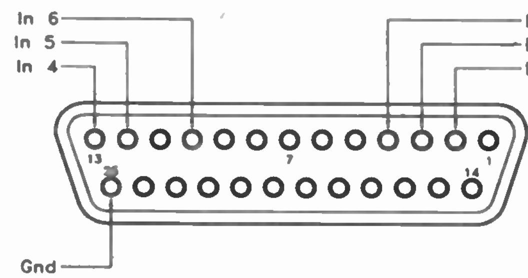


Fig. 4 (right). Connection details for the printer port. A 25-way male D-type connector is required.

Software

The software listing provided here is for a GW BASIC program which sets the track signals to the appropriate state each time the train activates one of the sensors. Additionally, on every fifth loop of the track the signal is held at red for a period of time, and the train must be brought to a halt as it approaches the signal on the next lap. After a preset period the signal is set at "green", and the system then operates normally again for a further five laps of the track.

The program is written for use with printer port one, but it is easily changed to operate with port two. Simply change the value at line 50 from &H378 to &H278, and the value at line 60 from &H379 to &H279.

The program spends most of its time looping around lines 80 to 170. Lines 80 to 100 read the input lines and branch the program to the appropriate subroutine if a sensor switch has been activated. The correct value is then output to the printer port.

The subroutine at line 180 also increments the variable called "LOOPS". Line 110 detects when this variable reaches a value of five, and branches the program to a subroutine at line 340.

This provides a delay of a few seconds which holds the signal at "red", before line 370 switches it to "green" and the program returns to the main loop. With a fast PC it will probably be necessary to use a different timing loop in order to hold the signal at "red" for a suitably long duration.

Lines 140 to 160 provide manual control of the signal. It can be set to "red", "amber", or "green" by pressing the "r", "a", and "g" keys respectively.

There should be little difficulty in customising this signalling system to suit individual requirements. It could easily be cut down to provide two aspect signalling, or extended to provide the four aspect variety (with two "amber" signal lights).

Further features could probably be implemented by modifying the software. For example, the train could be made to do a random number of laps before the signal was held at "red". The hold time could also be made random.

There is plenty of scope for a good deal of experimentation.

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The preamplifier circuits include low noise microphone and RIAA types, a tape head preamplifier, a guitar preamplifier and various tone controls. The power amplifier designs range from low power battery operation to 100W MOSFET types and also include a 12 volt bridge amplifier capable of giving up to 18W output.

All the circuits are relatively easy to construct using the p.c.b. or stripboard designs given. Where necessary any setting-up procedures are described, but in most cases no setting-up or test gear is required in order to successfully complete the project.

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See ELECTRONICS TEACH IN No. 6 above left.

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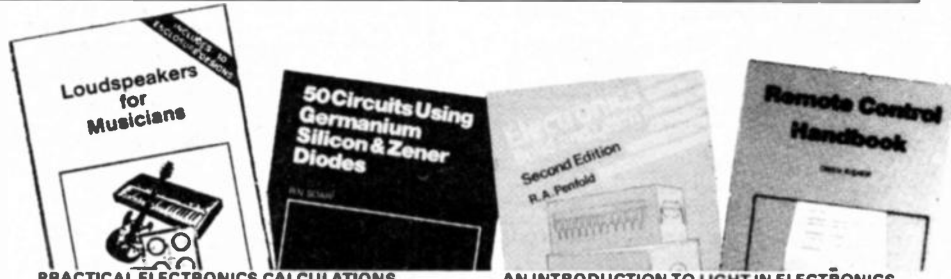

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REPORTING AMATEUR RADIO

Tony Smith G4FAI

GLOBAL ROAMING

The International Amateur Radio Union (IARU) has set up an "Ad Hoc Committee on Roaming License Qualifications", having as its ultimate objective "the forming of a consensus of the three regional organizations regarding the technical and operating qualifications that are appropriate to the Amateur Services."

This is in part response to the New Zealand proposal to the World Radio Conference *(WRC-95)* to abolish the amateur Morse test, which is due to be considered in Geneva as this column is being written. A number of countries have indicated opposition to the NZ proposal at this time because they have been actively pursuing the idea of a Global Roaming Licence.

Exact details of what this means are not clear at present. The general idea, however, is for a universal amateur radio licence acceptable in all countries, rather as the CEPT licence is in many European countries today.

ANY ALTERNATIVE

In the light of the pressure to abolish the Morse test, the IARU committee will undoubtedly need to reconsider that issue and suggest what alternative qualification, if any, is needed to allow access to the amateur HF bands.

The provisional timetable is for the committee to prepare a report within four months. This will be submitted to successive IARU Regional conferences, starting with Region 1 in Israel next September, and the aim is to achieve a world-wide consensus before *WRC-99*.

By that time the IARU visualises it should be in a position to make proposals to the ITU (International Telecommunications Union) for an amateur radio "global roaming license", but much depends on how *WRC-95* has dealt with the Morse issue.

LANGUAGE ENGINEERING

Up to now, the IARU has considered it to be a condition of access to the international radio bands that amateurs should be able to conduct rudimentary communications among themselves without regard to language barriers or limitations of their equipment.

It has considered that only Morse code, with its ability to be used with simple inexpensive equipment, and its internationally understood abbreviations and special codes, provides this facility. It has also recognised, that future advances in communications technology could change the situation.

The question is, how far away are such advances? Already language engineering technology allows computer input in one language to be received by another computer in another language. Eventually spoken messages will be sent and received in different languages.

It may be a while yet before this happens (there are an estimated 6,500 languages spoken round the world!), but much progress has already been made. Science and Technology Minister Ian Taylor referred to this at the second Language Engineering Convention (*LEC'95*) held in London recently under the auspices of the DTI and the European Commission.

He said, "it is already possible for a machine to take dictation in English, and produce a reasonably spelt and punctuated text in either English or another language; to convert a technical text from one language to another; to sort required information from a mass of documents in a foreign language; and give a speaking voice to people who have no control of their own larynx."

There are several "ifs" and "buts" here as far as radio amateurs are concerned, but when this technology becomes sufficiently developed, and universally available, amateurs would be able to converse with anyone in the world having a similar set-up. Language problems would be a thing of the past, and international communication would be possible far beyond the rudimentary requirements of today.

CALL FOR M

No more "G" prefixes for UK amateur radio callsigns will be issued after 31 March 1996. The current series on issue is running out, so from April 1 all new callsigns will have the prefix "M", even if some "G" calls remain un-allocated at that date.

Class A calls will start with M0 and Class B will be M1. Existing G calls will be unaffected, new Novice calls will continue with the present "2" series, and the G prefix will continue to be issued for repeaters, beacons and packet nodes.

The new M calls will have the same regional indicators as the G calls, so Wales will be MW, Scotland MM, Northern Ireland MI, Isle of Man MD, Jersey MJ, and Guernsey MU.

Amateur callsigns in Britain go back to 1910, when the Postmaster General informed holders of experimental radio licences (who at that time had no callsigns) that all stations should now "have a distinctive call-signal".

In 1913, A. W. Gamage Ltd published a "Directory of Experimental Wireless Stations in the United Kingdom licensed by the Postmaster General". This contained the names and addresses of 405 licensed transmitting stations and 360 receiving stations. Callsigns of that era consisted of three letters only, typically BOX, DNX, MXA, WBX.

On the resumption of amateur radio after the first world war, in 1920, new calls were issued beginning with "2", for example 2AZ, 2FG, 2GZ. In 1924, the Post Office approved the addition of the letter "G" to UK callsigns to help rationalise international call allocations – and the G-era had begun.

As more amateur licences were issued, the two-letter suffixes became three letters, G3 came into use, then G4, and so on until, 71 years later, virtually all possible allocations from G1 to G10 have been allocated (except G9 which is given to experimental stations).

While existing G-calls will remain in use, it will sound very strange at first to hear new UK stations signing with M-calls. To foreign operators used to referring to UK amateurs as "G-stations" or "the G's" it will seem as if several new countries have come on the air.

MONITORING SUCCESSES

The International Amateur Radio Union Region 1 Monitoring System has reported major successes in removing intruders on several amateur radio bands.

Following reports by the RSGB Intruder Watch to the UK official monitoring station at Baldock, the British authorities supported by several European countries were instrumental in the removal of two stations in the 40m band, four stations in the 20m band, one station on 30m, and ten stations operating illegally in the 17m band.

More recently, a station transmitting SITOR was reported operating to several ships at sea on 14·067MHz. It called itself an official maritime mobile coastal station, and used the callsign "EST". The station was reported by a member of the DARC (Germany) Intruder Watch, and collaboration between Germany, Greece and the UK resulted in the station being cleared from the amateur 20m band within days.

At present only 12 of the 78 IARU Region 1 member societies operate active monitoring services, and efforts are being made to encourage others to set up similar services to help protect the bands from further intruders. Radio amateurs who take part in a monitoring service are provided with an instruction manual, training materials, and an audio tape which helps in identifying intruding signals.

In the report, Ron Roden, G4GKO, the Region 1 IARUMS Coordinator, comments: "To be part of the IARU Monitoring Service provides radio amateurs with another interesting dimension of the hobby, and an opportunity to make a valuable contribution to the protection of the Amateur spectrum."

STOP PRESS

MORSE TEST CONTINUES

WRC-95 has referred the question of the amateur Morse test to a later conference, possibly in 1999. More details next month.

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