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JUNE 1996

PRACTICAL ELECTRONICS

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ULTRA FAST FREQUENCY GENERATOR/COUNTER

'SCOPES
Insight into this versatile piece of test gear

TELEPHONE LINK
Build yourself a simple phone for home, workshop, etc.

SARAH'S LIGHT
Toddler's cot light – banish fears of the dark

VU DISPLAY AND ALARM
Watch out for sound overload

THE NO. 1 INDEPENDENT MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

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9 770262 361072

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.

REMOTE CONTROLTANDATA TD1400 MODEM/ VIEWDATA Complete system comprising 1200/75 modem, auto dialler, infra red remote keyboard, (could be adapted for PC use?) psu, UHF and RGB output, phone lead, RS232 output, composite output. Absolute bargain for parts alone!£9.95 ref BAR33.

9 WATT CHIEFTAN TANK LASERS

Double beam units designed to fit in the gun barrel of a tank, each unit has two semi conductor lasers and motor drive units for alignement. 7 mile range, full circuit diagrams, new price £50,000? us? £349. Each unit has two gallium Arsenide injection lasers, 1 x 9 watt, 1 x 3 watt, 900nm wavelength, 28vdc, 600hz pulse frequency. The units also contain an electronic receiver to detect reflected signals from targets. five or more units £299 ea. £349 for one. Ref LOT4.

TWO WAY MIRROR KIT Includes special adhesive film to make two way mirror(s) up to 60"x20". (glass not included) includes full instructions. £12 ref TW1.

NEW HIGH POWER RF TRANSMITTERS AMPLIFIERS Assembled PCB transmitters, 4 types available,
12.6vdc 90 watt 1.5-30mhz 75 ohm in/out FM/AM £75 ref RF1
12.6vdc 40 watt 50-200mhz 50 ohm in/out FM/AM £65 ref RF2
28vdc 125 watt 1.5-30mhz 75 ohm in/out FM/AM £85 ref RF3
28vdc 100 watt 50-200mhz 50 ohm in/out FM/AM £75 ref RF4
A heat sink will be required, ring for price and availablity.
If you intend using these as audio transmitters you will need a also need a preamp. Complex module available at £40 ref RF5.

COMPUTER/WORKSHOP/HI-FI RCB UNITS Complete protection from faulty equipment for everybody! Inline unit fits in standard IEC lead (extends it by 750mm), fitted in less than 10 seconds, reset/test button, 10A rating. £9 each Ref MM5.

RADIO CONTROLLED CARS FROM £6 EACH!!!! All returns from famous manufacturer, 3 types available, single channel (left,right,forwards,backwards)£6 ref LOT1. Two channel with more features £12 ref LOT2. Two channel proportional (plug in crystals etc) £35 ref LOT3.

THOUSANDS AVAILABLE RING/FAX FOR DETAILS!

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

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 the certificate enabling you to reproduce (and sell) the manuals as much as you like! £14 ref EP74

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.

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. £199 ref BAR61. 1 years warranty

LIQUID CRYSTAL DISPLAYS Bargain prices,
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 to fit it to anything from videos to caravans, provides a years protection from 1

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

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.

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 NOW ONLY £3.50 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. +12v,-12v,+5v,-5v SALE PRICE £1.99 EACH worth it for the bits alone! ref DL1. TRADE PACK OF 20 £29.95 Ref DL2.

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

RED EYE SECURITY PROTECTOR 1,000 watt outdoor PIR switch SALE PRICE £6.99 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, reportwriter, 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!!!

COMPLETE PC 200 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. LAST FEW TO CLEAR AT £49 SAVE £30 ref LOT61

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

Check out our WEB SITE

http://www.pavilion.co.uk/bull-electrical

RACALMODEM 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 £39.95 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

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.

YUASHA SEALED LEAD ACID BATTERIES Two sizes currently available this month. 12v 15AH at £18 ref LOT8 and 6v 10AH (suitable for emergency lights above) at just £6 ref LOT7.

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

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. £8.99 REF SA25.

ECLATRON FLASH TUBE As used in police car flashing lights etc, full spec supplied, 60-100 flashes a min. £6.99 REF SA15B.

*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.

PLEASE ALLOW 7-10 DAYS FOR DELIVERY PHONE ORDERS WELCOME (ACCESS, VISA, SWITCH, AMERICAN EXPRESS)

TEL: 01273 203500

FAX 01273 323077

E-mail bull@pavilion.co.uk

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

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 SA16B

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

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

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

PHONE CABLE AND 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 utilizing the serial ports. Complete kit £8.99. Ref comp1.

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

***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 £5.99

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.

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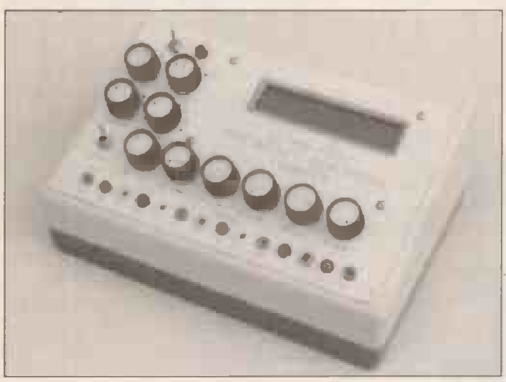
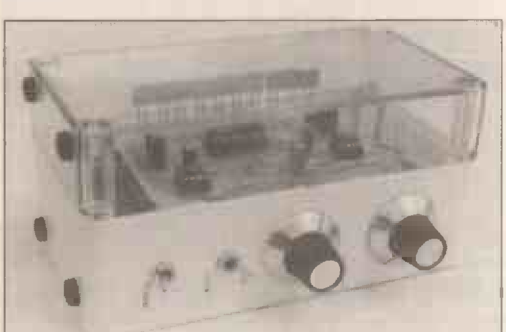
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

VOL. 25 No. 6 JUNE 1996

EVERYDAY PRACTICAL ELECTRONICS

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





Our July '96 issue will be published on Friday, 7th June 1996. See page 411 for details.

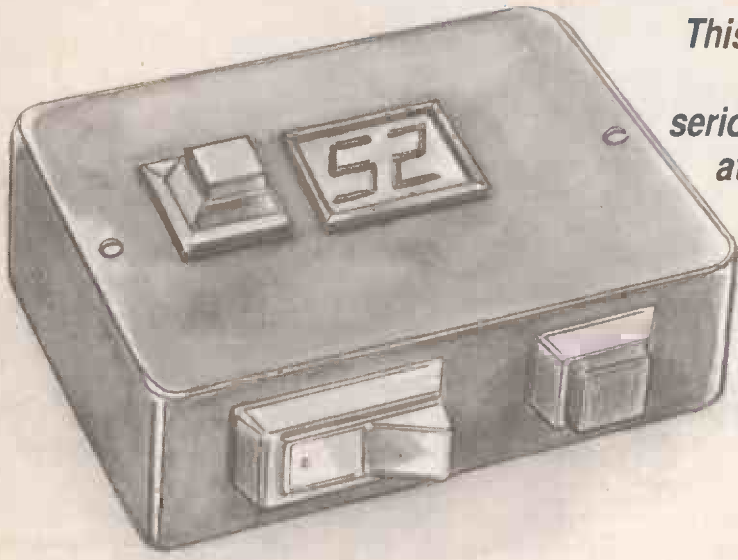
Projects

Series

Features

NEXT MONTH

GAMES COMPENDIUM



This simple PIC based project is meant just for fun, not for serious gamblers, it may be used at home or for fund raising for your favourite club or charity. It consists of one of four electronic games, selected on power up. All the games are displayed on a dual seven-segment display. The games are Bingo, Dual Dice, Roulette and Lottery.

ADVANCED NiCAD CHARGERS

Chargers for rechargeable NiCad batteries are fairly common nowadays. Various types are available which accept a variety of cell sizes and capacities, and some are quite sophisticated. The problem is that some are not, expecially at the cheaper end of the market. Readers may wonder exactly what current is being pushed into their expensive cells, especially when they start to become warm! Another difficulty occurs when the user forgets to remove the cells on completion of charging, so that they carry on receiving current long after the full charge has been achieved.

Two circuits are presented here. The first will provide a precise charging current that can be tailored to suit the cells to be charged, whilst the second has an additional feature for reducing the charge rate after a suitable period to keep the cells fresh and ready for use without damaging them.

TWIN-BEAM INFRA-RED ALARM

Designed to connect to an exisiting alarm system, or to be used independently, this twin-beam IR detector helps protect against unauthorised entry through doors, windows or passageways – a Teach-In '96 *project.*

THE NET

The Internet and the World Wide Web get plenty of mentions in the media these days but what are they, how do they work, what is on them, how do you get connected, what can they do for you? Our Internet specialist Alan Winstanley lays it all bare in understandable language, without the hype and padding, in this special feature next month.

Alan will also follow up with our own Net Work *page every month, looking at what's interesting, new and developing on The Net (including our own* EPE *Web Site) – with a bias towards the electronics enthusiast of course.*

EVERYDAY PRACTICAL ELECTRONICS

JULY ISSUE ON SALE FRIDAY, JUNE 7

MORE AMAZING SURPLUS BARGAINS FROM

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One off and pack prices **in bold** include VAT; qty prices don't. Number in brackets after order code is approx qty available. P&P **£3.00** per order. Pay by cheque, PO, Cash, Book tokens, Visa, Access or Switch. We are open for callers from 8-5.30 Mon-Sat.

Semiconductors

Some 74HC, HCT and F:

Code	Type	Qty	Price
EX4141	74F157	30	30p
EX4142	74F175	6	35p
EX4124	74HC00	15	15p
EX4125	74HC02	100	15p
EX4126	74HC04	16	15p
EX4127	74HC138	200	19p
EX4128	74HC139	500	19p
EX4129	74HC14	2	16p
EX4130	74HC166	150	50p
EX4131	74HC244	3	30p
EX4140	74HC257	50	36P
EX4132	74HC273	14	30p
EX4133	74HC393	200	24p
EX4134	74HC40106	86	95p
EX4135	74HC4075	25	22p
EX4136	74HC74	300	16p
EX4137	74HC238	2	80p
EX4138	74HCT259	65	60p
EX4139	74HCT573	100	50p

Rectifiers
EX4108 (300) In line bridge rectifier KBP04 by GI rated 400V 1.5A. **3/£1.00;** 100+ 0.20

Transistors
EX4116 (532) BDX34C Darlington PNP TOP66 case 100V, 10A, 70W, Hfe 750 @ 3A **Great Value at 3/£1.00!** 100+ 0.20
EX4120 (800) BC546 NPN TO92 case transistor. Vcb 80V, Ic 100mA, 500mW. **20/£1; Bag of 200 £6.00**
EX4147 (21) TIP135 TOP66 PNP 60V 12A 70W **2/£1.00**
EX4121 (20) 2N3740 TO66 **£1.00**
EX4123 (2000) 2N1893 TO39 transistor NPN 120V, 800mW, 0.5A Hfe 40 @ 150mA List 0.51 **Our Price 4/£1.00;** 100+ 0.14; 1k+ 0.10

Triacs
EX4117 (582) TIC225D 400V 8A TO220 case **4/£2**
EX4118 (500) TIC225M 600V 8A TO220 case **3/£2.00**

Linear ICs
EX4119 (30) LM2931 TO92 precision voltage reg 5V 150mA. **2/£1.00**
EX4122 (1000) LM101AH - TO99 case version of this useful op-amp. List 3.37 With data **£1.00**
EX4148 (50) TLC271CP programmable op-amp. **3/£1.00**
EX4114 (47) Z80 DMA **£1.00**

Opto
First, a couple of LCD modules
EX4096 (29) These are ex-equip. 24x2 dot matrix fitted with short ribbon cable with 14 way header skt. **£6.00**
EX4097 (5) As above, but with back light **£8.00**
EX4107 (30) BPW14C photodiode **£1.00**
EX4113 (500) H11A3 optocoupler. **3/£1.00,** 100+ 0.18

Wire & Cable
EX6824 (12) Heavy duty (40/0.2) red and black wire about 3m long, fitted one end with bullet plug and receptacle to open end/bullet. There's also another short piece of flex with in-line weatherproof blade fuseholder with 15A fuse. **£1.50**

Hardware
Two large socket head screws
EX6839 (450) 60mm long (37mm threaded) x 12mm dia (M12) Box of 25 (list 11.74) **£4.00**

EX6838 (1375) 25mm long x 12mm dia. (M12) Box of 25 (list 7.36) **£2.50**

Voltage Converter
EX6836 (91) DC-DC voltage converter NMXS0512. Rated 5W in PCB mntg package 50x50x10mm. Input 5V, output 12V 417mA. List 22.96. **Our Price £5.00**

Protective Covers for Computers
Although the machines these covers were intended for are probably dead and buried, they could possibly fit other electronic items. Made from leather look fabric backed plastic
EX6829 (150) Intellivision 36x22x6cm **£1.00**
EX6828 (100) Texas TI99 Size 37x24x6/3cm **£1.00**
EX6830 (40) Sinclair 18x15x3cmm, with an all round zip. **£1.00**

X9092 (20) Computer cassette recorder for the VIC20 or C64 computer. Brand new and boxed with instructions. **£3.00**

DYNAMIC MIC

EX6849 (300) We've had these before - and very popular they were, too! Foster DF-1X. Impedance 50k, FR 100-10,000Hz, Omnidirectional 1.5m cable. Supplied with table stand, holder + adaptor for floor stand and neck cord. **£8.00**

Lighting
EX6827 (5) Outdoor PIR light controller. Fully adjustable directional external PIR detector with time adjustment and sensitivity control. Will switch up to 1.2kW halogen lamp load. **£12.50**
EX9091 (5) Auto globe lamp. PIR sensor with 200mm dia globe. Uses 60W ES lamp. **£20.00**
EX9090 (5) Classic style lantern with PIR in white. These are good quality lamps with brass fittings Max 60W ES lamp. **£20.00**
EX9089 (5) Daylight sensor classic style lamp. Uses 60W ES lamp **£10.00**

Switches
EX4112 (100) Burgess microswitch 20A 20.5x19x13 with 1b and 1c/o contacts. **2/£1.00**

Capacitors
EX4111 (100) Variable cap with integral trimmers 20x2013. Value 300pF **2/£1.00**

Connectors
EX4109 (1000) 4mm black plug with screw connexion. **Pack of 100 £5.00**
EX4115 (73) 44 pin PLCC socket. **50p**

Resistors
Two high quality precision pots by Bourns. Model 6554S. These are servo mntg 33mm dia and have a rotational life of 20 million revolutions. Linearity 0.5%, Tol 10%. List on these is over £40
EX6841 (150) 2k **£5.00;** 100+ 3.00
EX6840 (150) 20k **£5.00;** 100+ 3.00

Some more trimpots:

Code	Qty	Part No	Val.	Price
EX4143	75	64 W	200k	4/£1.00
EX4144	75	43P	500 R	4/£1.00
EX4145	75	43P	5k	4/£1.00
EX4146	75	43P	10k	4/£1.00

Panel Meter
EX6833 (10) LED Digital panel meter, Farnell type DPM2C supplied with operating instruction booklet. 3½ digit 12.7mm display. ±1.999V. Needs 5V 150mA supply. Normal and BCD data outputs. 38x63x120mm Last list price £95.17. **Our Price £20.00**

Modem

EX6835 (18) Pace Linnet 1200 PC card - intelligent V21/V22/V23 modem. Auto dial and answer. Supplied with Datatalk+ software on 3.5" and 5.25" disks, also includes free Compuserve membership with 1hr on line free. **All for just £20**

EX6834 (240) Black ABS case 220x150x63mm drilled with 115mm dia hole in lid and base for mounting fan, also 28x10 hole for switch and 12.5 dia hole for cable entry. Fitted with rubber feet on long side. **£2.00**

Burrs

A superb selection of parallel sided and tapered burrs, all with 2.3mm dia shaft. The nine different types are available singly or in packs of six. There's also assorted packs.

Code	Type	Dia. (mm)	Qty
EX4098	FFXC½	0.8	432
EX4099	FFXC1	0.9	1296
EX4100	FFXC2	1.0	1728
EX4101	FFXC3	1.2	1296
EX4102	FFXC5	1.6	432
EX4103	TFXC009	0.9	6264
EX4104	TFXC010	1.0	5256
EX4105	TFXC012	1.2	432
EX4106	TFXC014	1.4	864

Note: EX4098-X4102 are parallel, EX4103-X4106 are tapered.
Prices: 75p each; Pack of 6 of one size £2.50
EK936 One each of the above types, total **9 £5.00**
EK937 6 each of the above types, total **54 £16.00**

Mobile Battery Chargers

The electronics of all these quick charger/conditioners is the same - the case size and shape differs to accommodate the battery.
Input voltage is 12V on a 2.5mm power socket. (Use lead X6718 to power from car battery). LEDs show charging, 50%, 70% 90% and ready. Battery may be conditioned, too.

Code	Qty	Mobile Phone Type	Price
EX6736	275	OKI 900, AT&T 3730	£6.00
EX	737	?	£6.00
EX6738	266	NEC P200/300, P201/301 Kenwood KMP-H700	£6.00
EX6739	35	Sony CM-H1, CM-H20	£6.00
EX6740	22	GE Pocketphone, Ericsson Hotline or Blaupunkt	£6.00
EX6741	300	Sony HM333	£6.00
EX6742	119	Mitsubishi 3000, DiamondTel 99X	£6.00
EX6743	227	Mitsubishi 4000, DiamondTel 22X	£6.00
EX6745	100	?	£6.00
EX6746	92	OKI	£6.00
EX6747	209	NEC	£6.00
EX6749	19	Technophone PC205A	£6.00
EX6752	51	Panasonic HH900 or EB-H50	£6.00

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EHOT005 Cyberplayground. ABC, Puz, Amnesia, Angela's tunes, Animals, Cays, Colour Me, Dino
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All the above titles are £9.95 each

...and a couple of other useful titles:
ETDG021 Chessmaster. Happily coinciding with our chessboard and pieces offer elsewhere in this advertisement, this superb CDROM contains an amazing amount of material - **Interactive tutorial** with speech and animation. **Teaching Display** - graphic illustrations of board coverage. Features for all levels of players - **Multiple Personalities, Time Controls, Tournament Play, Ranking, Notation, Solutions.**
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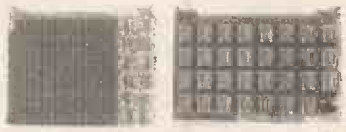
RELAY PANELS
PLEASE NOTE: On the two panels listed below, one or two relays have been damaged to prevent re-use of the board.



EX6845 (600) This is a great scoop! It seems unlikely you'd find relays at less than 16p each - yet by buying this panel, that's exactly what you will get! 128 miniature BT style DPCO 5V relays + 32 BC337 transistors, 16 x BC327, 4 x NE590 (addressable peripheral driver - 8 open collector darlington outputs cost 6.62 each), 4 x NE591, 4 x LS chips, 128 diodes, Rs, Cs etc. Board value is over £400! **Our Price £20.00**
EX6846 (200) This one has 32 low profile 4PCO relays with 2A contacts and 24V coil, 64 x 1N4004 and a 64 pin DIN connector. **£5.00**

SMPSUs
EX6843 (12) Made by Skynet measuring 197x108. 115/230V ac input, Outputs +5V 8A; +12V 3A; -5V 0.5A -12V 0.5A **£7.00**
EX6844 (8) Made by Amperor, this one measures 240x127x63 and includes gold coloured ally chassis. 115/230V ac input, Outputs +5V 8A; +12V 7.7A; -12V 1.4A. Comes with leads and sockets for fan and PC. **£10.00**

Removable Hard Disk Drive
EX6848 (117) Not too much info on this at present - it's a SyQuest SQ312RD and believed to be in perfect working order, but not new. No hard disks for them, though **£20**

SENSATIONAL MAGNET OFFER!

EX6826 Scoop purchase of 400,000 extremely powerful ferrite magnets, ideal for schools, modellers and hobbyists. They measure 12mm dia x 6mm thick and despite their small size will attract a paper clip from 20mm. If used with our X3545 miniature reed switches they will operate at 10mm and release at 15mm. Separating two takes 300g pull
They have arrived in cartons of 70, so this is the most economical buy.
10 for £1.00; Pack of 70 £3.50
For bulk buyers: (price each) 1400 0.035; 14,000 0.030, 140,000 0.028
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EW904 Large, 47mm long x 5mm dia body **40p each;** £25/10

CHESS

We've purchased a job lot of 'CONCHESS' chess boards intended for use as computerized games so all the squares have an LED showing and a 14mm long miniature reed switch underneath. There's also an interface panel, but the main plug in module is not in place. They're nice quality boards however, and can obviously be utilized for manual chess or draughts etc. after removing the components (if you want/need to).
Three sizes of board available:
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EX9094 (49) 380mm square with 1.5" squares. Although smaller, the board is of a better quality than above - the squares look like a genuine veneer. Supplied with a FREE set of chessmen EX6842 **£12**
EX9095 (40) 295mm square with 27mm squares. Bottom of the range, this one is much more basic - its sprayed silver and brown. **£6**
Chessmen
EX6842 (2200) Wooden, with a King height of 88mm, some of the pieces have a magnet in the base covered with a green felt pad. Complete set of 32 pieces. **£4.00**

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£1 BARGAIN PACKS – List 2

1,000 Items appear in our Bargain Packs List – request one of these when you next order.

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MAINS MOTOR to suit the 6½" blades. Order Ref: 88.
4·5V 150mA DC POWER SUPPLY. Fully enclosed so quite safe. Pack of 1. Order Ref: 104.
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15mm TWIN WIRE, screened. Order Ref: 122A.
100 PLASTIC HEADED CABLE CLIPS. Nail in type, several sizes. Order Ref: 123.
MES BATTEN HOLDERS. Pack of 4. Order Ref: 126.
COMPLETE POCKET SIZE MW RADIO. Believed OK but not tested. Order Ref:133R.
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13A SWITCH SOCKET. Quite standard but coloured. Pack of 1. Order Ref: 164.
30A PANEL MOUNTING TOGGLE SWITCH. Double pole, pack of 1. Order Ref: 166.
NEON NUMICATOR TUBES. Pack of 2. Order Ref: 170.
3/8 RUBBER GROMMETS. Pack of 100. Order Ref: 181.
BC LAMP HOLDER ADAPTORS. Pack of 6. Order Ref: 191.
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MAINS TRANSFORMER 8V-0-8V ½A. Order Ref: 212.
SUB MIN TOGGLE SWITCHES. Pack of 2. Order Ref: 214.
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EX-GPO SPEAKER INSERTS, ref 4T. Pack of 2. Order Ref: 352.
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24V 200mA PSU. Pack of 1. Order Ref: 393.
HEATING ELEMENT. Mains voltage 100W, brass encased. Pack of 1. Order Ref: 8.
MAINS INTERFERENCE SUPPRESSOR. Pack of 1. Order Ref: 21.
ROCKER SWITCHES, 13A mains voltage. Pack of 3. Order Ref: 41.
MINI UNI SELECTOR with diagram for electronic jigsaw. Pack of 1. Order Ref: 56.
APPLIANCE THERMOSTATS. Adjustable up to 15A. Pack of 2. Order Ref: 65.
MAINS MOTOR with gearbox giving 1 rev per 24 hrs. Pack of 1. Order Ref: 89.
ROUND POINTER KNOBS for flatted ¼" spindles. Pack of 10. Order Ref: 295.
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ROTARY SWITCH. 9-pole, 6-way, just one. Order Ref: D54.
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Smart Kit Electronics

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1041	25W HiFi Power Amplifier	4.60
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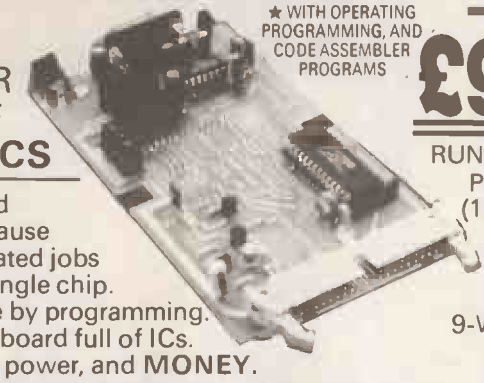

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4044	£0.35
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4047	£0.48
4048	£0.28
4049	£0.22
4050	£0.26
4051	£0.43
4052	£0.32
4053	£0.40
4054	£0.56
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4063	£0.29
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4070	£0.26
4071	£0.22
4072	£0.17
4073	£0.17
4075	£0.17
4076	£0.30
4077	£0.28
4078	£0.20
4081	£0.23
4082	£0.21
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4086	£0.26
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74HC253	£0.25
74HC257	£0.25
74HC259	£0.57
74HC273	£0.35
74HC299	£0.64
74HC356	£0.45
74HC365	£0.34
74HC367	£0.25
74HC368	£0.25
74HC373	£0.35
74HC374	£0.40
74HC390	£0.52
74HC393	£0.38
74HC423	£0.37
74HC553	£0.42
74HC563	£0.48
74HC564	£0.48
74HC573	£0.43
74HC574	£0.45
74HC640	£0.73
74HC688	£0.64
74HC4002	£0.16
74HC4017	£0.64
74HC4020	£0.36
74HC4040	£0.45
74HC4049	£0.25
74HC4050	£0.25
74HC4060	£0.44
74HC4075	£0.27
74HC4078	£0.32
74HC4511	£0.64
74HC4514	£0.84
74HC4538	£0.41
74HC4543	£0.90

74LS Series	
74LS00	£0.20
74LS01	£0.14
74LS02	£0.29
74LS03	£0.29
74LS04	£0.21
74LS05	£0.14
74LS07	£0.32
74LS08	£0.23
74LS09	£0.14
74LS10	£0.14
74LS11	£0.17
74LS12	£0.14
74LS13	£0.14
74LS14	£0.21
74LS15	£0.14
74LS20	£0.16
74LS21	£0.14
74LS22	£0.14
74LS26	£0.14
74LS27	£0.14
74LS30	£0.20
74LS32	£0.21
74LS37	£0.14
74LS38	£0.19
74LS40	£0.14
74LS42	£0.25
74LS47	£0.72
74LS51	£0.24
74LS73	£0.40
74LS74	£0.25
74LS75	£0.19
74LS76	£0.25
74LS83	£0.31
74LS85	£0.35
74LS86	£0.20
74LS90	£0.48
74LS92	£0.35
74LS93	£0.42
74LS107	£0.23
74LS109	£0.21
74LS112	£0.24
74LS113	£0.21
74LS114	£0.21
74LS122	£0.31
74LS123	£0.31
74LS125	£0.27
74LS126	£0.25
74LS132	£0.21
74LS133	£0.36
74LS136	£0.23
74LS138	£0.40
74LS139	£0.25
74LS145	£0.56
74LS147	£1.26
74LS148	£0.64
74LS151	£0.25
74LS153	£0.25
74LS154	£0.70
74LS155	£0.25
74LS156	£0.36
74LS157	£0.22
74LS158	£0.21
74LS160	£0.48
74LS161	£0.32
74LS162	£0.44
74LS163	£0.32
74LS164	£0.24
74LS165	£0.48
74LS170	£0.30
74LS173	£0.24
74LS174	£0.24
74LS175	£0.24
74LS190	£0.60
74LS191	£0.24
74LS192	£0.60
74LS193	£0.24
74LS195	£0.24
74LS196	£0.24
74LS197	£0.24
74LS221	£0.40
74LS240	£0.32
74LS241	£0.32
74LS242	£0.32
74LS243	£0.30
74LS244	£0.32
74LS245	£0.60
74LS247	£0.32
74LS251	£0.24
74LS257	£0.24
74LS258	£0.24
74LS266	£0.14
74LS273	£0.32
74LS279	£0.25
74LS365	£0.21
74LS367	£0.21
74LS368	£0.21
74LS373	£0.33
74LS374	£0.34
74LS375	£0.34
74LS377	£0.32
74LS378	£0.62
74LS390	£0.25
74LS393	£0.24
74LS395	£0.32
74LS399	£0.62
74LS670	£0.69

Linear ICs	
AD524AD	£23.04
AD548JN	£1.62
AD590JH	£5.40
AD592AN	£4.52
AD595AQ	£14.64
AD620AN	£9.88
AD625JN	£16.20
AD633JN	£8.25
AD648JN	£2.57
AD652AQ	£14.88
AD654JN	£7.25
AD698AP	£23.28
AD707JN	£2.36
AD708JN	£5.69
AD711JN	£1.51
AD712JN	£2.38
AD736JN	£8.75
AD795JN	£5.94
AD797AN	£8.69
AD811N	£6.73
AD812AN	£6.32
AD813AN	£8.81
AD817AN	£3.85
AD820AN	£3.24
AD822AN	£5.20
AD826AN	£5.33
AD829JN	£6.41
AD830AN	£6.14
AD847JN	£6.50
AD9696KN	£7.73
ADEL2020AN	£5.06
ADM222AH	£3.55
ADM232AAN	£3.55
ADM485JN	£2.97
ADM690AN	£5.13
ADM691AN	£6.48
ADM695AN	£6.48
ADM699AN	£3.58
AMP04FP	£10.94
BUF04GP	£8.56
CA741CE	£0.26
CA747CE	£0.39
CA3046	£0.37
CA3059	£1.16
CA3080E	£0.73
CA3130E	£0.98
CA3140E	£0.51
CA3189E	£1.22
CA3240E	£1.12
DG211CJ	£1.55
DG212CJ	£1.55
DG411DJ	£3.11
DG412DJ	£4.19
EL2020CN	£4.99
EL2030CN	£5.67
ICL7106	£2.80
ICL7611DCPA	£1.06
ICL7621	£1.70
ICL8038	£5.25
ICM7555	£0.36
ICM7556	£0.98
L165V	£2.63
L272M	£1.89
L297	£6.37
L298	£6.99
LF347N	£0.46
LF351N	£0.43
LF353N	£0.42
LF356	£0.84
LM301A	£0.25
LM308N	£0.58
LM311N-8	£0.32
LM318	£0.98
LM319N-14	£0.96
LM324	£0.30
LM335Z	£1.52
LM339N	£0.24
LM348N	£0.31
LM358N	£0.27
LM377	£2.57
LM380N-14	£1.12
LM381N	£2.64
LM386	£0.79
LM392N	£0.79
LM393N	£0.21
LM709T	£0.79
LM733	£1.04
LM748CN-8	£0.37
LM579CP	£3.38
LM1458	£0.37
LM1881	£3.92
LM2917N8	£3.10
LM3900N	£0.72
LM3909N	£1.76
LM3911	£2.56
LM3914	£2.30
LM3915	£2.70
LM13600	£1.66
LMC660CN	£2.16
LMC6032IN	£1.55
LMC6042IN	£1.82
LP311N	£0.74
LP324N	£0.74
LP339N	£0.73
MAX202CPE	£2.97
MAX208CNG	£6.99
MAX220CPE	£5.06
MAX222CPE	£5.06
MAX232CPE	£2.16
MAX238CNG	£5.81
MAX242CPE	£5.51
MAX631ACP	£4.99
MAX635ACP	£4.99
MC1488	£0.39
MC1489	£0.39
MC3302	£0.56
MC3340P	£1.60
MC4558P	£0.36
MV500DP	£2.63
MV601DP	£2.97
NE531	£1.47
NE555N	£0.25
NE556N	£0.36
NE565	£1.84
NE566N	£0.90
NE567N	£0.39
NE571N	£2.47
NE592	£0.62
NE5532N	£0.80
NE5534N	£0.64
OP07CN	£1.42
OP27CN	£2.90
OP77GP	£2.36
OP90GP	£3.11
OP97FP	£2.43
OP113GP	£3.44
OP176GP	£2.09
OP177GP	£1.89
OP183GP	£3.44
OP200GP	£5.60
OP213FP	£5.20
OP275GP	£2.57
OP282GP	£2.27
OP283GP	£5.20
OP290GP	£5.40
OP295GP	£4.73
OP297GP	£5.74
OP400GP	£11.81
OP467GP	£13.74
OP495GP	£8.69
PM1012GP	£5.20
RC4136	£1.00
SAA1027	£4.46
SG3524N	£1.08
SG3543	£6.88
SL486	£4.12
SL490	£4.05
SSM2017P	£3.38
SSM2131P	£4.19
SSM2141P	£4.21
SSM2142P	£6.40
SSM2143P	£3.78
TBA120S	£0.90
TBA800	£0.70
TBA810S	£0.64
TBA820M	£0.39
TDA1024	£1.49
TDA1170S	£2.48
TDA2002	£1.04
TDA2004	£3.11
TDA2030	£1.18
TDA2050V	£3.98
TEA5115	£3.11
TL061CP	£0.35
TL062CP	£0.60
TL064CN	£0.72
TL071CP	£0.48
TL072CP	£0.50
TL074CN	£0.58
TL081	£0.33
TL082CP	£0.54
TL084CN	£0.63
TL494CN	£1.49
TL7705ACP	£1.62
TLC271	£0.54
TLC272	£0.88
TMP01FP	£5.60
ULN2003	£0.52
ULN2004A	£0.48
ULN2608	£1.20
ULN2803	£0.90
ZN409CE	£1.89
ZN414Z	£1.16
ZN416E	£1.99
ZN1034E	£3.11

EPROM's	
2716	£5.50
2732	£4.84
2764-25	£4.20
27C64-25	£3.44
27C010	£5.74
27128-20	£4.08
27C128-20	£4.08
27256-20	£4.85
27C256-20	£3.68
27C512	£3.42

RAM	
4164-15	£1.78
6116-10	£1.53
6264-10	£3.16
41256-10	£2.80
62256-10	£5.35
511000-8	£8.54
514256-8	£6.88

A/D Converters Data Acquisition	
AD420AN	£25.38
AD557JN	£8.75
AD574AJN	£18.48
AD767JN	£20.88
AD775JN	£18.48
AD7226KN	£25.69
AD7528JN	£8.63
AD7545AKN	£14.04
AD7581JN	£25.80
AD7828KN	£20.33
AD7845JN	£14.04
ICL7109CPL	£7.75
TLC549IP	£3.51
ZN425E	£5.94
ZN426E	£3.13
ZN427E	£8.78
ZN428E	£5.94
ZN439E8	£7.13
ZN448E	£7.02

Voltage Regulators	
7805	£0.44
7808	£0.50
7812	£0.38
7815	£0.38
7905	£0.40
7912	£0.38
7915	£0.38
7924	£0.38
78L05	£0.26
78L08	£0.23
78L12	£0.23
78L15	£0.24
78L24	£0.39
79L05	£0.28
79L08	£0.28
79L12	£0.23
79L15	£0.28
79L24	£0.30
ADM666AN	£3.44
L200CV	£1.24
L296	£8.13
L387A	£3.24
LM2940CT	£2.30
LM317T	£0.58
LM323K	£2.84
LM334Z	£1.35
LM338K	£5.52
LM723	£0.29
LP2950CZ	£2.97
REF01CP	£3.44
REF02CP	£4.66
REF12Z	£1.28
REF195GP	£4.72
REF25Z	£1.24
REF50Z	£1.22
TL431CP	£0.45
ZN423	£1.55
ZN458B	£1.89

Diodes	
1N914	£0.06
1N916	£0.0[illegible]
1N4001	£0.0[illegible]
1N4002	£0.0[illegible]
1N4003	£0.0[illegible]
1N4004	£0.07
1N4005	£0.07
1N4006	£0.08
1N4007	£0.08
1N4148	£0.05
1N4149	£0.06
1N5400	£0.09
1N5401	£0.09
1N5402	£0.10
1N5404	£0.11
1N5406	£0.12
1N5407	£0.14
1N5408	£0.15
BA157	£0.10
BA158	£0.10
BA159	£0.10
BY126	£0.13
BY127	£0.18
BY133	£0.10
OA47	£0.28
OA90	£0.07
OA91	£0.10
OA200	£0.56
OA202	£0.29
Zeners 2.7 to 33V	
400mW	£0.08
1.3W	£0.14

Bridge Rectifiers	
W005 1.5A 50V	£0.19
W02 1.5A 200V	£0.20
W04 1.5A 400V	£0.22
W06 1.5A 600V	£0.22
W08 1.5A 800V	£0.27
W010 1.5A 1kV	£0.24
BR32 3A 200V	£0.36
BR34 3A 400V	£0.40
BR36 3A 600V	£0.33
BR62 6A 200V	£0.70
BR68 6A 800V	£0.59
1004 10A 400V	£1.39
2502 25A 200V	£1.68
2506 25A 600V	£1.75

Thyristors	
P0102AA	£0.30
TIC106D	£0.36
TIC116D	£0.66
TIC126D	£0.77

Triacs	
Z0105DA	£0.42
TIC206D	£0.65
TIC226D	£0.73
BTA08-600B	£0.99
TIC236D	£0.96

Diac, Si. Switch	
DB3, 32V	£0.20
BRY39	£1.30

Transistors	
2N1613	£0.31
2N1711	£0.26
2N1893	£0.29
2N2218A	£0.28
2N2219A	£0.25
2N2222A	£0.18
2N2646	£0.86
2N2904A	£0.25
2N2905A	£0.25
2N2907	£0.20
2N2907A	£0.20
2N2926	£0.16
2N3053	£0.27
2N3054	£0.85
2N3055	£0.62
2N3439	£0.62
2N3440	£0.50
2N3702	£0.09
2N3703	£0.10
2N3704	£0.10
2N3705	£0.10
2N3706	£0.10
2N3771	£1.44
2N3772	£1.51
2N3773	£1.70
2N3819	£0.33
2N3820	£0.66
2N3904	£0.10
2N3905	£0.10
2N3906	£0.10
2N4036	£0.34
2N5245	£0.80
2N5296	£0.57
2N5321	£0.57
2N5322	£0.57
2N5401	£0.11
2N5551	£0.11
2N6107	£0.60
2N6491	£1.58
2SB548	£0.30
2SD1730	£1.44
AC126	£0.44
AC127	£0.50
AC128	£0.40
AC187	£0.48
AC188	£0.48
ACY17	£3.84
AD149	£1.67
AD161	£0.92
AD162	£0.92
BC107	£0.16
BC107B	£0.17
BC108	£0.16
BC108A	£0.14
BC108C	£0.16
BC109	£0.17
BC109C	£0.18
BC114	£0.41
BC115	£0.41
BC116	£0.41
BC118	£0.41
BC132	£0.36
BC134	£0.36
BC135	£0.36
BC140	£0.25
BC141	£0.27
BC142	£0.31
BC143	£0.34
BC149	£0.21
BC154	£0.36
BC157	£0.12
BC159	£0.17
BC160	£0.28
BC170	£0.16
BC170B	£0.16
BC171	£0.11
BC171B	£0.16
BC172	£0.13
BC172B	£0.13
BC177	£0.18
BC178	£0.18
BC179	£0.18
BC179A	£0.17
BC182	£0.11
BC182A	£0.11
BC182B	£0.12
BC182L	£0.08
BC182LB	£0.08
BC183	£0.08
BC183L	£0.08
BC183LB	£0.08
BC184	£0.08
BC184L	£0.08
BC186	£0.33
BC204C	£0.72
BC206B	£0.72
BC207B	£0.74
BC208	£0.72
BC209A	£0.72
BC212	£0.08
BC212L	£0.08
BC212LB	£0.08
BC213	£0.08
BC213B	£0.08
BC213LC	£0.08
BC214	£0.08
BC214L	£0.08
BC225	£0.15
BC237B	£0.09
BC238B	£0.09
BC238C	£0.09
BC239C	£0.10
BC250A	£0.15
BC251	£0.13
BC252	£0.13
BC261B	£0.30
BC262B	£0.24
BC267B	£0.30
BC307	£0.10
BC308	£0.10
BC319C	£0.13
BC327	£0.10
BC327-16	£0.10
BC328	£0.10
BC328-16	£0.10
BC337	£0.10
BC337-25	£0.12
BC338	£0.10
BC338-25	£0.10
BC348B	£0.14
BC357	£0.25
BC393	£0.73
BC414C	£0.13
BC441	£0.40
BC461	£0.40
BC463	£0.29
BC478	£0.32
BC479	£0.32
BC490	£0.24
BC516	£0.20
BC517	£0.20
BC527	£0.20
BC528	£0.20
BC537	£0.20
BC546B	£0.08
BC546C	£0.08
BC547B	£0.09
BC547C	£0.08
BC548C	£0.08
BC549C	£0.10
BC550C	£0.10
BC556A	£0.08
BC557B	£0.08
BC557C	£0.08
BC558C	£0.08
BC559C	£0.08
BC560A	£0.09
BC560B	£0.09
BC637	£0.21
BC638	£0.21
BC639	£0.21
BC640	£0.21
BCY70	£0.22
BCY71	£0.20
BCY72	£0.20
BD124P	£6.86
BD135	£0.21
BD136	£0.21
BD137	£0.23
BD138	£0.22
BD139	£0.26
BD140	£0.25
BD150C	£0.82
BD165	£0.42
BD166	£0.35
BD187	£0.39
BD201	£0.40
BD202	£0.40
BD203	£0.40
BD204	£0.40
BD222	£0.58
BD225	£0.42
BD232	£0.50
BD237	£0.32
BD238	£0.32
BD240C	£0.37
BD243B	£0.50
BD244A	£0.53
BD244C	£0.53
BD245C	£1.18
BD246	£1.18
BD246C	£1.18
BD283	£0.61
BD284	£0.61
BD400	£0.79
BD441	£0.41
BD442	£0.37
BD534	£0.47
BD535	£0.50
BD536	£0.65
BD581	£0.62
BD597	£0.92
BD646	£0.52
BD648	£0.52
BD650	£0.53
BD707	£0.42
BD708	£1.04
BD807	£0.80
BDX32	£1.78
BDX33C	£0.49
BDX34C	£0.50
BDX53C	£0.47
BDX54C	£0.50
BF180	£0.31
BF182	£0.31
BF185	£0.58
BF194	£0.31
BF194B	£0.19
BF195	£0.19
BF244	£0.35
BF244B	£0.40
BF244C	£0.35
BF257	£0.33
BF259	£0.33
BF337	£0.40
BF355	£0.38
BF423	£0.13
BF451	£0.19
BF459	£0.33
BF469	£0.36
BFX29	£0.29
BFX84	£0.31
BFX85	£0.32
BFY50	£0.30
BFY51	£0.25
BFY52	£0.28
BS107	£0.21
BS170	£0.23
BSW66	£1.35
BU126	£1.32
BU205	£1.41
BU208A	£1.24
BU326A	£1.40
BU500	£1.54
BU508A	£1.42
BU508D	£1.44
BU526	£1.74
BU806	£1.06
BUT11A	£1.30
BUT11AF	£1.30
BUX84	£0.78
IRF540	£1.60
IRF740	£1.80
MJ2501	£1.60
MJ3001	£1.80
MJ11015	£2.11
MJ11016	£2.56
MJE340	£0.40
MJE350	£0.48
MPSA05	£0.14
MPSA06	£0.12
MPSA13	£0.12
MPSA42	£0.17
MRF475	£7.28
TIP29C	£0.31
TIP30C	£0.31
TIP31C	£0.41
TIP32C	£0.41
TIP33C	£0.72
TIP41A	£0.48
TIP42C	£0.52
TIP47	£0.48
TIP48	£0.62
TIP50	£0.53
TIP121	£0.48
TIP122	£0.48
TIP125	£0.46
TIP127	£0.40
TIP132	£0.46
TIP137	£0.56
TIP142	£1.08
TIP147	£1.12
TIP2955	£0.97
TIP3055	£0.63
VN10KM	£0.48
ZTX300	£0.16
ZTX500	£0.16

SAMEDAY DESPATCH

No Minimum Order Value

Electrolytic Radial Capacitors

µF	16v	25v	63v	100v
0.47	---	---	£0.05	£0.07
1.0	---	---	£0.05	£0.06
2.2	---	---	£0.05	£0.06
4.7	---	---	£0.06	£0.08
10	£0.05	£0.05	£0.06	£0.08
22	£0.05	£0.05	£0.09	---
47	£0.06	£0.06	£0.11	---
100	£0.06	£0.09	£0.11	---
220	£0.09	£0.12	£0.31	---
470	£0.15	£0.19	£0.57	---
1000	£0.22	£0.33	---	---
2200	£0.37	£0.57	---	---
4700	---	£1.11	---	---

Electrolytic Axial Capacitors

µF	16v	25v	63v	100v
0.47	---	---	---	£0.15
1.0	---	---	£0.11	£0.10
2.2	---	---	£0.10	£0.10
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SEMI-ILLEGITIMATE

I suppose I consider myself to be computer semi-illegitimate – I was educated before PCs married themselves into everyday life. But I can sort out some of the problems we have with the everyday glitches that present themselves on our various office software packages; however, the typesetting scanners, processors and image setters are another ball game.

I'm the sort of person who likes to know how things operate and to be able to put them right when they don't, but I don't mind admitting that there is no way I would ever try to delve into our various computer systems. However, PCs are incredibly useful and I wonder how we would cope without them now.

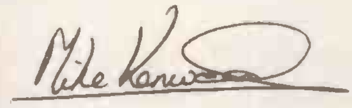
I well remember the then managing director of IPC magazines turning down my idea for a hobby computing magazine in the late seventies because he could "see no reason for anyone to want a computer in their home"! Within a few months *Personal Computer World* and *Practical Computing* had been launched by other publishers and their success is now obvious to all.

FACT OF LIFE

Like them or not, computers are now a fact of life and it is in everyone's interest to use these tools to their advantage. When it comes to project building you can design and test your own circuit "on screen" without ever seeing a real component. You can design and layout a p.c.b. for the project and you can program your own PIC (or similar) chip, dedicated to your project design; and there is no doubt that the use of PICs can simplify construction – see the PulStar article on page 456.

The other interesting area of computing relating to electronics is as an educator and information supplier. Teach yourself electronics theory using your PC, or plug into millions of data sources around the world via the Internet. Next month our own Internet expert, Alan Winstanley, will blast apart the jungle of computerspeak and hype that surrounds The Net to put you in the picture on the how, why, where, what and when of this global communications network.

Even if you detest PCs you should read this article. The Internet is beginning to have a significant effect on all sorts of areas of life, its uses and users are mushrooming and we believe that everyone should know what it's all about. Even if you are already aware and "On The Net" we are sure, as an electronics enthusiast, that you will find some interesting information in Alan's article.



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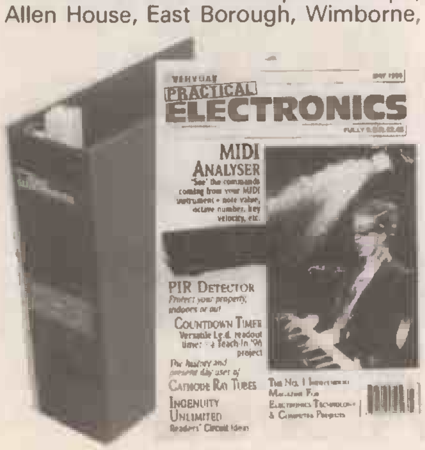

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Constructional Project

SARAH'S LIGHT

STEVE AZE

Banish the fears of darkness with this toddler's cot light. So simple, a one year old can use it!

SO YOU'RE not afraid of the dark? Imagine the scene: It's the middle of a winter's night when you're woken up by the sound of a creaking floorboard. Pulse racing, you try to get out of your bed, but find that you can't.

The hairs on the back of your neck stand up as you consider that from where you are there's no way you can turn on the light. So you crouch, trapped, staring into the darkness while your imagination parades a host of outlandish possibilities for your terror.

Sounds like a nightmare? It's a situation faced nightly by children who sleep in a cot – and then we wonder why kids are afraid of the dark! So the idea for Sarah's Light was born, to banish fears of the dark by giving the child control over it.

SARAH'S LIGHT

The specification was for a bedside light that could be operated by a seventeen month-old baby. A standard bedside light was dismissed right away on safety grounds: mains voltages, hot bulbs and breakable glass do not mix well with unsupervised children.

Sarah's Light would have to be intrinsically very safe – no high voltages, no hot areas, and no small pieces that could choke a child. It would have to be pushbutton operated, as rocker switches are a bit tricky for little fingers, but my daughter has been adept at using pushbuttons from as soon as she could make her own way to the hi-fi. The switches for this project would also have to "glow" so that they could be easily found in the dark.

As it's easy to fall asleep with a light on, particularly when reading before bedtime, the lamp would have to turn itself off after a while. However, as any parent will tell you, a lamp suddenly turning off can as easily wake a small child as one turning on, so a slow fade is needed.

This also helps when the light is used by an adult or older child; it fades out gently after a while if you've fallen asleep, but won't plunge you into darkness without warning just as you're coming to the end of a chapter.

CIRCUIT DESCRIPTION

The main circuit diagram for Sarah's Light is shown in Fig. 1. The power supply regulation and smoothing is shown in Fig. 2.

At the heart of the circuit are two 4526 CMOS programmable 4-bit binary down-counters, IC1 and IC2. When the "load" input (pin 3) on the 4526 is taken high, the binary-format numerical value on the four parallel inputs P0 to P3 (pins 5, 11, 14, 2) is loaded into the counter.

With each low/high transition on the clock input (pin 6) the count decreases by one, with the counter value appearing on outputs Q0 to Q3 in binary format. A high on the Reset pin (10) will take the count to zero.

The 4526 features a useful "zero detect" (ZD) pin which goes high when the counter value is zero. Note that when the counter is at zero, the next clock pulse takes the count around to binary 1111 (decimal 15).

To get what is effectively an 8-bit programmable down-counter, IC1 and IC2 are linked by connecting the Q3 output (pin 1) of IC2 to the clock input (pin 6) of IC1. In this format IC1 shows the four most significant bits of the combined 8-bit counter.

At power on, one of the gates of a 4093 quad 2-input NAND Schmitt trigger, IC5a, temporarily takes the Reset pins of the counters high, resetting the combined count to zero. The ZD pins of both i.c.s will then be high, so the output of NAND gate IC5c is low, inhibiting the system oscillator IC5b, so that the whole circuit is in a static condition.

Pressing the On button of switch **S1** loads the value 11111111 binary (255 decimal) into the combined counter (IC1, IC2), as programmed by the P0 to P3 data input pins of both i.c.s. IC1 ZD goes low (no longer zero count on IC1), so IC5c output goes high, enabling the oscillator formed around IC5b. This oscillates at about one kiloHertz (1kHz), which we'll call 1024Hz as it makes the maths easier(!).

A 12-bit binary counter, IC4, produces a square wave; with the output on Q12 being a square wave of $\frac{1}{2^{12}}$ (1/4096) of the frequency of the clock input. In this case this is 0·25Hz (1024/4096), or four seconds for each complete cycle. So the count on the combined 8-bit counter, which was initially set to 255 decimal by pressing the "on" switch, will now decrement by one every four seconds.

LAMP DRIVER

The main illuminating lamp(s) LP3/4 is driven by transistor TR1, which is a power MOSFET device chosen because it is easy to interface to CMOS outputs, and is a cost-effective way of handling the required current. TR1 is controlled by the output of NAND gate IC5d, which acts here as an inverse logic *OR* gate, so that if either input is low, its output is high and TR1 is on.

Whilst the 8-bit counter value is in the range binary 11111111 down to 00010000 (decimal 255 to 16), IC1 has a count of greater than zero, so the zero detector of IC1 is low, causing IC5d output to be high, switching TR1 and the main lamp(s) on.

After a period of about four seconds × 240 (about 16 minutes) following pressing the On switch, the count eventually falls to binary 00001111 (15 decimal). The zero detector (ZD), pin 12 of IC1, then goes high (zero count on IC1), and the output of IC5d becomes conditional on the A<=B output of IC3 pin 7.

When this is high, with IC1 ZD also being high, the output of IC5d will be low and TR1 will be off. Conversely, when the

A<=B output of IC3 is low, the output of IC5d will be high and TR1 will be on.

IC3 is an arithmetic comparator which compares two 4-bit words. The outputs of this device indicate the relative magnitudes of the two words.

Pin 7 output of IC3 is given as an A<B output. This means it is high when word A is smaller than word B, but by configuring the cascade inputs (pins 2, 3, 4) as shown, it becomes an A<=B output. This means that it is high when A is *less than* or *equal to* B.

COUNTING

When the oscillator IC5b is running, word B presented to IC3 is constantly counting from 0 to 15 decimal and then back to 0 again. It goes through this cycle 128 times a second (clock frequency 1024Hz divided by 2^3).

When the word at A (the outputs of IC2) is 15 decimal, the A<=B output will be high while word B is 15 decimal (the condition "Is A less than or equal to B?" is satisfied). IC1 ZD is also high (as IC1 is at zero), so IC5d output is low and TR1 is off.

For the rest of the word B cycle (values 0 to 14 decimal at word B), IC3 A<=B output will be low (A is *not* less than or equal to B), causing IC5d output to be high and TR1 to be on. Thus the lamp is driven by a 128Hz square wave with a mark:space ratio of 15:16 (i.e. it is on for 94 per cent of each cycle), and so glows with a slightly reduced intensity.

Four seconds later, the next low-to-high transition at the clock input to IC2 pin 6 will cause the word at A to decrease by one. The word at A is now 14, so the mark:space ratio of the pulse output of IC5d will be 14:16, so that TR1 is now on for only 88 per cent of the time and the lamp glows a bit dimmer still.

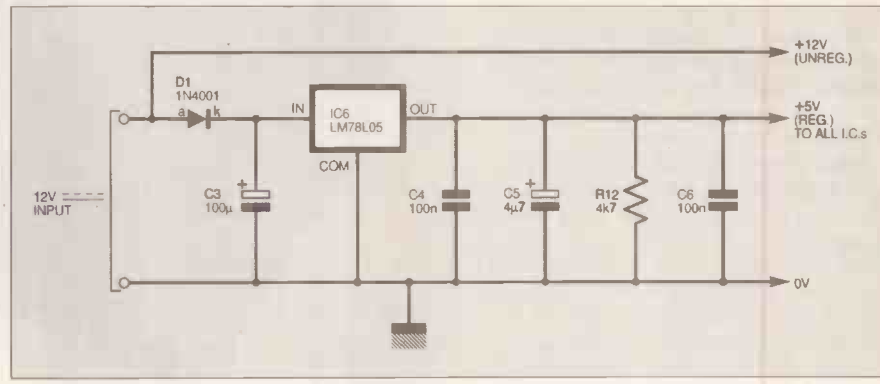


Fig. 2. Supply voltage regulation circuit for the i.c.s.

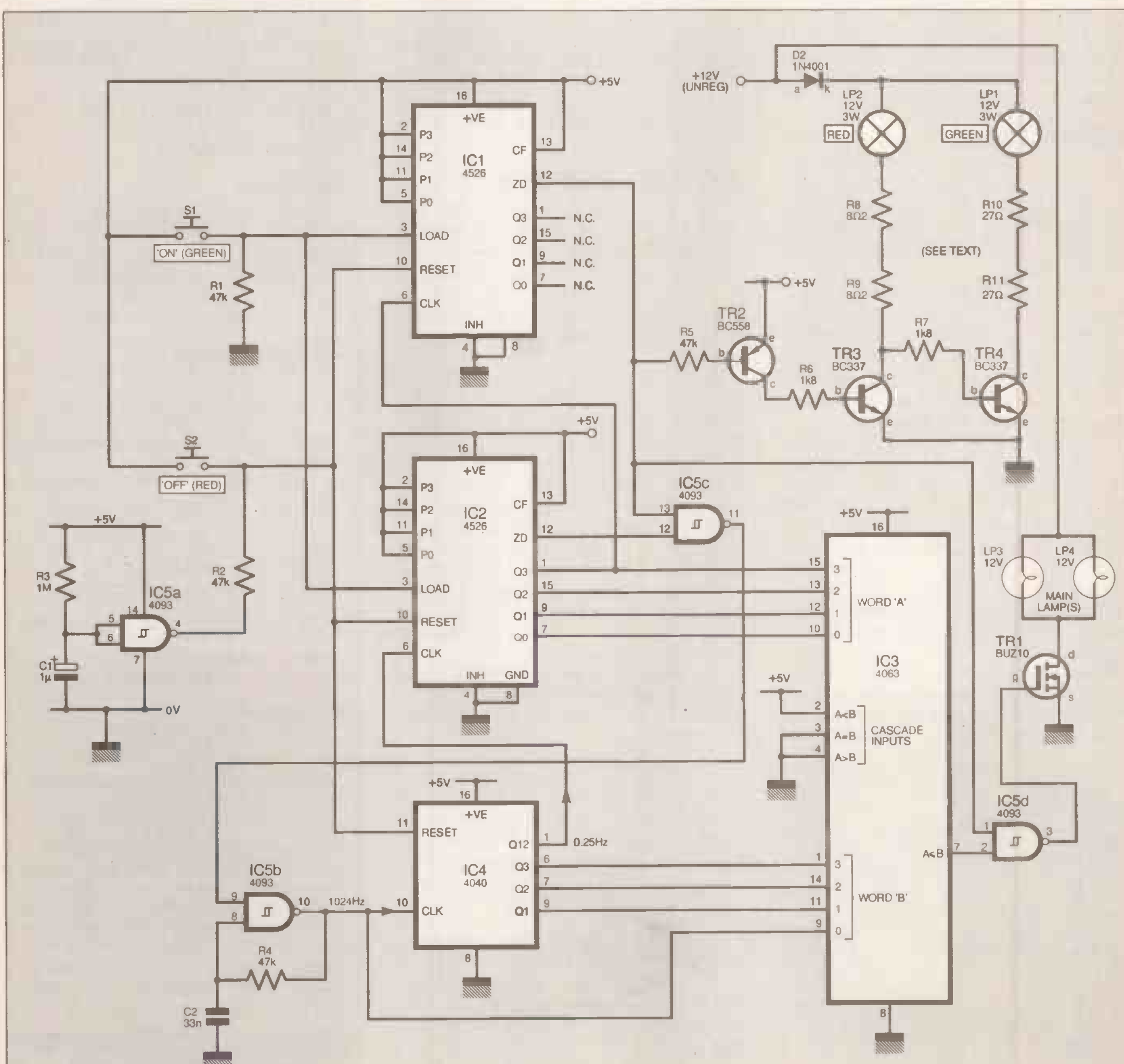


Fig. 1. Main control circuit diagram for Sarah's Light. Switches S1 and S2 are combined with indicator lamps LP1 and LP2.

In this way the brightness of the bulb decreases in 16 four-second steps, as the count on the 8-bit combined IC1/IC2 counter counts down from decimal 16 down to zero. When the IC1/IC2 combined count is zero, the action of IC5c then stops oscillator IC5b (IC1 and IC2 ZDs both high, so IC5c output goes low), and the circuit halts.

Word A at IC3 is now zero, which has to be *less than* or *equal to* word B, so IC3 A<=B output is high. IC1 ZD is also high, so IC5d output is low and TR1 is off. The dimming process therefore takes approximately four seconds × 16 (about a minute) from full brightness to fully off.

This pulse-width modulation or "chopper" action by transistor TR1 when dimming is preferable to that of a simple voltage follower with a decaying voltage, as the latter would cause a higher dissipation in the output transistor. This would then require heatsinking, leading to constructional complication and expense.

In the chopper circuit given here the MOSFET TR1 is only ever fully on or fully off, so the dissipation is kept low. The on-state resistance of the BUZ10 (TR1) is given as 0·08 ohms, so calculating the dissipation in TR1 as I^2R, it can be seen that moderately large currents can be handled with little or no heatsinking.

LIGHT TIME

The indicator lights, LP1 and LP2, for the On and Off switches are driven from the zero detection (ZD) output of IC1 via transistors TR2 to TR4, such that the Red light LP2 is on when the main lamp LP3/4 is at full brightness.

The Green light LP1 comes on at the beginning of the final countdown period, and remains on when the circuit is parked in the fully-off mode. Note that as TR4's base (b) current comes through the filament of the Red light, this bulb must be in place for the Green light to operate.

Ordinarily, pushbuttons are arranged so that they light up when pressed, but here they go off when pressed. This is so that when the main lamp LP3/4 is off and all is in darkness, the button to switch the lamp on is illuminated and so can be found in the dark. It also seems to make good sense to a one year old, who understands that to make something happen she/he needs to press the button that is glowing.

Resistors R8 to R11 adjust the brightness of the switch-illuminating bulbs to the desired level. The Green light shows when all is dark, so should be set up to glow very dimly, unless it is to double as a "nightlight" to light-up the whole room.

Running the lamp at a reduced power also greatly increases the bulb life, which is no bad thing as this bulb will be on for most of the time.

Completed Light unit showing the main lamps and pushbuttons.

POWER SUPPLY

The 12V needed to power the unit doesn't need to be particularly smooth, so a straightforward bridge rectifier and capacitor arrangement can be used to provide the d.c. with maximum efficiency. A suggested circuit diagram for a suitable power supply arrangement is shown in Fig. 3.

Diodes D1 and D2, in Fig. 1 and Fig. 2, give reverse polarity protection against the possibility of a wrong connection between PSU and lamp controller.

The voltage to the power MOSFET TR1 is picked off before diode D1, to avoid losing another 0·7V forward drop. The voltage by the time it gets to the bulbs is about 11V (9V transformer output $9V \times \sqrt{2}$, less two diode forward drops and a bit for ripple). When driving a 10W main lamp, the MOSFET drops less than 0·1V, compared to 0·7V for a bipolar device, so that helps.

The logic is a bit more fussy about ripple on the power supply, so it gets a stabilised 5V courtesy of voltage regulator IC6. See Fig. 2.

COMPONENTS

Resistors

R1, R2, R4, R5	47k (4 off)	
R3	1M	
R6, R7	1k8 (2 off)	
R8, R9	8Ω2 (2 off – see text)	
R10, R11	27Ω (2 off – see text)	
R12	4k7	

All 0·6W 1% metal film

See SHOP TALK Page

Capacitors

C1	1μ radial elect. 16V
C2	33n resin-dipped plate ceramic
C3	100μ radial elect. 35V
C4, C6	100n resin-dipped plate ceramic (2 off)
C5	4μ7 radial elect. 63V

Semiconductors

D1, D2	1N4001 50V 1A rec. diode (2 off)
TR1	BUZ10 *n*-channel power MOSFET
TR2	BC558 *pnp* silicon transistor
TR3, TR4	BC337 *npn* silicon transistor (2 off)
IC1, IC2	4526 4-bit programmable binary down-counter
IC3	4063BE 4-bit magnitude comparator
IC4	4040BE 12-stage binary counter
IC5	4093BE quad 2-input NAND Schmitt trigger
IC6	LM78L05 +5V 100mA voltage regulator

Miscellaneous

S1/LP1	Green illuminated pushbutton switch (see text)
S2/LP2	Red illuminated pushbutton switch (see text)
LP3, LP4	main lamp unit, 12V 3W bulb, (see text – 2 off)

Printed circuit board available from *EPE PCB Service,* code 996; plastic case, size to choice; 14-pin d.i.l. socket; 16-pin d.i.l. socket (4 off); strain-relief cable grommet; multistrand connecting cable; solder terminal pins; solder etc.

Note: components have not been included for the suggested power supply (P.S.U.) – see text.

Approx Cost Guidance Only £25 excluding P.S.U.

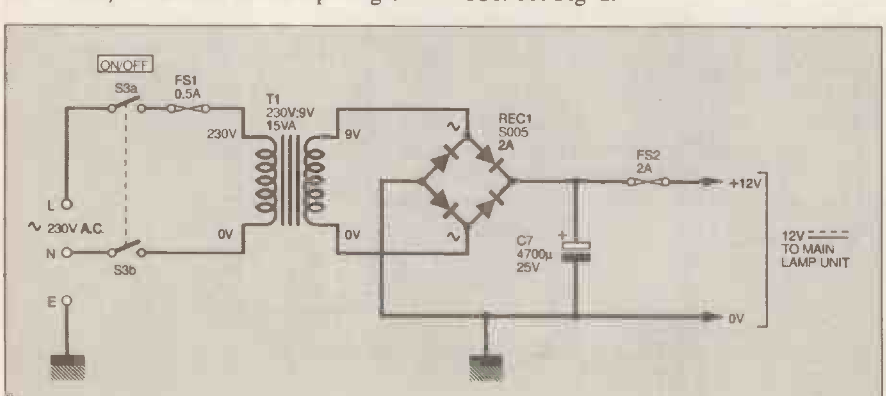


Fig. 3. Circuit diagram for a suggested mains driven power supply.

CONSTRUCTION

Please keep safety in mind throughout the construction. There must be no small parts that could become detached and present a possible choking hazard to young children.

The switches and lamps ***MUST*** have securely attached lenses that cannot be prised off, and the lamp(s) should be checked to make sure that no accessible parts become too hot to the touch. The unit should be immovably fixed to the child's cot or wall, and the cabling carefully secured so that there are no loops that could be hazardous.

CIRCUIT BOARD

The circuit for Sarah's Light is accommodated on a single-sided printed circuit board (p.c.b.). The only off-board wiring being to the combined On/Off switch/indicator lamps, main illuminating lamps and low voltage supply leads.

Topside p.c.b. component layout and full size underside copper foil master are shown in Fig. 4. This board is available from the *EPE PCB Service*, code 996.

Building the p.c.b. is straightforward enough. But normal CMOS handling precautions should be observed while handling any of the i.c.s. It is suggested that d.i.l. sockets be used for the i.c.s.

Depending upon the rating of lamp(s) to be used, it may be as well to build up the main current-carrying areas of the p.c.b. track with solder. These being: those areas of track interconnecting the power MOSFET TR1, the power supply input pins and main illuminating lamp output pins.

Commence construction of the p.c.b. by inserting the eight link wires, 12 solder pins and the five d.i.l. sockets. Do not insert any i.c.s until the board construction has been completed and checked for wiring faults or solder "bridges" across tracks.

Next, the resistors and capacitors should be mounted, in ascending size. Finally, the transistors should be soldered in place. Be extra careful to get the orientation of the transistors and i.c.s, plus the polarities of the electrolytic capacitors the correct way round.

The main output MOSFET TR1 does not need any heatsinking with lamps of up to 20W or so, as its low "on" resistance (about 0·1 ohms) and the chopper action of the lamp driver circuit keep heat losses very low.

Transistor TR1 is rated at 20A, so the circuit as shown can be used to drive quite a large load if a heatsink is used for it. Even if a 60W car headlight-sized bulb were to be used (more of a floodlight than a reading light), the dissipation in TR1 would be less than 3W, so a quite modest heatsink would suffice.

LAMP UNIT

In choosing a suitable 12V lamp unit, it was found that 3W is sufficient to see by, but if the unit is to be used by an adult or older child as a reading lamp, a reasonably focussed 10W is needed.

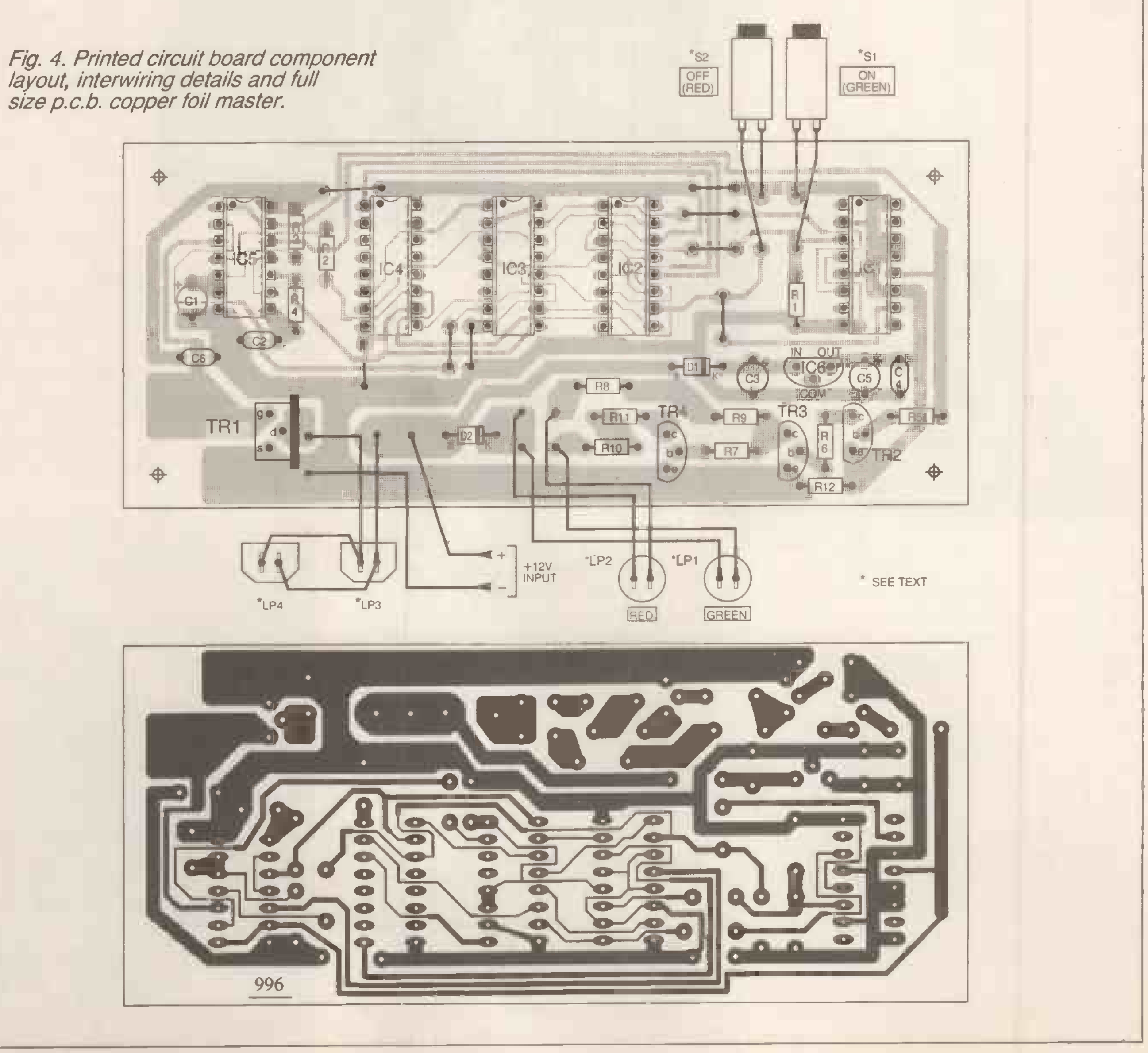
Finding a suitable 10W 12V lamp unit can be a problem, as most automotive lamps that could be used for this purpose (interior lights, number plate lamps, etc.) use 5W bulbs. Some trailer number plate lamps use 10W bulbs, but these can become rather hot to the touch.

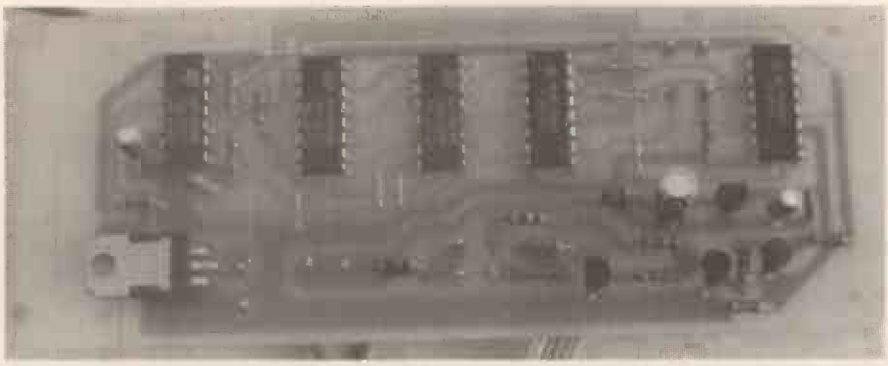
This problem was finally settled by using two 5W units. The author found that number plate lamps from a Fiat Uno give just the right pattern of illumination and are easy to mount.

They can be used with 5W or 3W capless bulbs. However, with the 5W bulb for which it is designed, the lens becomes quite warm to the touch, although not hot enough to burn.

The Fiat Uno lamps need to be adapted to fulfil the criterion of being secure against dismantling from the front of the panel. By taking off the spring mounting-lugs on the body and fixing the lamps into

Fig. 4. Printed circuit board component layout, interwiring details and full size p.c.b. copper foil master.





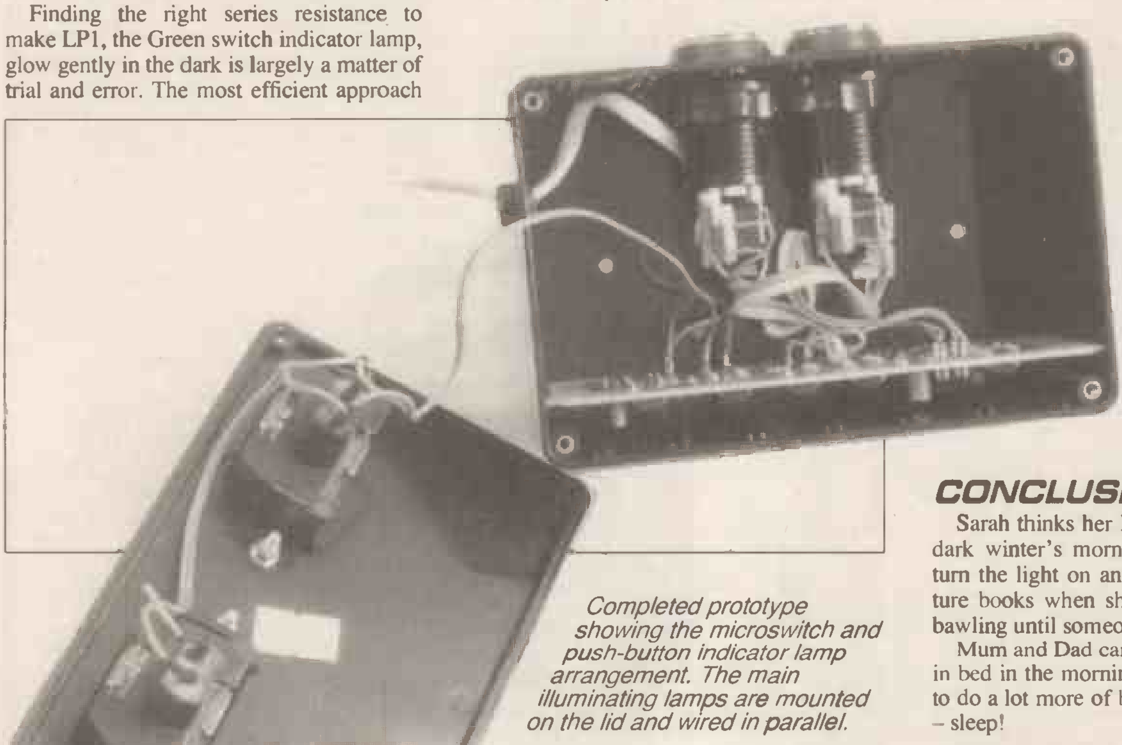
Component layout on completed circuit board. The power MOSFET TR1 has been carefully bent horizontally with the p.c.b.

the case cut-outs using screws, they are proofed against being prised out by little fingers.

On the prototype, the two lamps are mounted side by side and look like a scary pair of glowing eyes, but the author's daughter seems unperturbed.

INDICATOR LAMPS

Finding the right series resistance to make LP1, the Green switch indicator lamp, glow gently in the dark is largely a matter of trial and error. The most efficient approach is to use a 24V bulb, if available, which seems to give about the right amount of light for use under dark conditions when driven by a 12V supply. Otherwise, if using a 12V bulb, a series resistance of about the same value as the resistance of the bulb when hot is a good starting point.



Completed prototype showing the microswitch and push-button indicator lamp arrangement. The main illuminating lamps are mounted on the lid and wired in parallel.

The combination switch/lamp used in the prototype is an RS type (see *Shoptalk*) and is continuously rated for bulbs of up to 2W only. Unhelpfully, this is rather less than the smallest bulb (2·4W) which will fit them, so a series resistance is needed for the Red bulb as well.

With these switches, suitable series resistor values for the red bulb were found to be 8·2 ohms for R8 and R9 (total 16·4 ohms). If using a 12V 3W bulb for the Green indicator lamp, values for resistors R10 and R11 of 27 ohms (total 54 ohms) give the desired dim glow, or 10 ohms each (total 20 ohms) with a 24V 3W bulb.

Provision is made on the p.c.b. for two series resistors for each lamp, so a pair of 0·6W metal film miniature resistors will be adequate to cope with the required dissipation in most applications.

The mains power supply unit should be kept completely separate from the lamp unit and tucked away out of reach of little hands, so that only low voltage cables are run to the lamp unit site. The cable *must* be permanently attached at the lamp end (to avoid it being pulled out), and connected at the other end to the power supply by some type of adequately rated plug-in connector. Also, where the cable runs from the lamp unit it should be hidden away and firmly secured down the *outside* of the child's cot, away from inquisitive figners.

Double check to satisfy yourself that the unit does not present any hazard before leaving it with unattended children.

TESTING

If the circuit doesn't work when first switched on, a good initial check is to use a logic probe to look at the Q12 output on pin 1 of IC4. When the circuit is counting down, this output should be changing state every two seconds.

Trouble-shooting for the hard-up constructor without a logic probe of their own could be carried out by temporarily breaking-away the "ZD" side of resistor R5 from the rest of the circuit and using it to look at what is going on. The Green light will show for no connection or high, and the Red light will show for low.

Remember that if using the suggested switches and series resistors for the indicator lamps LP1 and LP2, the Green light is intended to be seen to glow dimly in conditions of darkness, and so may not seem to glow at all when viewed in bright conditions.

VARIATIONS

The delay period before turning off can be changed by varying the values of resistor R4 or capacitor C2 to give a different oscillator frequency. Doubling the value of either would halve the oscillator frequency and so double the delay time, producing a delay of about half an hour before turning off (with a two minute dimming period). The delay time could be increased up to about 45 minutes before the chopper action of TR1 produces a noticeable flicker during dimming due to the slower running of the oscillator.

For a delay of less than 15 minutes, but still with a one minute dimming period, the initial count loaded into IC1 could be made smaller. For example, taking IC1 P3 (pin 2) low (0V) instead of high would give a delay of about eight minutes (countdown from 01111111 binary, 127 decimal) before a one minute dimming period.

CONCLUSION

Sarah thinks her light is wonderful. On a dark winter's morning she now choses to turn the light on and look through her picture books when she wakes up, instead of bawling until someone comes to her.

Mum and Dad can now use the extra time in bed in the morning to do what they used to do a lot more of before they had children – sleep! □

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Single-Ended Class "A" Headphone Amplifier.

Most modern high fidelity amplifiers either do not have a headphone output facility, or this may not be up to the highest standard.
The new Hart "Chiara" has been introduced as an add-on unit to remedy this situation, and will provide two ultra high quality headphone outlets. This is the first unit in our 2000 Range of modules to be introduced through the year. Housed in the neat, black finished, Hart Minibox it features the wide frequency response, low-distortion and "musicality" that one associates with designs from the renowned John Linsley Hood.
Both outputs will drive any standard high quality headphones with an impedance greater than 30 ohms and the unit is ideal for use with the Sennheiser range. A signal link-through makes it easy to incorporate into your system and two extra outputs, one at output level and one adjusted by the Volume control are available on the back panel. The high level output also makes a very useful long-line driver where remote mounted power amplifiers are used. Power requirements are very simple and can be provided by either of our new "Andante" power supplies. Use the K3565 to drive the "Chiara" on its own, K3550 if driving other modules as well.
Volume and Balance controls are provided and as befits any unit with serious aspirations to quality these are the ultra high quality Alps "Blue Velvet" components.
Very easily built, even by beginners, since all components fit directly on the single printed circuit board and there is no conventional wiring whatsoever. The kit has very detailed instructions, and even comes with a roll of Hart audiograde silver solder. It can also be supplied factory assembled and tested.
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Underlying audio techniques and equipment is a world of electronics that determines the quality of sound. For anyone involved in designing, adapting or using digital or analogue audio equipment understanding electronics leads to far greater control over the reproduced sound.
The subjects covered include tape recording, tuners, power output stages, digital audio, test instruments and loudspeaker crossover systems. John's lifetime of experience and personal innovation in this field allow him to apply his gift of being so familiar with his subject that he can write clearly about it and make it both interesting and comprehensible to the reader.
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New Technology Update

Ian Poole investigates an exciting new polymer-based display technology.

SEMICONDUCTOR technology is moving in many new directions. Although the well known semiconductors like silicon, germanium and gallium arsenide are likely to remain as the most widely used materials for the time being, many new and interesting materials are beginning to appear. These have some very useful properties and are likely to change the face of electronics in many areas.

In one development a British company is leading the way. Called Cambridge Display Technology, it has developed a polymer material which promises to give an inexpensive method of manufacturing colour light emitting displays. This could make major inroads into the display market which was worth around 25 billion pounds in 1994 and is still growing fast.

Even though liquid crystal and other forms of technology are available, they are still very expensive and not suitable for applications like television because their response time is too slow. The new displays could overcome these problems and have a great chance of cornering a large section of the market.

Polymer Displays

The technology is based around a light emitting polymer material (l.e.p.), which is made from a derivative of poly-phenylene vinylene. The material exhibits semiconductor properties, even though it is not a traditional semiconductor material. The main differences occur because of the method of charge transportation.

The similarities mean that many of the lessons learned on traditional light emitting substances, like gallium arsenide, have been passed onto the new displays and development is progressing very swiftly. Already colours can be produced and switching speeds are very high.

To make the display, two 0·1μm layers of l.e.p. material are sandwiched between negative and positive electrodes as shown in Fig. 1. To obtain the *p-n* junction equivalent one layer is of poly-phenylene vinylene and the other is a cynaopoly-phenylene vinylene. With this structure efficiencies of over one per cent have been achieved from blue to near infra-red.

It is found that the l.e.p. material is intrinsically non-conducting laterally. This means that different pixels on the display do not need to be fabricated separately. All that is required is that the patterns of the display are defined by the conducting layers which are deposited on the top and bottom of the display.

This means that the size of the pixels and hence the definition is limited only by the capabilities of the deposition equipment. For future displays very high levels of definition will be available, far greater than anything which is currently on the market.

To fabricate the electrodes aluminium is used for the driving side of the display. However, for the viewing side it is necessary to have a transparent layer to allow the light through. This is achieved by using a transparent indium-tin layer.

Advantages

Displays using l.e.p. technology have a number of advantages over other types which are currently available. The first is their low power consumption. They can be run from a 3V supply and require only about 1mA for every square centimetre to give a light output of 10 candelas per metre squared.

Furthermore, they are light emitting unlike liquid crystal displays which need an additional light source, either from front- or back-lighting. They also have a wide angle of view, again scoring over liquid crystal displays.

Whilst it is possible to have a matrix of pixels giving very high degrees of resolution, the displays can also be made with defined patterns. This aspect is useful for applications where a limited number of digits or patterns need to be displayed, as on a watch or radio display.

Another advantage is that the drivers required for the displays are cheap and easy to produce. Unlike electroluminescent displays or cathode ray tubes which need high voltages, l.e.p. displays are low voltage devices making the on-board electronics much simpler.

They also do not need an alternating drive voltage like liquid crystal displays. This gives significant advantages in terms of electromagnetic compatibility and general radio frequency interference in radio based systems. This makes them ideal for use in the growing mobile phone market.

The fact that the display is based on a polymer has several mechanical advantages. It is very rugged and can also be deformed without damage. It is even possible to have the displays formed to a particular shape during manufacture – a factor which could give some very interesting possibilities.

The fact that they have fast response times is a further advantage. As they can handle the speeds required for video applications this is likely to open a large market very quickly.

Finally, they are easy to manufacture. They have a monolithic construction and the techniques required for manufacture do not present any major difficulties. This means the processes will be relatively low cost.

Developments

The development of these devices shows a great degree of promise, but like all new developments there are a number of hurdles which still need to be overcome.

One problem which is being addressed is that the displays have a limited life. This is brought about by the fact that the poly-phenylene vinylene is susceptible to oxidation. If the material is exposed to oxygen under power then the display will become less bright. Significant development is being undertaken to improve the material lifetimes through the use of improved materials, and through improved encapsulation. Currently sufficient lifetimes have been obtained to allow for them to be used commercially, but further improvements are still being sought.

Summary

L.E.P. development is progressing swiftly, and it promises to be one of the most revolutionary display technologies to appear in many years. It fulfils the major requirements to enable it to challenge the cathode ray tube for dominance of the market.

It will be cheap, have a colour capability, have a fast response time, and be capable of high levels of definition. This should make it a market winner. For further information contact *Mark Gostick at CDT on 01223 (44 1223) 276351* and please mention *EPE*.

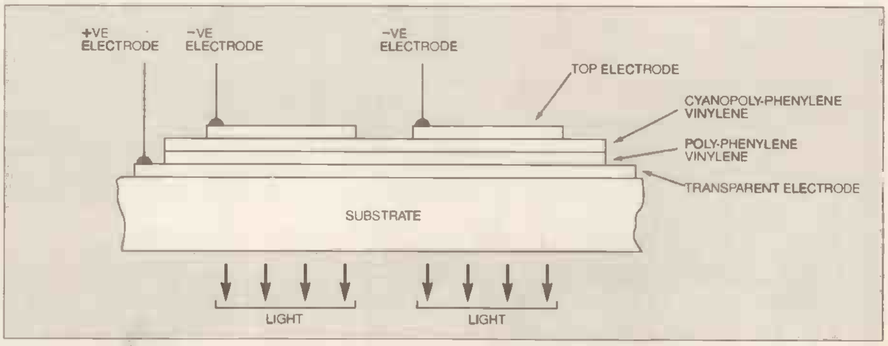


Fig. 1 The structure of a light emitting polymer display.

Innovations

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

PROGRAMMABLE HEARING

Pushbutton programming sets the new hearing aid to the response range preferred by the wearer for different acoustic situations

by Hazel Cavendish

A NOVEL electronic development for people with impaired hearing has been introduced to Britain by the multinational giant 3M. Through a firm in Devon, 3M is marketing a Swedish-designed programmable hearing aid with eight programs and multiple memories.

Hearing and Medical Appliances of Bradworthy in Devon have been training a team of Dispensers to teach clients how to use this revolutionary two-channel sound processing system, with its high performance circuit separating input sounds into high frequency and low frequency channels.

Digitally controlled analogue signal processing is used in the 3M Model 8200 hearing instrument, which stores eight settings in an integrated circuit which includes memory, control logic and a data-logging feature. The hard-of-hearing user can select any of the eight settings via pushbuttons on the instrument. Originally christened the *Memory Mate*, the concept was researched and developed in the Audiology Department of Gothenberg University.

The hearing instrument worn behind the ear (BTE) has two controls to select the user's required programme needs. The inset shows how small the unit's control boards are.

DISPENSING AID

Paul Lavis, MD of the Devon company, says that although the hearing aid was introduced in Britain last year, the first priority for his company has been the training of the first 20 human Dispensers.

"It has taken a lot of detailed training to prepare our team," he says, "which will be followed by another 20 to 25 trainees, all of whom have to be thoroughly computer literate to teach the new system. In the last three months our Dispensers have been helping over 1,000 clients and sales are escalating fast now." The clients, though, need know nothing of the interior workings of the hearing aid. Once the Dispenser has set it up to suit a particular individual, all the latter needs to do is press the buttons to get the best sound out of it.

NOISE IMMUNITY

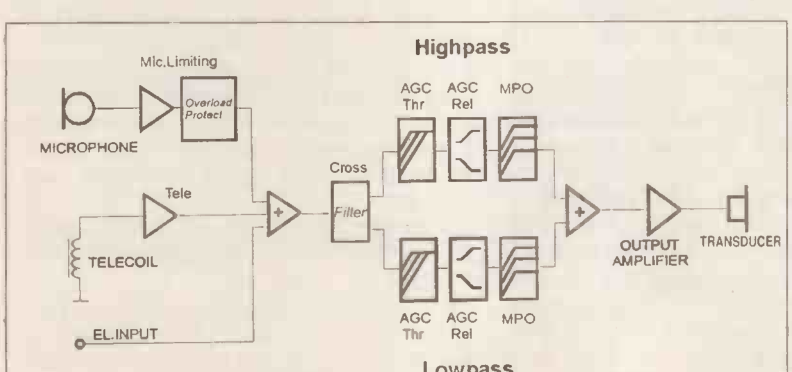
The main advantage of the new system is that it overcomes the problem of the crowded room – always an anathema to people with hearing difficulties. A conventional hearing aid has a frequency response that does not change much at normal listening levels. This makes it difficult for speech intelligibility and optimal listening comfort to be achieved simultaneously, particularly in different listening environments. By using a programmable hearing aid with multiple memories, the listener can choose between a range of sound pictures, which increases the chance of finding a suitable frequency curve for each listening situation.

The characteristics of the two-channel sound compression system are unlike others available in a programmable instrument. Most other systems operate according to a fixed logarithmic compression ratio.

Once the threshold of compression is reached, all input levels above this value (and below the threshold level of a front end limiter) are compressed at the same ratio. Low level sounds are compressed at the same ratio as high level sounds. Even if this ratio is "variable" (i.e. programmable), it remains fixed once the hearing instrument has been programmed.

On the other hand, the intensity-proportionate design of the 3M compression system automatically adjusts the compression ratio in real time, depending upon the level of the input. Sounds which are *slightly* above the compression threshold are compressed at a very low ratio, while loud sounds are compressed at a much higher ratio. The compression ratio varies in a curvilinear fashion over the operating range of the circuit. This design allows weaker sounds to be adequately amplified, while the loudest sounds are maximally compressed. Several advantages can be realised through this approach to compression.

Two-channel compression, also known as two-frequency band-separation, is a significant improvement over single channel instruments and deals effectively with 95 per cent of hearing losses. The other five per cent might find advantage in a design having three or more channels, but the performance trade-offs are significant.



Functional block diagram for the programmable Hearing Aid.

ANALOGUE FILTERING

Current technology allows designers who require three or more frequency channels to use switched capacitor filters. However, because these chop the signal at a high rate, they generate noise which in turn needs to be filtered out.

Dr Stephen Mangold, however, who is the inventor of the new hearing aid compression technology, as well as being R&D Manager at 3M's Diaphon facility in Gothenberg, has chosen to use analogue (RC) filters as an alternative to switched capacitors because they are continuous and therefore very quiet.

He has worked out a novel method of incorporating these filters within the signal processing circuitry. Three different inputs are available in the hearing aid: microphone, telecoil and direct electrical input. Transients in the input signal are suppressed by a soft clipper and the signal is then split by the filters into lowpass and highpass channels. Each channel has an independent automatic gain control circuit, after which the signals are recombined and fed to an output amplifier and transducer.

Two-channel sound Processing is available in many different 3M hearing instruments ranging from "behind-the-ear" (BTE) to "in-the-canal" (ITE) models. They have eight individual memories, and a total of ten parameters can be programmed into each of the eight.

The hearing aid also has data-logging capabilities which represent a novel concept in hearing instrument fitting and adjustment. Registers provide the Dispenser with information about the total time spent listening via each of the eight programmed memory modes, the total time the hearing aid has been switched on, and the number of switchings from one memory mode to another.

HEARING TRIALS

Twenty-two experienced hearing aid users of both sexes, aged from 22 to 77 agreed to take part in trials in Sweden before the invention was released. The volunteers compared the new programmable hearing aid with their own well-fitted conventional aids (the latter having been carefully checked for efficiency by the Institute for the Handicapped in Stockholm).

When the results were announced, seventeen members of the team found that the use of different frequency responses for acoustically different characteristics was beneficial. In direct paired comparisons with their personal aid, in six specified domestic situations, the programmable hearing aid was selected with confidence in 81 test situations out of 120. Speech discrimination scores were significantly better with the new aid. All but two of the team preferred the programmable aid, mainly because of its better sound quality and extended adjustment possibilities.

The University researchers had expected to find some resistance from "experienced" hearing aid users against using pushbuttons to adjust the aid. They were surprised to find that 67 per cent accepted them, with the unexpected reason for preferring the pushbuttons being a feeling of security in finding the amplification wanted.

Because the user had full control over amplification in distinct steps, he or she was easily able to avoid acoustic feedback. The result was generally more favourable than had been expected because the team were experienced wearers of carefully fitted hearing aids, and therefore expected to express more conservative opinions.

The cost of the hearing aids varies from £1,700 to £1,950, the in-the-ear model being the most expensive of the two.

Honouring Willy Johnson

WILLY JOHNSON, the prolific inventor whose imaginative creations have been mentioned in these pages from time to time, is to be awarded an Honorary Doctorate in Design (D.Des) by Southampton University, which describes him as "an internationally acclaimed inventor who has successfully combined academic research ideas with industrial development".

Southampton University points to Willy's work on improving the clarity of television and computer screens as being the main source of his new international recognition, a reference to his Microsharp technology sold to America two years ago and reported in *EPE* May '94 issue.

When ten honorary degrees are presented at ceremonies in July this year, and in Spring 1997, Willy Johnson will find himself in good company. Dr Tim Berners-Lee, involved in the creation of the World Wide Web, described by the University as one of the great pioneers of computing, and Professor George Gray, who received the international Kyoto Prize from the Emperor of Japan for his contribution to the science of liquid crystals, have been created Doctors of Science by Southampton. Both the latter worked in Poole, Dorset, respectively for Plessey Telecommunications and Merck Ltd.

Hazel Cavendish

Willy Johnson displaying the Elarm featured in EPE *February '96.*

PC-BASED STORAGE SCOPE

A NEW PC-based storage oscilloscope has been introduced by Pico Technology, who describe their ADC-200 as a high-speed Virtual Instrument. Together with PicoScope software (Windows and DOS versions included in the price), your PC-compatible computer can be used as a 50MSPS (million samples per second) digital storage oscilloscope (DSO), a spectrum analyser, frequency meter or voltmeter.

Pico believe that the ADC-200 breaks the price/performance barrier for DSO products. For less than half the price of the cheapest benchtop instrument you get a fully featured scope with such options as FFT (Fourier Fast Transform) analysis and waveform storage/printing normally only found on the most expensive models.

Not only does this design offer all the usual advantages that DSOs have over analogue scopes, but also takes things one step further. By making full use of the Windows environment, it is possible to view a signal in several ways simultaneously. The screen shows four different views of the same input signal. The scope shows the actual waveform, the spectrum of its frequency components, and the two meters show its a.c. voltage and frequency.

The 50MSPS version of the ADC-200 is priced at £459, and the 20MSPS unit is just £359.

For more information, contact Pico Technology Ltd., Dept. EPE, Broadway House, 149-151 St Neots Road, Hardwick, Cambridge CB3 7JQ. Tel: 01954 211716.

Blooming Spoofy Times

IT is a curious time-honoured tradition in Britain (do other countries have similar ones?) that the First of April should be commemorated by all manner of scams, spoofs, hoaxes and practical jokes. Such classics as well-documented reports about spaghetti that grows on trees, sheep dogs that drive cars, and the mining of silicon from Welsh beaches, all spring to mind. No doubt you've each got your own particular favourites.

This year a certain Zola McMalcolm hit the headlines by reporting in the April issue of *EPE* that her research laboratory had evolved the electronic technique of Chromo-floristics, a method by which flower colourings could be selectively modified through using light emitting diodes to irradiate plants. It was a technique which could have profound significance for floral culturists world-wide. Truth, though, had been hybridised, pruned and nurtured in prime mendacity!

It was a well-reasoned and plausible argument, the hall-mark of any good April spoof, and a circuit diagram and software program provided further authenticity to the report. Moreover, both the latter *do* actually work, although not in the botanical application quoted.

So, how many of you were persuaded by the argument? Many, we suspect – go on, admit it, and that you ran the program! Well, you are in good company: two of Britain's top media sources were convinced of the technique's genuineness, BBC's *Tomorrow's World* and *The Times* newspaper, both of whose technical researchers rang us wanting interviews with Zola!

Wickedly, our Technical Editor strung along *TW's* lady researcher for a while before revealing the nature of the report, much to her dumbfounded disbelief. Equally jocular, our MD similarly chatted with *The Times'* charming columnist who, as was eventually disclosed to her, had rung up on The Right Day – April 1st!

To her credit, though, Ms Anjana Ahuja became even more impressed by Zola's fantasy and proceeded to write a lengthy feature about the root of the floral tale, which was published in *The Times* on April 3rd. Fame for us all!

However, she also revealed Zola's hitherto secret but true identity - none other than our *previously* respected Technical Editor, causing a flurry of conversation here at *EPE* HQ when *The Times* was circulated round the office:

"But Tech Ed's the *real* April Fool", proclaims Adverts, promotionally.

"Mad as a March Hare", outlines Art Tart, pictorially.

"More like he's Nuts in May", cracks MD, managerially.

"Two chips short of a circuit", defines Deputy Editor, analytically.

"A character short of a sentence", inputs Typesetting, typically.

"The longer his Sentence the better", advances Subscriptions, committedly.

"He must be made accountable", adds Finance, summarily.

"Send him packing!", raps Despatch, expeditiously.

"Perhaps we can sell him", counters Sales, monetarily.

The phone rings:

"I think it's Kew Botanical Gardens – where can they get a bushel of l.e.d.s?", illuminates Secretarial, pam-purringly.

"Tell them to read *Shoptalk*", deputises Dep Ed, chattily.

"Oh, ain't it all Superchromafloralisticprimoaprilocious!", quips Tech Ed, quite logically.

THIN LITHY

PRODUCTION of the world's thinnest Lithium primary cell begins in May. So announces Yuasa, a world-leading battery manufacturer who first started producing batteries in the 1920s. The Yuasa "PowerFilm" is a Lithium 3V cell that is only *0.2mm thick* and uses solid polymer electrolyte (SPE). The other measurements are only 29.3mm x 22.3mm.

The cell incorporates a Lithium anode and a manganese dioxide cathode separated by a solid polymer electrolyte. These are encased between two micro-thin metal foils that also act as an external case and the positive/negative collector.

A significant development is the sealing of the outer edges of these collectors using a sealing compound that also provides the electrical insulation between the two polarities of the current collectors. This, claims Yuasa, makes the PowerFilm the safest and highest power-density SPE Lithium primary cell available.

For more information, contact Yuasa Battery Sales (UK) Ltd., Hawksworth Industrial Estate, Swindon, Wilts SN2 1EG. Tel: 01793 612723.

RADIO WITHOUT HASSLE

OFF-THE-SHELF pre-approved and aligned radio data transceiver modules are at last a reality! One company who can now supply such equipment are Radio-Tech, who have published a *free* catalogue listing over 60 licence-exempt module types.

These modules are suitable for a diverse range of applications, from simple remote controls, telemetry, temperature monitoring, and free-wire LANS, to rocket flight system monitoring. In effect, the modules can be treated as i.c.s and include everything you would expect for a radio system, from FM modulator to RF amplifier and filters. Frequencies are available covering over 95 per cent of the world. Transmission data is entered serially and at the receiver is again recovered as a serial data stream.

To assist first time users, evaluation kits are available. Not only that, and ideal for PIC microcontroller users, Radio-Tech have a unique range of low-voltage transceivers that can be driven directly from a PIC I/O port.

Prices of the various transceivers range from a mere £5 to £480, exclusive of VAT and carriage. Export enquires are welcome.

For more information, contact Radio-Tech Ltd., Dept. EPE, Overbridge House, Weald Hall Lane, Thornton Common, Epping CM16 6NB. Tel: 0181 368 8277.

Lazerlyte

SIZED just slightly larger than a pen, the Lazerlyte pointer has been introduced into the UK. Apparently, this laser pointer is the market leader in America and is becoming one of the top selling electronic toys there.

Lazerlytes have been on trial by Dixons' new stores and have sold so well that they are now stocking them all over the UK. Other retail groups, including Rymans, Viking, Globus/Office World and Techno, also stock them.

These pointers project a dot of laser light over a considerable distance and are both useful and fun. From company and conference presentations, to school blackboards and slide shows, from computer screens to atlases, indeed in a host of business and leisure environments, these pointers have thousands of uses.

Lazerlytes are available which have different brightnesses and distance coverage, the recommended retail prices range from £29.99 for the model 100, to £74.99 for the executive version. Try one, you'll like it!

BASiCALLY NOISY

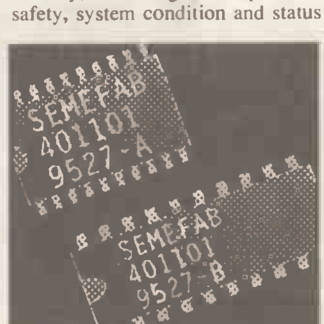
BASiCS UK Ltd. has launched the first in a range of innovative standard i.c. products. The device, a high performance tone generator chip, is said to lead the market through its broad range of available tones – 27 in all. Sounds available include sweeping, whooping, continuous and intermittent tones, at a range of frequencies.

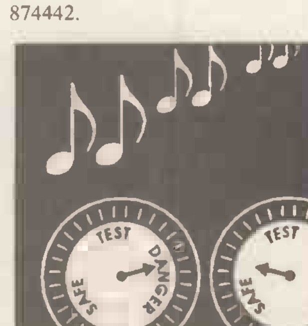
The range of applications must be almost infinite, but certainly embraces situations in which an audible alarm is needed, such as for vehicle and premises security, smoke, gas and personal safety, system condition and status monitoring, including level detection. Plus, of course, numerous applications for use with toys.

Whilst the chips do not include their own amplifiers or speakers, they are very easy to build into a system, requiring only a 5V d.c. power source, a 4MHz crystal and a suitable amplifier.

We are actively looking further into these chips for possible use in a future constructional project.

For more information, contact BASiCS UK Ltd., Cheapside Court, Buckhurst Hill, Ascot, Berks, SL5 7RF. Tel: 01344 874442.





ULTRA-FAST FREQUENCY GENERATOR AND COUNTER

JOHN BECKER

Part One

Improve your workshop facilities with this high-speed, multi-frequency item of test gear – it's a real freq-out!

THIS item of workshop test equipment was designed in response to the need for a frequency generator and 8-digit counter which could cope with frequencies well in excess of 40MHz and which had more than one signal generator.

The main features of the Ultra-Fast Frequency Generator/Counter are outlined in the "Specification" panel. The block diagram in Fig. 1 shows the basic function configurations for the unit.

OSCILLATOR-1

Circuit diagram details for Oscillator-1, the wide range square wave generator (0·05Hz to >40MHz), are shown in Fig. 2. The oscillator is formed around the Schmitt trigger inverter IC12a. Frequency is determined by the total feedback resistance formed by resistor R14 and potentiometers VR1 and VR2, in conjunction with the total capacitance, via switch S5, between IC12a pin 13 and ground (0V).

Potentiometer VR1 gives a rough or "coarse" setting of the required frequency and VR2 "fine" tunes it. Be aware, though, that VR2 only has a significant effect when VR1 is set to its lower resistance values.

Nine capacitance values can be selected by switch S5, as provided by C17 to C25, the largest value setting the slowest frequency range. They are arranged in ascendant decade steps, so that at each step the frequency range controllable is, theoretically, ten times slower than the previous one.

In practice, the actual range is slightly less well-defined since the tolerance factors for the capacitors will affect their precise values.

Additionally, for the highest frequency range available, it is not only the value of C17 which affects the range. The gate capacitance of IC12a and the stray capacitance caused by the surrounding components on the printed circuit board, plus that of the wiring to the potentiometers, become significant. Indeed, it is likely that the total additional capacitance will exceed the value of C17 which may, therefore, be omitted if preferred.

From IC12a pin 12, the frequency is buffered by Schmitt inverter IC12b and output through socket SK6. It is additionally routed to the frequency counter via switch S3 (discussed later). IC12e and IC12f in the drawing are unused inverters from the same hex package.

OSCILLATOR-2

Details of Oscillator-2, its frequency divider, and the sinewave filter are shown in Fig. 3.

This oscillator is formed around IC12c and functions in the same way as Oscillator-1, except that different frequencies (0·01Hz to 1·6Mhz) are available. Five capacitance ranges, set by C10 to C14, are selectable by switch S7.

Each ascending switched range is nominally ten times lower in frequency than the preceding one. Coarse and Fine tuning are carried out by potentiometers VR3 and VR4.

From IC12c pin 4, the frequency is output via socket SK7, routed to the

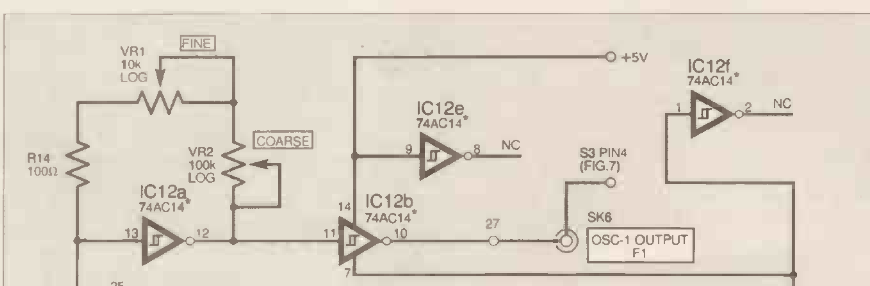


Fig. 2. Circuit diagram for Oscillator-1.

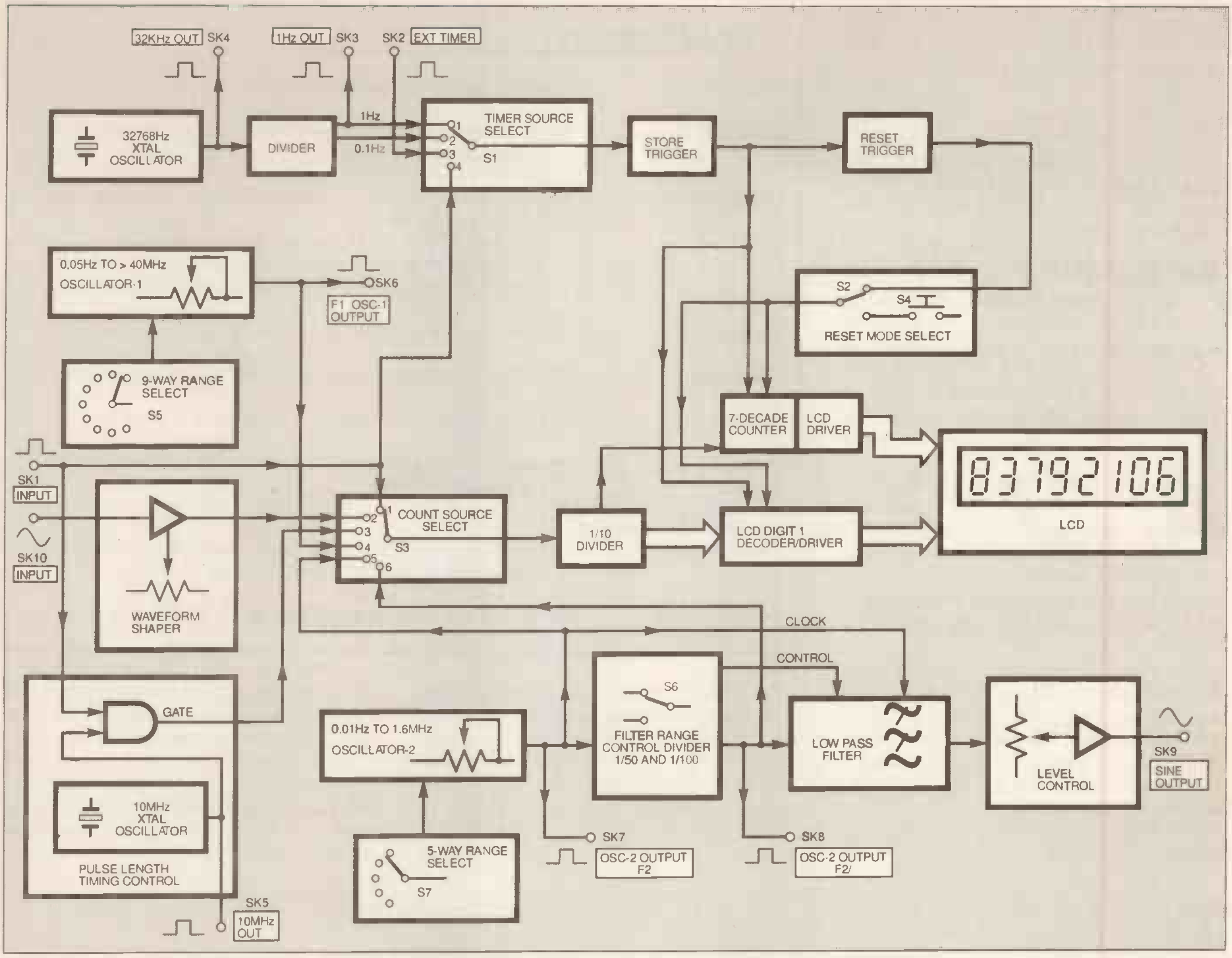


Fig. 1. Block diagram for the Ultra-Fast Frequency Generator and Counter.

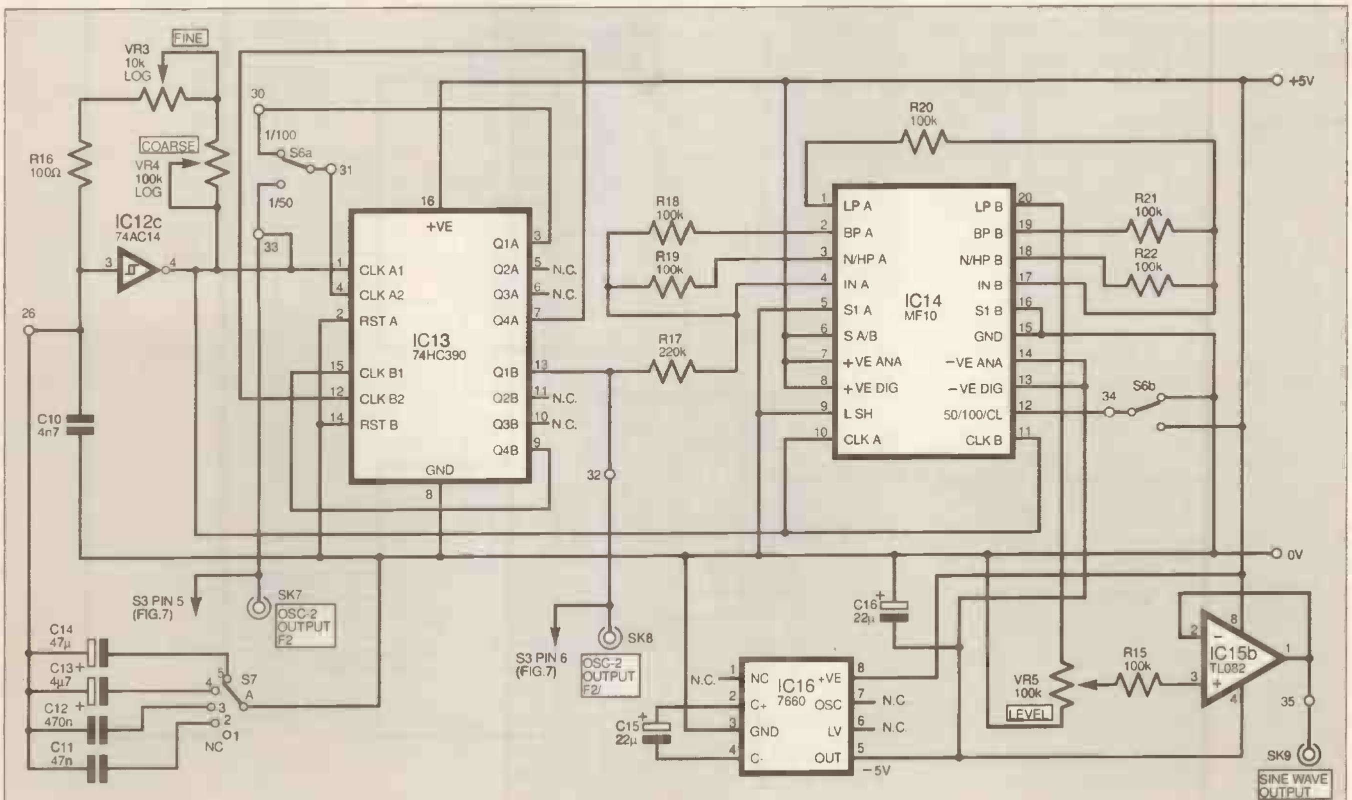


Fig. 3. Circuit diagram for Oscillator-2 and Sinewave filter stages.

frequency counter via switch S3, and is also fed into binary counter IC13. This counter consists of several stages which are connected so that the output at IC13 pin 13 can be switched by S6a for either 1/50th or 1/100th of the input frequency.

The divided square wave output frequency at IC13 pin 13 is fed to output socket SK8. It is also fed into the filter chip IC14 via resistor R17.

SINEWAVE FILTER

The square wave from IC13 pin 13 is converted into a sinewave by the switched capacitor filter chip IC14. The sinewave is generated in response to a controlling clock frequency which is either 1/50th or 1/100th of that of the input signal frequency. The 1/100 ratio results in a better shaped sinewave.

Here, the clock frequency is supplied direct from IC12c pin 4. As the filter's input frequency is always either 1/50th or 1/100th of the clock rate, filter precision, and thus sinewave shape, is assured. Switch S6b sets the correct control voltage on IC14 pin 12 to suit the clock/signal ratio.

The filter IC14 requires a positive and negative supply voltage. The latter is generated by the voltage inverter IC16. This is the familiar type 7660 device and is conventionally connected. Two filter circuits are contained within IC14. Both are configured as low-pass filters.

The signal from IC13 pin 13 is fed, via resistor R17, into IC14 pin 4. As set by the value of R17, the first stage attenuates the signal amplitude by a factor of two. Then, via resistor R20, the first stage low-pass output (LP A) signal at pin 1 is coupled into the second stage, where the resistor ratios maintain the same signal level.

From IC14's final low-pass (LP B) output pin 20, the sinewave signal is routed via Level control VR5 to the non-inverting buffer formed by op.amp IC15b. From here, it is output to socket SK9.

Up to about 100kHz, the maximum peak amplitude is about 2·5V. Above 100kHz, the maximum amplitude drops progressively to about 1·5V at the maximum frequency available.

Specification . . .

Display:	8-digit liquid crystal display (l.c.d.)
Oscillator-1:	Square wave output; 9 switched ranges; variable from 0·05Hz to over 40MHz
Oscillator-2:	Square wave output; 5 switched ranges; variable from 0·01Hz to 1·6MHz. Switched f/50 or f/100 square wave output. Switched f/50 or f/100 sinewave output. Sinewave amplitude variable from 0V to 2·5V peak max.
Oscillator-3:	10MHz fixed rate; crystal controlled square wave output
Oscillator-4:	32768Hz fixed rate; crystal controlled square wave output
Input 1:	Digital input; 0V to 5V logic; range to over 40MHz
Input 2:	Analogue input 2·5V peak-to-peak; range to over 400kHz; variable trigger level
Counter Reference Timing Options:	1Hz; 0·1Hz; external timer input logic 1, pulse length referenced to 10MHz; event counting
Power Supply:	7V to 12V d.c. from external source; 5V d.c. output

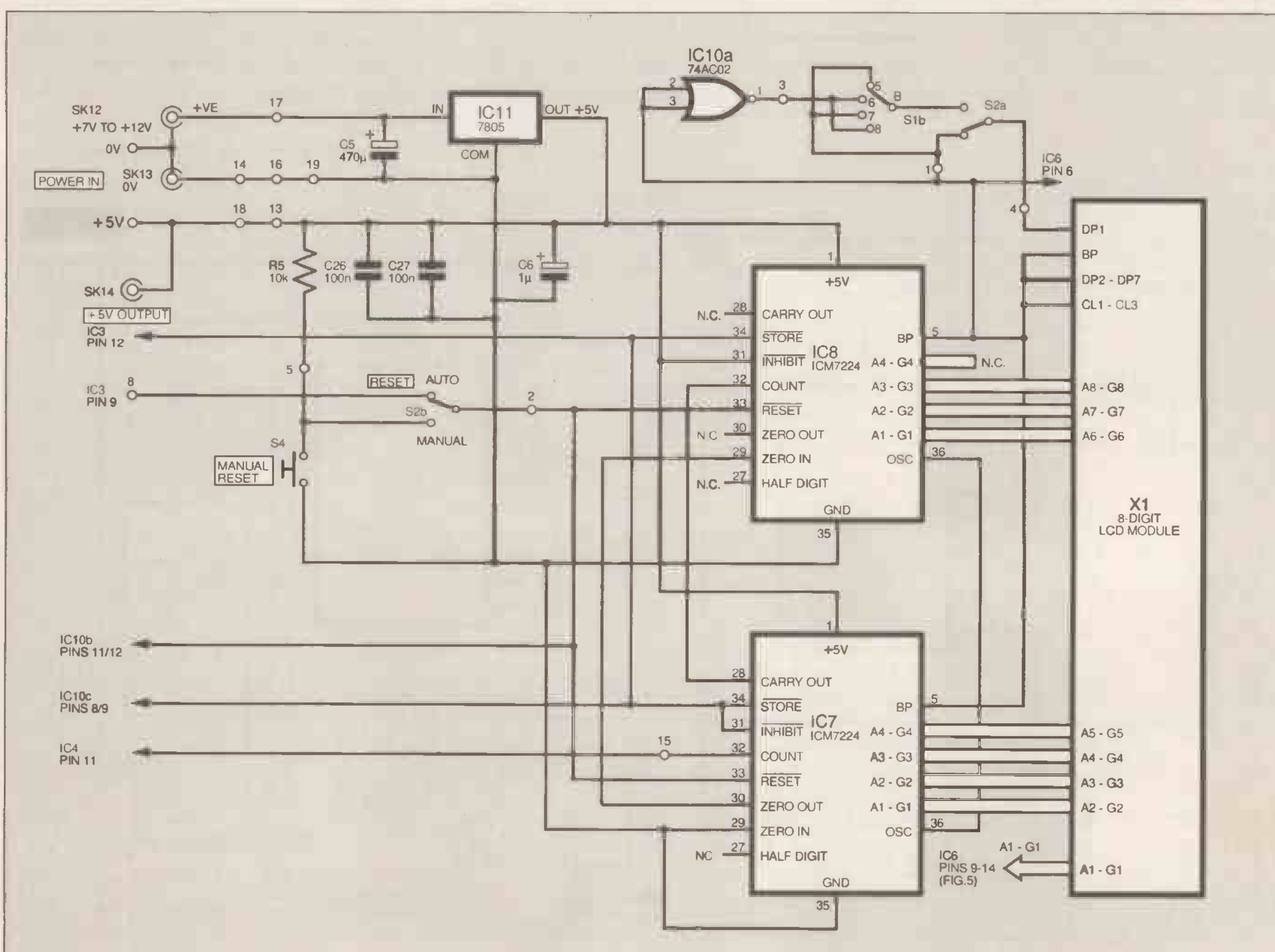
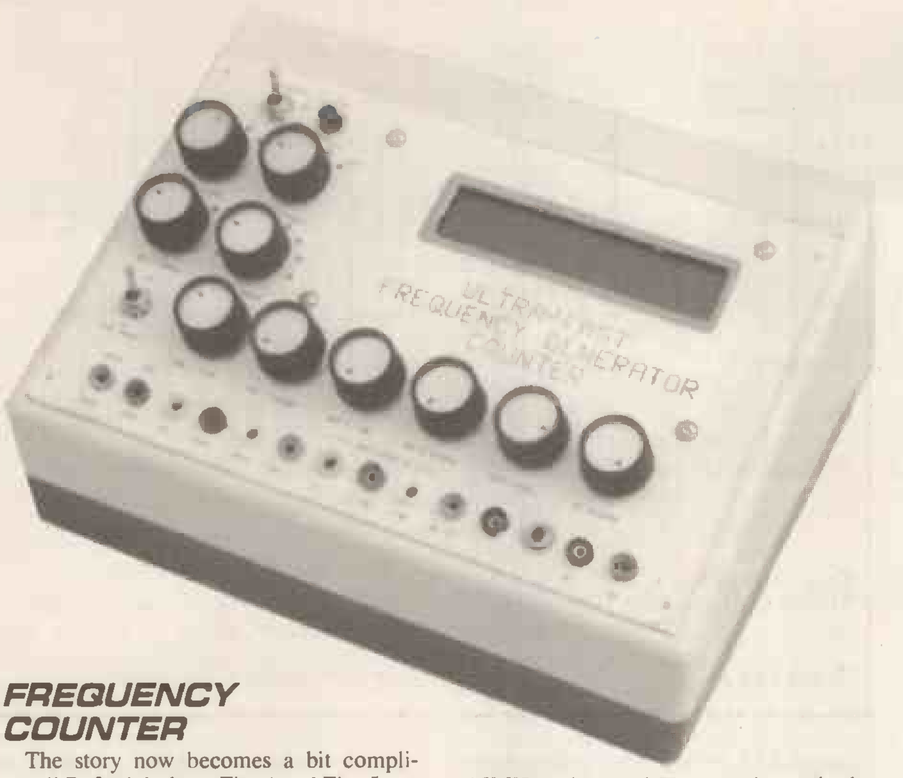


Fig. 4. Circuit diagram for l.c.d. digits 2 to 7 counter/driver, display and power supply.



FREQUENCY COUNTER

The story now becomes a bit complicated! Refer jointly to Fig. 4 and Fig. 5.

The Frequency Counter consists of eight cascaded decade counters whose contents are periodically output to an 8-digit display and then reset. The rate at which the reset occurs is normally one Hertz (1Hz), so that the display shows the frequency of the input signal in Hertz. As will be seen, other reset periods can be selected.

Seven cascaded decades are counted by IC7 and IC8 in Fig. 4. IC7 counts four of them and IC8 counts the other three. Each of these chips decodes the count into a format suitable for outputting to the l.c.d. module X1.

It might seem that all eight decades could be handled by these two chips, which are type ICM7224 4-digit l.c.d. counter/drivers. However, the maximum input frequency the ICM7224 can accept is 15MHz, whereas the counter is required to handle rates of at least 40MHz, and possibly more.

Consequently, a preliminary decade counting stage is required which will handle the higher rates. Its output, which is at a rate ten times lower than the original signal, is then cascaded into IC7.

The circuit diagram for this preliminary stage is shown in Fig. 5. The signal to be counted is input to the frequency divider IC4, whose Q3 output at pin 11 is fed to IC7 pin 32 in Fig. 4.

An additional design problem arose here in that the AC series (Advanced CMOS, very high speed) of logic chips did not include a decade counter, or a counter which can output to an l.c.d., or one which contains a latch. (When this unit was being designed, the AC series was very limited in its range – it still is, for that matter!) Consequently, as seen in Fig. 5, IC4 has to be fed into a latch, IC5, which then feeds into an l.c.d. driver, IC6, to control the digit 1 display.

The counter chosen for IC4 is a type 74AC161 4-bit binary counter. It is configured as a decade counter by taking its Q1 and Q3 outputs into NAND gate IC9a, whose output is inverted by IC9b and then, via NOR gate IC10d, passed to the Reset input at IC4 pin 1.

All three counter blocks, IC4/IC5 plus IC7 and IC8, need latching (Store) and resetting signals. There are several sources for these, as will be seen, but the result is that the Store signal comes to IC7/IC8 pins 34 (Fig. 4), and then (Fig. 5) is inverted by IC10c before going to IC5 pin 9, its clock input.

The Store signal causes the count value contained in IC5, IC7 and IC8 to be "frozen" and held until the next Store signal is received. Immediately the count values have been stored, the counters can be reset.

There are several sources for the Reset signal, as again will be seen. Referring to Fig. 4, whatever the source, from the pole of switch S2b, the Reset signal is fed to IC7/IC8 pins 33, and to IC10b pins 11 and 12 (Fig. 5). It is inverted by IC10b and then passed via NOR gate IC10d to IC4 pin 1. These Store and Reset arrangements keep the three counter chips synchronised.

Switch S2b is used to switch the counter resetting source from Automatic operation to Manually controlled by S4. This allows counts to be made over extended periods of time under user control. In other words, it allows the unit to be used as an event counter.

COUNTER TIMING

The normal counter Store and Reset sequence is required to operate at one second intervals, i.e. at 1Hz, so that the display shows the frequency rate in Hertz. Refer now to Fig. 6.

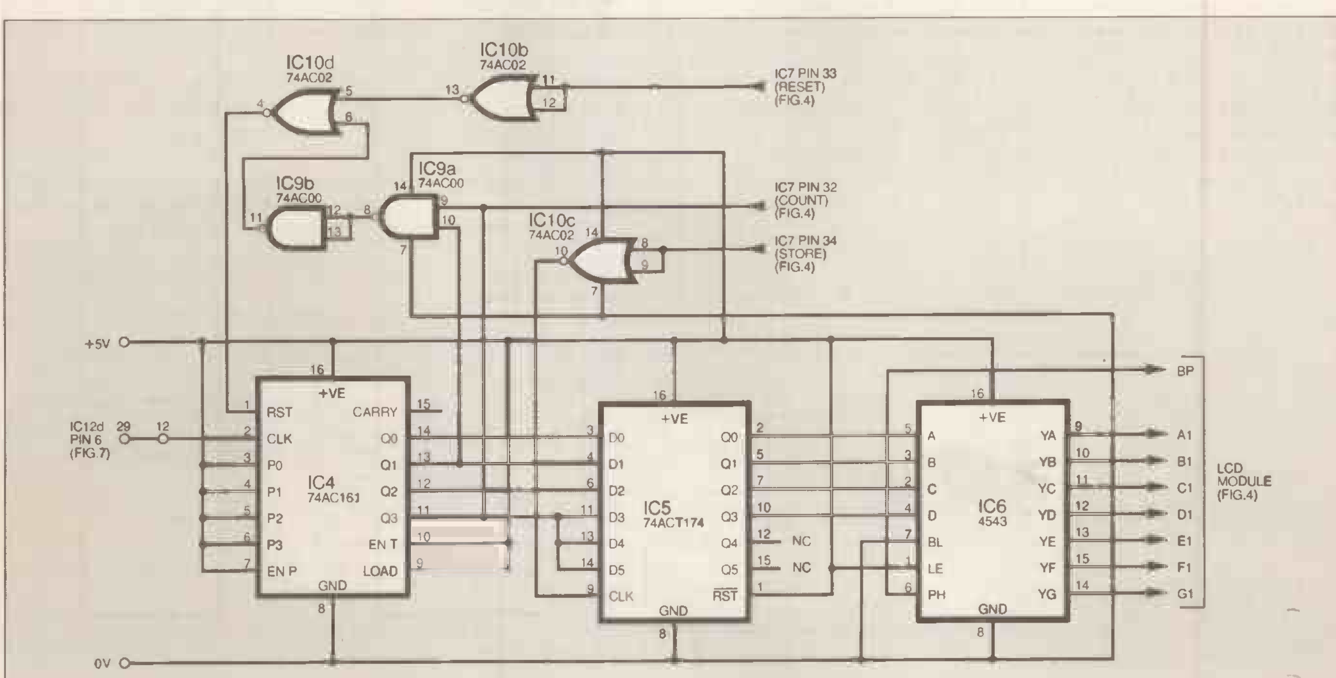


Fig. 5. Circuit diagram for l.c.d. digit 1 counter/driver.

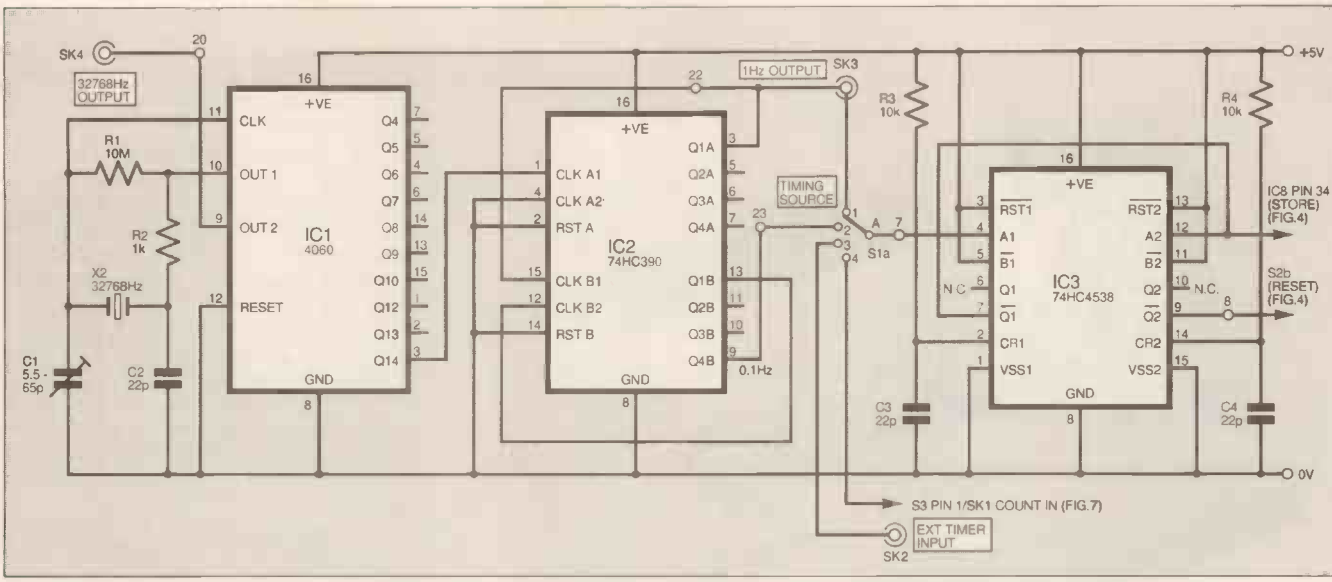


Fig. 6. Circuit diagram for timing period control and selection.

A crystal controlled oscillator and counter is formed around IC1. The basic crystal rate of 32768Hz is divided internally by IC1 so that a frequency of 2Hz is output from pin 3 (output Q14). The 32768Hz signal is also available as a signal source output via socket SK4.

From IC1 pin 3, the 2Hz signal is fed into counter IC2 at pin 1. The A1 stage of this counter divides the signal rate by two, outputting a 1Hz rate at pin 3. This 1Hz signal is made available to the outside world via socket SK3.

The 1Hz signal is now divided by stages B1 and B2, resulting in a 0·1Hz rate being output at pin 9. Both signals, 1Hz and 0·1Hz, are routed to switch S1a, as are other timing signal sources.

Which ever source is chosen, S1a (pole A) routes the timing signal to the dual monostable IC3, at pin 4. The first monostable has its pulse length set by resistor R3 and capacitor C3. Negative-going pulses output from pin 7 are the Store signals sent to the counters IC7 and IC8 (Fig. 4) and the latch IC5 (Fig. 5).

Negative-going pulses from IC3 pin 7 are also fed into the second monostable at IC3 pin 12. The pulse length of this stage is set by resistor R4 and capacitor C4. This monostable is triggered at the end of each Store pulse from pin 7. The negative going pulse output at pin 9 is the Reset pulse supplied to counters IC7 and IC8 (Fig. 4) and IC4 (Fig. 5).

The result is that each of the eight cascaded counters have their count values stored and output to the l.c.d. and are then immediately reset, allowing the counting to restart. As the previous count value has been stored, the l.c.d. only shows the final answer.

Selection by switch S1a of the 0·1Hz rate instead of 1Hz, relates the count to periods of ten seconds rather than one second. When this mode is selected, a decimal point is suitably turned on in the l.c.d. by switch S1b in conjunction with NOR gate IC10a, as shown in Fig. 4. Switch S2a turns off the decimal point when the unit is being used as an Event Counter.

COUNT SOURCES

Referring now to Fig. 7, signals to be counted, or pulses whose lengths are to be measured, first need buffering. Switch S3 selects the source which is routed to the buffering Schmitt inverter IC12d, from where they are fed to the display counter input at pin 2 of IC4 in Fig. 5.

Digital signals whose logic levels swing between 0V and 5V are brought into the Logic Input at socket SK1, then going via S3/1 directly to IC12d.

Signals whose peak voltage levels do not swing between 0V and 5V are brought in via the A.C. Input, SK10. Such signals include those whose swings contain a negative voltage, or are greater than or less than the 0V to 5V logic range.

Capacitively coupled by C7 and mid-way biassed by resistors R6 and R7, these "non-conformist" signals are fed via resistor R8 to op.amp IC15a. This is configured as a comparator whose reference voltage is set by potentiometer VR6. Resistors R9 and R10 limit the reference level extremes.

Each time the input voltage swings above and below the reference level, the output at IC15a changes state, switching between the op.amp's saturation output voltage extremes, just less than the power line voltage levels. Since the latter includes the −5V rail, resistor R11 and diode D1 are added to keep the minimum voltage fed via S3 to IC12d close to 0V.

Also fed to S3 are signals from Oscillator-1 and Oscillator-2, including the latter's 1/100 and 1/50 signals.

10MHz REFERENCE GENERATOR

Additionally Fig. 7 shows the 10MHz reference oscillator which is used for timing external pulse lengths. Pulse length is taken as the time that the pulse is high (logic 1).

Formed around IC9c, the 10MHz oscillator is output to the 2-input NAND gate IC9d. To the other input of IC9d is fed the input logic signal. Consequently, the output from IC9b only passes the 10MHz pulses when the input signal is high. These

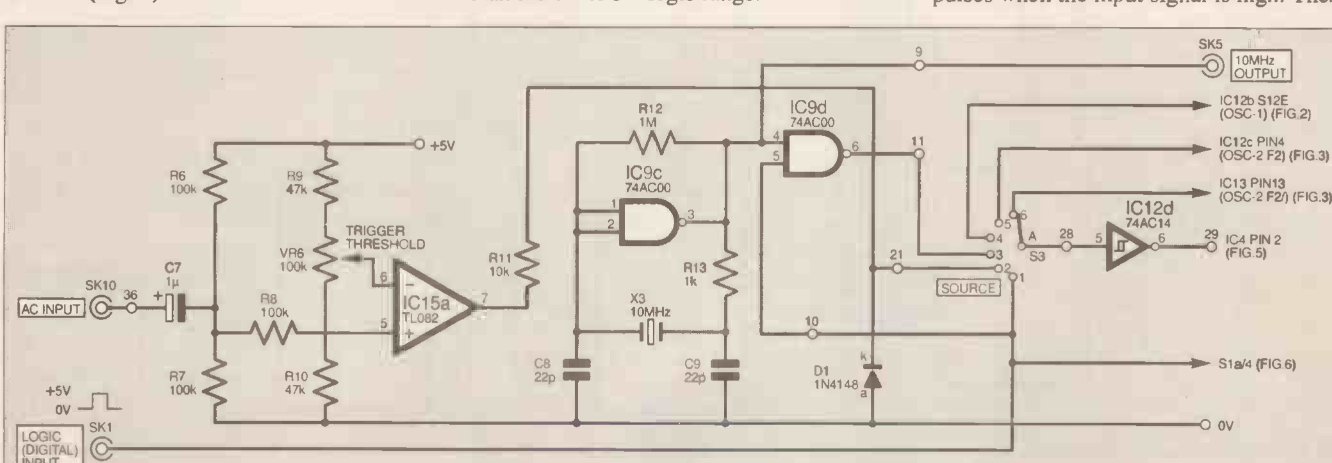
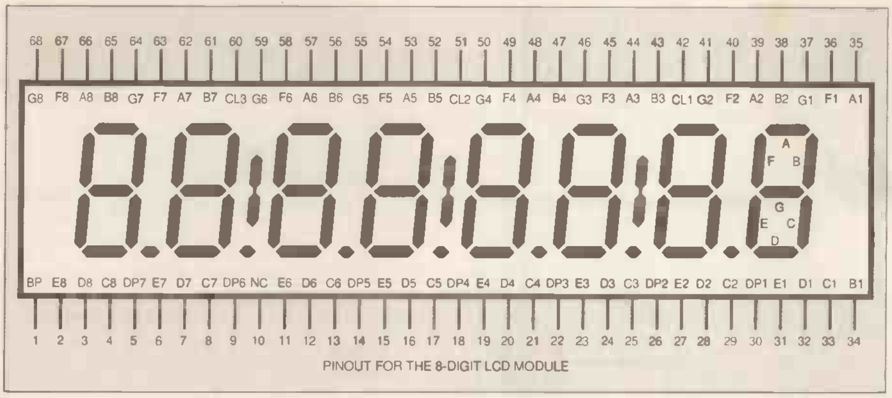


Fig. 7. Circuit diagram for a.c. input, 10MHz timing reference generator, and count source selection.



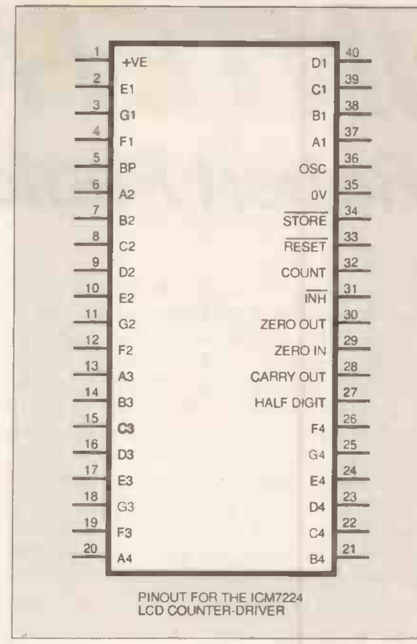


Fig. 8. Pinouts for the 8-digit l.c.d. module and (right) the ICM7224 counter/driver.

signals are fed to switch S3 from where they can be counted.

To measure the length of an input pulse period, the pulse itself is used as the timing source which controls the Store and Reset routines of the frequency counters (switch S1 in position 4). Using the 10MHz frequency as the signal source (switch S3 in position 3), the number of its pulses which are counted during the input pulse width represent the latter's duration in 0·1µs (i.e. ten oscillator pulses counted equals an external pulse length of one microsecond).

COMPONENTS

Resistors

R1	10M
R2, R13	1k (2 off)
R3 to R5, R11	10k (4 off)
R6 to R8, R15, R18 to R22	100k (9 off)
R9, R10	47k (2 off)
R12	1M
R14, R16	100Ω (2 off)
R17	220k

All 0·25W 5% carbon film or better.

See **SHOP TALK** Page

Potentiometers

VR1, VR3	10k rotary carbon, log. (2 off)
VR2, VR4	100k rotary carbon, log. (2 off)
VR5, VR6	100k rotary carbon, lin. (2 off)

All are p.c.b. mounting types (see text).

Capacitors

C1	5·5p to 65p trimmer
C2 to C4, C8, C9, C18	22p polystyrene (6 off)
C5	470µ radial elect., 16V
C6, C7	1µ radial elect., 10V (2 off)
C10	4n7 polystyrene
C11	47n polyester
C12	470n polyester
C13	4µ7 radial elect., 10V
C14	47µ radial elect., 10V
C15, C16, C24	22µ radial elect., 10V (3 off)
C17	2p2 ceramic plate (see text)
C19	220p polystyrene
C20	2n2 polystyrene
C21	22n polyester
C22	220n polyester
C23	2µ2 radial elect., 10V
C25	220µ radial elect., 10V
C26, C27	100n polyester (2 off)

All voltages are minimum values.

Semiconductors

D1	1N4148 signal diode
IC1	4060 14-bit counter with oscillator
IC2, IC13	74HC390 dual 4-stage counter (2 off)
IC3	74HC4538 dual monostable
IC4	74AC161 4-bit binary counter
IC5	74ACT174 Hex D-type flip-flop
IC6	4543 l.c.d. driver
IC7, IC8	ICM7224 4½ digit counter/driver (2 off)
IC16	7660 voltage inverter
IC9	74AC00 quad 2-input NAND gate
IC10	74AC02 quad 2-input NOR gate
IC11	7805 5V 1A regulator
IC12	74AC14 hex Schmitt inverter
IC14	MF10 switched capacitor filter
IC15	TL082 dual f.e.t. op.amp

See text regarding AC types.

Miscellaneous

S1	3-pole 4-way rotary switch
S2, S6	min. d.p.d.t. toggle switch (2 off)
S3, S7	2-pole 6-way rotary switch (2 off)
S4	min. s.p. push-to-make switch
S5	1-pole 12-way rotary switch
SK1 to SK11, SK13, SK14	2mm single socket (13 off) (see text)
SK12	min. power socket
X1	8-digit l.c.d. module
X2	32768Hz crystal
X3	10MHz crystal

Printed circuit boards (2 off), available as a pair from the *EPE PCB Service*, codes 994 (Osc.) and 995 (L.C.D. Driver); knob, screw-fix, with pointing mark (10 off); plastic case, 2-tone, sloped metal panel, 216mm x 155mm x 100mm (max. height); 8-pin d.i.l. socket (2 off); 14-pin d.i.l. socket (3 off); 16-pin d.i.l. socket (7 off); 20-pin d.i.l. socket; 34-pin s.i.l. socket (4 off) (see text); 40-pin d.i.l. socket (2 off); nuts (12 off) and bolts (4 off) to suit; cable ties; 1mm terminal pins; connecting wire; solder, etc.

Approx Cost Guidance Only **£79** **excluding case**

POWER SUPPLY

Returning once more to Fig. 4, the complete unit can be powered from a d.c. supply between 7V and 12V. It is brought in via socket SK12 and regulated down to 5V by IC11.

This voltage supplies all parts of the circuit. It is also available as an output voltage at socket SK14. The external 0V (common ground) socket is SK13.

Capacitors C5, C6, C26 and C27 provide power line decoupling.

SEMICONDUCTORS

Although IC12 is specified as a 74AC14, at the time of designing, these chips were in extremely short manufacturing supply. Consequently, the 74HC14 was used in the prototype. Both versions have the same pinouts, but the AC version can operate at higher frequencies than the HC (High-speed CMOS).

If the AC version can be obtained, using it may result in a higher maximum frequency available from Oscillator-1, although this has not been confirmed. With the HC version, the prototype's maximum frequency was about 46MHz.

Whether or not IC12 is obtainable as an AC type, with the other chips it is still worth while trying to get AC versions wherever these are specified (see *Shop Talk*).

If AC versions cannot be obtained, the HC versions may be substituted, though at a risk of reduced upper frequency handling range. Where HC versions are specified, there is nothing to be gained by substituting the AC types. *Note that the LS and standard TTL versions are NOT suitable for this unit.*

Pinouts for the 8-digit display and the ICM7224 counter/driver, are shown in Fig. 8.

Next Month: Circuit board construction, interwiring, case details and final testing.

INTERFACE

Robert Penfold

LAST month's *Interface* article covered simple circuits based on the 6402 UART which enable serial data from an RS232C port to be converted into bytes of parallel data. This month we progress to the transmitter circuits, and getting parallel data into a computer via the serial port. With the aid of a 6402 UART this is fairly simple, but it is not quite as straightforward as decoding serial information into bytes of parallel data. Some control logic may be needed with the receiver circuit, but for a serial transmitter circuit it is obligatory.

Self-Service

The receiver section of the UART places fresh bytes of data onto its parallel outputs as and when they become available from the decoder section. Often this is all that is needed, but if necessary the UART can be made to generate a strobe pulse each time a fresh byte of parallel data is made available.

This is just a matter of getting the Data Ready output at pin 19 to reset itself via the Data Ready Reset input at pin 18. Pin 19 goes high when a new byte of data is placed onto the parallel outputs, and it is reset by taking pin 18 low. The Data Ready output will therefore reset itself if it drives the Data Ready Reset input via an inverter.

In practice, it is often necessary to include a delay circuit in order to ensure that the output pulse is long enough to drive the peripheral circuit reliably. Experience has shown that a simple common emitter switching stage is adequate, and a circuit of this type is provided in Fig. 1. This type of circuit provides the required inversion. The delay is provided by capacitor C1 in conjunction with base feed resistor R1.

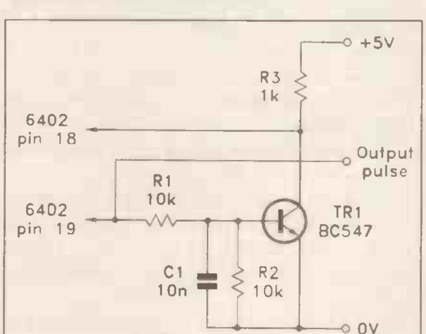


Fig. 1. Circuit which generates a strobe pulse each time a fresh byte of data is available.

Pin 19 of the UART goes high when a fresh byte of data becomes available, but even with C1 included the pulse duration will only be a few tens of microseconds. This is a fairly long duration by the standards of logic circuits, and it should be sufficient to activate the peripheral circuit properly. However, if necessary the pulse length can be increased by raising the value of C1.

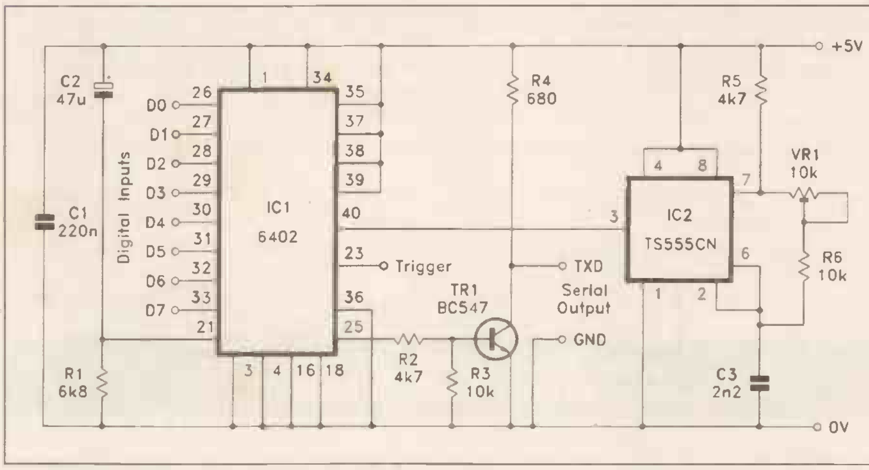


Fig. 2. The serial transmitter circuit. The trigger input is pulsed low to transmit a byte of data.

Transmitter Circuit

In Fig. 2 is shown the circuit diagram for a unit that provides basic parallel-to-serial conversion. Some of this circuit is much the same as the receiver circuit, with the control inputs again being connected to provide a word format of one start bit, eight data bits, one stop bit, and no parity.

The reset circuit connected to pin 21 is also the same, but note that in last month's receiver circuit resistor R4 and capacitor C1 were shown the wrong way round. The capacitor must go to the positive supply and the resistor to the negative supply, as shown in Fig. 2 here. This gives the required positive reset pulse at switch-on.

The clock circuit is the same as the one used in the receiver circuit, and correct adjustment of potentiometer VR1 should provide operation at 1200 baud. Adjusting VR1 is just a matter of using trial and error to locate a setting that enables the computer to reliably decode the serial data. If a frequency meter is available, adjust VR1 for an output frequency of 19·2kHz at pin 3 of IC2.

Of course, if preferred, the crystal controlled clock circuit provided last month can be used in place of the 555 astable. This avoids the need for any setting up adjustments. If both the transmitter and receiver sections of the 6402 are to be used, and the two sections will be run at the same baud rate, it is perfectly all right to drive both sections from the same clock circuit.

The bytes of parallel data are fed to the eight inputs at pins 26 to 33, and the serial data is transmitted from pin 25. The signal from pin 25 is at standard 5V logic levels, whereas an RS232C input requires nominal signal levels of plus and minus 12 volts. Also, the output from the UART is of the wrong polarity, and must be inverted before it can drive an RS232C input properly.

In practice, it is usually satisfactory if an RS232C port is driven with a 5V logic signal, provided a short connecting cable is used, preferably together with a baud rate of about 1200 or less. In most general interfacing applications, it is only necessary to use a short connecting cable of a metre or two in length, and a baud rate of about 1200 is adequate. This enables a simple common emitter switching stage to be used as the line driver.

In this circuit transistor TR1 is used as the inverter/driver. There are special RS232C driver chips available, and the MC1488P quad driver seems to be the "standard" device of this type. Pinout details for this chip are provided in Fig. 3. It has four drivers, which enable it to act as the line driver for any handshake outputs, and (or) to be used with more than one UART.

One of the line drivers is perfectly straightforward, but the other three provide a two input NAND gate function. In other words, the output of the driver goes low if both inputs are high, but is high if either or both inputs are low.

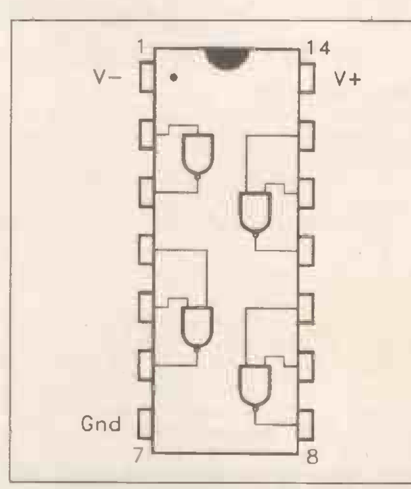


Fig. 3. Pinout details for the MC1488P quad line driver.

This effectively enables one input to be used to cut off the serial signal fed to the other input, but this facility is of little value in most practical applications.

If the two inputs of each NAND gate driver are wired together, they will operate as simple inverter/drivers, but may excessively load the serial output of the UART. It is safer if one input is connected to the +5V rail and the other input is fed with the serial output signal of the UART.

Connection details for both types of driver in the MC1488P are shown in Fig. 4.

When initially testing the circuit, it can be helpful to have the UART send a regular stream of bytes. One way of achieving this is to simply connect pin 23 to the clock input at pin 40. Obviously the clock will provide pulses at a much higher rate than the UART can transmit full bytes of data, but the UART seems to ignore any extra trigger pulses. This results in bytes of data being transmitted virtually end-to-end.

This method is simple, but it provides a rapid and continuous flow of data which the computer might find it difficult to digest, particularly if a high baud rate is used. The 555 oscillator circuit of Fig. 5 provides a simple alternative that enables the data rate to be set at practically any desired figure.

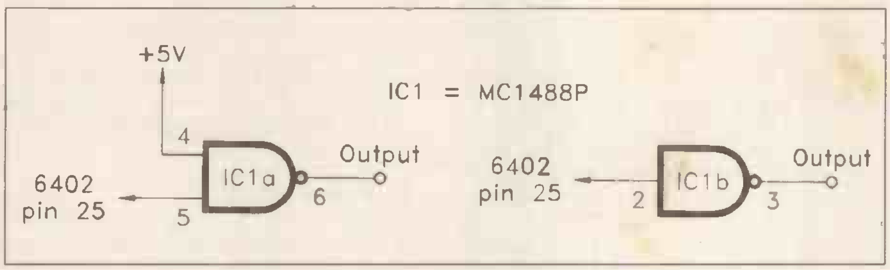


Fig. 4. Using the driver in the MC1488P.

A slight drawback of simple line driver chips such as the MC1488P is that they require dual balanced supplies of about ±12V (a maximum of ±15V for the MC1488P). Some of the more modern drivers generate their own dual balanced supplies from, a +5V supply. These "do-it-yourself" driver chips have the drawback of being relatively expensive, but in some cases could effectively pay for themselves by avoiding the cost of an additional power supply. Unfortunately, I have not yet had a chance to try one of these chips with the 6402 due to supply difficulties, but I will pursue this matter.

In Control

As pointed out previously, a control circuit cannot be regarded as an "optional extra" when using the 6402 to transmit data. As it stands, this serial transmitter circuit will simply sit there doing nothing, ignoring the bytes of data fed to its inputs!

In order to transmit a byte of data it is necessary to briefly pulse pin 23 of the UART low. Data is loaded into the transmitter-holding register on the falling edge of the pulse, and transmission commences on the rising edge.

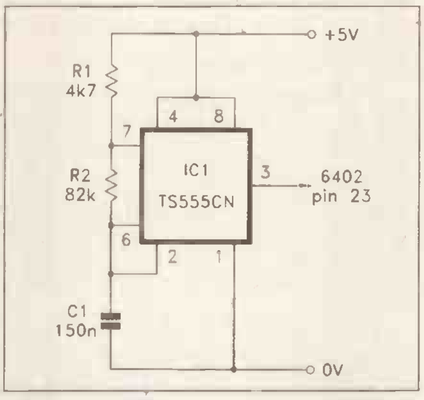


Fig. 5. A circuit which provides regular triggering to the 6402 UART.

Using the specified timing component values, the UART will be triggered at approximately 10ms intervals (i.e. at about 100Hz). A lower rate can be obtained by using a higher value for timing capacitor C1, and the operating frequency of the circuit is inversely proportional to the value of this capacitor. A value of 1µ5F for example, would result in bytes of data being sent at about 10 per second.

Although at first sight this method of control may seem to be valid for general use, it does have a major problem. The data on the parallel inputs must be stable during the pulse on pin 23. With this simple asynchronous method of control, the stability of the data cannot be guaranteed, and invalid data might be transmitted.

In an application where the data changes very slowly this might not matter, though. For example, a temperature interface could be designed to take readings at one second intervals. There would be little or no change from one reading to the next, and a software filter could be used to remove any erroneous results that occurred from time to time.

Running Free

The free-running method might also be usable in something like an alarm application where the binary input pattern would normally be the same for hours or even weeks at a time. The software would show the states of the sensors, and sound an alarm if a change was detected.

It is unlikely that a reading glitch as the system was triggered would prevent it from working properly anyway, but this is something that could easily be avoided by using appropriate software methods.

In applications where the data is constantly changing, it is essential to use a proper control logic circuit. Basically, all this has to do is latch each new byte of data into an 8-bit latch, and then trigger the 6402 UART.

Latching data using the 74LS273, etc. is a subject that has been covered in previous *Interface* articles and is not something we will consider again here. Some peripheral circuits, including most analogue-to-digital converters, have a built-in data latch, and also have a status output that can be used to provide the UART with a suitable trigger pulse. Circuits of this type can usually be interfaced to a serial transmitter with little difficulty.

Next month we will conclude our investigation of basic serial interfacing techniques.

FOX REPORT

by Barry Fox

Tandy Syndrome

At the knowledgeable end of the computer trade, they call it the "Tandy Syndrome". Someone buys a modem which, like all modern modems, has a US phone socket on the rear. For one reason or another they need a new lead, perhaps longer or perhaps because the original lead has American plugs on both ends.

The lead hunter goes to Tandy, because that is the only shop on the High Street that can be relied on to stock a good range of connectors. They buy a lead with an American plug at one end and a British BT plug at the other, plug it between the wall and the modem and try to send electronic mail or surf the Internet. But the modem sits resolutely dead. Exactly the same death is likely to afflict phones or fax machines.

Hell of a Hot-line

It is pure luck whether this happens or not, and Devilish hard to resolve because there is a conspiracy of silence inside the phone industry. By providing only inadequate or obscure explanations and instructions, the companies can so confuse the public that it is easier for people to buy new equipment.

Both the US and UK telephone systems rely on two wires to carry phone signals into the house. The house plugs and sockets have space for six pins but only four are used, numbered 2 to 5.

In the US system, the two "hot" wires go to the two centre pins of the small four-pin plugs and sockets. In the UK, the two hot wires go to the outer pins (2 and 5) of the larger four-pin plugs and sockets that BT uses.

So if a modem is wired for the US system, any lead which connects it to a UK socket must have the centre pins hot at the modem end, and the outer pins hot at the British plug and socket end. But for two reasons it is not that simple.

Some modem and phone manufacturers wire their rear panel US standard sockets in a non-standard way, with the outer pins hot. This way, when the equipment is used in the UK, the connecting lead uses straight through wiring without any need to swap the signal from centre to outer pins.

Leading Question

The trick is in knowing how the modem sockets are wired, because it is very difficult to tell by looking, especially if the socket has all four contacts present. This is one of the reasons for that Tandy Syndrome. The shop staff are unlikely to understand the problem, let alone offer help. You might as well toss a coin before buying a lead which may be straight through, outer to outer, or cross-over, centre to outer. You can also toss a coin over which leads your equipment needs.

And it gets worse. The US phone system works through the home on two wires but the British system needs a third wire to make the phones ring. More accurately, phones which are approved for use in the UK need the third wire to ring. Phones from the US will ring in British homes with only two wires. With only two wires you can make calls and talk on three wire UK phones but you won't know when there is an incoming call.

French Connection

UK fax machines also need the ringing tone if they are to auto-answer. Without it the machine can only send or receive faxes manually. People with holiday homes in France find this out to their cost when they take their British fax machine over the Channel. When plugged into a French phone line it stubbornly refuses to answer incoming faxes.

If only two wires come into the house, where does the third wire signal come from? It is derived from hot wires 2 or 5 by a capacitor. This passes the a.c. ringing tone to wire 3. The capacitor is built into the master socket at the point where the two incoming wires enter the house.

It is missing from the extension sockets which are then used all round the house. Wire 4 may provide an earth recall connection. Hence the need to use four wire cabling to connect the master socket to the extensions.

Golden Rule

After years of messing around with different phones, fax machines and modems, bought in a variety of countries and then used in a variety of countries, I can pass on only one golden rule. Whenever you buy any piece of telephone equipment, mark the lead which comes with it. That way you can always go back to first principles and use the original lead as a reference point.

This is a life-saver with equipment such as faxes and fax switches which will often leave the factory with US line sockets and connector leads which are wired with such wholly illogical configurations that they are completely useless once the original leads have been removed and mislaid.

The principle is the same as that of noting original computer software settings, or electronic hardware adjustments, before making any alterations. That way when you get in a mess, you can always go back to the original setting and start again.

Going . . . Going . . . Gone!

Gradually it all slips away. In 1991 the Government sold off the national research laboratories in Winchester which had been owned by the Independent Broadcasting Authority. Over the years the IBA pioneered digital video recording, and advances in analogue television, such as the clever but ill-fated MAC system.

The IBA's labs were bought for the knock-down price of £70 million by investment firm Mercury Asset Management. The privatised labs were re-named National Transcommunications Ltd and the IBA's successor, the Independent Television Commission, employed NTL to research digital television. NTL also diversified into satellite transmission and mobile radio. As Ian Armitage of Mercury said recently "The investment has proved to be outstanding".

Armitage was speaking as MAM sold off the last chunk of its hugely profitable investment.

Last year Rupert Murdoch's News International bought the section of NTL that had been employed by the ITC to develop digital television. It was hived off staff, stock and barrel, and re-named Digi-Media Vision.

In late March, Mercury flogged the remaining staff and stock to cable TV company CableTel. Although the official announcement makes much of the fact that CableTel is "Britain's third largest cable communications operator", the truth of the matter is that CableTel is an American company.

Although Rupert Murdoch never said how much he paid for the DMV share of NTL, CableTel is paying a total of £235 million, for a company that is earning over £100 million a year.

So research labs that were built to serve the British public, and transmit British TV and radio programmes, have now made the Government a piddling £70 million and earned the Mercury money men literally hundreds of millions.

The final sale negotiations were protracted, and the final deal was not signed until the small hours of the morning. By then the two companies had already kitted out a conference hall in London to puff the sale to city analysts. After the analysts had heard the news, NTL and CableTel held a joint press conference. It started at 11.30am. By the time 280 faxes had gone out inviting journalists to attend and ask questions, it was well into the afternoon and the conference was finished.

There would not have been much point in going anyway. MAM is in business to buy cheap and sell high. The culprits are the British government ministers who, in 1991, sold the IBA's labs cheap and so gave MAM the chance to make a small fortune.

The sting may be in the tail. If the BBC now goes ahead and sells its transmitter network to raise money, NTL is the most likely buyer. The transmission of all British radio and TV will then be controlled from America.

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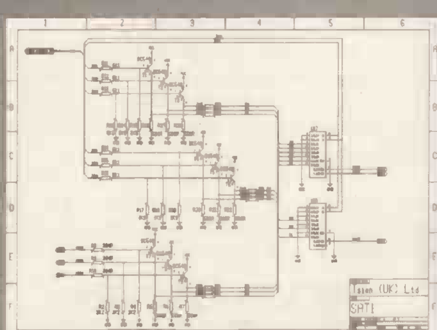

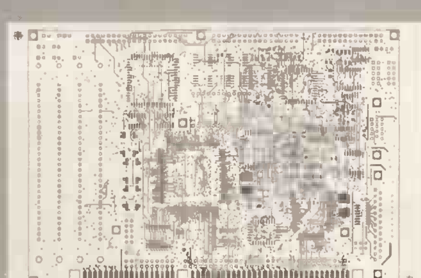

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Teach-In '96 – Constructional Project

VU DISPLAY AND ALARM

MAX HORSEY **PCB DESIGN BY DAN RUSBY**

Bargraph l.e.d.s and a buzzer give audio-visual warning of signal overloads.

BASED on the information provided in *Teach-In* Part 8, this article shows how modules may be selected and combined to produce a working project.

The VU (Volume Units) Display and Alarm has two distinct functions:

1. A set of l.e.d.s (light emitting diodes) which pulse according to the level of sound received by a built in microphone.
2. A stereo line input which may be connected to the output from an audio source, such as an amplifier, cassette recorder or video recorder, to monitor the sound level being recorded.

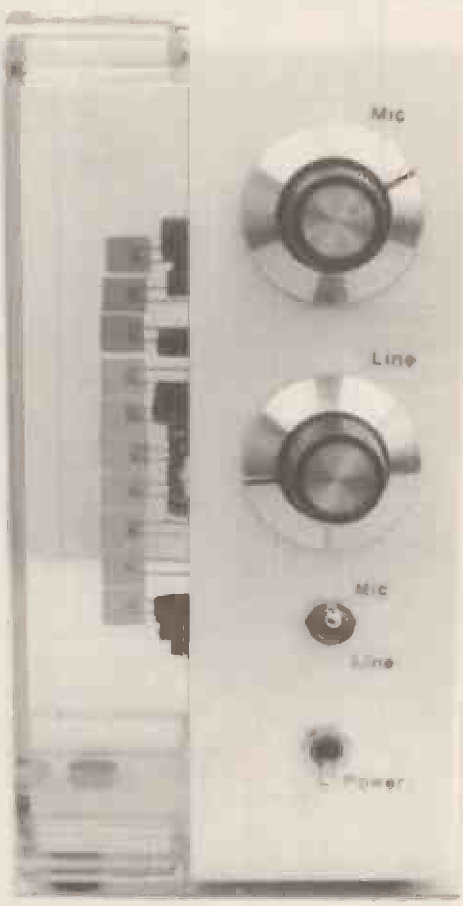
In both situations, if the level becomes too high, a buzzer sounds a warning.

The first application is mainly for display purposes, although if the buzzer is replaced by a lamp or l.e.d. the circuit could also warn of excessive noise level.

Note that the buzzer cannot be used as a warning device when the internal microphone is in use, since the buzzer's own sound will be picked up by the microphone and cause the circuit to latch.

The second application is particularly useful when recording cassettes or video tapes. In the author's experience, automatic sound level controls never produce good results, but it can be quite tedious watching the recording level indicators in case an unexpected sound peak makes the system over-record.

This circuit enables the user to relax, read, sunbathe etc., safe in the knowledge that the device will buzz or bleep if an excessive sound peak occurs (but it could still be necessary to start over again if it does!).



The circuit is designed to be connected either between, say, an amplifier "record output" and the cassette recorder or video recorder, or to the line output of the recorder.

The two stereo channels are mixed to produce a single signal for the circuit, but the separate stereo channels are sent on to the recorder. In other words, stereo channel source separation is not compromised.

BLOCK DIAGRAM

As seen in the block diagram of Fig. 1, the concept is achieved by using two input modules, namely the sound input circuit and the mixer circuit, selecting between them by means of a switch.

The signal is then processed by an integrated circuit (i.c.) and associated components which convert a rising and falling voltage into a rising and falling l.e.d. display.

The buzzer output module is connected so that when the appropriate l.e.d. lights, the buzzer sounds, indicating the excess level warning.

CIRCUIT DESIGN

Studying Fig. 2 reveals that the final circuit is a fairly close copy of modules discussed in *Teach-In* Part 8.

Op.amp IC1 is connected as a non-inverting amplifier with a gain of about 471 (i.e. (R4/R5) + 1). This part of the circuit provides a high gain suitable for a microphone, which should be an *electret* type. If a *dynamic* microphone is used, then remove R1 so that there is no connection between the microphone and positive rail. The signal level delivered to bargraph driver IC3 is set by potentiometer VR1.

Op.amp IC2 is connected as an inverting amplifier and is used as a mixer stage. It is intended for "line level" input signals – the type of signal associated with the outputs from cassette recorders and video recorders. It cannot be used with microphones.

As discussed in Part 8, the inverting input (pin 2) is a "virtual earth", which ensures that the signal arriving from one source cannot interfere with the other, and vice-versa.

The two stereo halves of the audio signal are mixed and, if necessary, amplified a little, but the separation between them on the source (input) side is retained. Both channels are given the same amount of

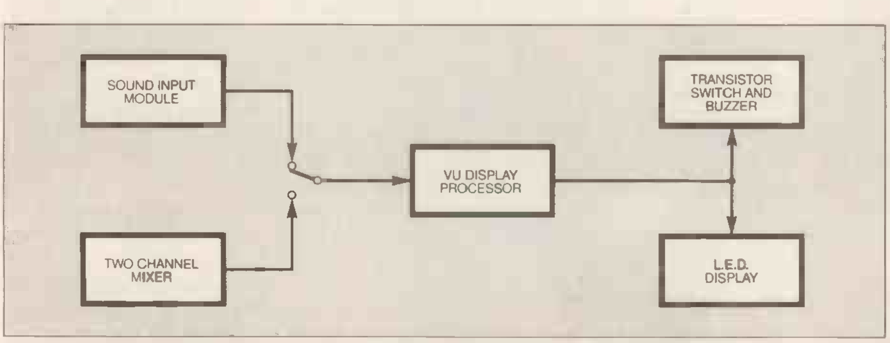


Fig. 1. Block diagram for the VU Display and Alarm.

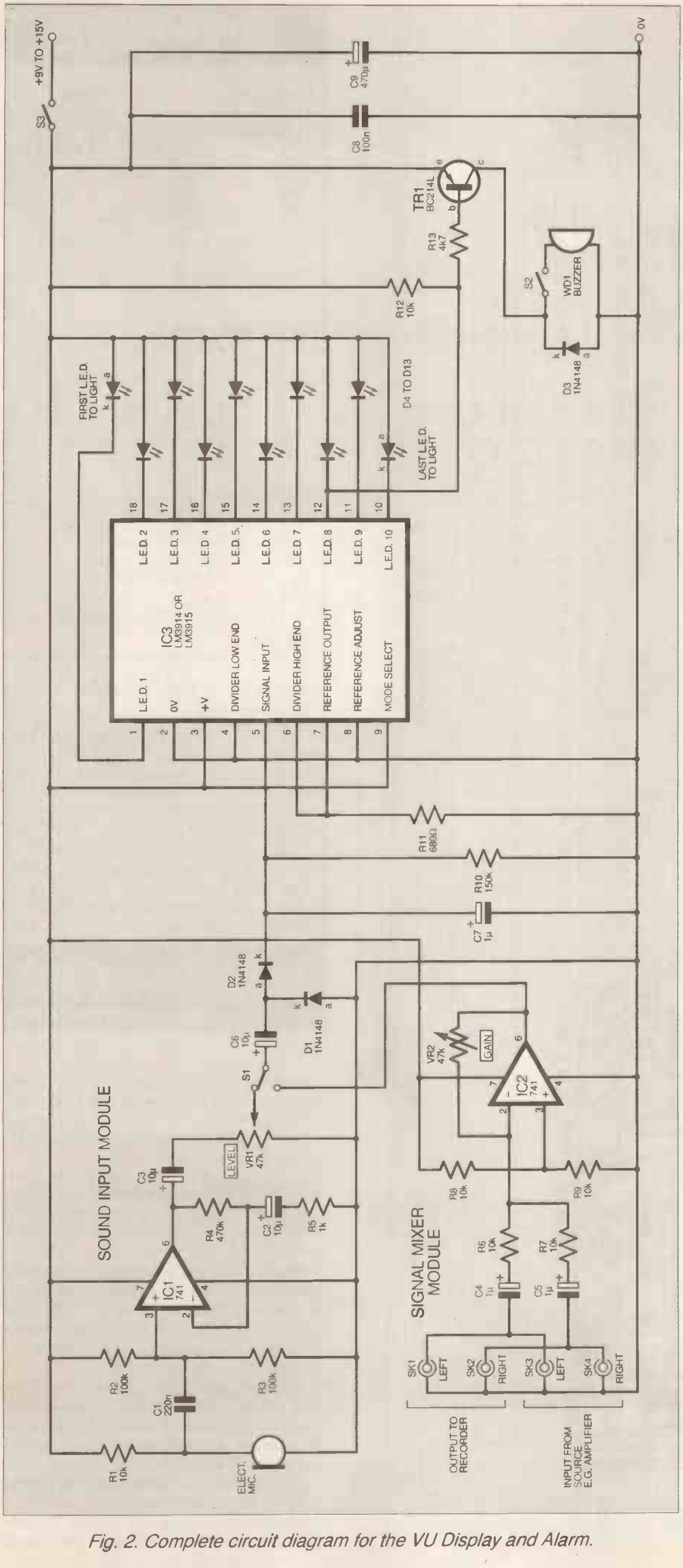


Fig. 2. Complete circuit diagram for the VU Display and Alarm.

gain since their input resistors, R6 and R7, have equal values.

The overall gain of this stage is variable from nil to about 4·7 times by potentiometer VR2, which is wired as a variable resistor.

Switch S1 selects between the audio input module and the signal mixer. Both modules require a d.c. blocking capacitor in series with their outputs, and so a single capacitor C6 is provided after the switch. Likewise, both circuits require an a.c. to d.c. converter (as within the dotted lines in Part 8 Fig. 8.4).

Here, in Fig. 2, the converter consists of diodes D1 and D2, capacitor C7 and resistor R10. The resulting d.c. voltage, which rises and falls according to the a.c. signal strength, is supplied to IC3 pin 5, to control the l.e.d. display, D4 to D13.

Note that each output at IC3 is "active low", therefore each l.e.d. is connected between the positive power line and the appropriate output. Resistor R11 sets the brightness of the display.

The eighth output was chosen as the "overload" warning source, and so pin 12 is used to control the buzzer WD1 via transistor TR1. Resistor R12 was added to ensure that the transistor turns off completely when pin 12 is not active. Switch S2 turns off the buzzer when not required.

Finally, decoupling is provided by capacitors C8 and C9, whilst S3 is the power on/off switch.

OMITTING MODULES

If either of the two input stages in Fig. 2 is not required, simply leave out the appropriate components. For example if the circuit is to be used only as a recording signal warning device, omit the microphone input stage, comprising IC1, R1 to R5, C1 to C3, VR1, S1 and the microphone.

When switch S1 is omitted, the positive side of capacitor C6 should be connected directly to the output of the retained input stage (i.e. to IC2 pin 6, or the wiper of VR1, as appropriate).

POWER SUPPLY

Although the circuit will operate from a PP3 (9V) battery for several hours, if it is likely to be used for considerably longer periods a mains power adaptor is recommended. A small regulated type offering 9V or 12V d.c. at up to 300mA is ideal.

HOUSING BENEFITS

Since the circuit is designed for producing a display, some thought should be given to housing the unit in a suitable case before starting. The printed circuit board (p.c.b.) is designed to allow a set of l.e.d.s to be inserted directly. The larger rectangular types (i.e. 7mm × 2·5mm) will fit exactly end to end.

If the l.e.d.s are to be mounted directly into the board, then decide at this stage how the p.c.b. will fit into the case, and whether a long slot will be cut (quite a difficult operation) or whether a case with a transparent top will be used.

Alternatively, a "normal" case can be used and holes made in the front for standard round l.e.d.s, connecting them back to the p.c.b. via wires. Note that only 11 wires are required (not 20); in other words, one for each l.e.d. cathode (k), plus one lead connected to all the l.e.d. anodes (a).

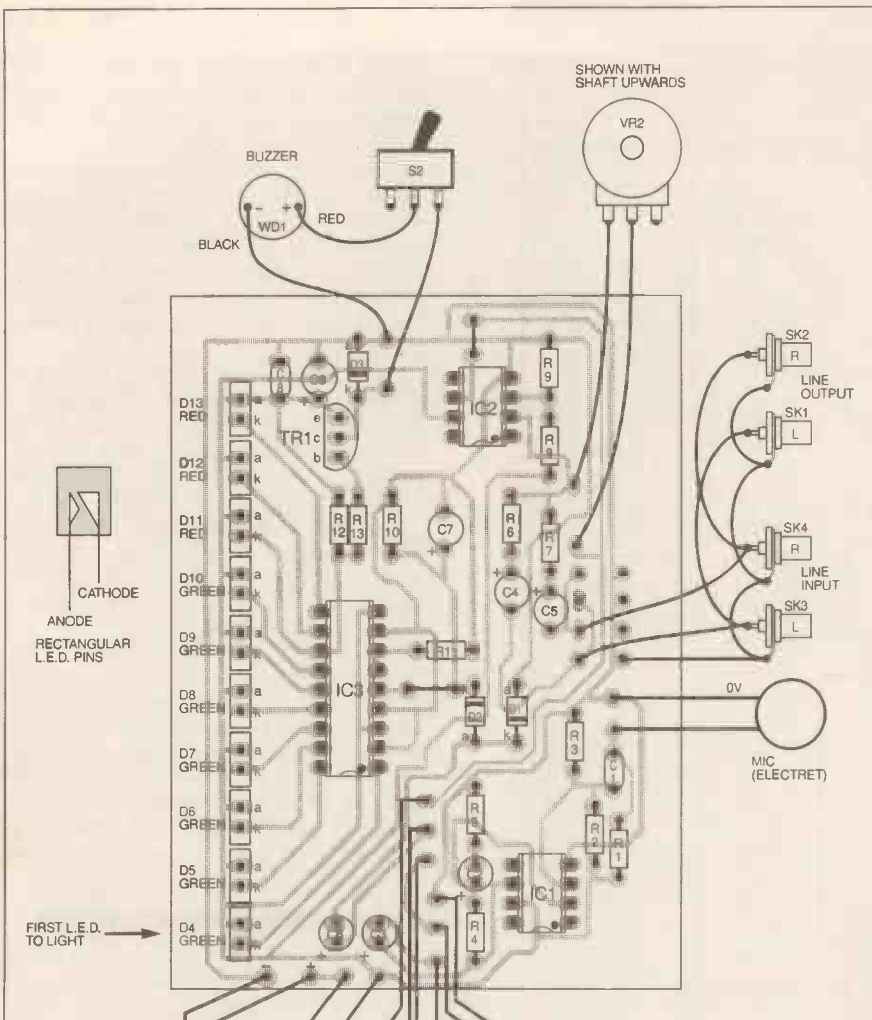


Fig. 3. Printed circuit board component layout and full-size underside copper foil track master pattern.

COMPONENTS

Resistors
R1, R6 to R9, R12 10k (6 off)
R2, R3 100k (2 off)
R4 470k
R5 1k
R10 150k
R11 680Ω
R13 4k7
All 0·25W 5% carbon film, or better

See SHOP TALK Page

Potentiometers
VR1, VR2 47k rotary lin. (2 off)

Capacitors
C1 220n ceramic disc
C2, C3, C6 10µ elect. radial, 16V (3 off)
C4, C5, C7 1µ elect. radial, 16V (3 off)
C8 100n ceramic disc
C9 470µ elect. radial, 16V
Voltages are *minimum* values

Semiconductors
D1 to D3 1N4148 signal diode (3 off)
TR1 BC214L *pnp* transistor
IC1, IC2 741 op.amp (2 off)
IC3 LM3915 logarithmic bargraph driver
D4 to D10 green l.e.d., rectangular, 7mm × 2·5mm (7 off)
D11 to D13 red l.e.d., rectangular, 7mm × 2·5mm (3 off)

Miscellaneous
WD1 solid state buzzer, 6V to 12V
S1 s.p.d.t. min. toggle switch
S2, S3 s.p.s.t. min. toggle switch
Printed circuit board, available from the *EPE PCB Service*, code 999; electret microphone insert; 8-pin d.i.l. socket (2 off); 18-pin d.i.l. socket; phono socket, red (2 off), phono socket, black (2 off); knob (2 off); plastic case 150mm × 80mm × 75mm, with transparent lid (see text); power input socket; 12V power supply (see text); terminal pins; wire; solder, etc.

Approx Cost Guidance Only £22 excl. case and PSU

Note that the p.c.b. is mounted in the case with the l.e.d.s on the left hand side. This is to ensure that the last l.e.d. to light will be at the top when the project is standing upright.

CONSTRUCTION

Details of the p.c.b. are shown in Fig. 3. This board is available from the *EPE PCB Service*, code 999.

Begin p.c.b. assembly with the smallest components and i.c. sockets, building up in size and finishing with the off-board connections. As usual, check the polarity of electrolytic capacitors, diodes and transistor TR1.

When connecting the l.e.d.s, also check their polarity carefully. Remember that the shorter l.e.d. lead (normally) represents its cathode (k), and is connected to the respective output of IC3.

Rectangular l.e.d.s may not be clearly marked with regard to polarity, and once the wires have been cut it may be difficult to fit them the correct way round.

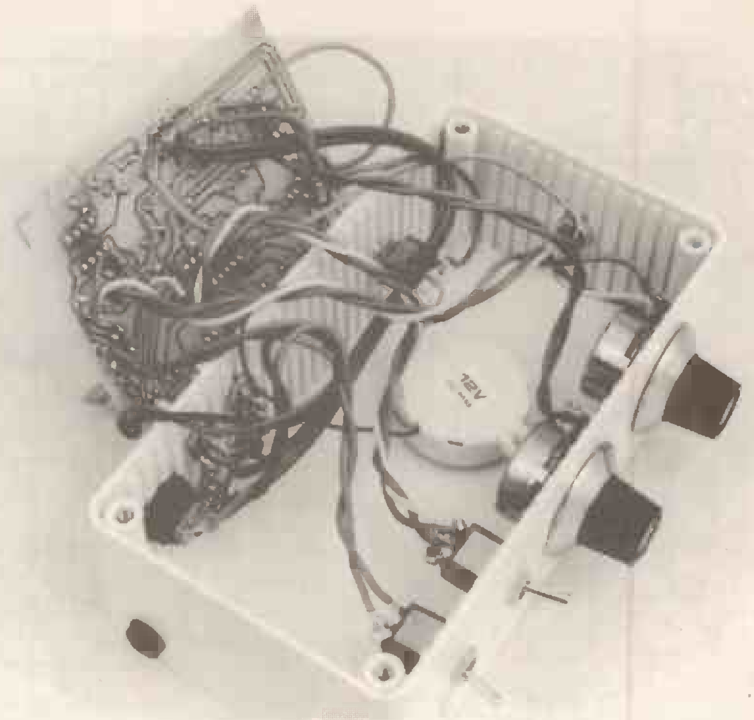
However, by comparing them carefully, it is possible to work out the polarity by checking the shape of the metal parts inside the body.

TERMINAL PINS

If the p.c.b. is to be fitted in a transparent case, it is better to fit all the wires for connecting to off-board components on the *track* side of the board so that they are hidden from view. They are best connected by means of terminal pins, which, in this instance, should be inserted with their heads on the *component* side.

Next, connect the electret microphone, taking great care with its polarity. The polarity is not always obvious and the catalogue from which the microphone was purchased may have to be consulted. Some suppliers sell microphone inserts with screened wires already connected, in which case the outer part of the cable is the negative (0V) side.

If wires are not already connected to the microphone insert, use normal wires (rather than screened cable) to make the connections if they are only a few centimetres long.



AUDIO LEADS

The circuit diagram, Fig. 2, shows how the audio line level signal can be routed through the project. This means that, for example, the output from an amplifier to a cassette recorder can be connected to the project, and another lead used from the project to the recorder. This method is shown in the wiring block diagram in Fig. 4a, but note that the gain setting on the recorder will not change the level of signal reaching the project.

If the connection method shown in Fig. 4b is used, then any changes made to the gain setting on the recorder will cause a change of signal at the project.

There is provision on the p.c.b. for routing the audio signal in and out via wires connected directly to it. However, it may be more convenient to just use three connections to the p.c.b. and connect the phono sockets, Left with Left, and Right with Right with short insulated wire links, as shown in Fig. 3. Since the two sockets are connected in parallel it is immaterial which are called "input" or "output".

Complete all the other connections to the potentiometers and switches.

When inserting the i.c.s, check carefully that the notch on each one lines up with the layout. Although they are not prone to static damage in the same way that CMOS i.c.s are, it is still sensible to handle them with respect.

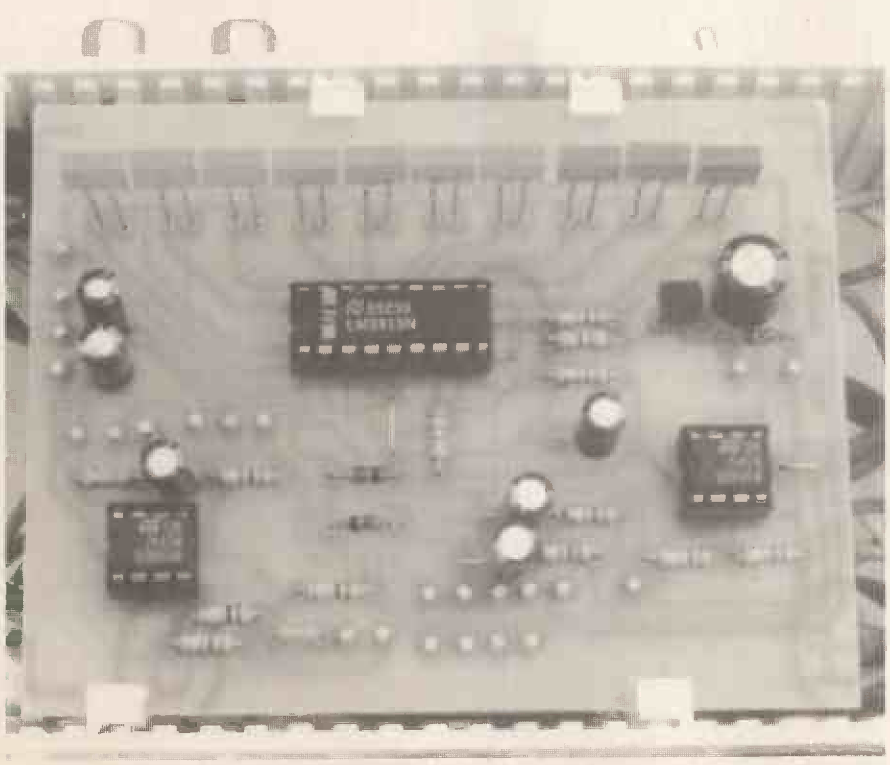
TESTING

A 12V 100mA regulated supply is ideal for testing the circuit. If powered by a battery, or an ordinary 9V to 12V power supply, check that components, the i.c.s in particular, do not become hot due to faulty wiring.

Switch S1 to "microphone", then wait for about 15 seconds for the capacitors to charge. Adjust VR1 until one or more of the l.e.d.s light, pulsing with sounds received by the microphone.

Now set S1 to "mixer" and connect the input to a cassette recorder output, or an amplifier line output. Adjust VR2 until the l.e.d.s again pulse with changes in the signal level.

If the circuit is functioning properly, the buzzer should sound (if switch S2 is on) when l.e.d. number eight lights up (the first of the reds). Failure in this area indicates that TR1 may be connected the wrong way round.



FAULT FINDING

Failure of one or other test should indicate the area of the circuit to check first. Read the fault finding guide provided in *Teach-In* Part 1 for general help.

An oscilloscope connected to output pin 6 of IC1 or IC2 should indicate a signal, but do not expect to trace a signal at pin 2 of IC2. Even though this is the input pin, there will not be any *measurable* signal present (see comments in Part 8 about "virtual earth").

A voltmeter should reveal a signal (i.e. a fluctuating d.c. voltage) at the cathode (k) of diode D2.

Check that the l.e.d.s are connected the correct way round.

THE CASE

Studying the photographs, prepare the case. Begin by drilling the holes for the power input socket, line input/output sockets, potentiometers and switches.

Phono sockets should be used so that the line input and output system is compatible with the majority of commercial equipment. Note that the retaining nuts on the phono sockets are responsible for holding the 0V connections securely, therefore they should be screwed very firmly.

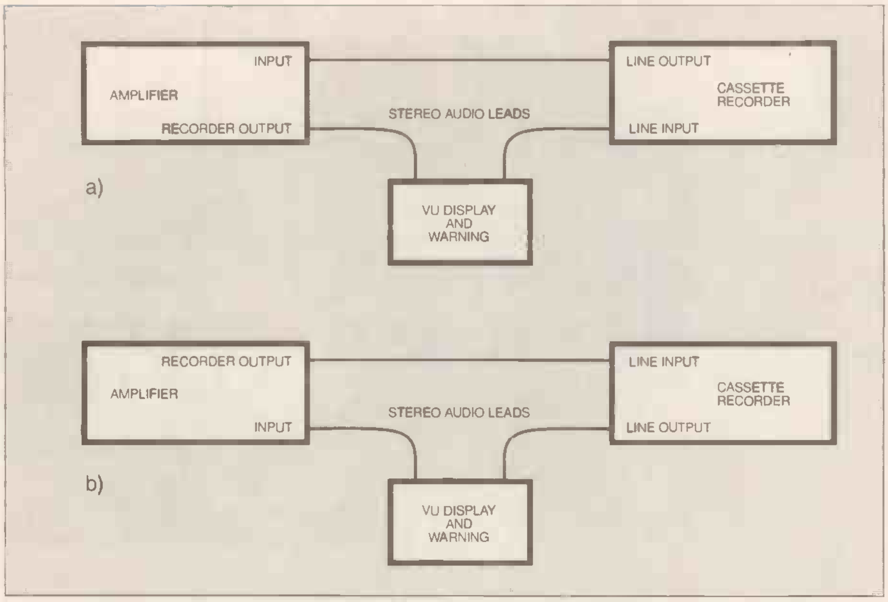


Fig. 4. Two methods for connecting the unit.

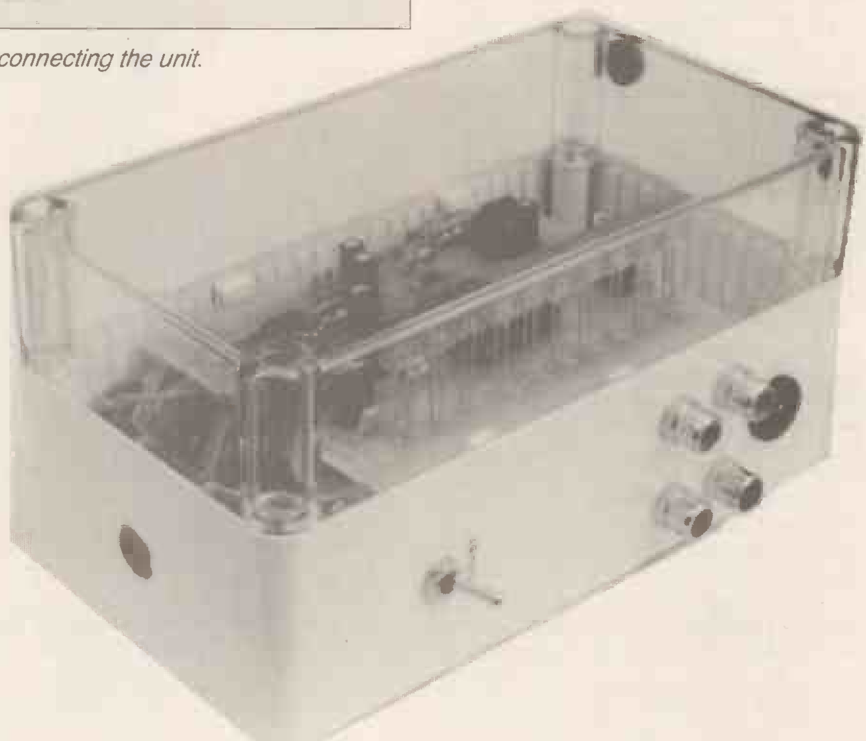
The electret microphone may be mounted on the inside of the case just behind a hole and held with glue. Alternatively, if your drilling accuracy is very good, a hole can be made into which the microphone may be pushed for a snug fit.

The p.c.b. may be secured with self-adhesive mounts, or, as in the prototype, placed at the top of the non-transparent part of the case and held firmly in place by the lid.

USING THE UNIT

If the recorder has a line output, it is more convenient to connect the project as shown in Fig. 4b, since the gain control on the recorder will then affect the signal level for the project as well.

Switch S1 to "line input", start the signal source (i.e. a second tape recorder, record player, CD etc.) and adjust VR2 until the level indicator on the recorder agrees with the l.e.d.s on the project. Switch on S2 and note that whenever the recorder moves into the "red", a warning bleep occurs in the unit.



If the connection method shown in Fig. 4a is used, then any adjustment of the gain setting on the recorder must be copied on VR2. Whichever connection method is used, the original signal is not *processed* in any way by the project. Although the unit does impose an additional load of about 10kΩ on the signal source, normally this should be of no significance.

TEACH-IN PART 9

The modules to be examined in Part 9 include an infra-red transmitter, missing pulse detector and reed switches.

The project associated with Part 9 is a Twin-Beam Break Detector. □

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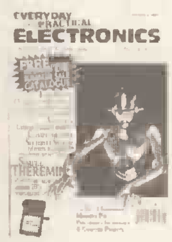

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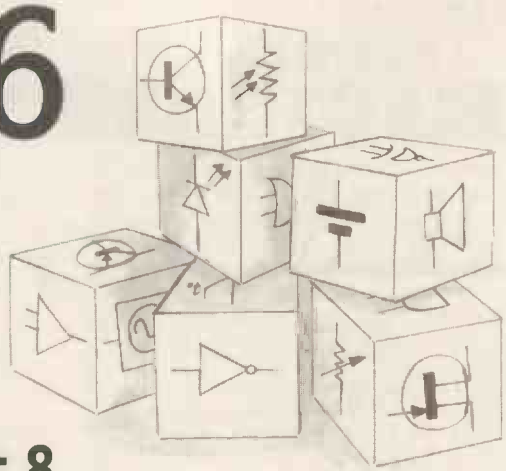


A Guide to Modular Circuit Design

Max Horsey **Part 8**

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 this eighth Part of *Teach-In* the following Input, Processor and Output modules are examined:

INPUT MODULES: Audio input, signal mixer, position to voltage sensor

PROCESSOR MODULE: VU display

OUTPUT MODULE: Single *pnp* transistor output

The project associated with this part is a VU Display and Alarm, which provides a pleasing visual display, and an audible over-level alarm buzzer.

AMPLIFIER CIRCUITS

The amplifier modules are based around an op.amp, such as the type 741. Op.amps were encountered in Part 1 of the series, where one was being used as a comparator. A comparator circuit, as the name suggests, compares the voltage at its two inputs and causes the output to switch between positive and negative (or 0V) according to their voltage levels.

The key point about a comparator is that its output *switches* "instantaneously", there is no half-way stage.

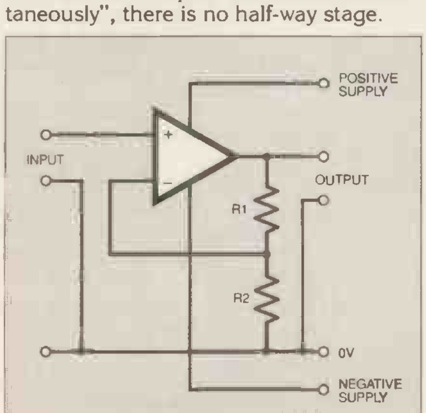


Fig. 8.1. Circuit diagram for an op.amp non-inverting amplifier.

An audio amplifier needs to provide an output waveform which is a faithful copy of the input waveform, even though it may be greater in magnitude (i.e. amplified). This is achieved by means of *negative* feedback. Not surprisingly, this is the opposite of *positive* feedback (discussed in Part 1, in which it was used to create a Schmitt trigger – a circuit with a particularly abrupt switching action).

The op.amp can be connected in two principle amplifying configurations, both with negative feedback. These are known as:

1. Non-inverting amplifier
2. Inverting amplifier

NON-INVERTING AMPLIFIER

The basic arrangement for a *non-inverting* amplifier working on a dual-rail supply is shown in Fig. 8.1. Note that the inverting input is denoted by a minus sign, and that the non-inverting input is denoted by a plus sign.

Feeding the signal into the non-inverting input, the output provides a signal which is exactly *in phase* (in step) with the input.

Resistor R1 is connected from the output to the inverting input and provides negative feedback. If the *full* output voltage were to be returned to the inverting input, the circuit would not amplify the signal, but merely "buffer" it, producing an output voltage of the same level as that at the input.

An amplifier in this configuration has what is known as "unity gain", i.e. a gain of one. To provide amplification (a gain greater than one), the feedback voltage is reduced by resistor R2.

Resistors R1 and R2 act as a potential divider, reducing the feedback voltage and allowing the circuit to amplify.

The gain of the circuit, i.e. the amount by which it amplifies, is set by the ratio of R1 and R2 according to the formula:

Gain = (R1 / R2) + 1

Typical values for the resistors might be, for example, 100kΩ for R1 and 10kΩ for R2. This would provide a gain of:

Gain = (100k / 10k) + 1 = 11

This means that if the input signal has a peak voltage of, say, 20mV, the output voltage will have a peak of:

20 x 11 = 220mV

The non-inverting op.amp input has a very high input impedance. In other words, it only requires a very small current. Therefore, amongst many possible applications, it is useful as a microphone amplifier.

DUAL-RAIL SUPPLY

The circuit in Fig. 8.1 is powered by what is known as a *dual-rail* supply. This may seem strange since there are, in fact, *three* supply lines: positive, 0V and negative. The term *dual* means that there are two rails in addition to the 0V rail to which they are referenced.

Virtually all professionally constructed amplifiers use this dual-rail system. The reason is that amplifiers are normally designed for amplifying alternating signals i.e. signals whose voltages swing

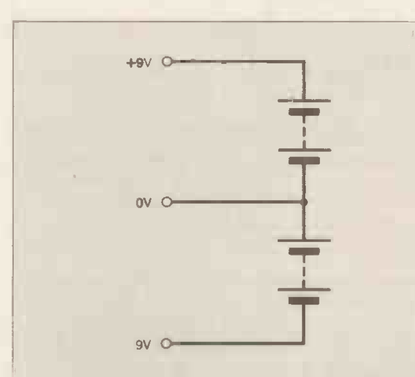


Fig. 8.2. A dual-rail supply formed from two batteries.

between positive and negative with reference to the 0V (ground or earth) line.

An amplifier without a negative supply cannot handle a negative signal. Referencing signals to the 0V (ground) rail also helps to reduce mains hum from being picked up by the circuit when it is powered by a mains driven power supply.

A dual-rail supply can also be produced using two batteries, as shown in Fig. 8.2. Note how the two 9V batteries in series can be regarded as supplying voltages which can be labelled +9V, 0V and −9V. (They could also be labelled as +18V, +9V and 0V, or other similar variants, depending on which terminal is regarded as the 0V reference point.)

Such a supply is rather cumbersome and in practice it is easier to modify the amplifier circuit so that it will operate on a single-rail supply (i.e. a "normal" 0V and positive supply). This is achieved by moving the average value of the alternating signal being amplified up from 0V to half the single supply voltage. (An example of this technique is shown later in Fig. 8.4.)

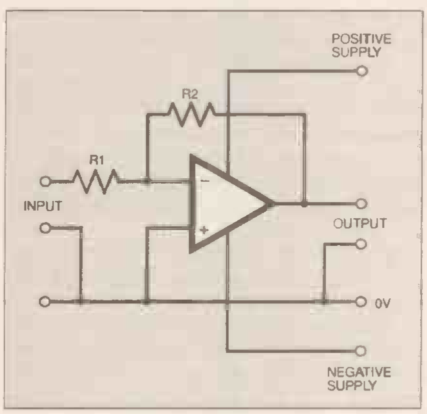


Fig. 8.3. Circuit diagram for an op.amp inverting amplifier.

INVERTING AMPLIFIER

An *inverting* amplifier circuit is shown in Fig. 8.3. It too can be powered by a dual-rail or single-rail supply.

The source signal is fed to the inverting input, making the output signal 180 degrees *out of phase* (i.e. exactly *out* of step) with it. This is sometimes known as "signal inversion". In many audio amplifier circuits, although not all, it is of no consequence.

The gain of the circuit is set by the ratio of the feedback resistor (R2) and the input resistor (R1):

Gain = −(R2 / R1)

Note the minus sign which indicates that a positive-going input signal will produce a negative-going output signal and vice-versa, i.e. 180° out of phase.

Typical resistor values might be, for example, 100kΩ for R2, and 10kΩ for R1. The gain would then be:

Gain = −(100k / 10k) = −10

Thus an alternating input signal with a peak voltage of 50mV would result in an output with a peak of −500mV.

The input impedance of this circuit is the value of resistor R1. This is generally much lower than the input impedance of the non-inverting amplifier.

However, the circuit has a particularly useful property in that the voltage at the inverting input is always "virtually" equal

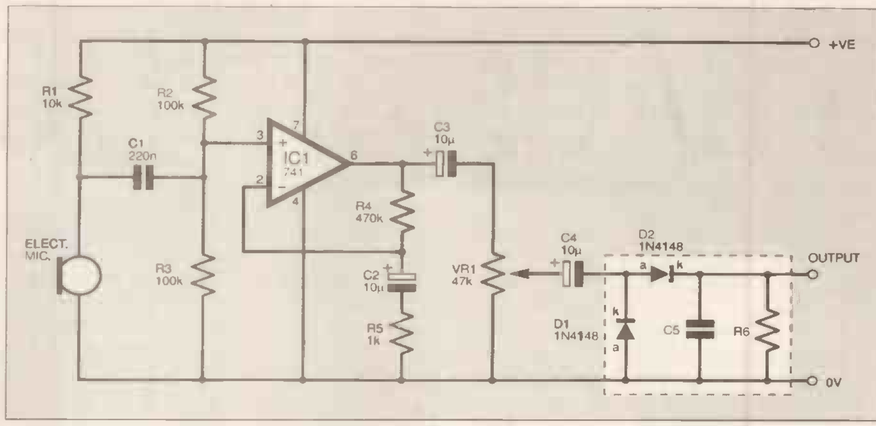


Fig. 8.4. Circuit diagram for the audio input module which produces a d.c. output voltage relative to the input signal amplitude.

to the voltage at the non-inverting input. The inverting input can therefore be regarded as a *virtual earth* – a very valuable asset if the circuit is used as an audio mixer.

Many signals can be directed simultaneously into a virtual earth input without any of the signal sources interfering with each other. In other words, signals can be *mixed* at a virtual earth input, as will be seen shortly.

AUDIO INPUT MODULE

The audio input module shown in Fig. 8.4 is based on the non-inverting amplifier in Fig. 8.1.

The circuit shown is designed to switch its output from low (a bit higher than 0V) to high (a bit lower than the positive supply line voltage) whenever the microphone picks up a sufficiently loud sound.

The module is based around a single op.amp, IC1, and the familiar type 741 works well in this application. The circuit may not be easy to recognise due to the components required to make the i.c. work on a single-rail supply. However, if you imagine the circuit with components R2, R3, C1 and C2 removed, it looks more like the arrangement shown in Fig. 8.1.

The circuit has been designed on the assumption that an *electret* (i.e. capacitive) microphone will be used. Such microphones require a constant d.c. supply, and this is provided via R1. If a *dynamic* microphone is used, R1 should be removed.

Resistors R2 and R3 maintain a steady d.c. supply equal to half the supply voltage at IC1 pin 3, the non-inverting input. In the absence of an input signal, this causes the op.amp's inverting input at pin 2, and its output at pin 6, to be held at the same voltage. Capacitor C1 prevents any flow of d.c. which could upset this voltage, but it allows the a.c. audio signal from the microphone to reach pin 3.

The gain of the circuit is set to about 470 by the ratio of resistors R4 and R5. The formula is as before:

Gain = (R4 / R5) + 1

In practice, the gain may be less than this figure, particularly at higher frequencies, but it is more than adequate in this application.

The d.c. output level normally rests at half the supply voltage (about 6V assuming a 12V supply). The amplified audio signal is superimposed on this d.c. level. Capacitor C3 blocks the passage of d.c. but allows the a.c. signal to flow into potentiometer VR1, which allows its output level to be varied as required. As one end of VR1 is connected to the 0V line, the a.c. signal swings above and below this voltage.

Notice the importance of the three capacitors C1, C2 and C3 in preventing the flow of d.c. voltage at three strategic points in the circuit, and therefore allowing the op.amp to work at an average of half the supply voltage.

If just an amplified version of the input signal is required, then ignore the components shown within the dotted line, and take the output from the wiper of potentiometer VR1.

A.C. TO D.C. CONVERSION

When the components within the dotted box in Fig. 8.4 are included, the varying a.c. signal output from the wiper of VR1 is passed through capacitor C4 and into the diode "pump" comprising diodes D1 and D2, plus capacitor C5. The circuit is a type of rectifier which produces a d.c. output voltage relative to the peak-to-peak voltage across the a.c. waveform.

Ignoring for the moment normal voltage drops across the diodes, it works as follows:

At the wiper of VR1, the a.c. signal swings above and below the 0V level. If C4 and D1 were omitted, with D2 connected to the wiper, the voltage pumped into C5 would be that portion of the signal above 0V. The voltage below 0V would be ignored.

With C4 included, the full a.c. waveform is transferred across it, but the midway level is still the same and so only the voltage above 0V passes through D2.

However, with D1 included as well, when the waveform on the output side of C4 tries to go below 0V, current is "sucked" from the 0V line via D1. Consequently, this side of C4 *never can* go lower than 0V (still ignoring diode voltage drop).

Moreover, next time the waveform output from C4 rises, the rise is now from the minimum level imposed via D1, i.e. from 0V upwards. Since the waveform itself is unchanged, the total voltage between its upper and lower peaks is now pumped through D2 into C5.

In reality, of course, the actual d.c. voltage will be less than the full peak-to-peak voltage due to the forward voltage drop across the diodes.

Capacitor C5 is Included to store the pumped peak voltage and prevent it from simply rising and falling in step with the amplitude of the a.c. signal. Since it is usually desirable to allow the peak voltage to eventually die away, resistor R6 is included through which it can flow.

During loud sounds, a steady voltage builds up on C5, but during a quiet moment current flows through R6 causing the voltage to fall slowly. In other words, and with the correct component values chosen, the voltage on the capacitor represents the average sound level received.

The values of the capacitor and resistor both determine the rate at which the stored voltage decays. The optimum values depend upon the effect required and the current used by the next stage of the circuit. As a rough guide, try a capacitor value of 1μF (positive end connected to D2) and a resistor of 22kΩ.

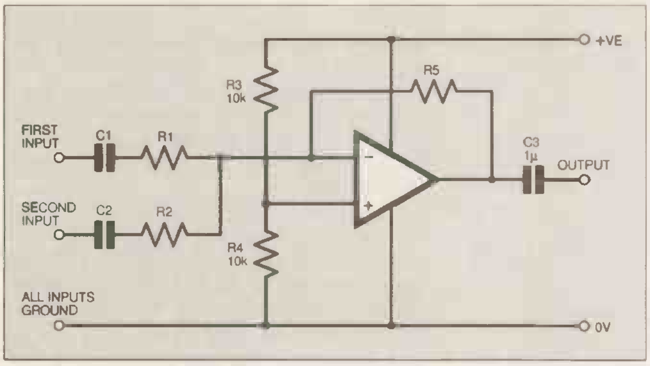


Fig. 8.5. Basic 2-channel op.amp mixer circuit.

MIXER MODULE

There are situations when a circuit requires two or more a.c. signals to be combined into one output channel.

Obviously, the input channels cannot be merely joined together – this would adversely affect their source circuits. Diodes in series with each signal cannot be used either, since the signals are likely to be alternating and one side of their waveform would be lost.

However, by capacitively coupling the signals into a virtual earth input via separate resistance paths, the signals can be *mixed* without affecting their source stages (providing the path resistance values are sufficiently great).

One way of doing this is to use an op.amp in its inverting mode, as illustrated in Fig. 8.5. This circuit is for mixing two a.c. signals, but, by similarly adding further resistors and capacitors in series at the inverting input, more channels can be brought in and mixed.

This circuit also operates on a single-rail supply. The "central" or reference voltage is supplied from the junction of the potential dividing resistors R3 and R4. Capacitors C1 and C2 isolate the a.c. signal from any preceding d.c. voltage. Similarly, C3 allows only a.c. signals to pass from the op.amp's output.

Each of the signals can be amplified individually. The amount of amplification or gain is governed by the ratio of the signal's input resistance value (either R1 or R2 as appropriate) to the value of the feedback resistor, R5. In this instance:

Input 1 gain = $-(R5 / R1)$
Input 2 gain = $-(R5 / R2)$

As commented earlier, the signal inversion (and its minus sign in the formula) can often be ignored.

A greater number of inputs may be used if required, even though only two are shown. In each case, the input resistor value should calculated for the gain required for that input signal path. Quite likely, the gain required will just be *one* (i.e. no amplification), so all input resistors will have the same value as the feedback resistor R5. Suggested values are between about 10kΩ and 100kΩ. A series capacitor is necessary for each input.

Note that when two or more signals are mixed, the total maximum peak voltage at the mixer's output is the instantaneous sum of the amplitudes of each signal. In some cases, this can result in a *reduction* of output amplitude if the signals have opposing phases. In other cases, there can be an *increase* when the signals are fully in phase.

In practice, this means that if many signals are being mixed, it may be necessary to decrease their individual levels to avoid overdriving the op.amp, which would cause output signal distortion.

With an op.amp in an inverting configuration, signal reduction (gain less than one) can be achieved by making the input resistance *greater* than that of the feedback, as can be proved using the above formula. (Note that with a *non-inverting* op.amp configuration, the gain cannot be set for less than one.)

If conversion of the a.c. output from the mixer to a d.c. voltage is required, the components shown within the dotted line in Fig. 8.4 should be added. It would also be wise to increase the output capacitor from 1μF to about 10μF, so increasing the output current transferred. Use an electrolytic with its positive side towards the i.c.

POSITION SENSOR

As shown in Fig. 8.6, using a potentiometer, VR1, a position-to-voltage sensor can be created. The method shown is a very simple idea, but it can be very effective when linked to the l.e.d. VU display processor discussed later.

The two ends of VR1 are connected across the power supply. Consequently, when the pot shaft is turned, there is a voltage change on its wiper relative to the rotation. In other words, the position of

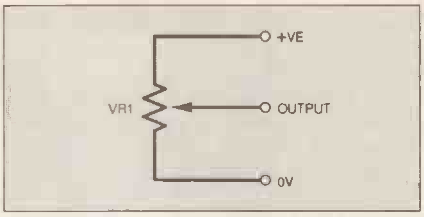


Fig. 8.6. A potentiometer can be used for position-to-voltage sensing.

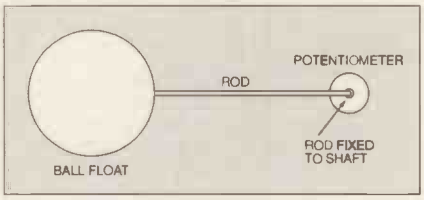


Fig. 8.7. Using a potentiometer to sense water level changes.

the shaft determines the output voltage. The value of VR1 will depend on other circuit aspects, but may typically be between 10kΩ and 100kΩ.

If the output from the wiper is connected to the input of the VU display processor, the movement of the shaft will be displayed on the row of l.e.d.s.

This device can form the basis of, for example, a water level controller. A float may be connected to the shaft, via a rod as shown in Fig. 8.7, so that as the water level changes the pot turns. It will be seen later how a warning device could be added to indicate a dangerously high or low water level.

It may be necessary to "tune" the output voltage to a desired range, and two possible circuits are shown in Fig. 8.8.

The circuit in Fig. 8.8a shows how the output voltage can be restricted to within a limited range set by the presets VR2 and VR3. The circuit in Fig. 8.8b pulls the maximum output voltage down to any required level, determined by the setting of VR2.

The circuits may be combined, and/or the values of the presets may be changed according to the application required.

BARGRAPH DISPLAY

The VU Display Module shown in Fig. 8.9 is based on the LM3914 or LM3915 bargraph i.c.s. These i.c.s switch on their ten outputs in relation to the voltage at the input, pin 5. With the devices wired as shown, if the input voltage is zero, no outputs switch on, but as the input voltage rises, the outputs switch on progressively in ascending order.

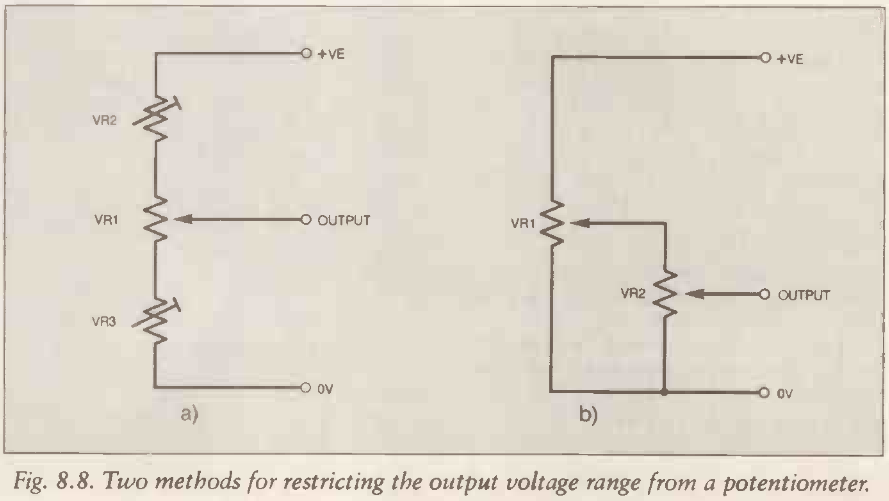


Fig. 8.8. Two methods for restricting the output voltage range from a potentiometer.

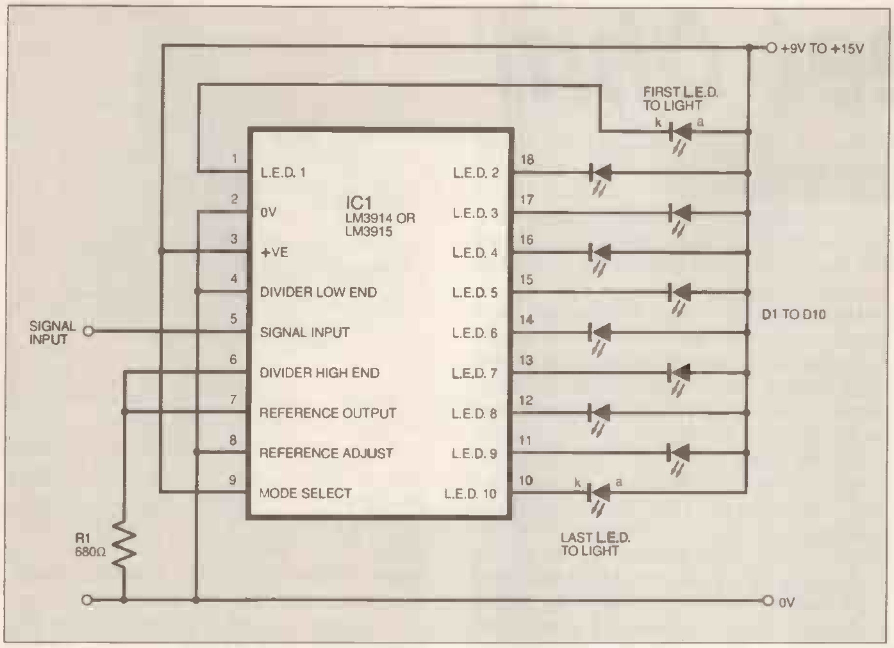


Fig. 8.9. Basic circuit diagram for a bargraph display.

The outputs are shown connected to a set of l.e.d.s for display purposes (e.g. like the sound level display on audio equipment). They can also be used in other ways – for example to trigger a warning device if a particular input voltage level is too high.

Note that the outputs are "active low". In other words, they are normally held high (positive) and switch to 0V when active.

LINEAR OR LOGARITHMIC

The LM3914 device features a linear scale, where each rise of 125mV at the input (pin 5) will cause another l.e.d. to light. Since there are ten outputs, the whole scale is covered by a rise of 1·25V. This assumes the connections are as shown in Fig. 8.9.

Type LM3915 has a logarithmic scale where each l.e.d. represents a 3dB change in input voltage level. This is ideal for monitoring sound levels since the human ear responds to sound in a similar way.

The simple circuit arrangement in Fig. 8.9 applies to both i.c. versions and shows the outputs connected to l.e.d.s. Note the absence of series resistors. This i.c. regulates the l.e.d. current automatically, according to the value of resistor R1.

(More information on these chips was published in the feature "Using Bargraph Displays" in EPE *October '95. Ed.)*

OUTPUT CURRENT

The current flowing from pin 7 through resistor R1 to 0V determines the l.e.d. current, which is about ten times that through R1. Since pin 7 is a voltage reference source and is set to 1·25V, a value of 680Ω for R1 will allow a maximum current of just over 15mA to flow through each l.e.d.

In practice, the current is likely to fluctuate, making the display less bright than expected.

RESISTOR CHAIN

Divider High End pin 6 is connected to the high end of the chain of resistors inside IC1, and pin 4 is at the low end. The voltages at these two pins determine the range of voltage at pin 5 to which the outputs respond.

In Fig. 8.9, the low end (pin 4) is connected to 0V and the high end (pin 6) to the 1·25V reference (pin 7). This sets the input range from 0V to 1·25V.

DOT/BAR MODE

Mode Select pin 9 is shown connected to positive. This causes the display to cascade in bar mode like the display on a tape recorder. The circuit can be changed to dot mode (i.e. only one output active at one time) by disconnecting pin 9 from the positive rail, and leaving it open circuit (i.e. not connected to anything).

OUTPUTS

The outputs are shown connected to single l.e.d.s. Two or three l.e.d.s may be connected in series with each output if required. The output pins can also be connected to other devices – for example transistors, or Darlington pairs, if you wish to drive larger lamps etc.

Remember, though, that the outputs are active low, in other words, when an output switches on, its voltage falls. This is the opposite of many of the outputs that have previously been discussed in this series.

Consequently, if the output pins of these bargraph i.c.s are to drive transistors, *pnp* types must be used (such as BC214L).

PNP SWITCH

PNP transistors have already been encountered in this series. For example, they were used in the Fail-Safe Siren module of Part 2 (Fig. 2.14) and the Motor Direction Control in Part 3 (Fig. 3.13). They work in the opposite way to *npn* types, and are therefore very useful if an output device, such as a buzzer, is to be turned on when the voltage of the controlling signal falls.

A single *pnp* transistor circuit is shown in Fig. 8.10a. Here, if the input is left open circuit (unconnected), or connected to positive, no current will flow through any device connected to the output shown.

If the input voltage is made lower than the positive supply, by about 0·7V or more, the transistor will turn on and current will flow through any output device connected across the arrowed points.

The circuit in Fig. 8.10b is similar except that a second *pnp* transistor (TR2) is used, forming a Darlington pair, so allowing a greater current to be switched. The dotted box indicates that a single *pnp* Darlington transistor could replace the two separate transistors shown.

If two transistors are used, TR1 should be a high gain low power *pnp* type, such as BC214L, and TR2 should be a higher power *pnp* transistor, such as TIP42A.

Alternatively, the single Darlington equivalent could be TIP127. See Part 1 Fig. 1.14 for the pin connections.

In both modules, a diode (D1) is shown connected across the output points to guard against voltage spikes which may be produced by relays, motors and other inductive devices (devices with electrical coils in them). The diode may be omitted if a non-inductive device, such as an l.e.d. (with suitable series resistance) is connected.

EXAMPLE PROJECT

The VU DISPLAY and Alarm unit elsewhere in these pages is the example project which shows how the modules in *Teach-In* Part 8 can be combined in a practical application.

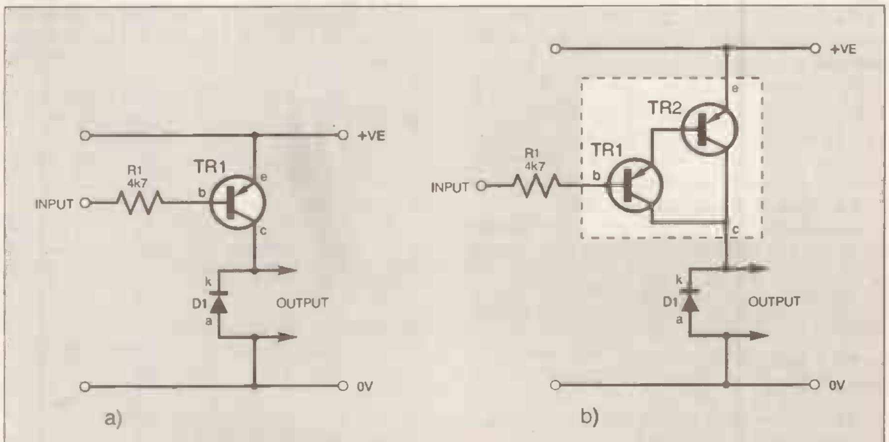


Fig. 8.210. Two examples of a pnp switch: (a) a single transistor and (b) a Darlington transistor.

Ohm Sweet Ohm

Max Fidling

Happy Holiday

Glancing at my 1996 calendar dangling from a nail I'd bashed in over the bench, today was a public holiday, and I'd planned to have the day to myself, rummaging in the shack. I'd hoped to tackle the construction of my newest brainchild, inspired by a magazine project. Unfortunately, some things never go to plan . . .

Being known as the one in the street who potters with electrical gadgets and stuff of a similar ilk, I've gained a reputation for repairing all manner of domestic appliances (or not), from toasters to TV's to washing machines. The trouble is, folks generally expect repairs doing for next to nothing and they want a lifetime's guarantee thrown in as well!

It would be nice, I often reflect, if I could make a decent living at this job like the professionals do. After all, I've got all the kit, including an array of tools and equipment, all carefully colour co-ordinated just as a real engineer's would be. Plus, of course, I've now got my yellow multimeter with the added ability to speak when called upon to pass judgment!

"ZERO VOLTS!" – I had left the talking meter switched on, so I prodded a rubbery button on it to silence the mechanically-voiced instrument. Piddles, my feline friend and general smart Alec, was nearby, munching and noisily clattering his bowl of cat food, which I'd recently refilled in an attempt to keep him occupied and out of my hair. (I failed.)

Calling the Tune

Just as I started to "paw" over the text of the magazine project, my neighbour waltzed in, carrying an ominous-looking bit of kit. Beware of neighbours bearing electrical goods, I always say!

A mains lead dangled from the gadget onto the floor, the plug batting the cat on the head. Piddles looked up temporarily before tucking in again, undeterred.

My neighbour, Albert, had brought in a very old stereo music centre – you know, one of those almighty wooden boxes with a large Perspex lid, containing a record deck, tape cassette and stereo tuner. Apparently the stereo amplifier had failed on one channel, Albert explained.

My eyes rolled upwards as I guessed what was coming next! I sensed a feeling of blackmail coming on – because having indirectly ruined Albert's croquet lawn with my electronic garden mole deterrent, it had taken me a week or two to patch things up and so, diplomatic relations restored, I guess I felt duly obliged to lend a hand.

Sonic the Edgy Mog

Waving Albert away cheerfully whilst expressing my gratitude at being presented with this "ever-so-exciting" challenge, I started to take the vintage stereo apart. Piddles jumped up onto the bench and starting nosing this latest addition.

Out came my multi-coloured screwdriver set, on went the iron and I soldered up my pair of surplus 8 ohm loudspeakers to the DIN sockets on the back of the cabinet. I plugged the lot into the mains and switched on, expectantly.

BZZZT! SSSHHHST!! A cacophony exploded from one speaker. Well, one channel worked anyway! Taken aback, the cat leapt off the worktop and hid behind my pile of washing machine spares.

The unforgettable smell of burning soon started to fill the workshop, though, followed by a *"Phut!"* as I switched off just in time to witness a plume of blue smoke curling out from the innards of the stereo.

A few twirls of the screwdriver revealed that a resistor on the main board had become CBB (Charred Beyond Belief), and even an attempt by the talking multimeter to establish its value failed dismally. "ZERO OHMS!" it burbled, when prompted. *Marvellous*, I muttered.

I spotted a similar-looking resistor on the other half of the amplifier board, and guessing that the two channels were the same I de-coked the p.c.b. and stuffed in a new component. A quick re-test confirmed my worst fears – one channel was still struck dumb! The new resistor started to smoulder ominously. I could feel a replacement output transistor coming on!

Fast Food

The moggie jumped up again and peered at the smoking stereo whilst I rummaged through my rusty tin of surplus semiconductors. *Please let me have an AD162*, I prayed. No joy . . .

Ah, well, whilst putting my feet up and checking through my transistor equivalents book, I placed a few cat food treats on the whirring record deck and amused myself by watching Piddles trying to snaffle them whilst doing 33 r.p.m. What a way to spend a holiday!

SHOP TALK

with David Barrington

PulStar

Not too may problems should be encountered by the Radio Control enthusiast who wishes to build the *PulStar* project to aid with the setting up and alignment of their models. The 16-character by 2-line display module type LM016L is currently being sold at the bargain price of £6 by **Greenweld Electronics** (*Tel: 01703 236363*).

A ready-programmed PIC 16C54 microcontroller is obtainable (Mail Order ONLY) from the designer, Phil Green, for the sum of £12 including postage. Overseas readers should add £2 to the order. All orders should be sent to: **Phil Green, 6 Yews Close, Worall, Sheffield, S30 3BB.**

The 3-terminal 4MHz resonator should be generally available from our advertisers. The one in the prototype came from **HB Electronics** (*Tel: 01204 525544*). Servo leads should be carried by model shops, Magenta Electronics and Maplin.

For those wishing to do their own programming, the software is obtainable on a 3.5in. disk from the Editorial Offices (see page 421) for the sum of £2.50 (overseas – surface £3.10; airmail £4.10).

Sarah's Light

Special care needs to be taken with respect to components for *Sarah's Light* to ensure the child safety aspect of the project. Illuminating switches/lamps with caps which cannot be prised off may be hard to find.

The ones in the model are RS type illuminating actuators, which also take the microswitches, and can be ordered through **Electromail** (*Tel: 01536 204555*), codes 335-075 and 335-069 for pushbutton actuator and 159-4534 for the microswitches.

The power MOSFET BUZ10 came from **Maplin**, code UJ32K. Not everyone stocks the 4526 4-bit programmable binary downcounter, but **Farnell** (*Tel: 0113 263 6311*), code CD4526BCN, and Electromail, code 641-083, do.

A trip down to your local car breakers yard should unearth the Fiat Uno number plate lamps and should set you back about £2 to £5 each.

Home Telephone Link

Just a couple of items need highlighting for the *Home Telephone Link* project. The elecret microphone insert is the omnidirectional type and stocked by most of our component advertisers.

The specified case, with transparent lid, and 38mm dia. "Lo-Z" loudspeakers came from **Maplin**, codes YU94C and W04E respectively. Strangely, you will not find any entry for the miniature speaker range in their current catalogue. However, we can confirm that these items are still in stock.

The lever-operated microswitch also came from the same source, code GW67X. If another microswitch is used, it is important to check for the pole contact as this *must* go to the "Line B" track on the p.c.b.

VU Meter and Alarm (Teach-In '96)

We do not expect any buying problems to arise with the *VU Meter and Alarm*, this month's *Teach-In* project.

When ordering the bargraph driver i.c., be sure to specify the "log." type LM3915. The case, with a screw-down transparent lid, came from **Electromail**, (*Tel: 01536 205444*), code 507-674.

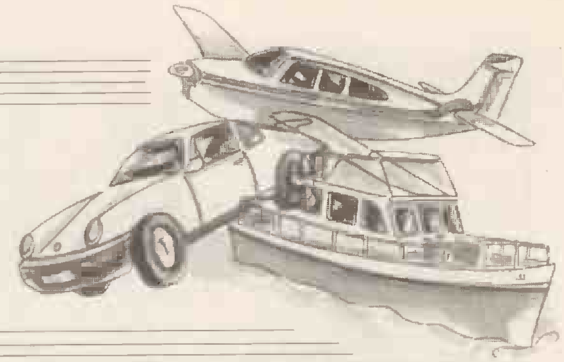
Ultra-Fast Frequency Generator and Counter

The latest 74AC advanced CMOS logic range of i.c.s used in the *Ultra-Fast Frequency Generator and Counter* are stocked by **Farnell** (*Tel: 0113 263 6311*) and **Electromail** (*Tel: 01536 204555*). They also list the 4543 l.c.d. driver (codes F-386-390 and E-641-207) and the 8-bit l.c.d. display (codes F-491-287 and E-589-294. *The LS and standard TTL versions are NOT useable in this circuit.*

For the MF10 active filter we came up with **Maplin**, code QY35Q. They also stock the 4½ digit counter/driver, code FP62S.

Details and prices for all of this month's p.c.b.s can be found on page 483.

Constructional Project



PULSTAR

PHIL GREEN

Servo motor pulse width alignment without tears!

SPECIFICATIONS

Microcontroller operation
Alphanumeric display
Pushbutton setting

Triple mode:
- GEN – generate (servo test)
- READ – measure Receiver output
- SWEEP – end-to-end travel

Channel pulse range 0·01ms to 2·55ms.
Frame rate range: 1ms to 255ms

Resolution:
- Channel 0·01ms
- Frame 1ms

Error detection:
- Channel > 2·55ms
- Frame > 255ms

Consumption 5mA typical from Receiver battery.

Anyone who has built a Radio-Control system will appreciate how much time and effort goes into setting up and alignment. Sheer determination keeps the R-C constructor going long enough to see the gear make its maiden flight!

Most critical are the radio frequency (r.f.) stages – a poorly aligned receiver could be pretty dangerous in a fast aircraft, and a splattering transmitter down at the local flying club might well result in several splattered models!

The digital timing section of a transmitter is less critical, but to ensure the system is compatible with other outfits, channel pulses have to be precisely set for Neutral and Throw.

Servos are also making appearances outside the modelling world, in robotics and animation projects, especially since they are so easy to interface. A simple insect-style robot, for example, might use six servos and, for each channel, pulses generated by the controlling program need tuning to give precise positioning.

SERVO ACCURACY

Channel pulse setting normally involves borrowing a "standard" servo, which was hopefully set up to a nominal spec at the factory. Each transmitter channel is tweaked to give Neutral on the standard servo, and this then becomes the standard channel setting for Neutral. Other servos can then be centralised, using just one channel to avoid compounded errors.

Once this tedious operation is complete, the system works, but the precise channel timings are still unknown. If no standard servo is available, the operation becomes even more hit and miss.

If only this finicky alignment could be done "off-line" . . . Well, it can, read on!

PIC CONTROL

Enter PulStar, which is a precision channel measuring device and pulse generator, built around one of the new generation of embedded controllers, the PIC16C54 microcontroller, with which many *EPE* readers will now be familiar. Being crystal or resonator controlled, this "computer-on-a-chip" provides spot-on timing, without any calibration.

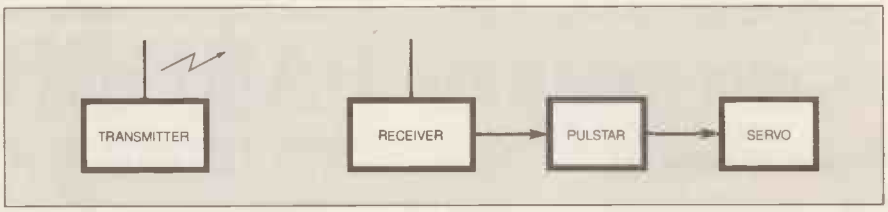
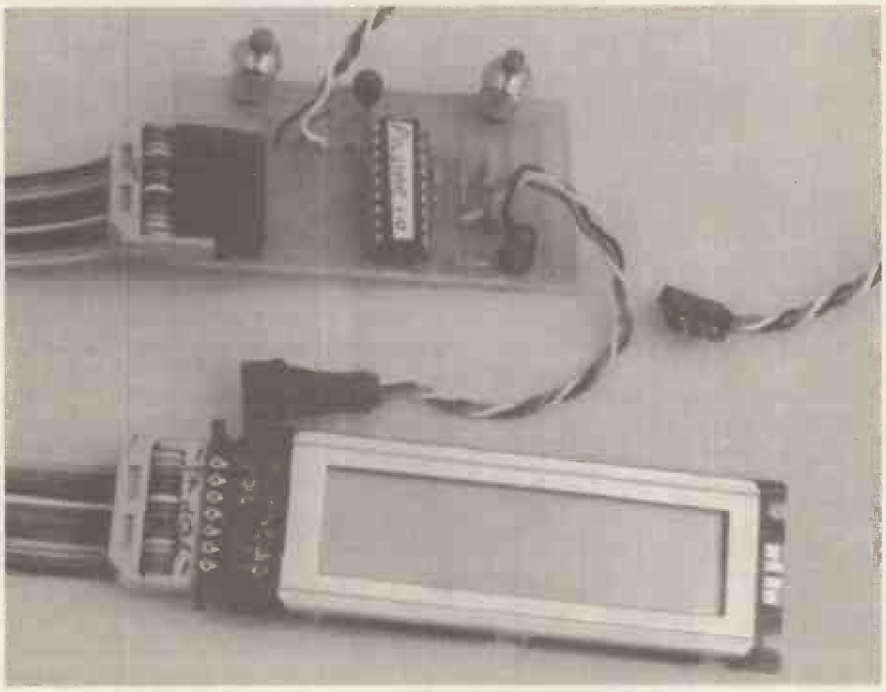


Fig. 1. Block diagram showing how PulStar fits into an R-C system.



PulStar basically consists of a simple printed circuit board and an "intelligent" display module.

Using a microcontroller means that rather than using lots of integrated circuits (i.c.s), we can do all the clever stuff in software, whilst keeping the hardware design down to just the one chip. Construction is therefore very simple (it's the software designer who does all the work!).

PulStar cannot help with setting up the r.f. section of an outfit (kit manufacturers often provide an alignment service), but it has proven to be invaluable when setting up mixers, speed-controllers, switches, and recalibrating old servos which were set to some non-standard pulse width.

Software details are given at the end of the article.

The block diagram in Fig. 1 shows how PulStar fits into the system.

CIRCUIT DIAGRAM

As can be seen from the photograph and the circuit diagram in Fig. 2, there is not much to PulStar, just the microcontroller

IC1, the display X2 and a few additional components.

The display is a 16-character by 2-line liquid crystal display (l.c.d.) which has some intelligence in itself. This simplifies the software in that it is not necessary to worry about which dots form the letter "A", for example. Thankfully, we just send the code for each character and let the display electronics do the rest.

The integral l.c.d. controller can operate by transferring eight bits at a time (i.e. a full ASCII character) or in 4-bit mode, whereby two transfers are needed to send a character. The 4-bit mode is slower, but has the advantage of using fewer interface connections.

In addition to the four or eight data lines, a few control lines are necessary: Line "E" strobes data into the display, and "R/S" selects whether the data is a character for display, or a command, such as "blink", for example.

Line "R/W" normally selects Read or Write to the display. In this application, though, it is not necessary to read from the display, and so the line is held at 0V.

One further control line is Contrast on pin 3 (V_0). Grounding this pin gives good readability in average lighting. (If readers want to experiment with varying the contrast voltage, this pin could be taken to the wiper of a potentiometer connected across the 5V power lines.)

Intelligent liquid crystal displays were once very expensive. However, mass-production now means that they can be bought quite cheaply from many outlets. Second-hand ones are also available from some surplus dealers (see *Shoptalk*). Amateur radio rallies are also a likely source. Two display lines are necessary, but 16, 20, 32 or 40 character types should work equally well, in a larger case.

CONTROLLER COMPONENTS

The microcontroller is IC1 and it operates at a basic clock speed of 4MHz, as set by the ceramic resonator X1.

For this application, the use a ceramic resonator instead of a crystal seemed acceptable. They are more durable, cheaper, and include damping capacitors. (*In some other designs, though, they may be less satisfactory than crystals since their frequency can drift with temperature. Ed.*)

If a 4MHz crystal is already available in the junk-box, by all means use it in place of the resonator, but also add a 33pF polystyrene capacitor between each of its leads (on IC1 pins 15 and 16) and ground (0V).

Signals from the receiver are brought into IC1 pin 2 (RA3) via plug PL1. Signals are output to the servo from IC1 pin 13 (RB7) via socket SK1. These connectors also supply power (5V) from the receiver to the circuit and to the servo.

Switches S1 and S2 are used to tell the microcontroller which mode it is to assume, Read or Generate.

Light emitting diode D1 indicates if the microcontroller thinks it has received an incorrect code from the receiver.

CONSTRUCTION

Details of the printed circuit board (p.c.b.) are shown in Fig. 3. This board is available from the *EPE PCB Service*, code 998.

RADIO CONTROL PRIMER

The very first radio control systems had a single pushbutton control, and used the presence or absence of a carrier wave to operate a clockwork actuator inside the model. Each press of the transmitter button gave only sequential left-right-left-right control, although many ingenious schemes evolved to give more complex functions, and experimentation was the order of the day.

In the first true multi-channel radio control systems, the carrier was amplitude modulated by an individual audio tone for each channel. As a result, a 10-channel transmitter, for example, behaved something like a 10-note piano keyboard. The receiver had either tuned filters, or more often a reed bank, like miniature tuning forks, each of which vibrated in sympathy with a particular tone.

This would be detected, amplified, and used to drive a motorised servo mechanism, which in turn moved the control surfaces of the model. This type of control was nicknamed "bang-bang" since each servo switched between extremes of movement – all or nothing, rather like driving a car with a foot hard on the accelerator, using the ignition switch to control the speed! For many years however, these systems were extremely successful.

PROPORTIONAL CONTROL

Little has changed in the field of digital proportional radio control since its arrival in the sixties, although it is now described more appropriately as Pulse Position Modulation (PPM). The term "digital" also now applies more realistically to modern Pulse Code Modulation (PCM) systems which make extensive use of microcontrollers such as the PIC.

In either case, PPM or PCM, the output from the receiver takes the form of a 3-wire connection for each servo, two carrying power (usually from a 4·8V Nicad battery) and one for the channel signal. Movement of a transmitter joystick controls the width of the corresponding receiver pulse, which is repeated about 50 times per second, i.e. a 20-millisecond frame rate.

One extreme of motion equates to a pulse width of 1·00ms, the other extreme to 2·00ms, with a smooth variation throughout the range, and neutral at 1·50ms. The period between pulses (about 8ms to 16ms) is used to synchronise the receiver to ensure that each output relates to the correct joystick.

Proportional control gave many advantages, including "trimming" an aircraft in flight, something which was impossible using "bang-bang" techniques.

Each proportional servo contains a monostable multivibrator or timer, the period of which is governed by the current position of the servo. This monostable is triggered by the arrival of a new pulse from the receiver, and the difference between the receiver pulse width and that of the monostable is used to drive the servo to correct the difference. The result is that the servo smoothly follows the position of the transmitter control.

MULTI-CHANNEL

Two-channel sets are common in buggies and model boats. These use Amplitude Modulation (AM) of a 27MHz or 40MHz carrier wave. For model aircraft using ailerons (roll), elevators (pitch), rudder (yaw), throttle, and optionally retracting undercarriage and flaps – four or six channels are common on the 35MHz band using Frequency Modulation (FM). The difference in the two signal patterns is shown in Fig. 6.

Regardless of the system or frequency, however, generally speaking, a servo is a servo is a servo.

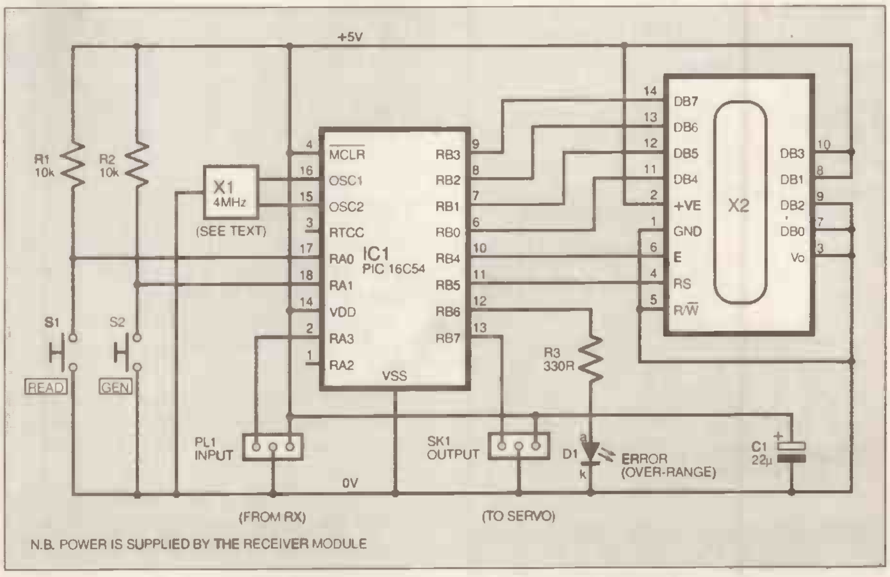


Fig. 2. Complete circuit diagram for PulStar.

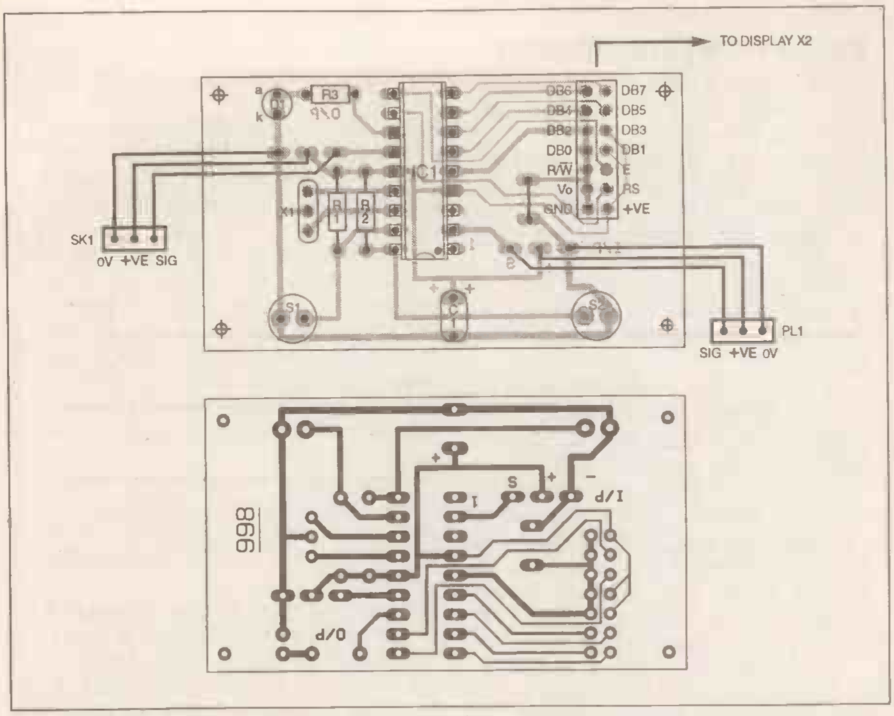


Fig. 3. Printed circuit board component layout and full size copper foil master track pattern for PulStar.

Using the printed circuit board makes the job simpler and neater, although Veroboard is equally suitable and was used for preliminary trials. The recommended p.c.b. has one short strap (on-board link wire), fit this first.

A d.i.l. (dual-in-line) socket must be used for IC1 as it can be damaged by static electricity, reverse polarity, or excess heat, any of which could, at the very least cause loss or corruption of the software programmed into it.

Switches S1 and S2 can be wired or mounted directly on the board, in which case they will also provide mechanical support. Watch the polarity of the Tantalum bead capacitor (C1), the display connector and the l.e.d. D1. Double check the correctness of the wiring to connectors PL1 and SK1 since errors could be expensive!

Be especially careful when connecting the display. Ribbon cable and IDC connectors were used for the display connections in the prototype. These make a robust, if bulky job.

Alternatively, thin, flexible hook-up wire (servo wire is ideal), could be soldered into the p.c.b. Connectors, though, certainly ease fault-finding and are a boon when testing second-hand displays. The display pinout details are shown in Fig. 4.

Do not connect the display or the servo to the p.c.b., until preliminary testing has been done.

The prototype was not mounted in box but used in its "naked" state. However, if it is preferred to house the completed board and display in a suitable case, ensure that nothing can short-circuit.

If the switches are not mounted on the p.c.b. but are wired back to it, fit them into the case beneath the display so that the READ and GEN legends which it generates at switch-on (see Fig. 5a) apply correctly.

COMPONENTS

Resistors
R1, R2 10k (2 off)
R3 330Ω
All 1/8W 5% carbon film, or better

See **SHOP TALK** Page

Capacitor
C1 22µ tantalum bead, 10V

Semiconductors
D1 red l.e.d.
IC1 PIC16C54 microcontroller (pre-programmed, see text)

Miscellaneous
S1, S2 min. push-to-make switch (2 off)
X1 3-terminal 4MHz ceramic resonator (see text)
X2 16-character x 2-line l.c.d. module

Printed circuit board, available from the *EPE PCB Service*, code 998; 18-pin d.i.l. socket; 3-way socket and plug suitable for R-C receiver and servo coupling; 14-way IDC socket (optional) (2 off); 14-way IDC connector, p.c.b. mounting (optional) (2 off); 14-way ribbon cable; 3-way stranded cable; solder, etc.

Approx Cost Guidance Only £25

TESTING

For the preliminary tests, first plug the input lead (PL1) into a suitable +5V power source or your R-C receiver.

Switch on, and check that the l.e.d. flashes once. This proves that the controller in running.

Any problems at this stage will be down to poor soldering – most likely around the display connector or on tracks between the chip leads.

Switch off, plug in the display, and switch on. Check that the sign-on message "PulStar" appears. If all is well, congratulations! You have a very useful addition to your toolkit!

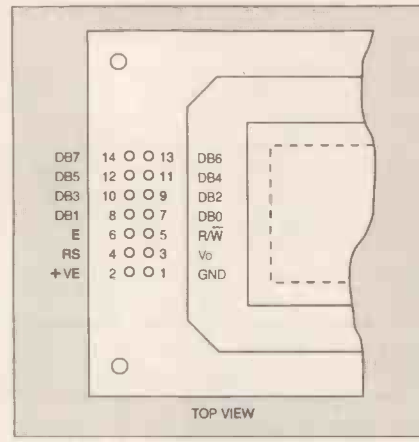


Fig. 4. Pinouts for the l.c.d. module.

USING PULSTAR

To use PulStar in a real situation, plug PL1 into your receiver just as you would a servo, and connect the servo to socket SK1.

On switching on, you will see a prompt to select which operating mode is required, with READ and GENerate legends above the two switches, as in Fig. 5a. Press READ (S1) and the display changes to show the current pulse width and frame rate. If no signal is being sent by the transmitter, the display in Fig. 5b will be seen. When a transmitter signal is being received, the display will be similar to that in Fig. 5c.

Switch off, pause to let the power supply line voltage drop back to 0V, and then switch on again. This resets the program back to the Mode Select option. Press GEN (S2) and PulStar will begin sending a continuous stream of pulses to the servo. The display will show the current pulse width, with the legends UP and DOWN above the two switches (Fig. 5d).

On start-up, the pulse width is set to 1·5 milliseconds, which is a common standard

DISPLAY SCREENS

At switch-on:

a)
```
PulStar*       v1.0
READ    <mode>     GEN
```

Read mode, awaiting signal:

b)
```
? ms pulse
? ms frame
```

Read mode, typical signal:

c)
```
1.73 ms pulse
018 ms frame
```

Generate mode:

d)
```
1.50 ms pulse
DOWN    SWEEP    UP
```

Generate mode: (sweep)

e)
```
Generate: SWEEP
```

Error condition: (also l.e.d. flashes)

f)
```
Over-range !
```

Fig. 5. The six basic screen display modes

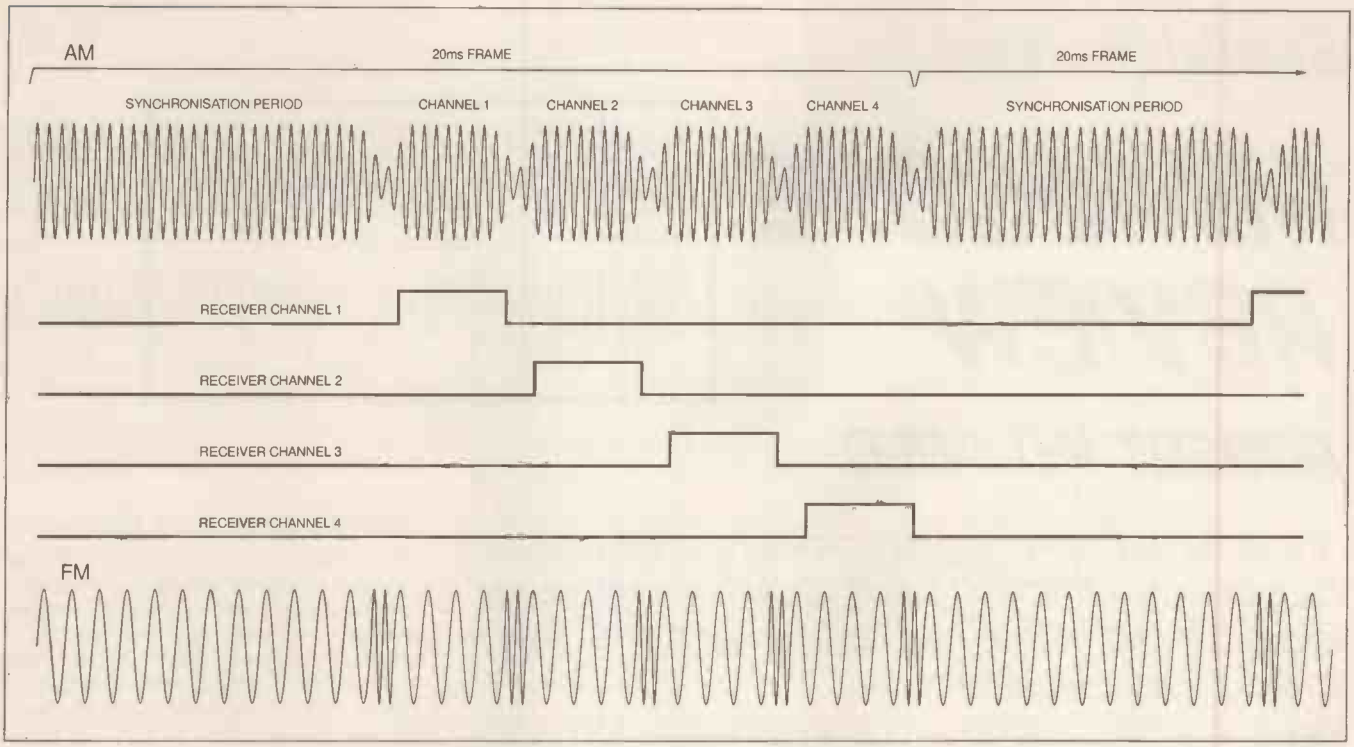


Fig. 6. Comparative waveforms generated by AM and FM systems to control four receiver channels.

for the Neutral position. Pressing UP will increase the pulse width steadily towards a maximum of 2·55ms, whilst pressing DOWN will narrow the pulse towards 0·01ms. Note that these values are extremes, beyond the ranges normally used by model servos, which have a useful range of about 0·8ms to 2·2ms maximum. If a servo is connected to the output lead, its shaft position will follow the internal pulse generator.

Between the UP and DOWN legends is the option SWEEP, activated by pressing both buttons together, resulting in the display shown in Fig. 5e. This function will sweep the servo side to side from its current position (use UP and DOWN to select neutral first).

The idea is that by connecting two servos via a "Y" lead, transit times can be compared. In a set of four servos, one will be slowest and can be used for throttle; and the fastest used for a more critical function such as ailerons.

(Note that data pin RB7 of the PIC16C54 (the pin which supplies current to the servo) can sink a maximum of 25mA, and source a maximum of 20mA. These maximum currents must not be exceeded.)

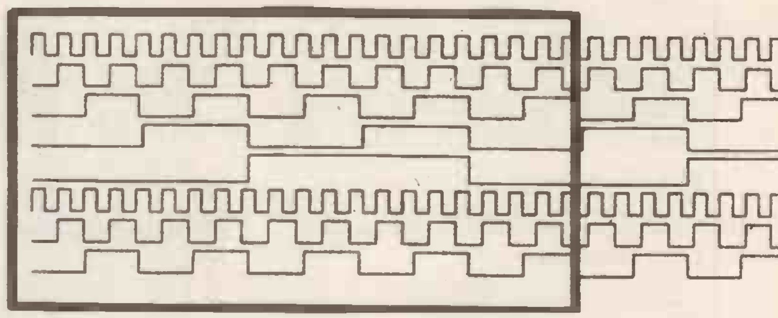
If pulses having a width outside that catered for are received, the error condition signal shown in Fig. 5f will appear.

SOFTWARE

For readers who wish to program their own PIC16C54, the software for PulStar is available on 3.5in disk for £2.50 from the Editorial office. Pre-programmed PIC16C54 chips are available from the author. For more details see *Shoptalk* page.

Special Review

MINISCOPE REVIEW



ROBERT PENFOLD

Tests show that the Miniscope l.c.d. oscilloscope/logic analyser has much to recommend it to the home user.

WHEN I first became interested in electronics, which I suppose was about 30 or so years ago, the average oscilloscope was pretty huge. In fact most oscilloscopes actually weighed so much that the average table or bench could not be relied upon to carry one! Instead, they were mounted on custom made trolleys that were usually of heavy steel construction.

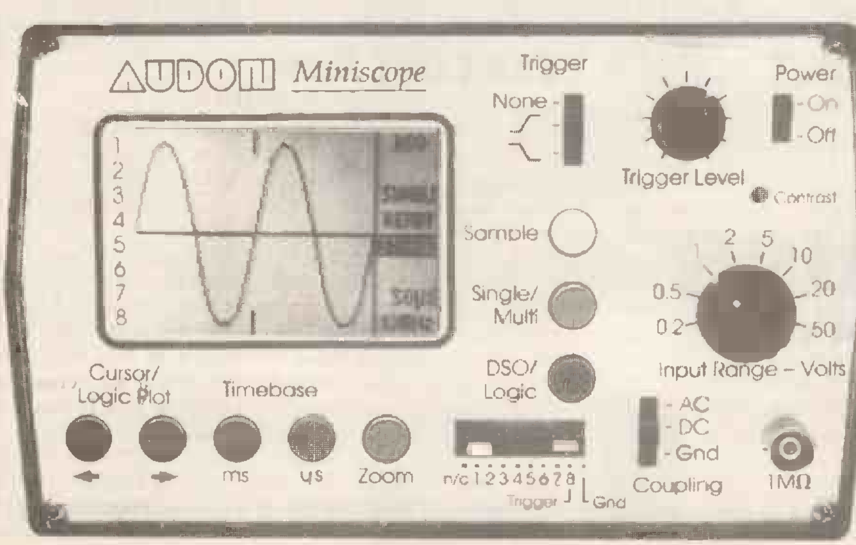
Scope for Improvement

Technology has moved on, and oscilloscopes no longer strain the floorboards. In fact truly portable oscilloscopes have been available for some years now. The original units were based on miniature cathode ray tubes (c.r.t.s), but many of the more recent portable oscilloscopes have been based on liquid crystal displays (l.c.d.s). The low power consumption and small size of a liquid crystal display makes it the obvious choice for a portable oscilloscope.

The unit reviewed here is the *Miniscope MS10* l.c.d. digital storage oscilloscope from Audon Electronics. In fact this is a two-in-one instrument that can act as a portable storage oscilloscope or eight channel logic analyser. It will be of interest to many *EPE* readers as it is designed specifically for electronics hobbyists. It is relatively simple and straightforward to use, and costs just £199-00 plus V.A.T.

The *Miniscope* is genuinely portable, with approximate dimensions of 198mm × 178mm × 108mm, and without the batteries installed it weighs in at just 0·5kg. It can be powered from six "C" size batteries, or from an optional mains adaptor. The mains adaptor is the best choice unless the complete portability of battery operation is essential, since using batteries is likely to be quite expensive in the long term.

The screen is quite small, with an active area that measures approximately 57mm × 39mm. Its resolution is 64 × 128 pixels, which gives far less resolution than a conventional c.r.t. oscilloscope screen, but it is substantially better than simple l.e.d. oscilloscopes. The right hand 25 per cent of the screen is used to display information such as the sweep speed and the mode in use, which somewhat reduces the effective size and resolution of the screen.



However, in use the screen seems to show plenty of detail, and it will accurately display overshoot and "ringing" on squarewaves and the shape of complex speech waveforms, etc. The contrast is relatively low unless you view the screen from almost directly in front of it, but this seems to be a problem with all liquid crystal displays.

In-Store

If we consider the *Miniscope* in its storage 'scope guise first, it has switchable a.c./d.c. coupling, and can sample at up to 10MHz. It has to be borne in mind here, that a sampling rate of 10MHz does not mean that it has a bandwidth of 10MHz. In order to obtain a reasonably accurate display it is necessary to have a sampling rate at least two to three times higher than the maximum input frequency.

Clearly, the sampling rate easily accommodates audio waveforms, which is likely to be the main area of application for a unit such as this. The *Miniscope* can just about handle a PAL composite video signal.

The sweep time is variable from 200ms to 10μs in the usual 1 – 2 – 5 – 10 sequence. Two pushbuttons are used to increment and decrement the sweep time, and the selected time is displayed on the screen, together with the sampling rate.

The latter is 10MHz for sweeps of 2ms or less, or 100kHz for sweeps of more than 2ms. The sweep time is the time for a complete sweep, incidentally, and not the time per cursor division. In fact there is no screen grid of any kind, just a line across the screen which indicates the 0V axis.

At most sweep speeds the unit takes in many more samples than the screen can display properly. The extra samples can be fully utilized by zooming in and displaying a selected section of the waveform.

Two pushbuttons permit a cursor to be positioned beneath the desired section of the waveform, and the Zoom button is then repeatedly pressed to cycle through the available zoom levels. This system works quite well, and at most sweep speeds effectively gives greatly boosted screen resolution.

Finger on the Trigger

The *Miniscope* can operate in single-shot mode or a form of free-running operation. In the free-running mode the repetition rate seems to be rather slow in comparison to a conventional oscilloscope.

Specifications

DSO

10 Mega-samples per second
0·2V-50V input range ±5%
200ms-10μs timebase ±0·1%
1MHz bandwidth (−3dB)
6 bit ADC resolution
1 Meg Ohm input impedance

Logic Analyser

10 Mega-samples per second
8 Channel inputs
5V TTL and 4·5-15V CMOS

General

64 × 128 pixel L.C.D. screen
Dimensions 198mm × 178mm × 108mm
Weight approx 0·5Kgs (excl. batteries)
Power Supply innteranl 6 × C batteries
Power supply external 7V-15V @ 300mA via 3·5mm jack

Triggering can be either Positive or Negative, or None. The latter provides arbitrary sampling in the free-running mode.

In the single-shot mode it results in a sample being taken when the Sample button is pressed. One disappointing omission is a lack of any facility for external triggering. A trigger level control enables the trigger point to be set when using positive or negative triggering.

There are eight switched sensitivities from ±0·2 volts to ±50 volts, again with the usual 1 – 2 – 5 – 10 sequence. The maximum sensitivity may seem rather low, but the quoted figures are those needed to provide a full height display, not the normal volts-per-scale division. The maximum sensitivity is still lower than that of most other oscilloscopes, but it is sufficient for the majority of applications.

Logic Analyser

The logic analyser has eight channels, and it can handle normal 5V TTL levels, or CMOS levels with a supply in the range 4·5V to 15V. Sample rates and sweep times are the same as those in the oscilloscope mode. The 10MHz sampling rate is a bit limiting, since the displayed waveforms will only have accurate timing if the sampling rate is much higher than the maximum input frequency.

A 10MHz sampling rate gives good results with input frequencies of up to about 1MHz or so, and with pulses of around 1μs or less, but with higher frequencies or shorter pulse durations the accuracy soon starts to fall away.

The logic analyser is clearly unsuitable for use with high speed TTL circuits, but it is usable with most circuits based on 4000 series CMOS chips, or TTL circuits operating at a few megahertz or less.

In the logic analyser mode, only single sweep operation is available. This is presumably a deliberate omission, since repetitive triggering would serve no obvious purpose in a logic context. With the trigger switch set to the None position the unit is triggered by pressing the Sample button.

With positive or negative triggering selected, the sweep commences when the appropriate type of transition is detected on the Channel 8 input. However, trigger pulses are ignored until the unit has been "cocked" by pressing the Sample button. This avoids unwanted multiple triggering of the unit.

As in the storage oscilloscope mode, at most sweep speeds the unit takes samples at a rate which is higher than the minimum needed to produce the display. At most sweep speeds this over-sampling enables the display to be "zoomed" to expand a selected section.

It is also possible to select a "scroll" mode when the unit is used as a logic analyser. The screen can then be scrolled sideways to effectively extend the display to the left. This is a useful feature, but it only works on a few sweep speeds, and the amount of scroll available is quite limited.

General

The *Miniscope* is supplied with a rather basic 16-page A4 manual. This is very brief and to the point, but it tells you everything you need to know in order to access all the available facilities. It does not provide a general introduction to oscilloscopes and their uses, so you will need a book or two on the subject if your knowledge of oscilloscopes is a bit sketchy.

The standard of construction is not equal to that of high quality professional equipment, but it is still quite well made and it looks quite tough. It should stand up to many years of use by an enthusiastic electronics hobbyist.

A standard BNC oscilloscope test lead is supplied with the unit, and this is terminated with a pair of crocodile clips. A "professional" probe lead having an ×1/×10 facility is available as an optional extra, but the standard lead is perfectly adequate for most purposes. The unit is also supplied with a short 9-way test lead for the logic analyser port. This is terminated with miniature probe clips.

Summary

First and foremost the *Miniscope* is a digital storage oscilloscope. The logic analyser is something of an afterthought, but it is certainly an extremely useful storage oscilloscope and logic analyser at a bargain price. It was not designed as such, and is not put forward by the manufacturers in this guise. It is designed specifically for the home user, with a price and specification that should appeal to many in this target group.

The *Miniscope* has definite limitations. The screen size and resolution is limited but adequate, as is its bandwidth. The lack of a graticule plus the limited screen size make it impossible to measure time, frequency, or voltage very accurately. It also lacks a dual trace facility, and is not at its best when used with constantly changing waveforms in the free-running mode.

For most potential users these factors will be easily outweighed by its small size and relatively low cost. This unit is well suited to "kitchen table" project construction, which is not really true of conventional oscilloscopes, even the modern ones.

The *Miniscope* is also very simple and straightforward to use, which is another plus point for the home user. It is very different to any oscilloscope that I have used before, but I soon became accustomed to using it.

Last, and by no means least, this is a proper storage oscilloscope, which will catch fleeting one-off waveforms, and display them in a clear and unambiguous fashion. The test period was something less than extensive, but the *Miniscope* always performed flawlessly each time that I used it.

Conclusion

The *Miniscope* is a very impressive instrument which can certainly be recommended, particularly to those who are interested in audio and (or) low to medium frequency logic circuits.

Its £199.00 price tag is boosted to £247.92 when the optional mains adaptor (£6.00), postage (£6.00), and V.A.T. have been added, but it still represents very good value for money at this price. For experienced constructors a kit version is available at £169.00 plus V.A.T., but this version was not reviewed.

For further details contact: Audon Electronics, 36 Attenborough Lane, Chilwell, Nottingham, NG9 5JW. Phone/Fax 0115 925 9737. □

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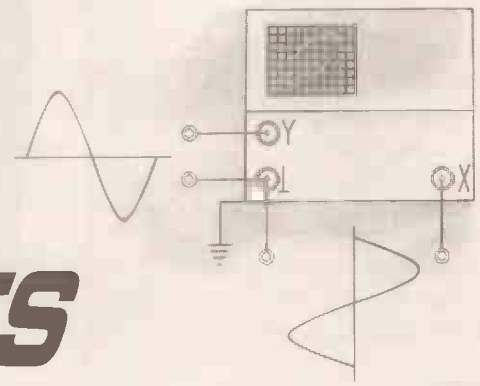
MORE SCOPE FOR GOOD MEASUREMENTS



ROY BEBBINGTON

Part 1

Using an oscilloscope to examine an electronic circuit is like having a blindfold removed – you can really see what is happening, if you know how to look properly.

EVERY picture tells a story, and the more detailed the picture, the better the story. Generally, we all think in pictures, and this also applies when we measure physical or electrical signals. For example, we observe the analogue indication of the hands of a watch, or a pointer on a meter.

Electrical quantities, voltage, current or resistance, can be measured by using the heating and magnetic effects of an electric current to indicate their strength by deflecting a pointer over a meter scale. Although such meters are in common use, the visual indication of the pointer may tell only half the story (0·707 of peak for sinewaves!), and one that is not entirely true. For instance:

- reading errors occur if the meter takes power from the circuit under test
- problems arise when the quantities on test vary with time, especially at speed
- mechanical pointers are easily damaged by an overload signal and, moreover, give no mental image of its actual waveshape

The need to visualise waveforms pictorially is evident by the numerous graphs that are drawn to illustrate electrical signals. Fortunately, the oscilloscope (scope) can provide an automatic trace of that picture for us!

With a scope we can check the history of a signal and observe the shape of things to come if we leave it to "baby-sit" the circuit of interest. Whereas a voltmeter generally shows root-mean-square (r.m.s.) values and is restricted to one signal, an oscilloscope shows the signal variations with time – peaks, troughs, transients, distortion, warts and all! And, for good measure, it usually compares two or more signals at the same time.

Unlike the voltmeter pointer or display, the cathode ray oscilloscope (c.r.o.) employs an almost weightless beam of electrons that can easily follow a rapidly varying analogue signal and display it in graphical form – in short, a voltmeter with pictures!

SCOPES AVAILABLE

Analogue scopes are widely used to troubleshoot and calibrate all manner of repetitive signals, and cathode ray tubes (c.r.t.s) with long-persistence phosphors enable viewing times to be extended for a few seconds to view low-frequency and once-only events.

The advent of *storage* scopes meant that waveforms could be displayed long after they had disappeared from the input sockets. Analogue storage scopes considerably extend the viewing period by using special storage tubes with extremely high writing speeds.

Digital storage scopes (d.s.o.s) offer the greatest benefits in terms of flexibility in capturing and storing signals. As its name implies, a d.s.o. stores signals in a digitally-coded form – which is available indefinitely.

Although most scopes are built around a cathode ray tube, a recent breakthrough in design is the liquid crystal display (l.c.d.) which, when combined with large-scale integration techniques, provides a handheld scope.

C.R.T. DISPLAYS

The simplified layout of a cathode ray tube is shown in Fig. 1. The cathode of the electron gun, coated with barium sulphate

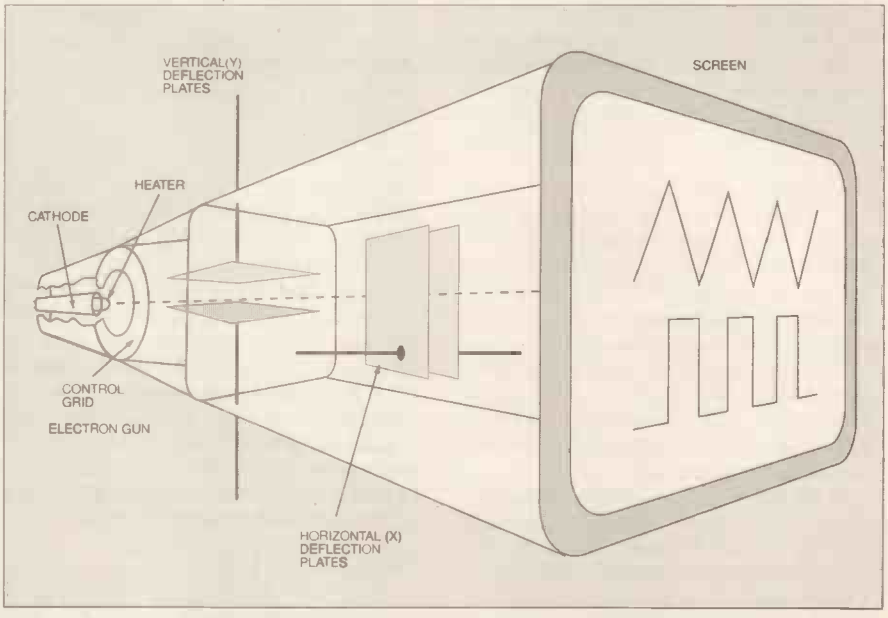


Fig. 1. Basic details of a cathode ray tube as used in an oscilloscope, excluding focussing and acceleration anodes.

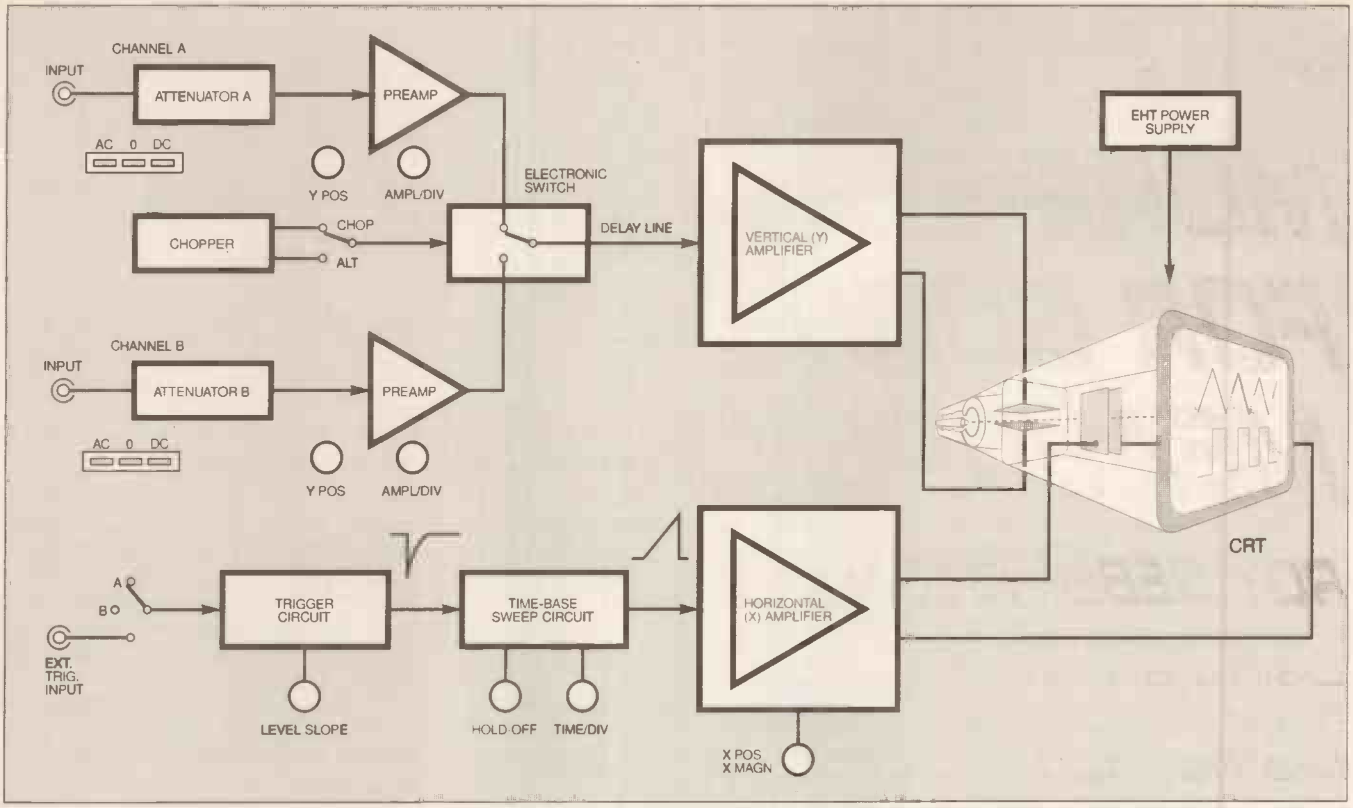


Fig. 2. Block diagram of an analogue dual-trace oscilloscope, excluding focus and brilliance controls.

similar to that in a "normal" thermionic valve, emits electrons that pass through a series of electrodes towards the screen.

The electrons are focussed into a beam to form a spot in the centre of the screen. As with a TV, the surface of this screen has an inner coating of a luminescent layer that emits light, usually green, when struck by electrons.

Focus

To obtain a sharp trace on the screen, the focus electrodes, supplied with positive and negative voltages to create a lens effect, control the beam spot size so that it remains sharp for different intensities and sweep speeds. A manual focus control is also included.

Deflection Plates

The two pairs of deflection plates can shift the electron beam, moving the spot on the screen by electrostatic deflection when voltages are applied. These are known as the *X* (horizontal) and *Y* (vertical) deflection plates.

As you would expect from these graphical expressions, the *Y* plates are controlled by the signal voltage to be measured, and the *X* plates are usually controlled by a timebase (*Y-T* displays).

Intensity

Anodes at positive potentials control the speed of the electron beam and therefore the trace intensity. At very fast sweep speeds, the phosphor coating of the screen is energised for a shorter period, so the intensity needs to be increased, otherwise the trace will not be seen.

Conversely, at slow sweep speeds, the intensity needs to be reduced to prevent "burn-in" of the phosphor.

Fortunately, most modern oscilloscopes have automatic adjustment of intensity to compensate for different sweep speeds. For high frequency inputs, i.e. high writing speeds, post-deflection acceleration is applied by a voltage of 10kV or more in the area of the screen.

Screen

On striking the flat inner surface of the c.r.t., the energy of the electron beam is converted into light by the phosphor coating. Unlike a graph plotter with its continuous roll of paper, the c.r.t. has a screen of limited width. Consequently, a continuous time axis has to be represented by repeatedly sweeping the *X* trace from left to right of the screen as a timebase.

To be able to measure the waveforms on the screen, some form of scale is necessary. A graticule can be affixed externally in front of the screen, but most modern oscilloscopes have internal graticules in the same plane as the phosphor, to avoid errors due to parallax.

OSCILLOSCOPE CIRCUIT BLOCKS

When a c.r.t. is used at the heart of an oscilloscope, as is usually the case, what are the circuit blocks that make it "tick"? If we take the power supplies for granted, the basic blocks for a two-channel analogue oscilloscope are as shown in Fig. 2.

Vertical Deflection

Two identical *Y* (vertical) channels allow two input signals, A and B, to be compared simultaneously on the screen by a dual-trace technique using electronic switching.

Each signal input has an input attenuator and a pre-amplifier with a manual control (AMPL/DIV), calibrated in mV/div and V/div to adjust the amplitude of the signals to suit the required display size.

Channel A and B waveforms, suitably conditioned, can be selected manually and displayed in either the chopped (CHOP) or the alternate (ALT) mode. In the chopped mode, a pulse from a free-running multivibrator (astable) chops at a rate of 200kHz or more between the two input signals. At time coefficients lower than about 0·1ms/div, each trace appears to be continuous, but for higher sweep speeds

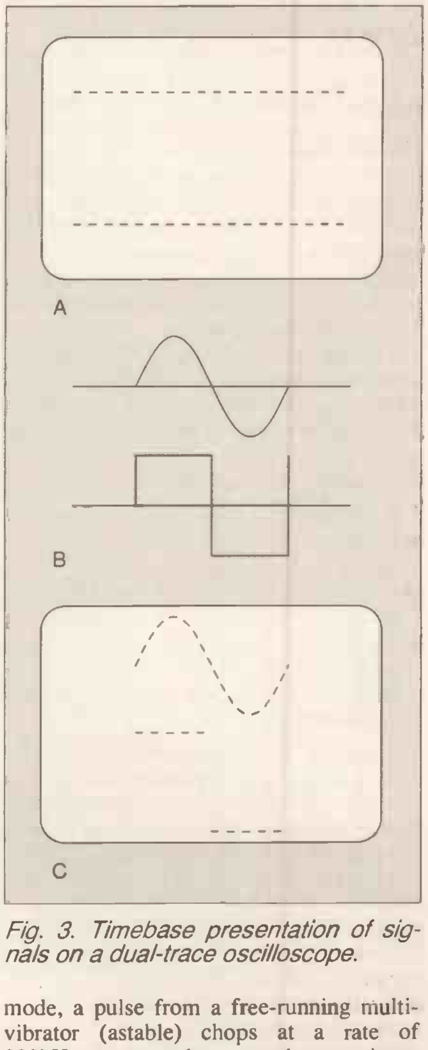


Fig. 3. Timebase presentation of signals on a dual-trace oscilloscope.

the traces will appear as dashed lines (Fig. 3), so imposing an upper limit for the CHOP mode.

In the **ALT** mode, pulses are derived from the timebase circuits, synchronised with the end of successive sweeps; i.e. one channel signal is traced per sweep. As shown, the electronic switch then changes over to trace the other channel signal.

With ALT selected, at slow sweep speeds the traces appear to be written one after the other and are therefore difficult to compare.

From the foregoing, it will be realised that the ALT mode is more suitable for faster sweep speeds, whilst the CHOP mode is better for slower sweep speeds and single-shot events.

Delay Line

A built-in delay line might be included in the vertical channel of some scopes to compensate for the longer delays introduced by the electronic circuits of the horizontal channel. This ensures that the *X* and *Y* signals arrive together so that leading edges of waveforms can be viewed on the screen.

A final vertical deflection amplifier provides sufficient output to the *Y* deflection plates to allow a sizeable vertical trace capable of being shifted to show signal details of interest without distortion. Typically, the maximum deflection might be the equivalent of 24 divisions (three screens).

Each trace can be centred or positioned as desired on the vertical axis of the screen by means of a manual control (Y POS).

Input Coupling Switch

Each channel has an input coupling switch, often labelled AC-0-DC. By selecting "0", the channel can be switched to the 0V (ground) level. This facility allows the channel reference levels to be adjusted individually or in respect to one another.

The AC setting is used to block a d.c. component in a signal that would otherwise form the major part of the signal. This position allows you to see more of an a.c. transient that is of interest, adjusting the respective controls accordingly. However, remember that no d.c. level with respect to ground is seen, and low-frequency components in a signal may show distortion.

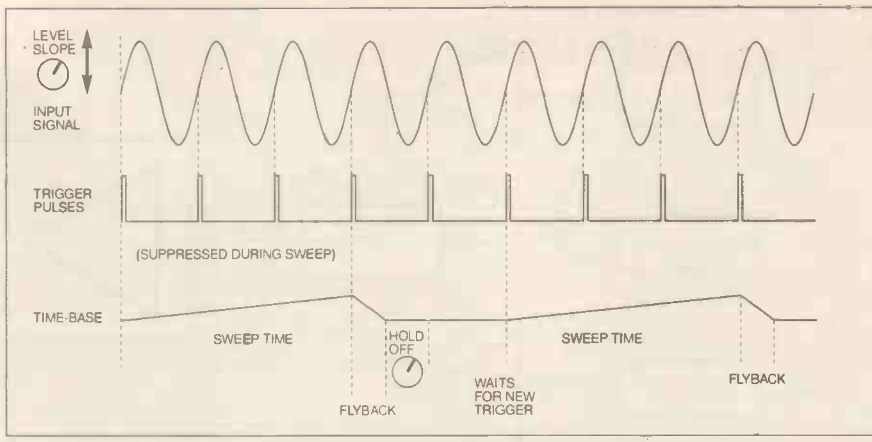


Fig. 4, Timebase generator output waveforms.

The DC setting allows measurements of d.c. voltage levels to be taken.

In some scopes, signals from the two vertical channels can be added (ADD), or inverted to give subtraction. These options are useful for removing hum, or for differential measurements.

Horizontal Deflection

Horizontal (X) deflection represents the time axis, against which the signals on the vertical channels are plotted. An internal timebase supplies the horizontal information by means of an accurate sweep generator at user-selectable speeds.

Sweep speed (TIME/DIV) is measured in µs/div to s/div. The timebase generator provides a sawtooth signal, a linear positive-going ramp that deflects the spot from left to right on the screen at a speed determined by the TIME/DIV setting. The timebase generator waveforms are indicated in Fig. 4.

On reaching the right-hand side, the sawtooth waveform drops sharply to return the spot quickly to the left-hand side, from where it starts the next trace. This rapid return path, known as "flyback", is suitably blanked to prevent any confusion with the trace. By selecting different sweep periods, with a continuously variable timebase control it is possible to view one or more periods of a waveform across the screen, or zoom in on a point of interest (X MAGN).

The trace can be moved horizontally by a control (X POS) to coincide with a graticule line for measurement purposes.

Triggering

For the electron beam to return repeatedly to the same point on the screen, and to follow exactly the same path each time, accurate timing is required. This is the task of the trigger circuit. It ensures that the timebase starts each time at a pre-determined point on the input signal, to obtain a stable waveform that is traced repeatedly without jitter.

A hold-off pulse prevents extra trigger pulses from interfering with the start of the sweep and causing "double-writing".

The trigger controls are typically SOURCE, LEVEL and SLOPE. Often the trigger source is from the signal itself, or from an external trigger. A trigger LEVEL control determines at which voltage level the timebase will start. SLOPE selects whether the trigger is positive- or negative-going.

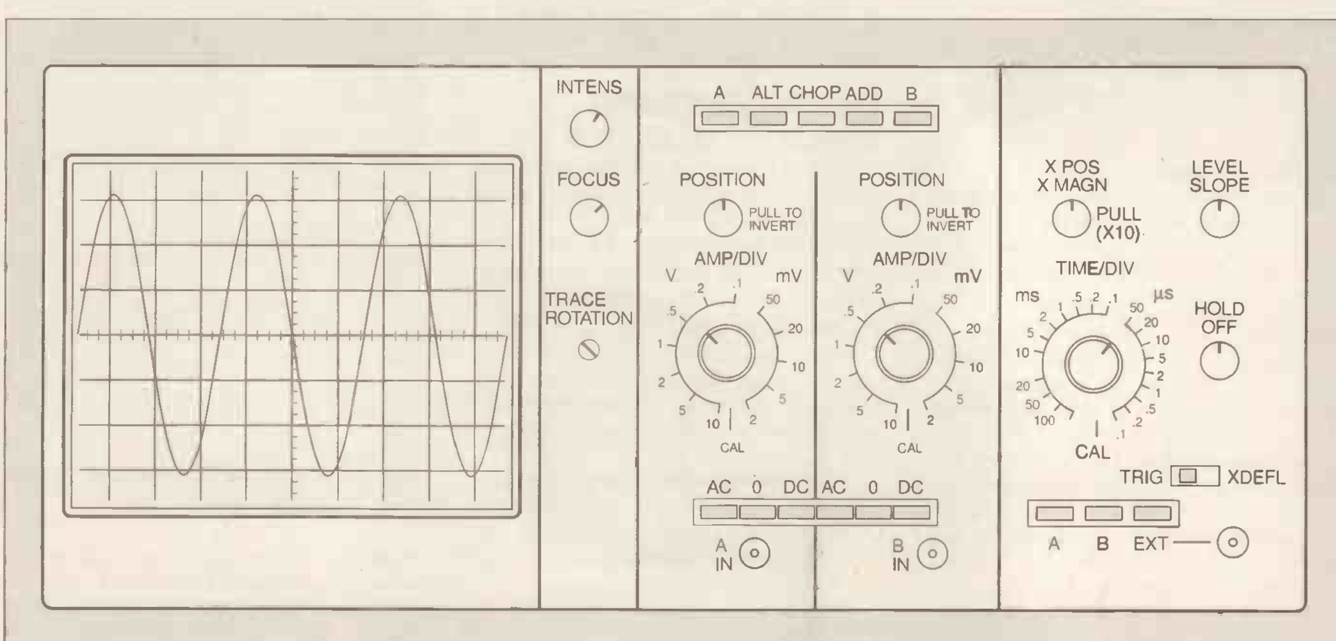


Fig. 5. Stylized layout of the basic controls on a typical dual-trace oscilloscope.

A horizontal deflection amplifier feeds the timebase waveform to the *X* deflection plates at the requisite level.

An example of a typical front panel layout for an analogue dual-trace scope is shown in Fig. 5.

ADDITIONAL FEATURES

As discussed above, in addition to the *X* and *Y* sections, scopes have a third section which controls the electron gun, allowing brilliance and focus of the beam spot to be varied, and is known as the Z-axis.

Normally, the spot is blanked during the flyback time, but in some scopes this blanking can be usefully controlled via an external signal, e.g. to provide time markers from clock pulses, via a Z-input. This facility is known as Z-modulation.

For detailed study of complex waveforms, scopes having *dual* timebases become necessary: a main timebase (MTB) and a delayed timebase (DTB). Part of the MTB can be displayed more brightly to indicate the start of a DTB that has a much faster sweep speed in order to expand the point of interest.

So far, only the built-in timebase (Y-T mode) has been discussed for the horizontal deflection system. However, with many scopes an external signal can be substituted to deflect the signal along the X-axis, referred to as the X-Y mode. This allows two signals to be plotted simultaneously to see their relationship.

COMMON WAVEFORMS

Perhaps the most familiar standard waveforms are the sinewave, the triangular waveform and the square wave. In the timebase generator we also met the sawtooth waveform, a variant of the triangular waveform. The ramp waveform is a special case variant of the sawtooth, with the fastest possible transition between the voltage extremes at the end of the ramp period. Examples of these waveforms are shown in Fig. 6.

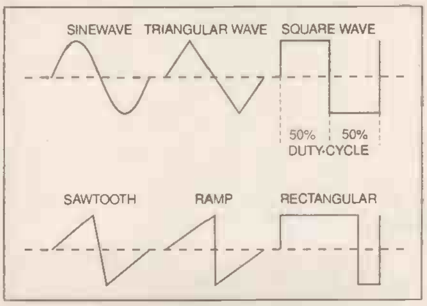


Fig. 6. Idealised standard waveforms.

Similarly, the rectangular wave is a variant of the squarewave, i.e. when the duty-cycle is not 50 per cent. Both these waveforms can also be referred to as pulse waveforms.

The frequency and amplitude of a sinewave are represented as shown in Fig. 7, from which it will be seen that the time taken between the same point on successive waveforms is known as one *cycle* or *period*.

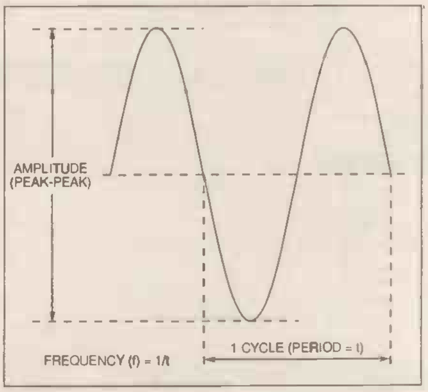


Fig. 7. Sinewave parameters.

The number of complete cycles occurring in one second, i.e. the frequency, is expressed in Hertz (Hz). Therefore, for example, if the period of a waveform is 20ms, its frequency is calculated as:

$$f = 1/(20 \times 10^{-3}) = 50\text{Hz}.$$

Next to frequency, the amplitude or peak-to-peak voltage is the next most common parameter that is checked.

Repetitive waveforms are the easiest to measure on an oscilloscope since single or infrequent waveform occurrences may happen too fast to be seen.

BANDWIDTH

An oscilloscope's most important specification is, perhaps, the frequency response, or *bandwidth*, of its vertical system. As shown in Fig. 8, this is expressed as the maximum frequency that can be displayed on the screen with an amplitude that is not more than 3dB below the signal under test (71 per cent of the input signal).

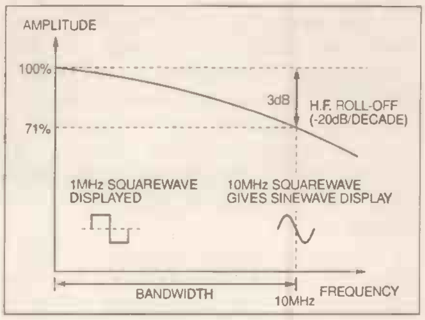


Fig. 8. Frequency response of a 10MHz oscilloscope.

From the graph in Fig. 8, it can be seen that an oscilloscope used towards its upper frequency limit will give misleading results. High-frequency amplitude measurements can be up to 30 per cent less than those of low-frequency signals.

Also, as high-frequency pulses are formed from a fundamental sinewave and its harmonics, a 10MHz squarewave displayed on a 10MHz bandwidth scope, as shown, would appear as a sinewave, since all harmonics higher than the first would be heavily attenuated by the high-frequency roll-off. The solution is to keep well within the upper frequency limits of your scope, or to use one with a wider bandwidth for making high-frequency measurements.

PULSE PITFALLS

Because pulses do not change from one level to another in zero time (nothing in nature is truly "instantaneous"), then their shapes will not conform to the idealised square wave shown in Fig. 6. Some of the imperfections that might occur are illustrated in Fig. 9 and should be recognised if oscilloscope measurements are to be meaningful.

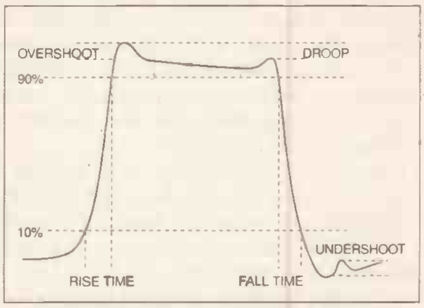


Fig. 9. Pulse imperfections.

The finite time taken for a pulse to attain a higher level is known as its *risetime*; the time taken for a pulse to fall to its lower level is known as its *falltime*. These parameters are defined as the transition time between the 10 per cent and 90 per cent levels of the pulse amplitude value – in theory, the fastest transition the scope can display.

There is a direct relationship between risetime and bandwidth, stated as:

$$\text{bandwidth (Hz)} \times \text{risetime (s)} = 0.35$$

Thus, the risetime of a 15MHz oscilloscope is equal to:

$$0{\cdot}35 / 15 \times 106 = 23\text{ns}$$

For a 50MHz scope, the risetime is 7ns.

Graticules are usually calibrated so that the top and bottom of signals can be aligned against zero per cent and 100 per cent marks to allow risetime to be read along the X-axis against the 10 per cent and 90 per cent verticals, in conjunction with the TIME/DIV control.

If the risetime of your scope is comparable with that of the signal, then substantial reading errors will occur; e.g. a 1:1 ratio of signal-to-scope risetime gives a 40 per cent error. In comparison, a scope risetime that is ten times faster than the signal reduces the error to a negligible 0.5 per cent.

An amplifier system that can reproduce more harmonics, linearly and in phase, will give shorter risetimes, higher bandwidths and better results. Other effects such as overshoot, undershoot and droop may be caused by capacitive coupling and stray capacitances in amplifier stages.

PROBES

The connecting lead between a circuit under test and the oscilloscope forms an important link in the quest for meaningful measurements. Because they are used to probe about in the circuit under test, these leads are generally called "probes"!

Passive probes incorporate only passive components such as capacitors and resistors and usually attenuate the incoming signal. On the other hand, there are active probes that provide amplification. If d.c. voltages are being measured, the input connection gives no problem provided the scope input impedance (often standardised at 1MΩ) is much greater than that of the signal source.

However, when a.c. voltages are being measured, stray capacitances, in the coaxial cable for instance, will heavily load the signal, especially at high frequencies. If possible, it is better to measure at a low-impedance point in a circuit to reduce the load on the input of the oscilloscope. When this is not feasible, then a 10:1 passive probe can be used to compensate for the cable capacitance.

It is important that screened cable is used for the probe connection, otherwise interference, such as mains hum, radio signals or the local taxi service, could play havoc with your measurements.

Always check the specifications of the probe carefully to see that it is suitable for the task in hand. Remember that a 50MHz probe used with a 50MHz scope gives a combined bandwidth that is less than 50MHz – the probe capacitance is added to that of the scope and the combined risetime will be increased.

For higher frequencies, up to 650MHz, f.e.t. (field effect transistor) probes are available with very low input capacitance (1·5pF), suitable for measuring fast transients in high impedance circuits.

Current probes, using sensing transformers in the probe tip, are also available to enable current measurements to be made without the need to break into a circuit.

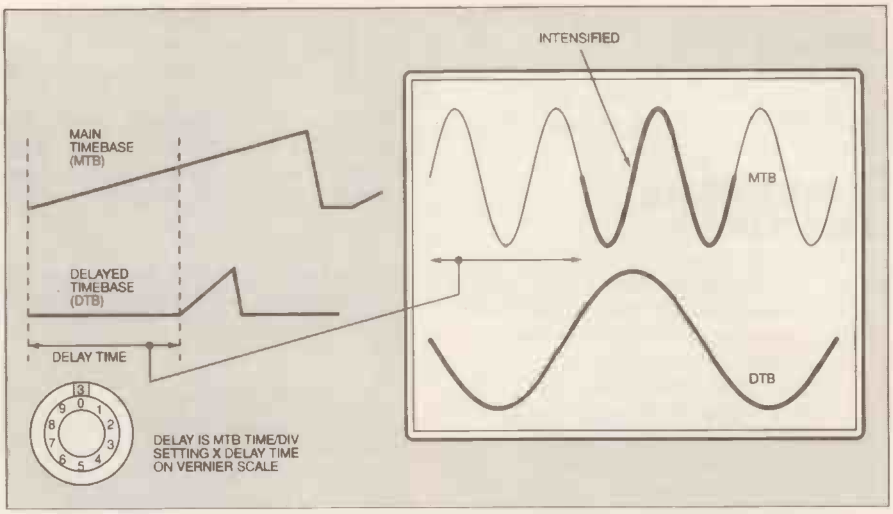


Fig. 10. Delayed timebase showing expanded display of main timebase.

LOOKING FOR DETAIL

Earlier, the X MAGN control was mentioned. This magnifier enables the signal detail to be enlarged by a factor of ten. In addition to this facility, many scopes have a delayed timebase (DTB) that enables parts of the main timebase (MTB) sweep to be selected and amplified to show even greater signal detail.

The controls are similar to those shown in the X section of the basic controls diagram in Fig. 5, but also includes a DELAY TIME control with a vernier scale for accurate location of the point on the MTB at which the DTB starts (see Fig. 10).

The length of the MTB part to be expanded for examination is determined by the setting of the DTB TIME/DIV setting. This part is intensified by the electron beam. A d.c. voltage set by the DELAY TIME control generates the DTB by comparison with the MTB sweep voltage. The DTB starts when the two voltages are equal. By means of the ALT-mode, the intensified part of the MTB trace and its expanded form, the DTB trace, can both be displayed, as shown.

NEXT MONTH

In the concluding part of this article next month, we discuss oscilloscope applications and experiments, and take a look at storage scopes.

Constructional Project

HOME TELEPHONE LINK

MICHAEL McLOUGHLIN

A low-cost "personal" home phone-link, with a range of up to one kilometre.

A TELEPHONE is a fairly easy thing to make. An exchange is more complicated, but to start with, you don't need one!

Two telephones will talk to each other quite happily without an exchange. Such an arrangement is called a telephone link. This article will describe suitable telephones, and show how to link two of them together.

The microphone has always been the critical component in the telephone. For 100 years the carbon type was used. This relies on carbon granules (fine grains), packed between two electrodes. The granules are compressed and released by sound waves, and the resistance between the electrodes varies accordingly.

Connect this type of microphone in series with a magnetic earphone, and you have a telephone. To use it, see Fig. 1.

A complete telephone needs five parts: • Microphone • Earphone • Bell (or other sounder) • Dial (or other signalling device) • Switch, to control d.c. supply.

MICROPHONE

The modern electronic telephone uses the 10mm diameter condenser microphone (mic.). (Condenser is the old word for capacitor). This mic. is small, sensitive, well shielded, and requires little power. It is also cheap, and readily available.

It works on the electret principle, but to lower the output impedance a f.e.t. (field effect transistor) has been incorporated. This has three consequences. First, polarity has to be respected. Second, the current drawn is not greatly affected by voltage applied, so long as this is in the permitted range of 1·5V to 9V. Finally, the mic. constant current shows considerable variation from one specimen to another. It can be anything from 100µA to 400µA.

Normal speech originating 50mm (2in.) from the mic. superimposes on this a signal current with peaks of ±5µA, producing ±50mV peaks if the series resistor, as shown in Fig. 2, is 10 kilohms. The condenser mic. is robust, but it has to be handled with care when attaching leads to it, as in Fig. 2.

Output impedance of the circuit in Fig. 2 is just the 10k resistor. When connected correctly, the traditional carbon mic. produces about ten times the output voltage, with only one hundredth of the output impedance. This means ten thousand times more signal power! Plainly, the electret mic. will need an amplifier, to boost output.

Nowadays, the earphone is usually a small loudspeaker, with an impedance of anything up to 200 ohms. We shall use a small speaker, but stick to 8 ohms impedance, to assist with availability.

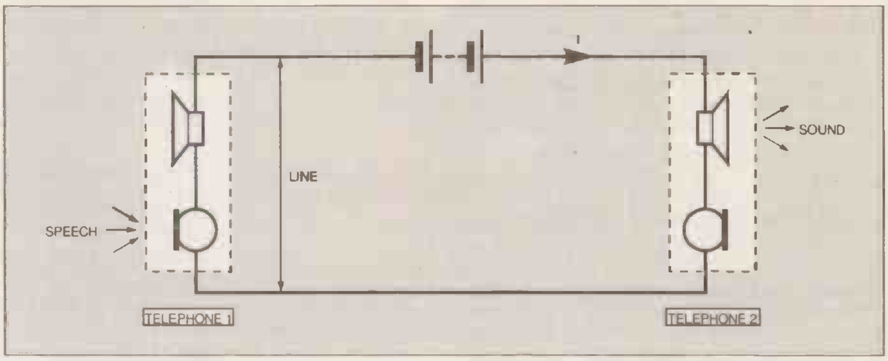


Fig. 1. Simultaneous two-way communication. Speech at either microphone modulates the circulating current I, reproducing the sound in both earphones.

The chosen speaker requires an audio signal of ±50mV on peaks, to deliver good telephone sound. That is just the voltage produced by the condenser mic. But try driving 8Ω from a 10k source impedance!

In a "two-station" telephone link the destination of the call is obvious, so the dial is unnecessary. The bell can be replaced by a buzzer, and the cheapest type is an electromechanical type.

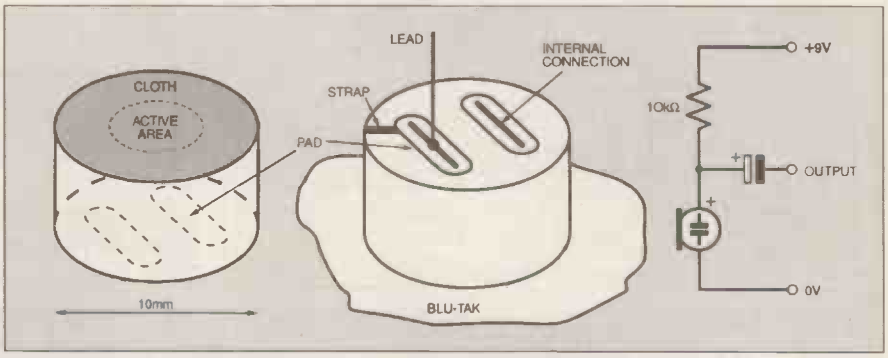


Fig. 2. Condenser (electret) microphone. The negative terminal is identified by the strap which connects it to the case. Two pads are provided for leads. These are loaded with solder, which conceals the internal connections shown. To solder a lead, press the mike into some Blu-tack. Then melt the solder on the pad, and stand a vertical wire outside the internal connection, as drawn. To lift the mic. from the Blu-tack, rock gently. Output is taken from a series resistor, as indicated.

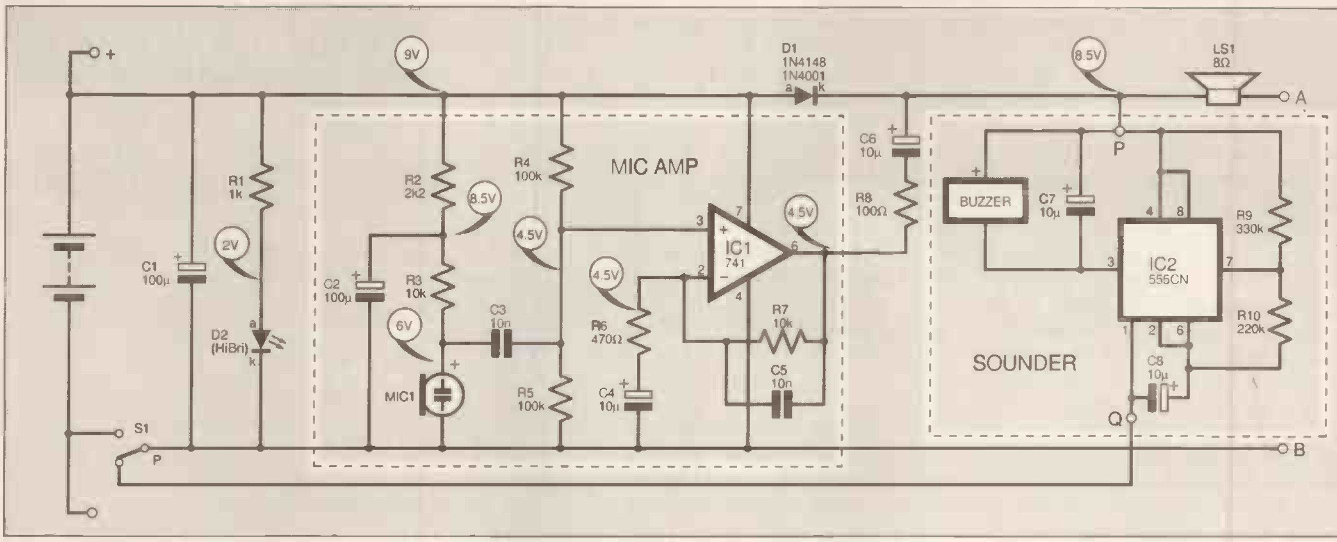


Fig. 4. Complete Home Telephone link Circuit diagram. The voltages marked should appear when the phone is lifted, if the test meter negative lead is connected to the B *wire. Nothing should be attached at* A *and* B*. Speaking into the mic. should raise the voltage at* P.

This buzzer produces the sound by hammering, in the traditional manner, but an internal transistor replaces the usual contact breaker. As a result, polarity is again important, and the positive lead is red.

SWITCHING

As the telephone link will only be used occasionally, and there should be no standby current, operation from a 9V battery is convenient. This suggests a 6V buzzer , as its permitted supply voltage is anything from 4·5V to 9V. But a switch will be needed to control the supply.

In early phones the user operated this switch, but that is a recipe for disaster. It is much too easy to forget to switch off, and that soon leaves a dead phone.

So the gravity switch was invented: when the phone is hung up or laid down, its weight automatically switches off the power. Nowadays every phone has a gravity switch.

A microswitch can do this job very well and was adopted in this design. But its operation is still checked by including an l.e.d. As dialling is superfluous, picking up your phone ought to sound the far buzzer at once. In fact, a single microswitch can control both the d.c. power and the buzzer, as in Fig. 3.

CIRCUIT OPERATION

Suppose that the phone shown in Fig. 3 is lifted, altering the position of the microswitch S1. Then d.c. is applied to the line via the diode, and the distant phone buzzer sounds. The pulses of current drawn by that buzzer flow through the local speaker, producing a useful ringing tone.

When the distant phone is lifted, its buzzer is disconnected. The stronger battery then takes control of the voltage on the *A* wire, biasing the remote diode into non-conduction. Speech voltages are rectified by the remaining diode, and promptly bias it out of conduction also, leaving the line as the only circuit left open for speech currents.

Because of its negative feedback the mic. amplifier will have a very low output impedance (milliohms). Thus the output voltage delivered by the amplifier has no difficulty driving signal current down the line and through both speakers. At the far end the signal current flows easily to ground, via the low output impedance of the local amplifier.

PRACTICAL CIRCUIT

The full circuit diagram for the Home Telephone Link is shown in Fig. 4. This circuit is repeated for the distant phone.

The loudspeakers need 50mV on peaks, which requires only 6mA of signal current. That is well inside the 10mA current limit of the ever popular 741 op.amp, so it can be used to drive the speakers!

However, there is a snag. In the circuit of Fig. 3, just 16 ohms of line resistance is enough to cut the received signal voltage in half. Standard indoor telephone cable has a loop resistance (there-and-back) of 20 ohms per 100 metres, so that is about the maximum range.

Spectacular improvement occurs if a 100 ohms resistor is inserted in series with capacitor C6. To deliver the same signal current the 741 has now to produce 13½ times as much output voltage, but that only requires a gain adjustment.

With the 100 ohm resistor in place, the loop line resistance must now be twice 108 ohms to divide the received voltage by two. This gives a line length of 1·1km. By improving line matching, the extra resistor has multiplied the range of the Telephone Link by 13½ times.

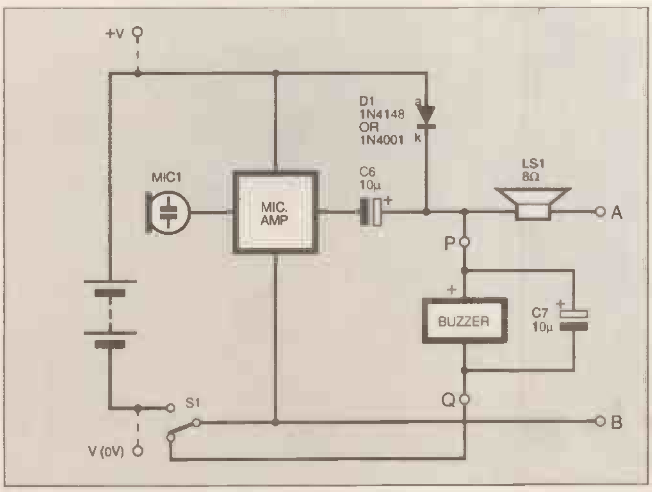


Fig. 3. Telephone with automated calling. The line connects A *and* B *to the same points on the distant phone. When the phone is not in use, the gravity switch S1 adopts the position shown. For the dotted connections see the text.*

The completed prototype phone, built on stripboard.

It is tempting to insert a larger resistor, but then the 741 output voltage starts to approach its limits, at least if the battery is getting old. A weaker speech signal could of course be heard over much longer distances. But the buzzer used here sets a definite limit: with a 9V supply it fails at line lengths over 1km.

The buzzer in Fig. 3 has capacitor C7 in parallel. This helps to provide the 60mA current pulses required, particularly if the battery is old or the line is long.

However, it is clear that the two components between *P* and *Q* could be replaced by any other calling system that works on d.c. For example, a 555 and buzzer could be inserted here, to simulate the international ringing cadence. This is one second of sound, followed by three seconds of silence, and it is also used in the UK on internal exchanges.

Generating a ringing cadence allows the caller to listen to the ringing tone, instead of having to control the ringing on his microswitch. More decisively, inclusion of the 555 also deals with the following difficulty.

Refer to the circuit of Fig. 3. When the conversation is finished, one user will put down their phone before the other. This reproduces the calling situation (one phone lifted and one not). The result is that the first person to put down the phone receives a loud buzz, which lasts until the other phone is put down.

This could be tolerated, because the users know each other. But using the 555 to generate a ringing cadence eliminates the difficulty. There is a five second delay between applying voltage to the 555 and the buzzer sounding, and that interval is more than sufficient to allow both parties to lay down their phones. Unexpected final buzzes disappear.

ON-LINE

The most expensive part of a telephone system is the line to the user. So this is rarely more than two wires. However, 2-wire indoor cable is not so easy to buy, and anyway it is not much cheaper than the standard 4-wire cable. If 4-wire cable is used, paralleling of conductors would double the range.

A more interesting possibility is to use the extra pair to carry the battery supply from one telephone to the other. Then only one phone need carry a battery.

If the line is less than 500 metres in length, 4-wire cable should be considered. It confers a repetitive saving on batteries, at the cost of a comparable one-off additional sum spent on the cable.

To use 4-wire cable, find the terminals, plus (+) and minus (−) which are shown dotted in Fig. 3, and use the extra pair to connect these terminals to their mates on the other phone (+ to +). Either phone can carry the single battery required.

This brings us to the final circuit of Fig. 4, which includes the 555 timer IC2.

CONSTRUCTION

You will need to make two phones, but the work is light. Many things take longer to describe than to carry out. A basic method of construction is given as a guide.

The construction of the Telephone Link requires two identical printed circuit boards (p.c.b.s), one for each phone. This p.c.b. is available from the *EPE PCB Service*, as a pair, code 997.

The topside p.c.b. component layout and full size copper foil master pattern are shown in Fig. 5. The lever-operated microswitch **S1** is mounted on the board trackside, as can be seen in the photographs.

Commence construction by first carefully cutting the p.c.b. to the shape indicated in Fig. 5 – the larger cutout is to locate the battery in the box and the two smaller ones aid wiring and provide some "elastic" support for the speaker when finally shutting the case on completion.

For the "handset" enclosure a box with a transparent lid was used, this allowed the operating l.e.d. to be seen without having to drill any holes in the lid. To slide this box open, apply end-to-end finger pressure on the upper and lower faces.

COMPONENTS

Resistors — See SHOP TALK Page

R1	1k
R2	2k2
R3, R7	10k (2 off)
R4, R5	100k (2 off)
R6	470Ω
R8	100Ω
R9	330k
R10	220k

All 0·25W 5% carbon film

Capacitors

C1, C2	100µ axial elect. 10V (2 off)
C3, C5	10n disc ceramic, lead pitch 5mm (2 off)
C4, C6, C7, C8	10µ axial elect. 10V (4 off)

Semiconductors

D1	1N4148 signal diode or 1N4001 rec. diode
D2	5mm high brightness red l.e.d.
IC1	741 op.amp
IC2	555CN timer

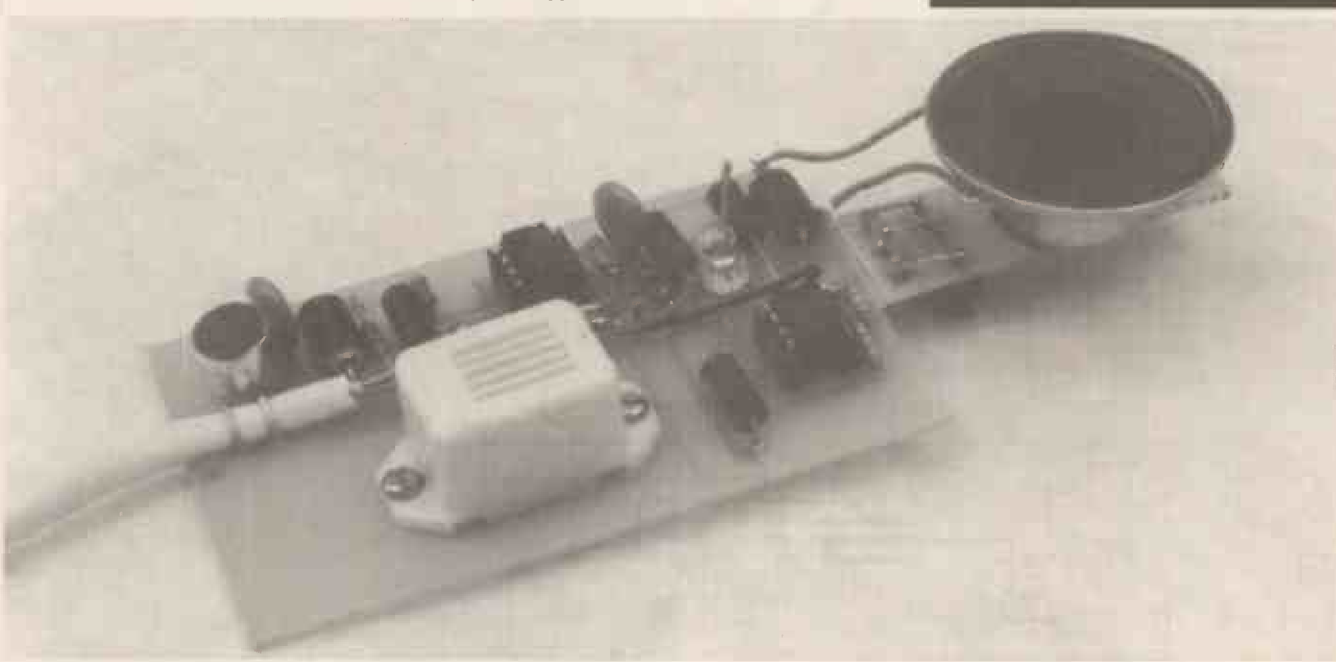
Miscellaneous

MIC1	electrect microphone insert, 10mm dia.
LS1	8 ohm 38mm dia. moving coil loudspeaker
S1	lever-operated sub-minature microswitch
WD1	6V electromechanical buzzer
B1	9V PP3 type battery, with clips

Printed circuit board available as a pair from *EPE PCB Service*, code 997; plastic case, with transparent lid, size approx. 141·5mm x 57mm x 23·5mm; 8-pin d.i.l. socket (2 off); 4-way terminal block; 4-way (or 2-way) indoor telephone cable; M2·5 screws 12mm (2 panel and 2 cntsk); M2·5 nuts (4 off); M2·5 washers (2 off); aluminium strip; solder pins; solder etc.

(2 sets required – one for each phone)

Approx Cost Guidance Only* £21 *per phone (excluding cable)



The first prototype phone built on a printed circuit board. This prototype was not intended to be housed in a case so the microphone and buzzer were mounted directly on the p.c.b. When inserted in the case, the p.c.b. has to be cut to take the battery, the microphone mounted inside the lid and the buzzer on the outside of the case.

The base section has a 1mm rail on each side intended to support the circuit board about 1mm above the box floor. You may need to rub down the edges of the p.c.b., with fine sandpaper, to obtain a snug fit on the support rails.

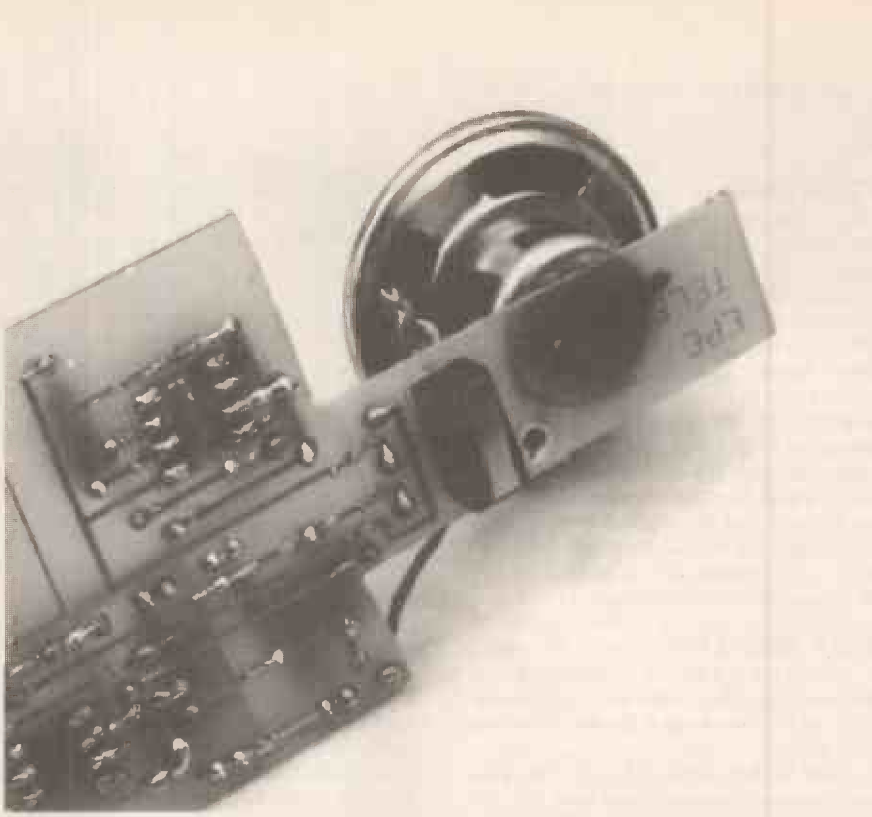
Identify the two blind holes nearest to the right hand edge on the p.c.b. and drill them out to 3mm diameter. Rest the p.c.b. on its support rails in the base of the box, and use the same drill to make two holes in the base of the box, directly beneath the p.c.b. holes. Before drilling, back the box with a wooden strip to prevent sudden breakthrough damaging the box.

Back to the p.c.b. Position the link wires and two d.i.l. sockets and solder in place. Next, the resistors and two disc ceramic capacitors should be mounted on the board.

The axial type electrolytic capacitors, diode and the l.e.d. should follow next. Particular care should be taken to get their polarities the right way round. The cathode (k) of the l.e.d. is indicated by a "flat" on its body, and it is the shorter lead.

Use clear glue to stick the microswitch to the copper track side, at the "flexi" end, of the board with the actuating lever pointing down. On the component side, solder short insulated connecting leads to microswitch pins and take the "free" ends to the required copper pads on the p.c.b.

Glue the loudspeaker in position, with its connections as indicated in Fig. 5. Be sure that the speaker does not overhang the right hand edge of the p.c.b. or it will not fit into the case.



The lever-operated microswitch is mounted on the copper track side of the p.c.b. The pole (p) of the switch connects to line B. Note the position of the loudspeaker.

Next, cut and strip a 20cm length of indoor telephone cable, to provide a supply of fine wire. Cut a two metre length of cable, connect its wires according to the colours suggested, and then tie it to the board with the fine wire as indicated in Fig. 5. Cut the leads on the battery clip to 5cm length, and fix it.

Referring back to Fig. 2, solder to the microphone two fine wires 10cm in length

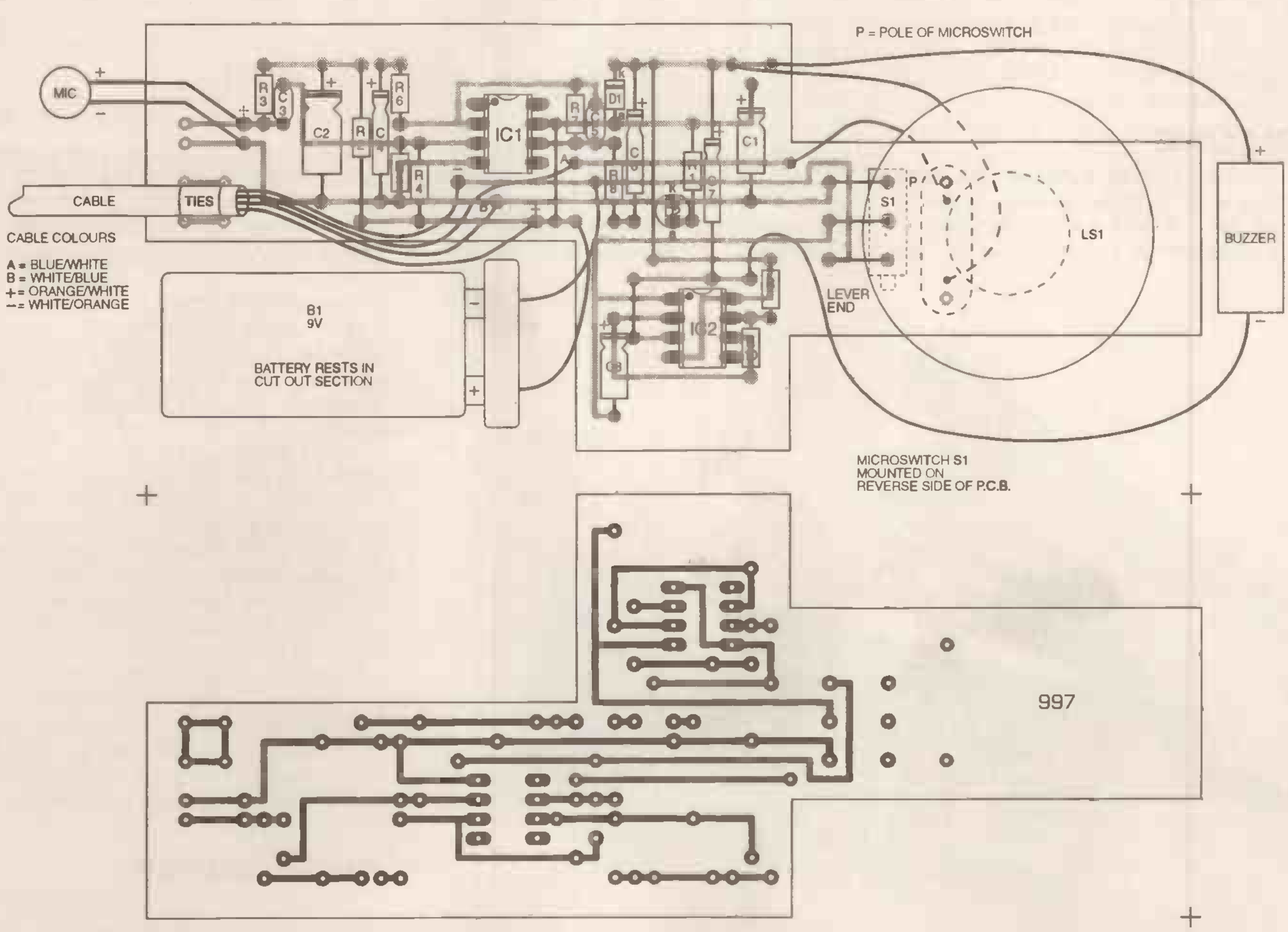


Fig. 5. Printed circuit board component layout and full size copper foil master pattern. The buzzer is mounted on the outside of the case at one end.

respecting polarity, solder these wires to their copper pads on the p.c.b. Temporarily connect the buzzer.

TESTING

Before boxing your phone, you can test it as follows. Connect the four wires of its cable to a piece of terminal block, and at the block add a 10µF capacitor from the A wire to the B wire (+ goes to A).

Connect the battery, in series with a current meter. When the phone is lifted, the l.e.d. should light. Current should be around 10mA, and fingering the pad on the mike should produce noises in the speaker.

Whether the phone is lifted or not, joining the two lower connections on the microswitch should cause the buzzer to sound, after a five-second delay. It draws an average current of 30mA. Disconnect the battery before proceeding.

The microphone insert and buzzer are not mounted on the p.c.b. in the final version. The board is carefully cut to make space for the battery and the microphone is glued to the inside lid of the case – see below.

BOXING-UP

When working on the box, remember: Before drilling, back the box with wood, to prevent sudden breakthrough. Do not use a punch to start holes! Use a compass point, or a track-break tool, used for cutting copper tracks on stripboard.

Rest the board on the rails, with its two holes lined up against those in the box. Use a marker pen to draw on the outside of the box the outline of the microswitch. Now use drills and files to produce a rectangular aperture for the microswitch, leaving about 1mm clear all round to assist later assembly.

Use screws to fix the buzzer on the outside end of the box, symmetrically between the two holes in the box floor. Fix it as near to the floor as possible, to prevent fouling of its leads as they enter the box through a third hole near the rim of the loudspeaker. Holes of 3mm diameter are suitable, with M2·5 screws. It is helpful to drill out to 4mm the holes in the buzzer.

Now start work on the upper section of the box (the lid). Draw on paper a square of 10mm, and cut it out. Use Blu-tack to fix it centrally on the outside of the lid, with its edge 15mm from the open end. Mark the box at each corner of the square.

Remove the paper, and add by eye a mark at the centre of the square. Drill 3mm diameter holes at all five points, to allow sound to escape from the loudspeaker. Then drill a 3mm hole in the end wall of the lid, and enlarge it to 5mm to carry the external cable.

MICROPHONE

Drill a 3mm hole in the lid for the mic., centred 10mm from the insides of the nearby walls. Unsolder the microphone leads from the board, used when "testing", and straighten them to serve as a handle. Make a small pool of clear glue, and rotate the microphone in it so that just the side walls are generously covered.

Place the microphone centrally on the prepared hole, and use a matchstick to push the glue down to meet the box material. You can bring up extra glue on the match. There must be a complete seal all round, to prevent audio feedback.

Place the board on its rails, so that the microswitch drops through its hole. Remove the terminal block, and thread the "line" cable through the 5mm hole in the side. Solder the mic. leads back on to their connecting pins (+ to +), in such a way that they will not tangle with the cable when the box is closed. Solder the buzzer to its pins.

Connect the cable once more to the terminal block. After that is safely done, connect the battery, fold its leads, and place it in the box. To extinguish the l.e.d., rest the phone on the table.

If you with to hang the phone on the wall rather then rest it on a table, cut a strip 10mm by 86mm from 16s.w.g. aluminium sheet. Use two countersunk 12mm screws M2·5 to attach this strip to box and circuit board, using the holes already prepared.

The phone will now hang on two panel pins driven into the wall at 30 degrees to the horizontal, centred exactly 70mm apart. Alternatively, cut a strip 35mm high from an unwanted plastic card in your wallet, and use that.

Now prepare to close the box. To do this, it is necessary to depress the speaker. The resultant pressure between speaker and lid produces a partial seal when the box is closed, providing good audio coupling to the ear. The depression required is easy to achieve, if the specified 38mm dia. loudspeaker is used. The 40mm diameter speaker supplied by RS is less suitable, as it has an additional 1mm depth.

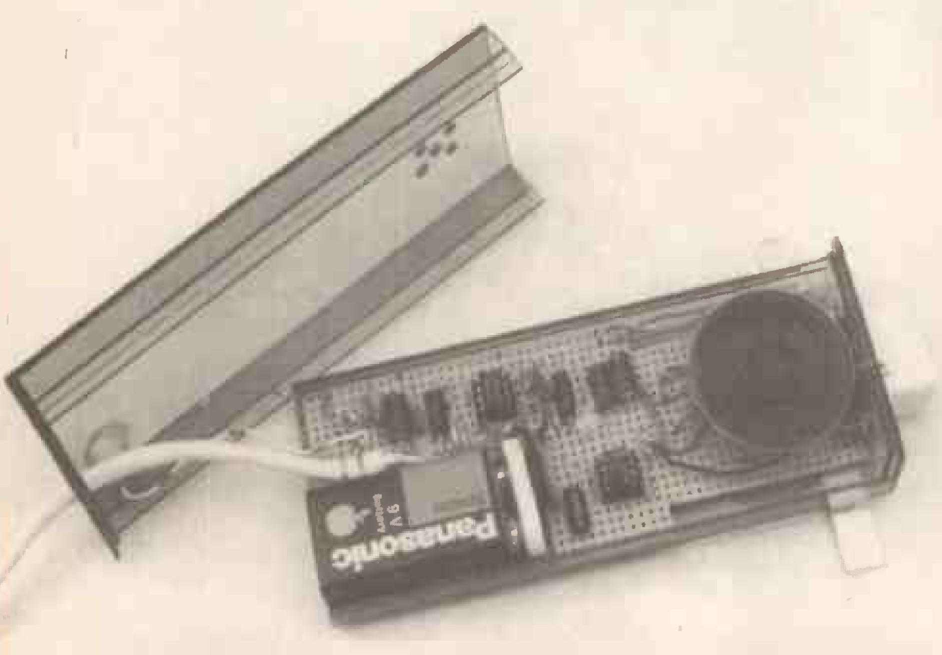
Do not slide the lid shut, as its leading edge may catch the speaker cone, and strip it from the metal rim. To close the box, proceed more carefully, as follows.

Lower the lid slowly towards the base section, so that the box will be mostly closed when lid and base meet. Aim to leave uncovered just one quarter of the speaker cone. While the two sections are approaching, encourage the 10cm microphone leads to fold tidily down the side of the box, and gradually extract the surplus of telephone cable.

Continue to press down on the lid, keeping one quarter of the speaker uncovered, until the lid clicks into place. Carefully slide the box shut. To open the box, cautiously slide open the lid, as far as the mic. leads permit, and then gently prise it upwards at its leading edge.

INSTALLATION

The terminal block on the cable can be attached to the skirting board, and the fixed line can run from there, with the cable held by clips at 230mm (9in.) intervals. Where a portable link is desired, a simpler arrange-



Prototype stripboard version mounted inside the specified case, with transparent lid. Note the positions of the microphone and buzzer.

ment is allowable – wire both phones directly to a 100 metre drum of cable.

If 4-wire cable is used, the second phone does not need a battery or clip, and its board does not need a cut-out for the battery. If the phone is not to hang on the wall, omit the two holes in the board and the box floor.

STANDARD TELEPHONES

Standard (BT) telephones derive their operating current from the exchange battery, use different voltage parameters, and include a tone-based signalling system. Further, they are superior to those described here in three other ways. Their range is greater. This is because line matching is more sophisticated, and because the sounders used need much less current than our buzzer. Second, sidetone (what you hear of your own voice) is reduced, for your comfort, and to make you speak up. Thirdly, the phone senses the length of the line to the exchange, by noting how much current it is receiving, and the output signal is adjusted accordingly.

To produce a similar ringing cadence to a standard phone, the circuit diagram shown in Fig. 6 can be used. This replaces the components between points *P* and *Q* in Fig. 4. You will, of course, have to design your own small circuit board to take the components. □

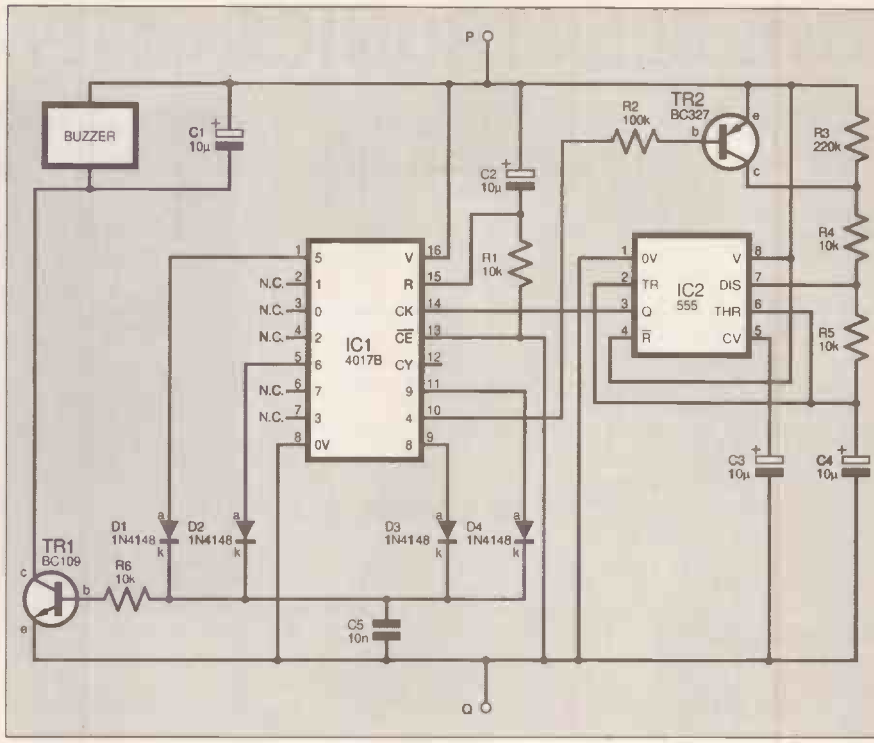


Fig. 6. Circuit for producing the familiar BT ringing cadence. The 555 timer period is 0·2 sec., and the 4017 IC1 sounds the buzzer at counts 5+6 and 8+9. Count 4 is stretched. This circuit replaces components between points P *and* Q *in Fig. 4 if required.*

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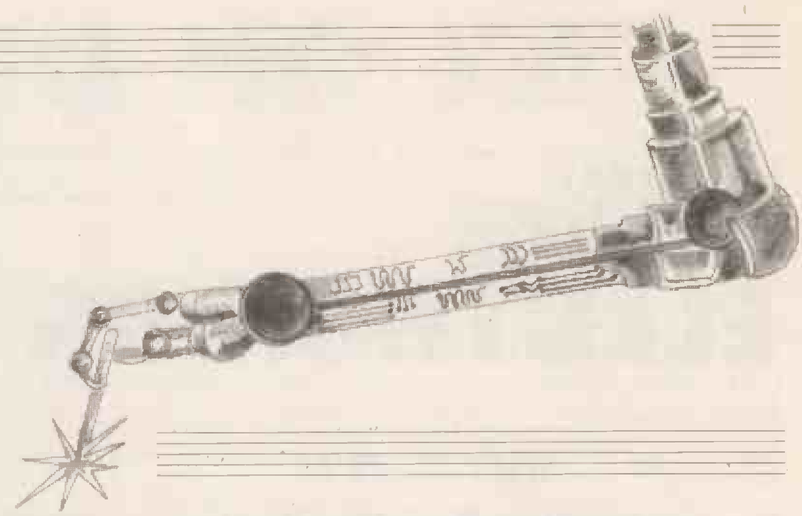
CIRCUIT SURGERY



ALAN WINSTANLEY

Hot on the heels of the last* Surgery, *we follow up with more analysis of the "single resistor" 555 astable, we take the lid off R-C snubbers and look at suppressor capacitors, too.

555 Astable – Fun With!

In April's *Circuit Surgery* I made a minor but obvious blooper, which I attribute to a memory parity error on my part! My thanks to regular reader *Barry Taylor* of Rickmansworth who sets the record straight, keeps me on my toes and adds several very interesting extras. I've re-drawn the astable oscillator circuit in question, see Fig. 1. Mr. Taylor writes:

I was pleased to see your note that a bipolar 555 configured as in April's Fig. 3b cannot give a 50 per cent duty cycle. This will probably surprise many readers because a few other texts insist that this type of astable will indeed give an equal mark-to-space ratio.

The problem is that although the low period is 0·693RC (usually quoted as 0·7RC), the "high" period is longer in this circuit because the voltage available to charge the capacitor is less than the full supply voltage. Thus the capacitor takes longer to charge from 1/3 Vcc to 2/3 Vcc than it would with the CMOS version. The voltage drop is due to the Darlington pair used in the upper half of the 555 output stage, and a figure of 1·35V drop is reasonable.

Calculator ready, here's how the "high" period for this circuit is figured out:

$$T_{HIGH} = -RC_{LN}\left[\frac{\frac{2Vcc}{3} - (Vcc - 1{\cdot}35)}{\frac{Vcc}{3} - (Vcc - 1{\cdot}35)}\right]$$

(T_{HIGH} being the high period, $_{LN}$ being the natural log, Vcc is the supply rail voltage).

For Vcc of +5V, I calculate T_{HIGH} is 1·83 RC, duty cycle 72·5 per cent and the frequency is 0·396 ÷ RC. For a 15V rail, T_{HIGH} is 0·863 RC and yields a 55·5 per cent duty cycle.

However, I didn't follow your note regarding how the CMOS 7555 high-input impedance allows a 50 per cent duty cycle to be generated (p.268). Surely the reason is that the 7555 output "high" voltage is equal to Vcc?

Many thanks for the lucid explanation, and you're right of course – the input impedance has little influence on the duty

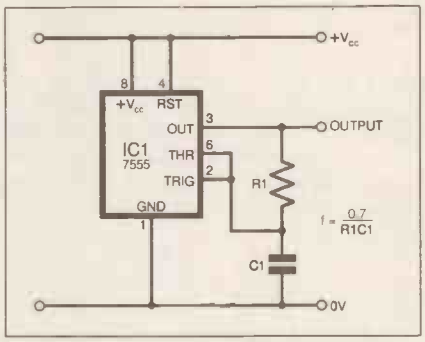


Fig. 1. A CMOS 555 astable.

cycle obtained; sorry about the blooper. An important feature of the CMOS 7555 chip is that its output switches from rail to rail.

The bipolar type is handicapped by the fact that, due to its internal circuitry, its "high" output is always two diode drops below the positive supply rail. So the *most* you'll get out of a vanilla 555 with a 5V rail is typically about +3·8V. A 7555 will offer +4·5V or more.

Referring to Fig. 2, if you use the bipolar 555 in the "single resistor" astable circuit, you can't get a 50 per cent duty cycle (if it matters) for this reason: the chip has a threshold voltage (which pin 6 looks for) of two-thirds Vcc. When the capacitor's charging up, the output is high for this period.

In a classical two-resistor 555 astable, the capacitor charges from the full supply rail voltage. If you have a 10V rail, say, the threshold voltage is +6·66V; so when this voltage is reached, the chip switches over internally and its output goes low.

Different Strokes

Now, if you're charging the capacitor C1 from the *output* pin instead, in the bipolar's case this is always *lower* than the supply rail by about 1·4V. But the chip's threshold voltage is still the *same*, +6·66V.

Because the capacitor charges exponentially (on a curve), it must take progressively longer for it to charge up to +6·66V from a 8·6V rail (i.e. 77 per cent of the applied voltage) than it does from a 10V rail (66 per cent). Hence, the output *high* time is longer for a bipolar than a CMOS 7555 and you can never achieve a 50 per cent duty cycle. That's why the CMOS 7555 is sometimes a better bet.

There are times when the CMOS and the bipolar 555 timer chips do behave as quite different animals. When launched, the CMOS timer was claimed to be a direct plug-in replacement for the bipolar version.

This proved not to be so, and the fact that the NE555 is still soldiering on means that there's plenty of life yet in the old warhorse. One key area concerns the amount of "clout" a 555 chip can deliver.

I remember using the CMOS 7555 for the first time in the mid 1980s and it soon became apparent that in my own circuits, all was not well. The CMOS chip had

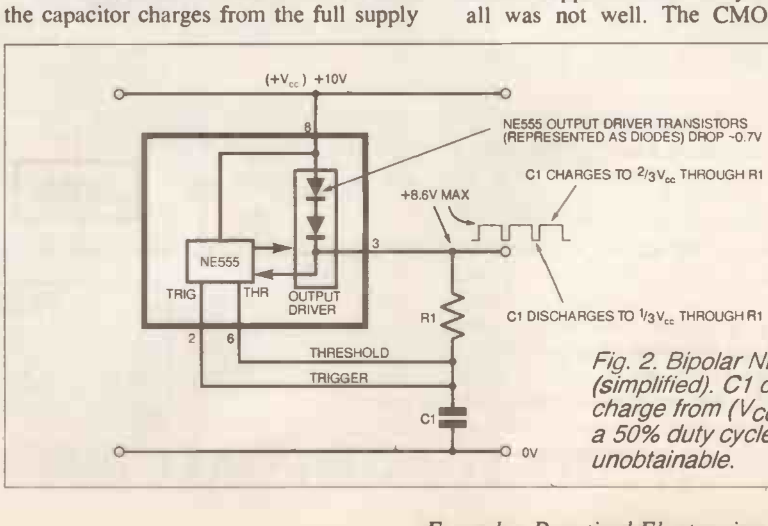


Fig. 2. Bipolar NE555 (simplified). C1 can only charge from (V_{CC}– 1·4V); a 50% duty cycle is unobtainable.

a worse specification for output current sourcing, and I found bizarre behaviour such as the output voltage dropping if I tried to draw anything more than a few tens of milliamps.

It wouldn't drive relays very well. It really needs buffering with a driver transistor (or driver i.c.) on the output if you plan to do spectacular things with it. The bipolar type is more useful in this respect and can sink or source up to 200mA.

Of course, the CMOS type can operate reliably at higher frequencies (2MHz compared with a few hundred kHz) and it has a lower supply current than its bipolar brother (about 0·3mA compared with the bipolar's 6·0mA). It's horses for courses, but at least you now know why they're a bit different.

Wheatstone's Origins

Also following on from April's issue, Mr. Taylor adds: *"It is often forgotten that Wheatstone did not invent the arrangement which bears his name. S.H. Christie described it in 1833 and it was used by Wheatstone with improvements in 1847."*

My thanks to ***Mr Norman Spivey*** of the University of York who sent the following E-mail:

Dear Alan, I am very grateful for the CMOS 555 astable circuit in your article. I like circuits which do the same for less! I found that it modulated an LC v.h.f. oscillator just by connecting it to the same battery – no need to use the output pin!

Also, your UK Sources FAQ *is an excellent source of addresses etc. which I am now storing on my PC, using a text editor to search for names when necessary.*

Thanks! Several readers asked for the document to be E-mailed and we happily obliged. It can be stored on hard disk for future reference, or it prints out at over 20 pages.

By the way, April's issue contains ordering details for those wishing to purchase a printed copy. The *UK Sources FAQ* (Frequently Asked Questions) is also posted into the Internet newsgroup *sci.electronics.components* quarterly. The next one is due in June 1996.

Relay Contact Suppression

I know that several G.P.O. (for younger readers, General Post Office – BT's predecessor) engineers read this column and my item on "contact suppressors" (April 1996 issue) prompted the following from ***Mr. A. Malcolm*** of Bromsgrove.

I'd like to point out that the practice of fitting RC *filters across the contacts can be quite dangerous! It could cause delayed release of relays, for example.*

The solution I was taught (G.P.O. RIS.) was to always fit the suppressor across the inductive load. This should "fail safe", i.e. the resistor will go open circuit if the capacitor fails as the resistor can only dissipate a fraction of a watt.

As a matter of interest the suppressor as supplied by the old G.P.O. (Type FS44) was 100 ohms in series with 0·035µF, sealed in a resin pot. This proved very effective in the hundreds of applications I fitted them over the years.

Thank you for your letter, Mr. Malcolm. I hadn't personally experienced any problems in the past by placing these snubbers across relay contacts (which is, after all, one of their specified applications), and the time constant of the suggested standard *RC* network (100 ohms and 100nF) is very low indeed – 10µs – so I'd be rather surprised if this delay had any detrimental effect on external circuitry.

There are a few examples where suppressors have to be placed directly across contacts, though – such as audio equipment, switches controlling large inductive loads and certain test equipment. Fig. 3 shows a few applications.

Your point is taken though that it is wise to suppress the source of the interference first, rather than the contacts. One must always be mindful of "worst case" conditions, especially when parts are connected directly across the mains.

Class Act

Mains-rated capacitors intended for suppression purposes are generally classified as one of two types, see Fig. 4.

- *Class X – designed for direct connection across the mains, between Live (Line) and Neutral.*
- *Class Y – higher spec., for filtering noise and spikes from Live or Neutral, directly to Earth.*

Being connected to Earth, Class Y capacitors have a much tighter specification for maximum permitted leakage currents, and strict rules exist for their use, especially in medical equipment filtering.

According to the handy book *Newnes Electronics Toolkit* (Geoff Phillips, ISBN 0-7506-0929-X), Class X types further divide into *X1* which are rated for noise pulses exceeding 1·2kV, and *X2* class for spikes equal to or less than this level. ***Be sure to use ONLY Class X or Y mains rated capacitors for DIRECT connection as suppressors across the mains.***

Resistors, too, need careful consideration if used in mains-voltage circuits. Whilst you'll often bear in mind the *power dissipation* value (I^2R) for a resistor as a matter of course, it's rare that you have to consider its *voltage rating*. A rating of 200V a.c. is typical.

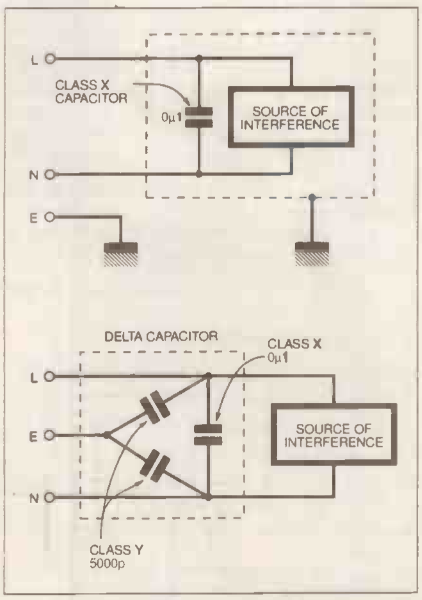


Fig. 4. Suppressor capacitors help prevent interference generated by equipment, feeding into the mains supply, and reduce electromagentic interference.

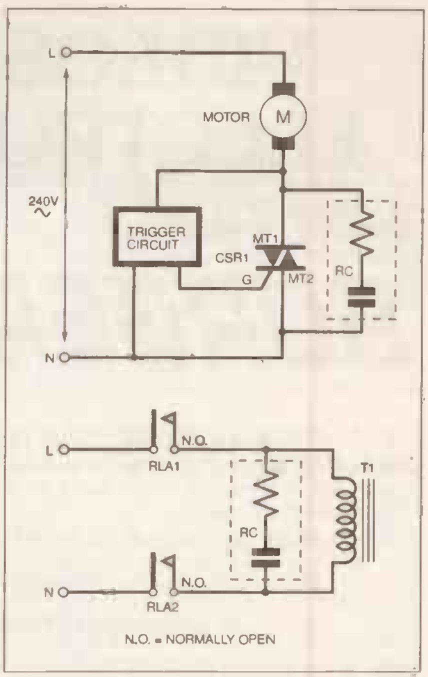


Fig. 3. Typical RC *snubber applications*

The trick is to use two resistors in series if required, so that the applied a.c. voltage is dropped across both of them, keeping them well within their voltage rating.

An unusual place where filter capacitors may crop up unexpectedly is in the secondary side of power supplies. Very occasionally, a ceramic capacitor may be seen placed across the secondary winding, and even across the rectifiers of a bridge rectifier network. They shunt any spikes, which helps to protect the rectifiers from transients borne on the a.c. supply.

Another source of noise is apparently the rectifier itself. An effect which I believe is "hole storage" noise (I'm open to correction – any offers?) can occasionally arise which may become apparent with audio equipment, for example. I once heard a low frequency crackling/buzzing noise on an amplifier which was only eventually eliminated by adding capacitors around the bridge rectifier.

Back Next Month!

I'm delighted to say that due to demand, *Circuit Surgery* returns to its regular *monthly* slot starting next month. This is ***your*** column and ***your*** chance to have your say! If you have any hints and tips which you'd like to pass on, any questions you'd like to quiz us with – or any topical comments to make, then write in!

Drop a line to Alan Winstanley, *Circuit Surgery*, Wimbome Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF, United Kingdom. E-mail **alan@epemag.demon.co.uk.** Send a stamped addressed envelope for a written reply.

For Internet users, you'll also see a new regular column appearing which is geared specially towards the electronics enthusiast, which is penned by yours truly and deals with Internet, World Wide Web and general connectivity issues. A lot is going on at the moment in this area, here at EPE . . . watch this space!

Next Month: I hope to follow up with a few more 555 circuit hints, plus a look at current sources and capacitor charging curves.

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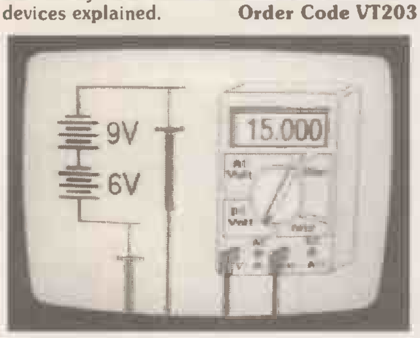

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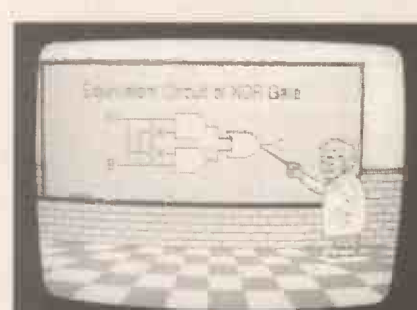

Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier. (All videos are to the UK PAL standard on VHS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

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This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world"
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In fact everything you need to know in order to get started in this absorbing and creative hobby.
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R. A. Penfold
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ELECTRONICS SIMPLIFIED – CRYSTAL SET CONSTRUCTION
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.
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UNDERSTANDING DIGITAL TECHNOLOGY
F. A. Wilson C.G.I.A., C.Eng., F.I.E.E., F.I. Mgt.
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Various chapters cover: Digital Arithmetic, Electronic Logic, Conversions between Analogue and Digital Structures, Transmission Systems. Several Appendices explain some of the concepts more fully and a glossary of terms is included. Altogether a useful foray into the digital world both for newcomers and also for those who need some revision or updating.
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A REFERENCE GUIDE TO PRACTICAL ELECTRONICS TERMS
F. A. Wilson C.G.I.A., C.Eng., F.I.E.E., F.I. Mgt.
Electronic devices surround us on all sides and their numbers are increasing without mercy. Ours is the problem therefore in keeping up with this relentless expansion. Unfortunately we cannot know it all and most of us do not wish to afford the cost of large reference books which explain many concepts in fair detail. Here is an answer, an inexpensive reference guide which explains briefly (but we hope, well) many of the underlying electronics features of practical devices, most of which, to a certain extent, control our lives.
This book is in effect more than just a dictionary of practical electronics terms, it goes a stage further in also getting down to fundamentals. Accordingly the number of terms may be limited but the explanations of the many which are included are designed to leave the reader more competent and satisfied – and this is without the use of complicated mathematics which often on first reading can be confusing.
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Owen Bishop
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R. A. Penfold
This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

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I. D. Poole
Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.

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R. A. Penfold
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The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.

Contains everything you need to know in order to get started in this absorbing hobby.
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A. Pickford
Communications and broadcast satellites are normally inaccessible to individuals unless they are actively involved in their technicalities by working for organisations such as British Telecom, the various space agencies or military bodies. Even those who possess a satellite television receiver system do not participate in the technical aspects of these highly technological systems.

There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively inexpensive equipment. This equipment can be connected to a home computer such as the BBC Micro or IBM compatible PCs, for the decoding of received signals.

This book describes several currently available systems, their connection to an appropriate computer and how they can be operated with suitable software.
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A GUIDE TO THE WORLD'S RADIO STATIONS (1995/96)
P. Shore
Provides the casual listener, amateur radio DXer and the professional radio monitor with an essential reference work designed to guide him or her around the ever more complex radio bands. This new edition has been completely revised and rewritten and incorporates much more information which is divided into the following sections:

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HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
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Audio and Music

PRACTICAL MIDI HANDBOOK
R. A. Penfold
The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.

The Practical MIDI Handbook is aimed primarily at musicians, enthusiasts and technicians who want to exploit the vast capabilities of MIDI, but who have no previous knowledge of electronics or computing. The majority of the book is devoted to an explanation of what MIDI can do and how to exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those manuals.
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V. Capel
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V. Capel
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The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

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R. A. Penfold
This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases).

The preamplifier circuits featured include: Microphone preamplifiers (low impendance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A. equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

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COMPUTERS AND MUSIC – AN INTRODUCTION
R. A. Penfold
Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

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This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.
174 pages **Order code PC107** **£8.95**

ELECTRONIC PROJECTS FOR GUITAR
R. A. Penfold
This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.
110 pages **Temporarily out of print**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold
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REPORTING AMATEUR RADIO

Tony Smith G4FAI

EMC AND KITS

The European Community's Directive on electromagnetic compatibility (EMC) came into force in January 1996. This requires that electrical and electronic equipment sold commercially must now comply with defined EMC protection requirements. In general, this means that such products must have the ability to operate without mutual interference.

Concern has beeen expressed by the Radio Society of Great Britain about the impact of the Directive on the small manufacturers of kits aimed at the amateur radio market. Such kits are an intrinsic part of the Novice Licence training scheme, they provide a relatively inexpensive way to enjoy amateur radio, and provide a degree of self-training which is fundamental to the hobby.

The RSGB's EMC Committee recently posed a number of questions about the effect of the Directive on home-made equipment to the DTI Standards and Technical Regulations Directorate and the following information was received relating to the status of kits:

"Amateur radio apparatus is outside the scope of the EMC Directive 89/336/.EEC, so long as it is not offered commercially for sale. If the kit i.e. set of parts is assembled by an amateur radio operator, it does not have to comply.

"Also, if a kit is deemed a sub-assembly it does not have to comply. When a kit is offered as a finished product when assembled (not amateur radio) it does have to comply."

The RSGB has issued a press release detailing its correspondence and representations to the DTI on this matter over the last six years. The outcome, it says, "will come as a great relief to many kit manufacturers who faced going out of business because of the expense of the compliance procedure."

In case it is thought that users of amateur radio kits are receiving special privileges not accorded to other kit users, it should be mentioned that all amateur radio equipment, home-made or not, is still subject to the terms of the Wireless Telegraphy Acts. The conditions of the amateur licence continue to impose stringent requirements to ensure that no interference is caused to other radio services, including a requirement to close down when in breach of the regulations.

THE AMATEUR'S CODE

In 1928, an American amateur, Paul A. Segal W9EEA, wrote an *Amateur's Guide* which to this day describes what a radio amateur should aspire to. The code is re-published annually in the American Radio Relay League's *Handbook for Radio Amateurs* and the wording is specific to the USA.

A few years ago, New Zealand's national society, NZART, suggested an amended non-specific version of the code and the International Amateur Radio Union invited all member societies to adopt this version as their own. The amended code reads as follows:

"The Radio Amateur is:

CONSIDERATE . . . never knowingly operates in such a way as to lessen the pleasure of others.

LOYAL . . . offers loyalty, encouragement and support to other amateurs, local clubs, and the national member-society of the International Amateur Radio Union, through which Amateur Radio is represented to government and internationally.

PROGRESSIVE . . . with knowledge abreast of science, a well built and efficient station and operation above approach.

FRIENDLY . . . slow and patient sending when requested, friendly advice and counsel to the beginner; kindly assistance, cooperation and consideration for the interests of others. These are the hallmarks of the amateur spirit.

BALANCED . . . radio is an avocation, never interfering with duties owed to family, job, school, or community.

PATRIOTIC . . . station and skill always ready for service to country and community."

With its roots in the '20s the wording of the code is slightly archaic, and calls for standards that nowadays seem to be somewhat out of fashion. It does show, though, that within at least one area of secular activity such values are still regarded as something to try to live up to!

MEGS MORSE TUITION

While there is a possibility that the amateur Morse test may be abolished in 1999, there is also a possibility that it will be replaced by some other test, such as a computer examination. In the meantime, anyone wishing to obtain a licence to operate on the amateur bands below 30MHz must still pass a 12w.p.m. Morse test.

There are plenty of ways to learn Morse, but one particular scheme shows very clearly how dedicated some people are in putting back into their hobby something of what they have taken out. Their activities are a good example of what the Amateur's Code is all about!

In this instance, I'm referring to MEGS (Morse Enthusiasts Group Scotland), which provides assistance to beginners or existing operators wishing to improve their Morse skills.

All are welcome to join the Group, without geographical restriction, and to take part in its comprehensive training programme. This ranges from a beginners' course to advanced techniques, using both tape and "on-air" training methods as appropriate.

Life membership costs just £1, and further information can be obtained from *George M. Allan GM4HYF, 22 Tynwald Avenue, High Burnside, Rutherglen, Glasgow G73 4RN*. Please mention that you read about MEGS in this column.

To encourage members to achieve greater ability, and to enjoy using Morse on the air, the Group has introduced a progressive Proficiency Award. The 12w.p.m. award requires one contact at that speed with MEGS club stations GM0RSE or GM0RSE/P plus contacts with two other MEGS members.

Awards for higher speeds at 15, 18, and 20w.p.m., each require a further contact with GM0RSE or GM0RSE/P and a further two members, so that for the final 20w.p.m. award four contacts with the club station are required (at 12, 15, 18 and 20w.p.m.) plus eight other contacts with MEGS members.

Qualifying contacts are arranged by calling in to the MEGS nets on 3·530MHz on Monday and Thursday evenings from 7.30p.m. to 8.30p.m. local time. Any amateur station may call in and work MEGS stations on these 12w.p.m. nets but only members may take part in the awards programme.

ISWL NEW PUBLICATION

The International Short Wave League has published an updated version of its booklet containing all amateur radio callsign prefixes worldwide, listed alphabetically by country and alphanumerically by prefix. This new publication includes all new prefixes allocated since the last edition.

It has two separate listings. The first is the official DXCC list, showing all countries with which contacts qualify for the prestigious DX Century Club Awards administered by the American Radio Relay League. This list is also used for many awards issued by other organisations.

The second listing is intended for those working for ISWL awards or taking part in ISWL contests. This expands on the DXCC list and includes the call areas of countries such as Australia, Canada, and the USA, plus many islands and other locations.

While particularly useful for DXers and contesters, this book is also helpful for other licensed amateurs or shortwave listeners, enabling them to identify the country of origin (and sometimes the particular part of that country) where an amateur station worked or heard is located.

The price is unchanged at £2.50, and IRCs or postage stamps to the same value are also acceptable. The book can be obtained from the *International Short Wave League (Ref. EPE), 3 Bromyard Drive, Chellaston, Derby DE73 1PF*.

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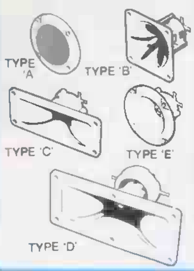

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ALL EARBENDER UNITS 8 OHMS (Except EB8-50 & EB10-50 which are dual impedance tapped @ 4 & 8 ohm)

BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED SURROUND

8" 50watt EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 7KHz SENS 97dB. **PRICE £8.90 + £2.00 P&P**

10" 50WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz, FREQ. RESP. TO 5KHz, SENS. 99dB. **PRICE £13.65 + £2.50 P&P**

10" 100WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz, FREQ. RESP. TO 3KHz, SENS 96dB. **PRICE £30.39 + £3.50 P&P**

12" 100WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz, FREQ. RESP. TO 3 KHz, SENS 93dB. **PRICE £42.12 + £3.50 P&P**

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

5¼" 60WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz, FREQ. RESP. TO 20KHz, SENS 92dB. **PRICE £9.99 + £1.50 P&P**

6½" 60WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz, FREQ. RESP. TO 20KHz, SENS 94dB. **PRICE £10.99 + 1.50 P&P**

8" 60WATT EB8-60TC (TWIN CONE) HI-FI, MILTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz, FREQ. RESP. TO 18KHz, SENS 89dB. **PRICE £12.99 + £1.50 P&P**

10" 60WATT EB10-60TC (TWIN CONE) HI-FI, MULTI ARRAY DISCO ETC.
RES. FREQ. 35Hz, FREQ. RESP. TO 12KHz, SENS 98dB. **PRICE £16.49 + £2.00 P&P**

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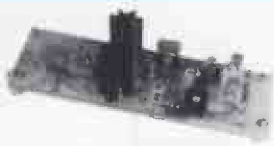

PHOTO: 3W FM TRANSMITTER

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