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MAY 1994

INCORPORATING ELECTRONICS MONTHLY

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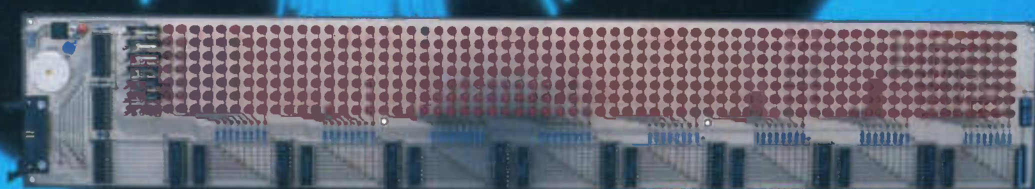
TRANSCUTANEOUS PAIN RELIEF

L.E.D. MATRIX MESSAGE DISPLAY



MOVING MESSAGES AND GRAPHICS

STEREO NOISE GATE

CAPACITANCE AND INDUCTANCE METER

THE No. 1 INDEPENDENT MAGAZINE for ELECTRONICS, TECHNOLOGY and COMPUTER PROJECTS

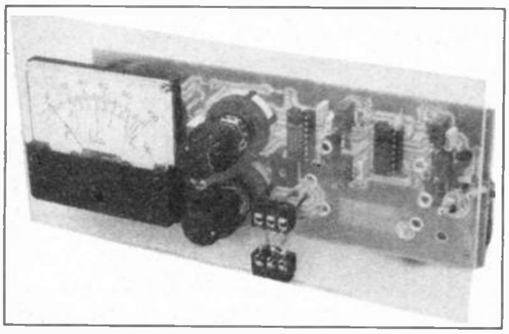
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

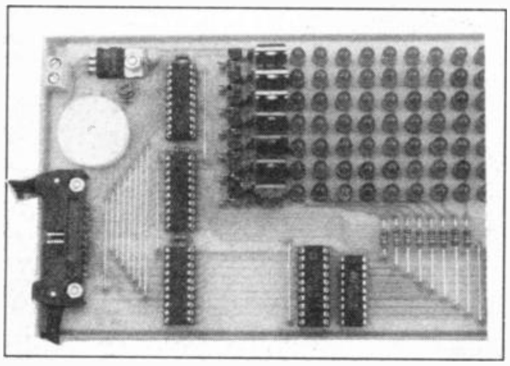
VOL. 23 No. 5 MAY 1994

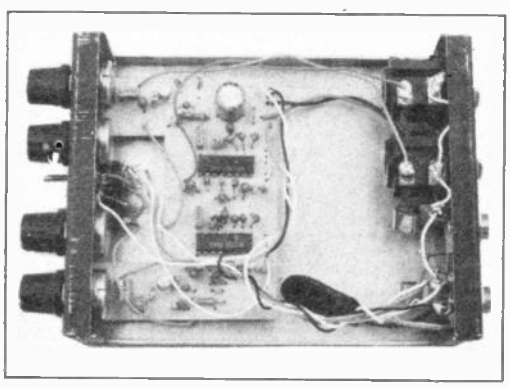
EVERYDAY WITH PRACTICAL ELECTRONICS

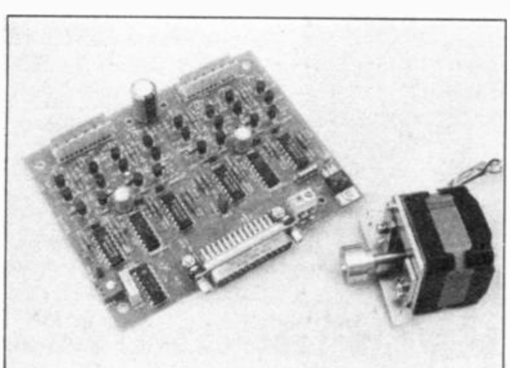
INCORPORATING ELECTRONICS MONTHLY

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









Projects

Series

Features

Our June '94 issue will be published on Friday, 6 May 1994. See page 335 for details.

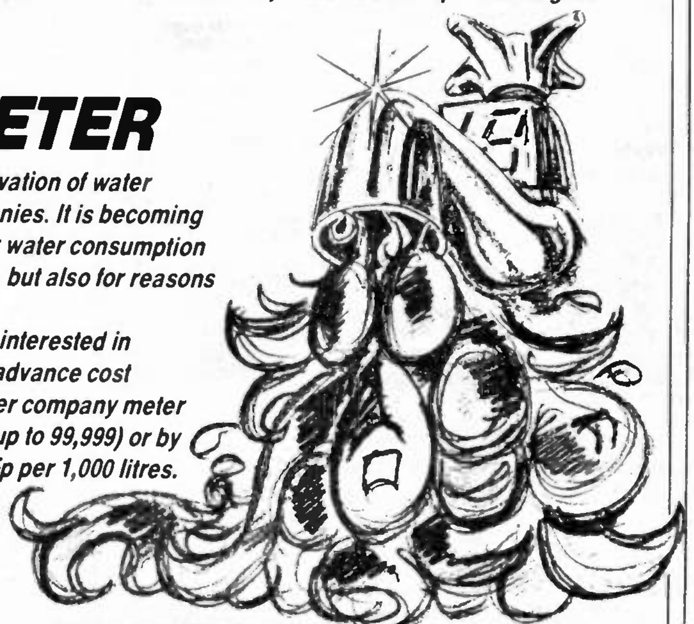
P.I. MICROCONTROLLER METAL DETECTOR

A deep seeking pulse induction metal detector using a dedicated microcontroller to simplify the circuitry and enhance performance. No ground effect, easy to build, crystal controlled and neatly housed. A complete kit together with all hardware will be available.

DIGITAL WATER METER

Lately there has been much publicity concerning conservation of water supplies and the rates charged by regional water companies. It is becoming increasingly obvious that not only must we decrease our water consumption for ecological reasons, particularly in Southern England, but also for reasons of cost.

This water meter is intended for use by anyone who is interested in monitoring their water consumption. It will also provide advance cost guidance to those who may be considering having a water company meter installed. The unit displays water consumption in litres (up to 99,999) or by cost up to £999.99. The unit cost can be set from 1p to 255p per 1,000 litres.



SMART SWITCH

Prevent your house lights being switched on when they are not essential or being left on inadvertenly. This switch replacement unit uses a microcontroller to decide if the lights are required and turn them off if they are not.

With the imposition of VAT on fuel bills this unit could start to save you some hard cash.

EVERYDAY WITH PRACTICAL ELECTRONICS

OUR JUNE ISSUE WILL BE ON SALE FRIDAY MAY 6TH

NEXT MONTH

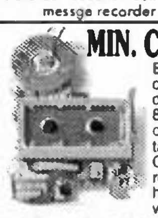
AMAZING OFFERS FROM GREENWELD

SOUND EFFECT CHIPS

Brond New Ronge, unovoiloble elsewhere! Greot collection of COB's (Chip-on-boord-micro chip bonded to PCB to which you odd o few components) oll ot super prices, with mossive discounts for volume buyers!

Code	Description	Prices (any mix) 1-24	25-99	100+
SG1	- Four troin noises	3.04	1.52	1.01
SG2	- Phone tones	1.58	0.80	0.53
SG3	16 door chime tunes	2.84	1.43	0.95
SG4	3 sirens ond mochine gun(!)	1.89	0.95	0.63
SG5	Ding-dong door chime	1.79	0.90	0.60
SG6	Melody IC in TO92 pockoge	1.60	0.80	0.53
SG7	As SG6, but complete with bottery, slide switch ond piezo on odhesive cord to use in book or greetings cord.	2.10	1.05	0.70
SG8	28 second solid stote messge recorder	11.76	5.88	3.92

MIN. CASSETTE DECK



Extremely high quality compact mini cassete deck. Overall size only 89x57x16.5mm. 3V operation. Motor has tacho sensor. Combined 4 track record/playback/erase head. Another motor with worm drive just 14x11 mm dia used to engage the pinch roller with the capstan. Brass flywheel, diecast frame. No electronics, but flying leads from motor, head and switch. **Suberb value at £4.95.**

SPECIAL PURCHASE OF REDUCED SHANK TUNGSTEN CARBIDE PCB DRILL BITS

All have 3.15mm shank. They normally cost around £3 each, but we have about 6000 of the four sizes listed below at very special prices!

Available in these sizes only:

Code	Size	1+	25+	100+
Z3232	0.85mm	£1.00	0.50	0.40
Z3233	0.95mm	£1.00	0.50	0.40
Z3234	1.10mm	£1.00	0.50	0.40
Z3235	1.15mm	£1.00	0.50	0.40

K884 Pack of 8 drill bits - 2 each of above sizes £5.95

Micro - Professor

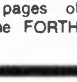
As featured last month, still have good supplies of these! (we purchased over 5000!) Full details in BL102 - briefly they are:

Z9197 EPROM Programmer board. This 157x107mm panel has a 28 pin ZIF skt, 8255, 2732 and 3 x HM6116LP-3 RAM chips, all in sockets + 7 other chips. £3.95

Z9198 Input/Output control and memory expansion board, with a breadboard user area, overall size 222x158mm. All this for £5.95

Z9196 Printer board 157x108mm. This is probably the most useful panel, and we hope to supply a disk with it to use with a PC. £7.95

Z5714 BASIC chip (27C64 EPROM) + programming manual. Again, for use with the Micro-Professor. 12 chapters + 9 appendices - 196 pages of informative text. £3.95



Z5715 FORTH chip (2764 EPROM) + programming manual 146 pages of comprehensive information on the FORTH language. £2.95

LED MATRIX MESSAGE DISPLAY

As featured in this months E&PE!!

High spec self build unit with a host of features! Complete kit of parts, including all PCB's EPROM & hardware. *(not cases).* **Order Code EK102**

Individual component prices SAE list. ***ALL FOR £119.95***

EPE SOUNDAC

A low cost sound card for your PC!

As featured in last months E&PE!!

Complete kit of parts, including PCB & Software. **Order Code EK101** ***FOR JUST £12.95***

CD & CASSETTE DEAL

We've just tied up a deal with **Tring International PLC**, the biggest and fastest growing budget CD and tape manufacturer in the UK, to become one of their wholesalers. This means we'll be stocking a wider range of their product, some at even lower prices! Just Introduced is their *Royal Philharmonic Collection*. In return for being sponsored by Tring and Classic FM, the RPO have produced exclusive superb quality recordings at incredibly low prices - watch out for rave reviews in the classical music press! To promote this new range, a sampler CD has been produced featuring 14 popular classical tracks lasting over an hour ***and all for just £2.99!***

Order Code **TRP999 - Royal Philharmonic** ***Collection Sampler Album - £2.99***

Features track(s) from each of the CD's listed below

Order Code **TRP001 - Beethoven - £3.99**
Symphony No.6 in F Major, Opus 68 'The Pastoral'

Order Code **TRP010 - Dvorak - £3.99**
Symphony No. 9 in E Minor 'From the New World'

Order Code **TRP009 - Vivaldi - £3.99**
The Four Seasons

Order Code **TRP005 - Gershwin - Ravel - Debussy - £3.99**
Mixed Collection

Order Code **TRP006 Tchaikovsky - £3.99**
The Nutcracker Suite/Swan Lake Suite

Order Code **TRP007 - Hoist - £3.99**
The Planets Suite, Opus 32
St Paul's Suite for string orchestra, Opus 29 No.2 £3.99

Order Code **TRP002 - Bizet**
Carmen Suites No. 1 and 2
Grieg
Peer Gynt Suites No. 1 and 2 - £3.99

Order Code **TRP004 - Mozart - £3.99**
Symphony No. 40 in G Minor, K550/
Symphony No. 41 in C, K551 'Jupiter'

Order Code - **TRP008 - Wagner - £3.99**

Order Code **TRP003 - Rimsky - Korsakov - £3.99**
Scheherezade - Symphonic Suite: Opus 35
Capriccio Espagnol, Opus 35

Sound Effects CD's

Absolutely essential for all drama groups & video producers - this set of 5 CD's will ensure the right effect is available.

SPECIAL OFFER!

ALL 5 DISKS FOR £19.95

EFX001 SOUND FX - Frights of the night Including Ghostly Sounds, Demonic Laughter, Chains, Footsteps, Screams and many more. £4.99

EFX002 SOUND FX - 101 Sound Effects Including Roller Coatster, 707 Jet Landing, Champagne Cork pops, Clock Ticking and many more. £4.99

EFX003 SOUND FX - Outer Space Including Cruisers Landing, Caverns, Vision of Mars, Space siren and many more. £4.99

EFX004 SOUND FX - Workshop of Sound Including Roulette Wheel, Basketball Game, Cats Meowing and many more. £4.99

EFX005 SOUND FX - Musical Including Bass & Drums, City Chase, Sultry Trumpet, Lullaby and many more. £4.99

Phone Nos: **SALES 0703 236363**; Technical 325999; Accounts 231003; Fax (All depts) 236307; FaxOnDemand 236315*

*To obtain latest lists, info etc, just dial 0703 236315 from any fax machine and follow instructions.

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All 1 off and pack prices include VAT, qty prices do not. P&P £3 per order (£9.50 next day). Min Credit Card £12; Official Orders welcome from Education - min invoice charge £15. Payment accepted by cheque, PO, cash, book tokens, Access, Visa, Connect. Our stores (over 10,000 sq ft) have enormous stocks. We are open from 8-5.30 Mon-Sat. Come and see us!

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NEW KITS, NEW KITS, NEW KITS

Message Recorder

Kit 43 New to the range of kits currently stocked is a low cost solid state message recorder. The simple to assemble PCB measures just 51x38mm and has the audio processor already mounted and bonded. Everything necessary to complete the kit giving up to 28 secs of recorded speech is included. It uses a miniature electrec microphone and 78mm speaker, and once the message has been recorded, it can be played back once or continuously. **Excellent value at £19.95**

CADD 6.0

Design and Drafting Software for the PC. Brand new sealed package with 3.5/5.25" disks for the professional. Full spec on request. List price of V6.1 is £420. **Our price £69.95**

AIR PURIFIER AND IONIZER

BO47E

Power 12Vdc 1.8W
Dims . . . . 110 x 65mm

A compact, stylish ionizer and air purifier designed specifically for car, truck and bus use with a coverage volume of 14m3. Removes unpleasant smells, airborne dust, bacteria, tobacco smoke, etc. Supplied with a double sided self adhesive pad.

½PRICE!! £4.95

VIDEO LIGHT

TO84

20W halogen video light with 6V 1700mAh battery pack. The video light is provided with a synchronisation lead which, when the light is switched to "remote", allows the light to switch on when the camcorder is switched on (Sony and Panasonic camcorder). The on/off/remote switch has a lock button to prevent accidental movement.

ONLY **£24.95**

Did you know - we carry over 50 different power supplies? Voltage from 3V upwards in currents 100mA to 50A at prices from 50p to £1.00. This massive range of new & surplus units is shown in our main catalogue & latest Bargain Lists.

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PROFESSIONAL QUALITY KITS

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Whether your requirement for surveillance equipment is amateur, professional or you are just fascinated by this unique area of electronics SUMA DESIGNS has a kit to fit the bill. We have been designing electronic surveillance equipment for over 12 years and you can be sure that all our kits are very well tried, tested and proven and come complete with full instructions, circuit diagrams, assembly details and all high quality components including fibreglass PCB. Unless otherwise stated all transmitters are tuneable and can be received on an ordinary VHF FM radio.

Genuine SUMA kits available only direct from Suma Designs. Beware inferior imitations!

UTX Ultra-miniature Room Transmitter
Smallest room transmitter kit in the world! Incredible 10mm x 20mm including mic. 3-12V operation. 500m range £16.45

MTX Micro-miniature Room Transmitter
Best-selling micro-miniature Room Transmitter
Just 17mm x 17mm including mic. 3-12V operation. 1000m range £13.45

STX High-performance Room Transmitter
Hi performance transmitter with a buffered output stage for greater stability and range. Measures 22mm x 22mm including mic. 6-12V operation, 1500m range £15.45

VT500 High-power Room Transmitter
Powerful 250mW output providing excellent range and performance. Size 20mm x 40mm. 9-12V operation. 3000m range £16.45

VXT Voice Activated Transmitter
Triggers only when sounds are detected. Very low standby current. Variable sensitivity and delay with LED indicator. Size 20mm x 67mm. 9V operation. 1000m range... £19.45

HVX400 Mains Powered Room Transmitter
Connects directly to 240V AC supply for long-term monitoring. Size 30mm x 35mm. 500m range £19.45

SCRX Subcarrier Scrambled Room Transmitter
Scrambled output from this transmitter cannot be monitored without the SCDM decoder connected to the receiver. Size 20mm x 67mm. 9V operation. 1000m range £22.95

SCLX Subcarrier Telephone Transmitter
Connects to telephone line anywhere, requires no batteries. Output scrambled so requires SCDM connected to receiver. Size 32mm x 37mm. 1000m range £23.95

SCDM Subcarrier Decoder Unit for SCRX
Connects to receiver earphone socket and provides decoded audio output to headphones. Size 32mm x 70mm. 9-12V operation £22.95

ATR2 Micro Size Telephone Recording Interface
Connects between telephone line (anywhere) and cassette recorder. Switches tape automatically as phone is used. All conversations recorded. Size 16mm x 32mm. Powered from line £13.45

★★★ Specials ★★★

DLTX/DLRX Radio Control Switch
Remote control anything around your home or garden, outside lights, alarms, paging system etc. System consists of a small VHF transmitter with digital encoder and receiver unit with decoder and relay output, momentary or alternate, 8-way dil switches on both boards set your own unique security code. TX size 45mm x 45mm. RX size 35mm x 90mm. Both 9V operation. Range up to 200m.
Complete System (2 kits) £50.95
Individual Transmitter DLTX £19.95
Individual Receiver DLRX £37.95

MBX-1 Hi-Fi Micro Broadcaster
Not technically a surveillance device but a great idea! Connects to the headphone output of your Hi-Fi, tape or CD and transmits Hi-Fi quality to a nearby radio. Listen to your favourite music anywhere around the house, garden, in the bath or in the garage and you don't have to put up with the DJ's choice and boring waffle. Size 27mm x 60mm. 9V operation. 250m range £20.95

UTLX Ultra-miniature Telephone Transmitter
Smallest telephone transmitter kit available. Incredible size of 10mm x 20mm! Connects to line (anywhere) and switches on and off with phone use. All conversation transmitted. Powered from line. 500m range £15.95

TLX700 Micro-miniature Telephone Transmitter
Best-selling telephone transmitter. Being 20mm x 20mm it is easier to assemble than UTLX. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. 1000m range £13.45

STLX High-performance Telephone Transmitter
High performance transmitter with buffered output stage providing excellent stability and performance. Connects to line (anywhere) and switches on and off with phone use. All conversations transmitted. Powered from line. Size 22mm x 22mm. 1500m range £16.45

TKX900 Signalling/Tracking Transmitter
Transmits a continous stream of audio pulses with variable tone and rate. Ideal for signalling or tracking purposes. High power output giving range up to 3000m. Size 25mm x 63mm. 9V operation £22.95

CD400 Pocket Bug Detector/Locator
LED and piezo bleeper pulse slowly, rate of pulse and pitch of tome increase as you approach signal. Gain control allows pinpointing of source. Size 45mm x 54mm. 9V operation £30.95

CD600 Professional Bug Detector/Locator
Multicolour readout of signal strength with variable rate bleeper and variable sensitivity used to detect and locate hidden transmitters. Switch to AUDIO CONFORM mode to distinguish between localised bug transmission and normal legitimate signals such as pagers, cellular, taxis etc. Size 70mm x 100mm. 9V operation £50.95

QTX180 Crystal Controlled Room Transmitter
Narrow band FM transmitter for the ultimate in privacy. Operates on 180 MHz and requires the use of a scanner receiver or our QRX180 kit (see catalogue). Size 20mm x 67mm. 9V operation. 1000m range £40.95

QLX180 Crystal Controlled Telephone Transmitter
As per QTX180 but connects to telephone line to monitor both sides of conversations. 20mm x 67mm. 9V operation. 1000m range £40.95

QSX180 Line Powered Crystal Controlled Phone Transmitter
As per QLX180 but draws power requirements from line. No batteries required. Size 32mm x 37mm. Range 500m £35.95

QRX180 Crystal Controlled FM Receiver
For monitoring any of the 'Q' range transmitters. High sensitivity unit. All RF section supplied as a pre-built and aligned module ready to connect on board so no difficulty setting up. Outpt to headphones. 60mm x 75mm. 9V operation £60.95

A build-up service is available on all our kits if required.

UK customers please send cheques, POs or registered cash. Please add £1.50 per order for P&P. Goods despatched ASAP allowing for cheque clearance. Overseas customers send sterling bank draft and add £5.00 per order for shipment. Credit card orders welcomed on 0827 714476.

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Digital Lux Meter ■ 3 ranges ■ 3½ digit LCD ■ Data hold output terminal £68.95

Sound Level Meter ■ 40 to 120 db ■ Two ranges £51.95

Analogue Clamp Meter ■ 0/300 amps ■ AC 5 ranges ■ 0/750 VAC 0/75v DC ■ 0/200 K OHM £36.95

Digital Clamp Meter ■ 3½Digit ■ 11 ranges incl temperature ■ Data hold etc £63.50

AC/DC Current Clamp ■ 0/2000 amps AC/DC two ranges for use with Dmm's £58.95

Temperature Measurement ■ Dual input 3½ Digit °c/°f with thermocouple (XI) £45.95

BENCH INSTRUMENTS

Digital LED Capacitance autorange bench meter 0.1% £99.95

LCR bridge £126.00

7 Digit frequency 10HZ to 200MHZ £89.95

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†single meter *twin meter

0/24v dc 0/3amps †£79.95

0/24v dc 0/5amps †£97.00

0/30v dc 0/3 amps *£145.00

Twin version *£265.00

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6 Range RF Gen 100 KHZ to 150 MHZ (350MHZ Harmonics) £124.00

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Expandable to cover virtually any programmable part including serial E^2, PALS, GALS, EPLD's and microcontrollers from all manufacturers.

DESIGN: Not a plug in card but connects to the PC serial or parallel port; it comes complete with powerful yet easy to control software, cable and manual.

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VARIABLE POWER SUPPLY. Stabiized, short circuit protected. Gives 3-30v DC at 2.5A, ideal for workshop or laboratory. £14 kit, £18 built. 24VAC required.
LEAD ACID CHARGER. Two automatic charging rates(fast and slow), visual indication of battery state. Ideal for alarm systems, emergency lighting, battery projects etc. £12 kit, £16 built.
PHONE LINE RECORDER. Device that connects to the 'phone line and activates a cassette recorder when the handset is lifted. Ideal for recording 'phone conversations etc!. £8 kit, £12 built.
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PHONE BUG DETECTOR. This device will warn you if somebody is eavesdropping on your 'phone line. £6 kit £9 built.
PHONE BUG. Small bug powered by the telephone line. Only transmits when the phone is used. Popular surveillance product. £8 kit, £12 built.
STROBE LIGHT. Bright strobe light with an adjustable frequency of 1-60hz. (a lot faster than conventional strobes!) £16 kit, £20 built.
4W FM TRANSMITTER. 3 RF stages, audio preamp. 12-18vDC. Medium powered bug £20 kit, £28 built.
3 CHANNEL LIGHT CHASER. 3x 800w output, speed and direction controls, can be used with 12 led's (supplied) or TRIACS for mains lights (also supplied). 9-15v DC. £17 kit, £23 built.
25W FM TRANSMITTER. 4 stage, a preamp will be required. (Our preamp below is suitable) £79 built.(no kits).
SOUND EFFECTS GENERATOR. Produces any thing from bird chips to sirens! add sounds to all sorts of things £9 kit £13 built.
FM/AM SCANNER. Well not quite, you have to turn the knob yourself but you will hear things on this radio (even TV) that you would not hear on an ordinary radio! A receiver that covers 50-160MHZ both AM and FM. Built in 5w amplifier. £15 kit, £20 built.
CAR ALARM SYSTEM. Works on vibration and/or voltage drop from door etc being opened. Entry and exit delays plus adjustable alarm duration. Low cost protection! £12 kit, £16 built.
15W FM TRANSMITTER. 4 stage, high power bug. You will need a preamp for this (see our preamp below which is ok) £69 built. (no kits).
1W FM TRANSMITTER. 2 stage including preamp and mic. Good general purpose bug. 8-30VDC. £12 kit, £16 built.

50 I/C's for £1.50
Nice mix of chips at a bargain price!

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Good mixed pack of 100 capacitors for just £1.00

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100 small mixed electrolytic capacitors just £1.00

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250 low wattage resistors, ideal for most projects etc. Just £1.00

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Hi wattage pack, good selection of mixed wattages and values 50 in all, bargain price just £1.00

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Nice selection of 25 mixed preset pots for just another £1!

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10 different connectors, again for £1

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30 mixed 1.25" fuses again ideal for spares etc. Just £1.00

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25 Metres of insulated wire for just £1.00, good for projects etc.

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100 assorted pieces of sleeving for connectors etc. Yours for just £1.00

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100 assorted diodes for just £1.00

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20 light emitting diodes for £1.00

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50 mixed transistors, another bargain at £1.00

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10 things that make a noise for just £1.00!

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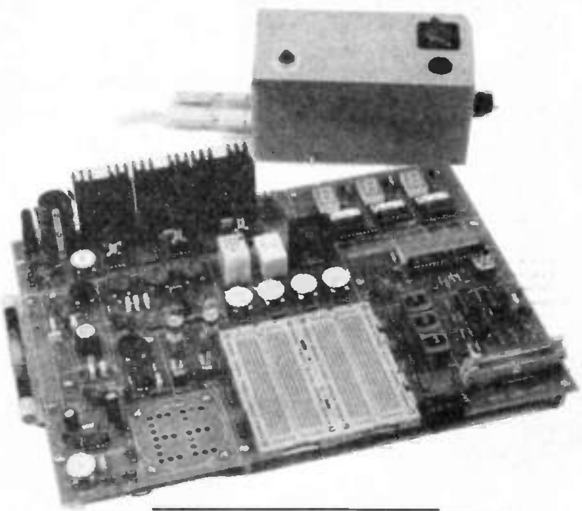

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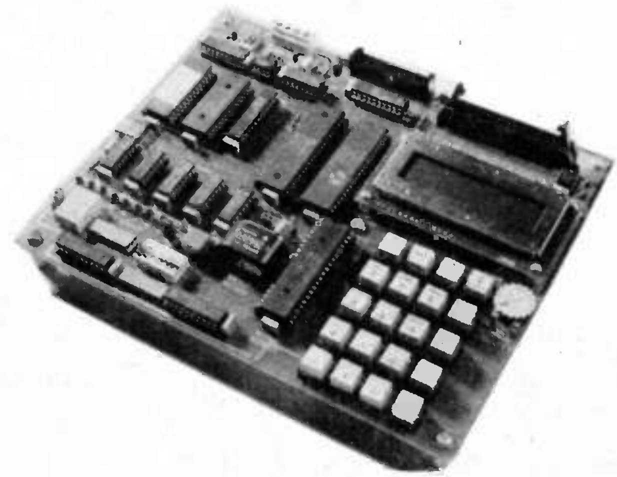

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1.0	–	–	£0.05	£0.06	£0.15
2.2	–	–	£0.05	£0.06	£0.18
4.7	–	–	£0.05	£0.08	–
10	£0.05	£0.05	£0.06	£0.08	£0.48
22	£0.05	£0.05	£0.09	–	–
47	£0.06	£0.06	£0.11	–	–
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470	£0.15	£0.19	£0.57	–	–
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2200	£0.37	£0.57	–	–	–
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2.2	–	–	£0.10	£0.10	£0.22
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10	–	£0.12	£0.12	£0.12	–
22	–	£0.09	£0.13	£0.17	–
47	£0.10	£0.11	£0.16	£0.20	–
100	£0.10	£0.13	£0.21	–	–
220	£0.13	£0.18	£0.42	–	–
470	£0.21	£0.24	£0.69	–	–
1000	£0.33	£0.40	£1.05	–	–
2200	£0.52	£0.64	–	–	–
4700	£0.90	–	–	–	–

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LF353	£0.41
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LM377	£2.57
LM380N	£1.12
LM381	£2.70
LM386	£0.48
LM387	£1.60
LM392N	£0.79
LM393N	£0.28
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INCORPORATING ELECTRONICS MONTHLY

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PLANNING

I keep a large wipe-off planning chart in my office on which the main projects and features for a year's issues of EPE are listed and juggled to give a good balance. I tend to plan each issue well ahead and at the present time have a good idea of what will be featured over the next seven or eight months. We can of course always swap things around if something topical, or right up to the minute in design, comes up.

Usually I tend to select what I feel will be the most popular projects and spread them across a few issues, then add items like test gear, alarms or household gadgets in an effort to carry something to interest everyone in each issue. So what is all this waffle leading up to?

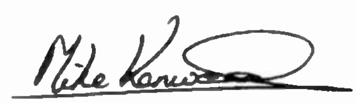
PROJECTS

I don't think that at any time in the last few years we have had such a wide range of excellent projects under preparation. Over the last couple of months we have published the very popular CCD Camera, MOSFET P.S.U. and EPE SounDAC, in this issue we have the Message Display Unit and the TENS Unit beside the other excellent articles.

We presently have "in the pipeline" a Digital Water Meter, Metal Detector, Stereo Hi-Fi Controller, plus a range of Video Modules for camcorder users, a Guitar Tuner, Solid State Voice Recorder and an Experimental Noise Cancelling Unit. On the topical side we also have a Smart Switch which should help to cut the electricity bill and offset at least some of the VAT now being added. That together with the Metal Detector should be in next month's issue.

MAKE SURE

The message is that you should make sure you don't miss any issues of EPE. Please place a regular order with your newsagent, he will either deliver or shop save an issue for you. Alternatively why not take out a subscription, a year's supply costs less than the cover price of the twelve issues and we post them in time to arrive at your home before they appear on the newstands (in the UK), you don't pay anything for the postage and you avoid any cover price increase during the year. See page 402 for a subscription order form.



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Certain back issues of EVERYDAY ELECTRONICS, PRACTICAL ELECTRONICS and EVERYDAY with PRACTICAL ELECTRONICS (from Nov '92 onwards) are available price £2.20 (£3 overseas surface mail) inclusive of postage and packing per copy – **£ sterling only please,** Visa and Access (MasterCard) accepted, minimum credit card order £5. Enquiries with remittance, made payable to Everyday with Practical Electronics, should be sent to Post Sales Department, Everyday with Practical Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH Tel: 0202 881749. In the event of non-availability one article can be photostatted for the same price. *Normally sent within seven days but please allow 28 days for delivery.* **We have sold out of Jan, Feb, Mar, Apr, May, June, Oct, & Dec 88, Mar, May & Nov 89, Mar 90, April, Aug & Sept 91 Everyday Electronics, and can only supply back issues from Jan 92 to Aug 92 (excluding Mar 92) of Practical Electronics. Dec 92, Jan, Feb and Merch 93 Everyday with Practical Electronics are also unavailable.**

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We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply must be accompanied by a **stamped self-addressed envelope** or **a self addressed envelope and international reply coupons.** Due to the high cost **we cannot reply to overseas readers queries by Fax.**

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

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

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

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Constructional Project

SIMPLE TENS UNIT

ANDY FLIND

Research suggests that up to 70 per cent of "pain" victims get relief by using a TENS unit – If you can afford one!

Our pocket-size unit will cost you a fraction of the price of current units used by the NHS, and it features continous or pulsed operation plus amplitude control.

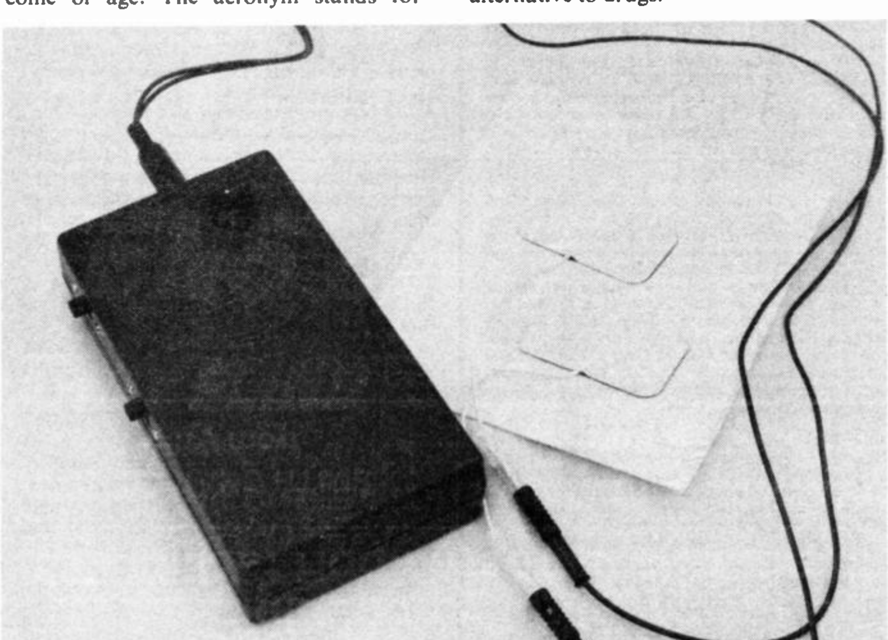
MANY years ago, the author owned a gadget described as a "medical coil". The heart of this device was a six-inch long induction coil, with a buzzer-like armature and contact arrangement for rapid supply current interruption. A chrome plated brass tube could be moved in or out of the coil to adjust mutual inductance to the secondary winding, connected to which were electrode "handles" to be held by the user.

With green cotton insulation, chromed tube, brass fittings and a polished wood base the instrument was a handsome sight, and with the tube fully withdrawn it could administer a most unpleasant shock. The exact benefit of this was never fully understood, but no doubt the makers had some good reason for its production.

With TENS, the direct application of electricity for medical purposes has come of age. The acronym stands for "*Transcutaneous Electrical Nerve Stimulation*" (try saying that after a few pints of Black Label!) and it's usual application is in pain relief.

No longer a curiosity, TENS is now widely used by the NHS, where some readers may have already experienced it. In use, two or more electrodes are placed on the skin surface, usually above or to either side of the site of the pain, and a small, pulsed current is passed between them.

In many cases this produces significant relief. The reason for this is not fully understood. Some literature refers to "blocking of the nerve impulses", but the generally accepted theory is that the treatment stimulates the release of chemicals known as "endorphins", a sort of naturally produced opiate. Either way, for many sufferers TENS is a safe and useful alternative to drugs.



SIMPLE REMEDY

Some TENS units can now be purchased without prescription. However, they tend to be prohibitively expensive, a price of around £80 for the simplest unit putting them beyond the reach of many sufferers.

Fortunately it is possible to construct one for considerably less. The unit described here is fairly simple, with switch selectable "continuous" or "pulsed" modes and adjustable output level for maximum effect.

The normal output is a stream of 75µS wide pulses at around 90Hz, with a maximum of about eighty volts peak. The pulsed output consists of groups of eight of these pulses repeated at a frequency of about 1·4Hz. These seem to be accepted as the optimum settings for general use, and the arrangement results in an instrument that is simple to construct and operate.

A fairly high output voltage is required to pass the current through the body. Commercially manufactured TENS units often generate this with a step-up transformer, which also removes all d.c. content from the output. Unfortunately, no suitable transformer seems to be available to the home constructor.

Mains transformers do not have the frequency response for handling the brief pulses, whilst audio types usually have too low a turns ratio. The closest the author could find was a 100V line-matching transformer for PA loudspeakers, but these tend to be large and heavy.

The design objective was a lightweight, pocket-sized TENS unit. To overcome the transformer difficulty, this design powers it's output stage from a miniature voltage-multiplier circuit producing about 80V from the 9V PP3 battery supply. A capacitor in the output blocks d.c. current flow.

The only disadvantage with this approach is the extra components that have to be assembled, but most home constructors probably won't object to this. With tiny ceramic capacitors and vertically mounted diodes the multiplier is remarkably compact.

CIRCUIT DESCRIPTION

The voltage multiplier can be seen in the upper part of the full circuit diagram, Fig.1. An oscillator consisting of IC3a and IC3b generates anti-phase signals at about 100kHz. These are buffered by IC3c and IC3d and the transistors TR6 to TR9, and then used to drive the diode multiplying stages in parallel through capacitors C7 to C22.

This parallel drive by anti-phase signals produces an increase of nearly twice the supply voltage for each stage, the only losses being the forward voltage drops of the diodes. Sufficient stages are provided to maintain the required output until the battery supply deteriorates to around six volts.

However, with a fresh battery, about 17V per stage will be produced so the final output could be well above 100V, requiring larger and more expensive capacitors. To overcome this, simple voltage regulation is used.

When the output exceeds about 80V the two Zener diodes D18 and D19 start to conduct, turning on transistor TR5, which pulls one of the inputs to IC3a low to stop the drive oscillator. With supplies between six and nine volts, therefore, a fairly constant output of about 80V is produced. The efficiency of this circuit is excellent at around seventy to eighty per cent, probably as good as a transformer.

PLEASE NOTE

A TENS unit should NOT be used in the following circumstances:

By any person or persons with a Heart Pacemaker. Especially where the pacemaker is a "demand" type and might interperate the TENS pulses as signals from the heart.

Connections on the body where the TENS signal may pass across the heart, such as an electrode on each arm.

Siting the electrodes on the NECK, in the area of the "carotid arteries". Nerve centres here are connected with control of blood pressure and oxygen levels.

For obvious reasons the current should NOT be allowed to pass through the head. – Never use TENS for Headaches.

If you are in any doubt YOU must consult YOUR Doctor.

PULSE GENERATION

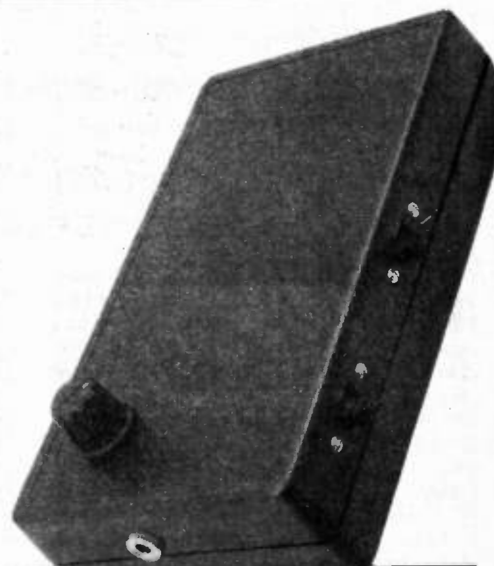
Moving on to the pulse generation part of the circuit, the prime mover is a CMOS 4060B i.c., which is a 14-stage divider with a built-in oscillator circuit. The frequency depends on the values of components connected between pins 9, 10 and 11 and in this circuit is set at about 1·4kHz.

The fourth divider output, from pin 7, is thus close to 90Hz. Capacitor C4 and resistor R4 differentiate this, resulting in pulses of around 85 microseconds duration from the output of the AND gate IC2b, providing the other two inputs are held positive.

Whilst switch S2 is closed the two inputs will be held positive, resulting in a continuous output. For pulsed output, opening S2 places these two inputs under the control of IC2a which combines outputs 8, 9 and 10 of IC1 to produce a positive output only when *all three* are high. The result is bursts of exactly eight output pulses at about 1·4Hz.

The output from IC2b is applied to transistor TR1. When high, it causes about half-a-milliamp to flow from its collector (c) which turns on transistor TR2, causing the multiplier output voltage to appear across the Amplitude control VR1 and resistor R7. The signal from the wiper of VR1 is therefore a pulsed voltage from about four to eighty volts, depending upon setting.

A simple "follower" circuit comprising the transistors TR3 and TR4 provide drive power for the output. Resistor R8 limits the maximum output in the event of an accidental short-circuit, whilst capacitor C5 blocks d.c. current flow and ensures safety in the event of a fault during use.



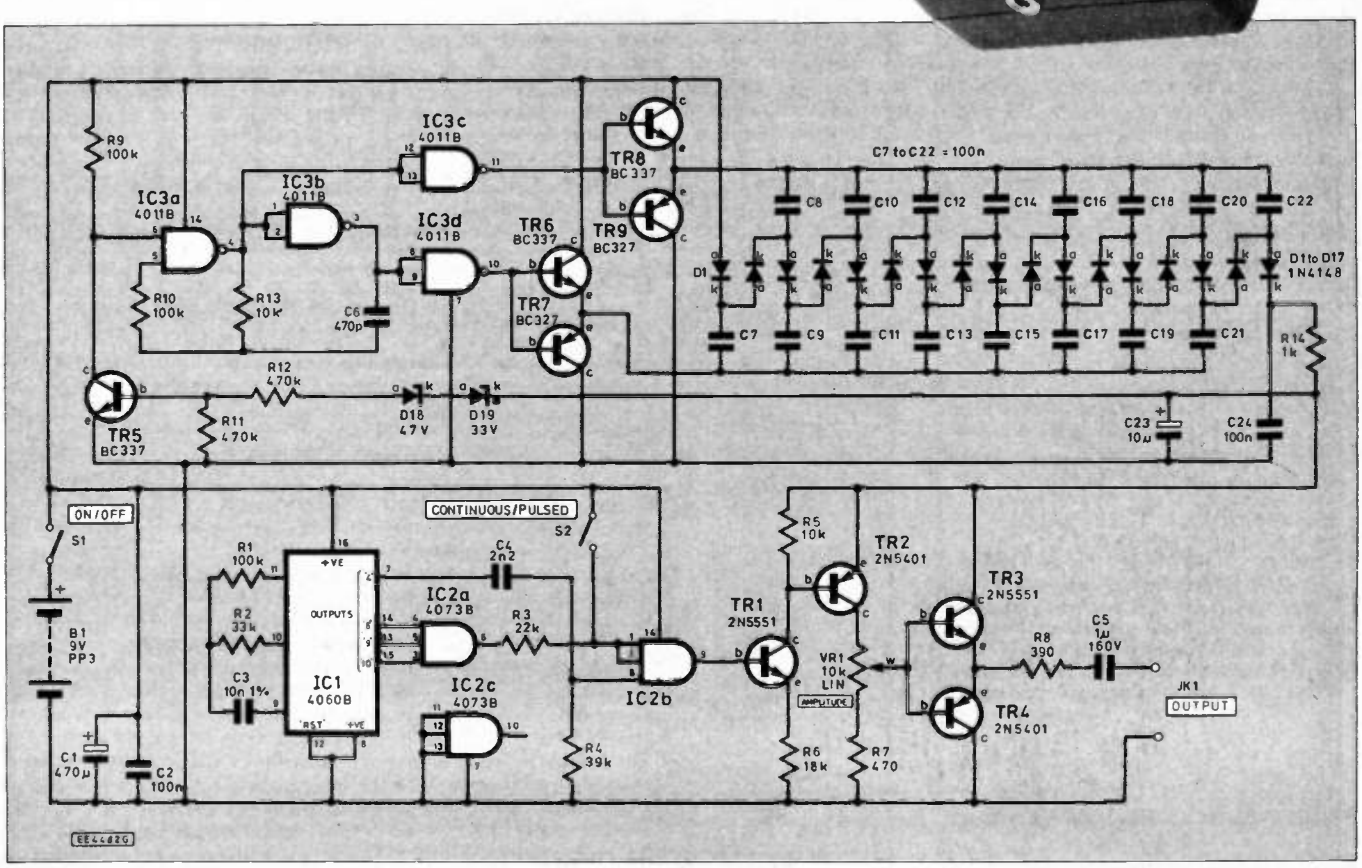


Fig. 1. Complete circuit diagram for the low-cost Simple TENS Unit.

CONSTRUCTION

The Simple TENS Unit is built on a small compact printed circuit board (p.c.b.). This board is available from the *EPE PCB Service*, code 875.

Construction is simple, though the compact layout for a pocket sized instrument means some care is required along with a fine-tipped soldering iron. Component positions, together with a full size copper foil master pattern, are shown in the layout drawing, Fig. 2.

There are four wire links which should be fitted first. The remaining components can then be assembled in order of physical height, especially those of the multiplier, where the capacitors C7 to C22 should precede the diodes.

With the exception of diode D1 all the diodes are fitted vertically and, for simplicity, all including the Zeners D18 and D19 have their cathode (marked) ends uppermost as shown in Fig. 3. Fitting of IC1, IC2 and IC3 is best left until testing of the board is commenced, the use of d.i.l. sockets is suggested here.

The recommended output capacitor C5 is a 160V polypropylene type, though a smaller and cheaper polyester component with a minimum "100 volt working" rating would probably suffice. The p.c.b. will accept either type.

COMPONENTS

Resistors

R1, R9, R10	100k (3 off)
R2	33k
R3	22k
R4	39k
R5, R13	10k (2 off)
R6	18k
R7	470
R8	390
R11, R12	470k (2 off)
R14	1k

All 0·6W 1% metal film

See SHOP TALK Page

Potentiometer

VR1	10k min. rotary carbon, lin.

Capacitors

C1	470µ radial elect. 16V
C2, C7 to C22, C24	100n monolitihic resin-dipped ceramic (18 off)
C3	10n polystryene, 1%
C4	2n2 polystryene, 1%
C5	1µ polypropylene, 160V or polyester 100V
C6	470p monolithic resin-dipped ceramic
C23	10µ radial elect. 100V

Semiconductors

D1 to D17	1N4148 signal diode (17 off)
D18	47V 1·3W Zener diode
D19	33V 1·3W Zener diode
TR1, TR3	2N5551 *npn* high-voltage silicon (2 off)
TR2, TR4	2N5401 *pnp* high-voltage silicon (2 off)
TR5, TR6, TR8	BC337 *npn* silicon transistor (3 off)
TR7, TR9	BC327 *pnp* silicon transistor (2 off)
IC1	4060B CMOS 14-stage divider with oscillator
IC2	4073B CMOS triple 3-input AND gate
IC3	4011B CMOS quad 2-input NAND gate

Miscellaneous

B1	9V battery (PP3)
S1, S2	DPDT slide switch (2 off)

Printed circuit board available from the *EPE PCB Service*, code 875; plastic handheld case (with battery compartment), size 145mm x 80mm x 34mm; 14-pin d.i.l. socket (2 off); 16-pin d.i.l. socket; small piece of aluminium sheet – see text; multistrand connecting wire; solder etc.

Commercial electrodes – see Shoptalk page.

Approx cost guidance only **£22**

TESTING

Before testing the board, wires of the correct length should be cut, stripped and fitted to the various connection points. The first check is to connect the supply voltage without any i.c.s in place. Following a brief surge as capacitor C1 charges, there should be virtually no drain from the supply.

The divider/oscillator IC1 can now be inserted after, of course, disconnecting the supply. When the power is restored, the drain should be about half a milliamp.

Pin 7 of IC1 should produce a measured voltage reading of half the supply volts, as it should be oscillating at about 90Hz with a precise 50 per cent duty cycle. The squarewave output at about 1·4Hz should

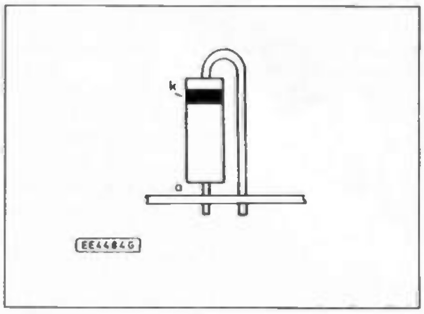


Fig. 3. Preforming the diode leads for mounting vertically on the p.c.b.

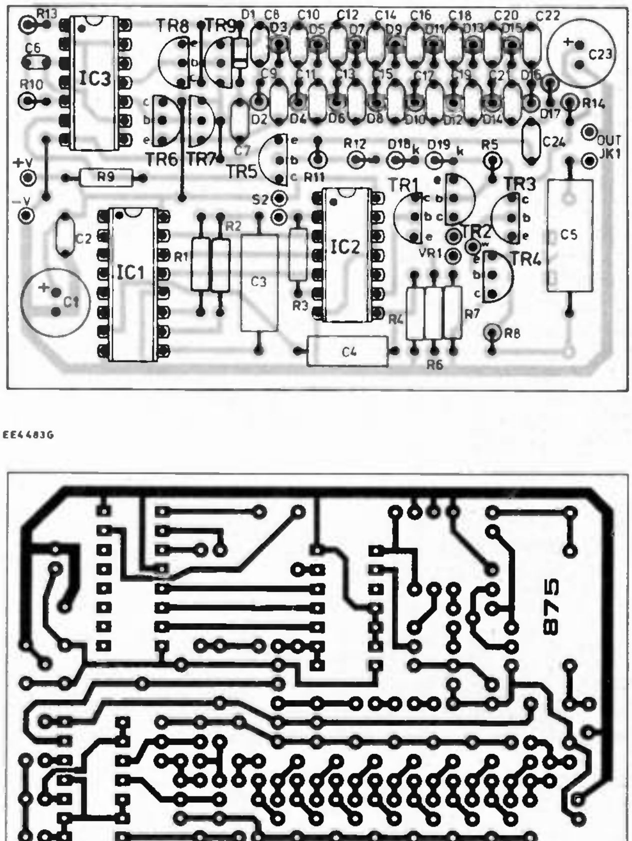
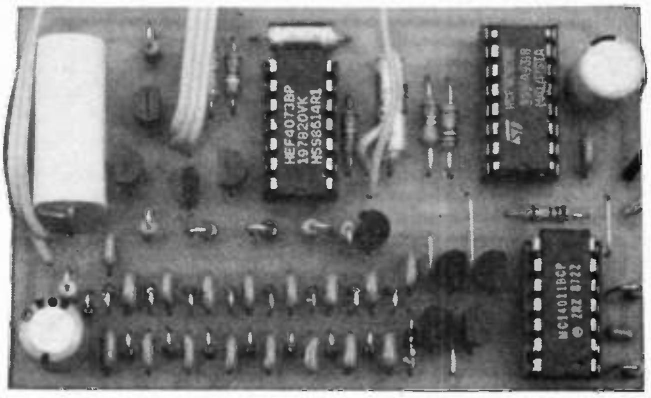


Fig. 2. Printed circuit board component layout and full size copper foil master pattern. The completed p.c.b. is shown below.



be present at pin 15, at this frequency it will be observable on a meter. IC2 can be fitted next. This will make little difference to the supply drain which should still be about half a milliamp.

Pin 6 of this i.c. should show brief positive pulses at about 1·4Hz, not so easy to observe as the output from pin 15 of IC1, but still visible on an analogue meter. If an oscilloscope is available the output pulses from pin 9 of IC2 can be checked, though the brief duration of these means they cannot be seen with the meter.

MULTIPLIER OUTPUT

With IC3 fitted, the supply current will rise to about 1·5mA. The multiplier output voltage can be checked at the top of resistor R14, where it should be around 75V to 80V. Note that in the absence of output loading, the multiplier oscillator will not run most of the time as the regulator circuit will be inhibiting it.

In the event of a problem with this part of the circuit, a useful approach is to reduce the supply to five volts so that the output will not be high enough to operate the regulator. The drive oscillator will then run continuously so that IC3 pins 3,4,10 and 11, and the emitters of transistors TR6 to TR9, which should all have an operating duty cycle close to 50 per cent, produce readings of about half supply on a meter, and become easily observable with an oscilloscope.

Assuming the high voltage is present and the rest of the circuit has checked out correctly, the next step is to connect the control VR1 and short the wires for switch S2 together for a continuous output.

The narrow-pulsed nature of this makes it difficult to observe with a meter, though on a sensitive a.c. range it may be visible and the effect of VR1 apparent. On a 'scope, of course, the pulses are easy to see with their peak value of up to nearly eighty volts controlled by the potentiometer.

The effect on the body may be tried too! It may not be felt by just holding the wire ends, but with a reasonable surface contact area the tingling effect should be felt as the setting of VR1 is increased.

FINAL ASSEMBLY

The p.c.b. can now be housed in a case of the constructor's choice, though much effort has been made to ensure it will fit neatly into the one specified. Positioning of the various parts is shown in the photographs.

An aluminium plate was first cut to the dimensions given in Fig. 4, and checked for fit over the pillars in the upper case half. The hole for the potentiometer (pot) VR1 shaft in the case was marked out and drilled with the help of the plate, to which VR1 is then fitted.

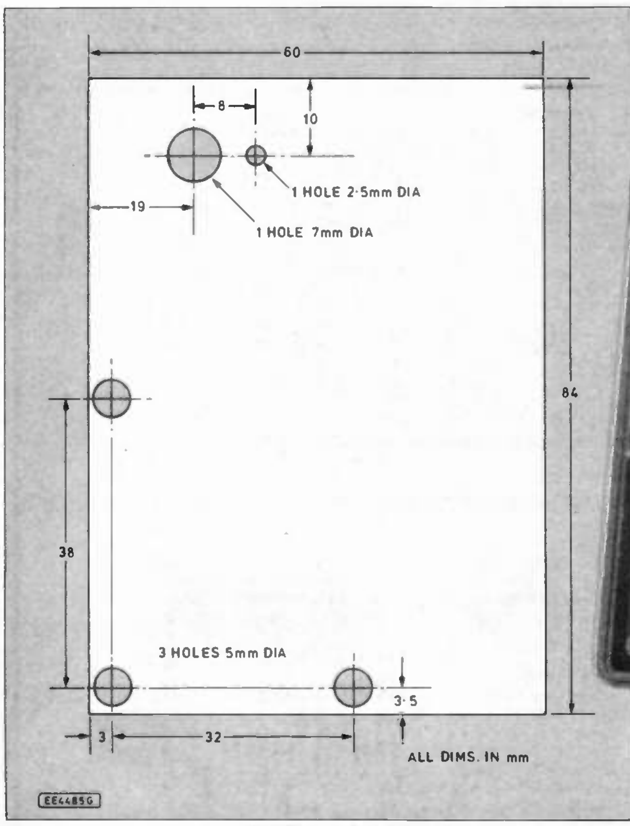
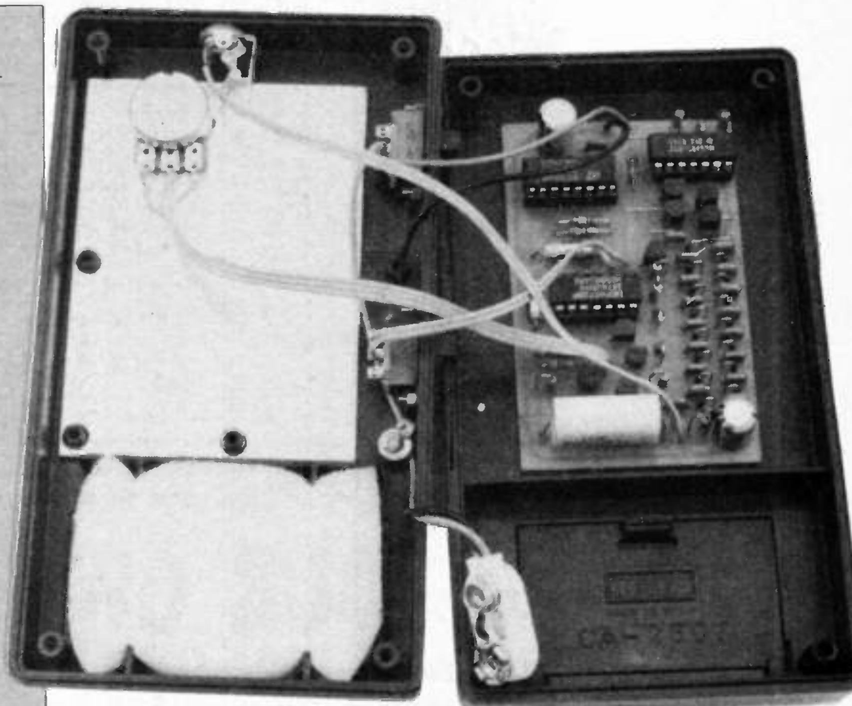


Fig. 4. Dimensions and drilling details for the mounting plate.



Layout of the components in the case, the aluminium mounting plate can be clearly seen.

The plate was attached to the case with double-sided sticky tape. To accommodate the thickness of the nut and washer two layers of this were used. Of course, it is possible to simply screw the pot straight into the case, but the plate avoids the thread and securing nut projecting beyond the case surface so that a low-profile knob can be used.

Some constructors may prefer not to use a projecting knob at all. One possibility is to cut the shaft of the pot to a length of a few millimetres with a slot for adjustment with, say, a 5p coin. This would eliminate any chance of accidental control movement during use.

Care should be taken when placing the 3·5mm mono output jack socket to avoid contact with the aluminium plate holding the pot. The two slide switches S1 and S2 are well clear of other components so their position is not critical.

The circuit board was fixed to the back half of the case with a "dollop" of Evo-stick glue, allowed to dry overnight. If it is positioned as shown there should be no problems with internal clearances. The various connections can be made as shown in Fig. 5 and, following a final

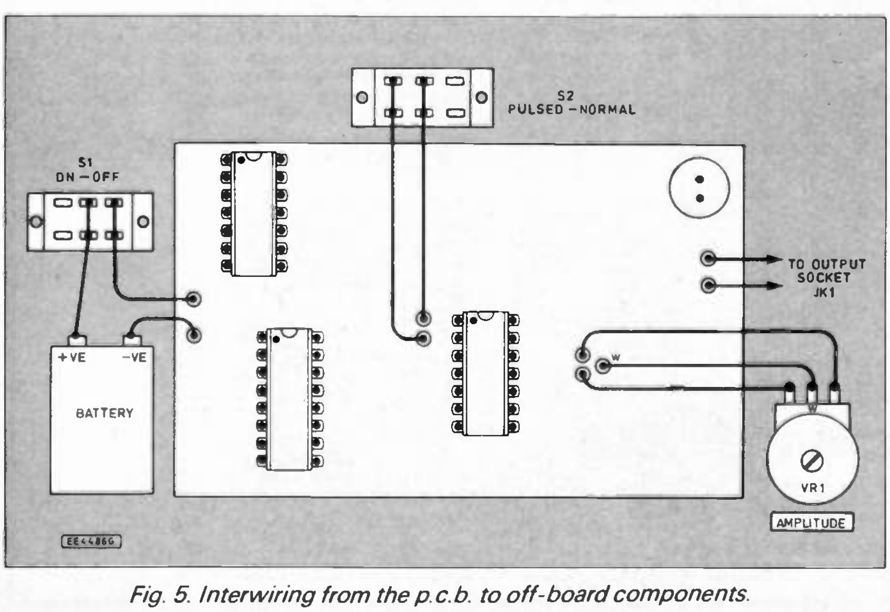


Fig. 5. Interwiring from the p.c.b. to off-board components.

functional check, the case halves can be screwed together to complete the project.

ELECTRODES

The general principle of the electrodes is that they should have sufficient surface area to maintain adequate skin contact. Deterioration to a small area during use may cause "electrode burns", despite the tiny currents involved. It is also considered bad practice to allow a metal part of the electrode to make direct contact with the skin, probably because this too may lead to burns.

Electrodes can be constructed with the aid of cotton wool around a metal plate on the end of a lead, impregnated with conducting gel or liquid. "KY jelly", obtainable in tubes from chemists, can be used, or a drop of salt water, though this is messy and tends to dry out during use.

For best results and ease of use, constructors are strongly recommended to purchase electrodes manufactured especially for use with TENS units. These consist of flexible pads coated with conductive adhesive gel, with short wires for connection to the leads from the TENS unit.

They are re-useable, and are stored on a special backing sheet. To use, one simply peels them off this sheet and sticks them on the skin, as easily as applying a plaster. For convenience and lack of mess they are far superior to home-made electrodes. A supplier of suitable 45mm square electrodes is Spembley Medical – see *Shoptalk*.

The electrodes are connected to the unit via a 3·5mm mono jack plug, with about a metre of single-core flexible wire to each. Polarity is, of course, unimportant.

IN USE

A description of the use of this unit should begin with some warnings as to how it should NOT be used! In general TENS is very safe, there seem to be few, if any, instances of harm arising from their use.

However, they should not be used by anyone with a heart pacemaker, especially one of the "demand" type where the pacemaker might interpret the TENS pulses as signals from the heart. Connection allowing the signal to pass across the heart, such as an electrode on each arm, is unwise though there seems no good reason to try this anyway.

A less obvious danger is siting on the neck in the area of the carotid arteries. Nerve centres here are connected with control of blood pressure and oxygen levels. For obvious reasons the current should not pass through the head – don't try TENS for headaches! – though it is recommended for trigeminal neuralgia, where the electrodes are sited on the same side of the head, one at the back of the jaw and one just in front of the ear.

For lower back pain and sciatica, one each side of the base of the spine is suggested. For general problems, joint pain for instance, one either side of the joint is usually indicated. In general, deep-seated sources of pain are not suitable for treatment with TENS.

TREATMENT

The Amplitude control VR1 should initially be set to zero when the instrument is switched on, then increased until a not-too-uncomfortable tingling sensation is felt. Treatment should usually continue for around twenty to thirty minutes, though if necessary this can be extended.

The "Pulsed" output mode should be used for extended treatments to reduce the body's tendency to become accustomed to the signal, although users might like to experiment with this mode anyway. A point worth mentioning is that where the signal passes through a muscle, it tends to cause it to contract.

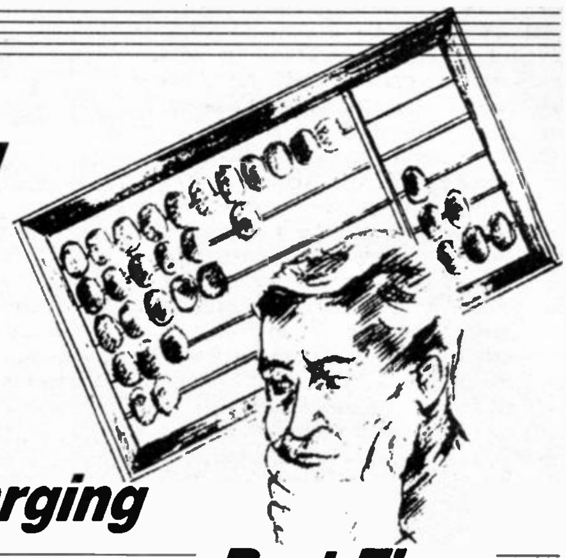
Normally this effect won't be noticeable, but pulsed mode with over-generous output settings can produce some interesting effects. Presumably this is the operating principle behind electronic muscle-toning and slimming machines.

It should be remembered that TENS will not cure any condition, it is purely a pain relief device. *The cause of prolonged pain, if not known, should always be medically investigated.*

Published research suggests that about seventy per cent of pain victims obtain significant relief with the use of TENS, and it has been known to succeed where all other means have failed. With this project, hopefully, many more sufferers will be able to try it for themselves.

The design of this project has been deliberately kept simple to allow easy operation, but the use of different frequencies and pulse widths has been found beneficial in some cases. Next month an advanced unit offering control over these functions will be published for those who would like to experiment further with this technique. □

Next Month: An Advanced TENS Unit.



CALCULATION CORNER

Capacitors – series, parallel, energy and charging

S. KNIGHT

Part Five

This series is designed to help you make your way, at your own pace, through the often imagined fears of mathematics, as this is applied to electronic and electrical engineering matters.

HAVING had a good look at resistors and their applications, we now come to the second of the three important passive components of the electronics scene, the capacitor.

Any two conductors between which a voltage is applied and an electric field established forms a **capacitor**. This is a device for storing electric charge.

Fig. 5.1 shows a parallel plate capacitor and such an arrangement forms the basic construction of nearly all practical forms of capacitors. When the switch S is closed, there is a *momentary* flow of current around the circuit from plate A to plate B. This current is known as a **displacement current**; the electrons do *not* pass between the plates (the **dielectric** of the capacitor) but leave plate A deficient in electrons and therefore positively charged, and move around the circuit to plate B where they form a surplus, so giving this plate a negative charge. In a very short while this displacement ceases and the capacitor is then fully charged, the p.d. between the plates then being equal (and opposite) to the applied potential V.

Charge, you will recall, is measured in coulombs; here the charge on each plate is identical but of opposite sign and is proportional to the p.d. between the plates. The ratio Q/V is known as the capacitance C; the greater the capacitance, the greater the charge which can be stored for a given voltage.

The unit of capacitance is the **Farad**, and this is the capacitance in which a p.d. of one volt establishes a charge of one coulomb. Thus capacitance is the charge per volt.

Practical values of capacitance are usually measured in microfarads (μF), nanofarads (nF) or picofarads (pF) where $1F = 10^6\,\mu F = 10^9\,nF = 10^{12} pF$. As the charges stored are also very small in relation to the coulomb, they are generally expressed as microcoulombs (μC) or millicoulombs (mC).

Here are a couple of worked examples to get you on your way.

1. What voltage must be applied to a 22μF capacitor to charge it to 1,100μC?

We have $C = \frac{Q}{V}$ or, rearranging, $V = \frac{Q}{C}$.

In these equations we must have, as always, everything expressed in the right units; here C must be in Farads, Q in coulombs, to give V in volts.

So $C = 22 \times 10^{-6}F$, $Q = 1{,}100 \times 10^{-6}C$.

Then $V = \frac{1{,}100 \times 10^{-6}}{22 \times 10^{-6}} = \frac{1{,}100}{22} = \mathbf{50V}$

Notice how the 10^{-6} terms cancelled out; we shall see that this fact helps us quite a lot in capacitor problems.

2. What is the charge of a 6·3μF capacitor when the applied voltage is 250V?

Here $C = 6{\cdot}3 \times 10^{-6}F$, $V = 250V$.

Then $Q = C \times V = 6{\cdot}3 \times 10^{-6} \times 250 = 1{,}575 \times 10^{-6}C$

$= \mathbf{1{,}575\mu C}$

Here the insertion of 10^{-6} has enabled us to conveniently express the answer in μC.

CAPACITORS IN SERIES

Suppose we have three capacitors C_1, C_2 and C_3 wired in series across a voltage source V volts (Fig. 5.2). The important point about the series connection is that each capacitor, irrespective of their capacitances, carry *identical* charges. The charge (or number of electrons) Q coulombs on one plate of C_1 involves a movement of *exactly* the same charge (or number of electrons) from its second plate to one plate of C_2, and similarly to C_3 and back to the source. Hence the displacement of electrons is constant throughout the circuit, just as a continuous current is constant throughout any series circuit made up of resistors.

With different values of the various capacitors, the voltage across each of them, given by $V = Q/C$, will be different, in the same way as the voltage across each resistor in a series arrangement is different. The equivalent capacitance C_E of a number of

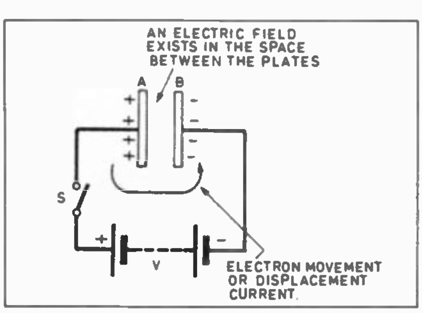


Fig.5.1. The displacement current establishes an electric charge on the plates.

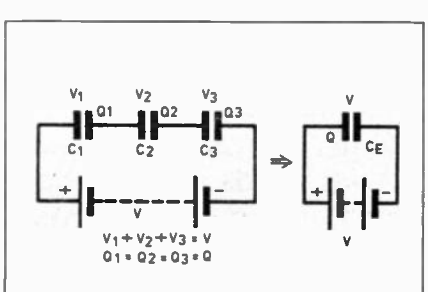


Fig. 5.2. Finding the equivalent capacitance of capacitors in series.

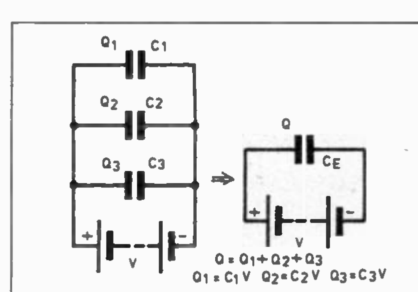


Fig. 5.3. Finding the equivalent capacitance of capacitors in parallel.

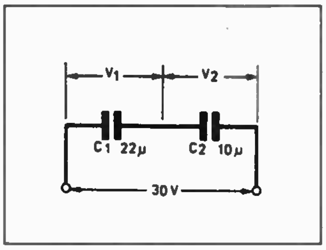


Fig. 5.4. Finding the voltages.

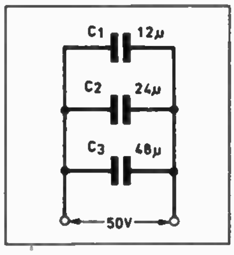


Fig. 5.5. Finding the charges.

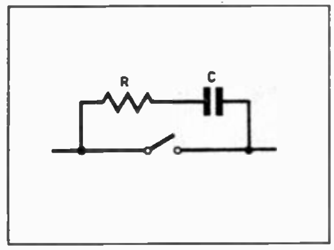


Fig. 5.6. Switch contact protection.

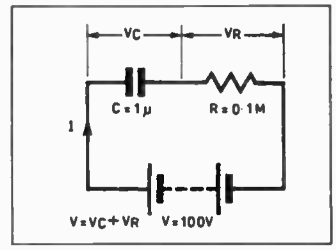


Fig. 5.7. Illustration of the time constant.

capacitors in series is given by a reciprocal formula similar to that used for resistors in parallel:

$$\frac{1}{C_E}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}+\cdots$$

where C_E is always smaller than the smallest capacitance in the series chain.

If only two capacitors are involved, the product/sum rule will make things a bit easier:

$$C_E=\frac{C_1\times C_2}{C_1+C_2}$$

CAPACITORS IN PARALLEL

When capacitors are connected in parallel, as in Fig. 5.3, the same voltage is applied across each capacitor and the total charge Q is the sum of the individual charges. If C_E is then the equivalent capacitance of the combination, $Q=VC_E$ and the individual charges are $Q_1=VC_1$, $Q_2=VC_2$ and $Q_3=VC_3$

Hence $\quad Q=Q_1+Q_2+Q_3$

and so $\quad VC_E=VC_1+VC_2+VC_3$

$\therefore \quad C_E=C_1+C_2+C_3$

So, for capacitors in parallel, the equivalent capacitance is simply the sum of the individual capacitors. This is similar to that for resistors in series.

Now follow these worked examples carefully.

3. A 22µF capacitor is in series with a 10µF. What is the combined capacitance?

As only two capacitors are used we can use $C_E=\frac{\text{product}}{\text{sum}}$, working simply in microfarads to avoid the use of 10^{-6} in the calculation.

Then $\quad C_E=\frac{22\times 10}{22+10}=\frac{220}{32}=\mathbf{6{\cdot}875\mu F}$

4. If a p.d. of 30V is applied to the above series circuit, what will be the voltage across each capacitor?

The charge on the equivalent capacitor C_E already calculated is the same as the charge on each of the individual capacitors.

So $\quad Q=C_EV=6{\cdot}875\mu\times 30\text{ volts}=206{\cdot}25\mu C$

Notice that since we leave the capacitance in µF, the answer for the charge will be in µC. hence, referring to Fig. 5.4

$$V_1=\frac{Q}{C_1}=\frac{206{\cdot}25\mu C}{22\mu F}=\mathbf{9{\cdot}375V}$$

$$V_2=\frac{Q}{C_2}=\frac{206{\cdot}25\mu C}{10\mu F}=\mathbf{20{\cdot}625V}$$

Notice particularly that the *greatest* voltage is developed across the *smallest* capacitance. As a working check, adding these two voltages gives us the supply voltage, i.e. 30V.

5. What capacitance would you connect in series with one of 400pF to give an equivalent capacitance of 300pF?

Here we have $\frac{1}{C_E}=\frac{1}{C_1}+\frac{1}{C_2}$ where $C_E=300pF$ and $C_1=400pF$

Then $\quad \frac{1}{C_2}=\frac{1}{C_E}-\frac{1}{C_1}=\frac{1}{300}-\frac{1}{400}=\frac{400-300}{400\times 300}$

$\therefore \quad C_2=\frac{300\times 400}{100}=\mathbf{1{,}200pF}$

What we really use here, as most of you will have realised, was the formula

$$C_2=\frac{\text{product}}{\text{difference}}$$

Notice also that we have worked solely in pF.

6. Three capacitors of 12µF, 24µF and 48µF are wired in parallel across a 50V supply. Calculate the equivalent capacitance and the charge on each capacitor. Fig. 5.5 illustrates.

$$C_E=12+24+48=\mathbf{84\mu F}$$

The total charge $\quad Q=C_EV=84\times 50=4{,}200\mu C$

Then $\quad Q_1=C_1V=12\times 50=\mathbf{600\mu C}$

$\quad Q_2=C_2V=24\times 50=\mathbf{1{,}200\mu C}$

$\quad Q_3=C_3V=48\times 50=\mathbf{2{,}400\mu C}$

STORED ENERGY

When a capacitor is charged, energy is stored in the form of an electric field in the dielectric *between* the plates – not on the plates themselves. When the capacitor is discharged, this energy is returned to the circuit where it may be dissipated as heat or converted into another form such as a magnetic field.

If a capacitor C farads is charged to a voltage V volts the energy stored in the capacitor is found from $W=\frac{1}{2}CV^2$ joules.

A capacitor is often connected across switch contacts, as in the ignition system of a car. When the switch opens or breaks, the energy which would normally be dissipated in a spark is now absorbed in charging the capacitor, hence the switch contacts are protected. To dissipate this stored energy when the switch opens, a resistor is usually wired in series with the capacitor as Fig. 5.6 shows.

THE C-R CHARGING CIRCUIT

Suppose a capacitor is connected in series with a resistor R across a source of potential V as shown in Fig. 5.7. Let the component values be, by way of illustration, C = 1µF, R = 0·1MΩ and V = 100V.

At the instant the voltage V is applied the capacitor will be uncharged and the total circuit resistance will be that due to the resistor R. The initial current will consequently be V/R = 1mA. Now if we assume a *uniform* charging rate, the capacitor will be supplied with a charging current of 1mA and the p.d. across its terminals will build up at the rate of 1,000V per second, or 100V per 0·1 second. The capacitor, charged uniformly at this rate, will therefore be fully charged to the potential of the supply in 0·1 second, and a graph showing the way in which the voltage rises would be a straight line building up from zero volts at a time t = 0 to 100V in a time t = 0.1 second.

This line $P-P_1$ is shown in Fig. 5.8. However, the initial rate of charge cannot be maintained on account of the fact that the capacitor voltage at any instant after t = 0 opposes the supply voltage and so limits the charging current to something *less* than 1mA. Consider the instant when t = 0·01 second. From the graph (point P_2) we see that the capacitor has charged up to 10V; these 10V will be opposing the 100V of the supply and at this instant the voltage available for continuing the charge will be 90V. The charging current will therefore be 0·9mA and the rate of charge will be 900V/second. Since C has to acquire a further

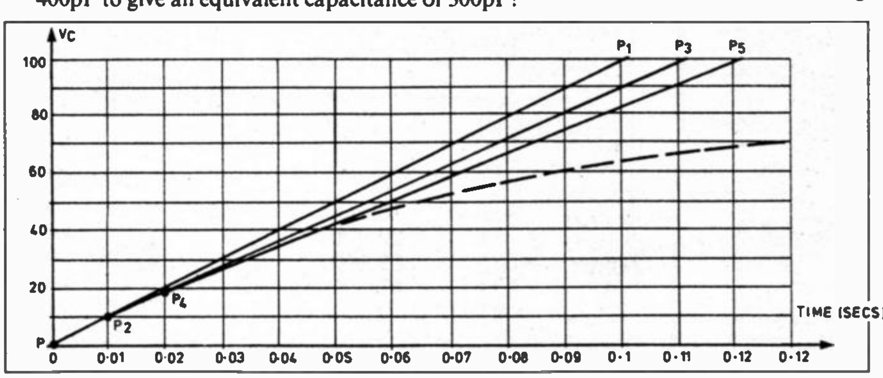


Fig. 5.8. Analysing the shapre of the charging curve.

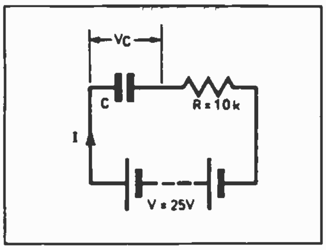


Fig.5.9. Calculation example.

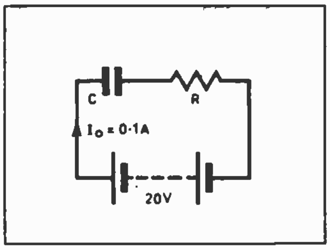


Fig.5.10. Example of illustration 8.

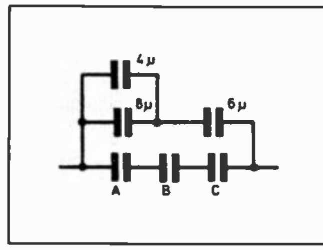


Fig.5.11. Capacitor network.

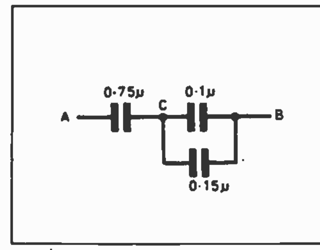


Fig.5.12. Circuit for problem 6.

90V to be completely charged, the time required to do this *if this new rate was maintained* would still be 0·1 sec. Once again, however, this new rate cannot be maintained. During the passage of a further 0·01 sec of time, the capacitor voltage has risen to 19V (point P_4) and so at this instant $t = 0{\cdot}02$ sec there are only 81V available to continue the charge. The charging current is consequently 0·018mA and the rate of charge will be 810V/sec. Since C now has to acquire a further 81V to be completely charged, the time required to do this if *this* new rate is maintained will again be 0·1 sec.

Lines ($P_2 - P_3$ and $P_4 - P_5$ respectively) have been traced on the graph of Fig. 5.8 to illustrate both of these new constant rates. Carrying on in this way (and it would be a good exercise to have a go at this) it can be seen that at *any* instant of time after $t = 0$, the state of the voltage across C is such that the charging current is limited to a value where C *still* requires 0·1 sec to be fully charged. From this argument, it is apparent that C can never be completely charged no matter how long the charging process may continue! Astonishing, maybe, but theoretically true.

The actual shape of the charging curve resulting from an infinity of constantly changing straight lines is shown in the heavy broken line; this curve is known as the **expotential** curve and has important properties. The period 0·1 sec which has turned up in this particular example is known as the **time constant** of the circuit of Fig. 5.7. We shall come to other important interpretations of this concept in the next part of the series.

For the time being, follow the next worked examples carefully.

7. A capacitor C in series with a 100kΩ resistor is connected to a 25V d.c. supply. What is the current at the moment of switch-on? What will be the capacitor voltage V_C when the charging current has diminished to 1mA?

Fig. 5.9 shows us the circuit. The initial current at time $t = 0$ is

$$I_0 = \frac{V}{R} = \frac{25}{10{,}000}\ A = 2{\cdot}5mA$$

When the current is 1mA, the voltage drop across R will be

$$V_R = IR = 10^{-3} \times 10^4 = 10V$$

Notice that we have expressed 1mA as 10^{-3} and 10kΩ as 10^4Ω. Hence the voltage V_C across C is $(25 - 10) = $ **15V**

8. When a capacitor is connected to a 20V d.c. supply the initial current is limited to 100mA by a series resistor R. What is the value of this resistor and what will be the charging current when the capacitor voltage has fallen to 5V?

From Fig. 5.10 the value of R will be that of the applied voltage V divided by the initial current $I_0 = 100$mA or 0·1A.

$$\therefore \quad R = \frac{V}{I_0} = \frac{20}{0{\cdot}1} = \mathbf{200\Omega}$$

When the voltage across C is 5V, the voltage across R will be $(20 - 5) = 15$V. Hence the charging current at this instant will be

$$I = \frac{15}{200} = 0{\cdot}075A \text{ or } \mathbf{75mA}$$

9. A 220μF capacitor is charged from a 100V d.c. supply. What will be the charge on the capacitor and the energy stored?

Here $C = 220 \times 10^{-6}F$, $V = 100V$.
Then $Q = CV = 220 \times 10^{-6} \times 100 = $ **0·022C**.

We could of course have ignored the 10^{-6} so leaving the capacitance in μF, and obtained as our answer **22,000μC**.

The stored energy is given by $\frac{1}{2}CV^2$ J. Substituting the given figures we have

$$W = \frac{220 \times 10^{-6} \times 100^2}{2} = \mathbf{1{\cdot}1J}$$

I think that we have now covered enough to keep us busy for this month, so here are your self-assessment problems, followed as usual by last month's answers.

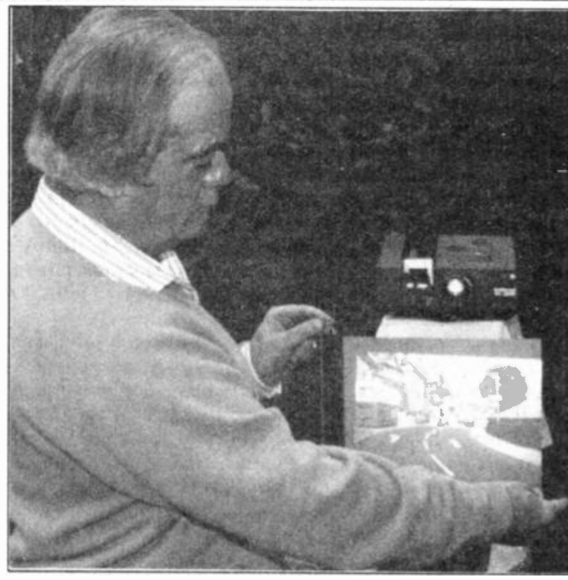
1. Three capacitors of 3μ, 5μF and 15μF are joined first in parallel and then in series. What is the equivalent capacitance in each case?
2. Fig. 5.11 shows a network of capacitors in which A, B and C are identical in value. if the total equivalent capacitance of the network is 5μF, find the values of A, B and C.
3. 1 joule of energy is stored in a capacitor that carries a charge of 10mC. What is the voltage and the capacitance?
4. Show that the energy stored in a capacitor may also be expressed as ½QV joules.
5. You have a number of 1μF capacitors each rated at 1,000V working. Find an arrangement which would give you an effective capacitance of 2μF with a working voltage of 2,000V.
6. Three capacitors are connected as seen in Fig. 5.12. A 10V d.c. supply is connected across the points AB. What will be the steady voltage across the points AC?
7. A 100μF capacitor is charged by way of a series 47kΩ resistor from a 50V d.c. supply. What is (a) the initial current, (b) the voltage across C when the current has fallen to 0·5mA? Can you estimate the time constant of this circuit?
8. Explain the difference between charge and energy relating to a capacitor.

Last month's answers: 1. 6,666.7Ω. 2. A 75kΩ multiplier is required. 3. 3·75V, 2/3 f.s.d., 1,125μW. 4. The resistance of the meter is unlikely to be more than a few hundred ohms, so his argument was quite valid. The resistor wattage was quite inadequate, however, a 2W high-voltage type would be needed. 5. Circuit (a) is preferable; if any resistor fails it would affect *all* ranges in circuit (b), $R_1 = 850Ω$, $R_2 = 9{,}850Ω$, $R_3 = 99{,}850Ω$, $R_A = 850Ω$, $R_B = 9{,}000Ω$, $R_C = 91{,}000Ω$. 6. 1·5V, with X positive; change the 3Ω to 1·5Ω. 7. 1Ω; apply the bridge principle to this network.

WONDER SCREEN

U.S. Company buys British invention which will make TV set obsolete

by Hazel Cavendish



THE genius of Hampshire inventor William Johnson – who introduced both "Gogglebox" and Microsharp to the electronic field – has been recognised by a leading American company which has hailed his new state-of-the-art display screen as a remarkable breakthrough. Using completely new technology, it produces a picture so sharp, detailed and brilliantly lit that it eclipses anything seen before, and is likely to change the way we watch television in future. It will also enhance cinema screens, massive airport and railway terminal information displays, and even the screens we use at home to view our slides and videos.

By producing such brilliance of light the potential for back-lit screens is particularly promising; portable projection TVs with the new screen can be used out-of-doors in the brightest sunshine without any detriment to the picture (see photo). The transformation of fuzzy outlines in underlit situations into sharp, detailed pictures must hold great promise for improvement in police videos.

In the home the boxy and cumbersome TV set which has for so long dominated our living rooms will soon be replaced by a slim wall-mounted screen, or free-standing screen on a stand which can be rolled up when not required. The screen itself contains unusual optical qualities which produce a crystal-like image that is sharply lit, while projection will be from a small, unobtrusive unit mounted high in the corner of a room.

The invention is the result of 9 years' research and development pioneered by a team headed by Professor Nicholas Phillips, based at Loughborough University. Jonson's invention of the diffusion film Microsharp alerted many British scientists to its various promising applications last year, although British industry was characteristically slow to pick it up.

NASHAU DEAL

Now Johnson has sealed a deal with Nashua Corporation, an American photographic company which also deals extensively in advanced office equipment. They will manufacture and market the screen in conjunction with Durand Ltd of Guernsey, which owns the technology and will continue research in the techniques. Japan has been quick to spot the potential of the invention, and sales contracts are being negotiated currently with 25 Japanese manufacturers.

The inventor regrets that British companies approached showed only luke-warm interest in his product, an all-too-familiar scenario. "British industry appears to be terrified of taking on anything new", he remarked.

"For once this invention is a departure from electronics. Years ago everyone was talking about ways of getting better pictures, and it was when I was developing Gogglebox that I began to think that increasing lines and pixels was not the only answer. While one could get better definition with advanced electronics there would always be a problem of "visual noise", because without the depixillation of LCDs the screen would still send up bad pictures with all that matrix and too much black in them.

You might say you had the picture "warts and all" and I decided that what I had to do was to get rid of the warts. It came to me very suddenly that we could use the same material we used for Microsharp depixillation, but with a different approach. It was the screen we should be thinking about, not the projection side at all.

"Science had all the answers, but it was a question of finding them. Our experiments finally led us to Graded Refractive Index (GRIN) as an answer. Next our search revealed Du Pont Photopolymer, a flexible film able to be laminated on to a substrate. We found the molecular structures could be moved internally to form GRIN micro-lenses within the material.

Instead of there being "surface relief", columns of one-micron-thick lenses were able to be created in the material in perfect or random array.

The use of these remarkable lenses enables a projector to be placed at a sharp angle off the screen (as in the corner of a room, at ceiling level) and the picture comes out exactly straight, and wide-angled. "When we manufacture the screen we put into the Photopolymer exactly what we want, and it will move the molecular structure into the picture it is receiving. We can put millions of sub-micron lenses – and yes, I do mean millions and not thousands – on to a sheet of Photopolymer with a focal depth of around 75 microns."

A recent development reported from Guernsey by Durand is the approach to them by one of the major US car manufactures with a request for a prototype of an in-car screen, providing information to the driver. This has been presented to the car company this month. "The potential for world-wide markets is infinitely exciting," says Johnson.

THE EARLY HISTORY OF RADIO

By G.R.M. Garratt

ISBN 0 85296 845 0

It is not often that we review books in EPE but this one is rather exceptional.

Gerald Garratt had a special interest in what might be termed the "pre-history" of radio. His book therefore outlines the sequence of development from Faraday's first prediction and concept of the electromagnetic field, the mathematical definition of the conditions for propagation of waves by Maxwell, the demonstration of their physical existence by Hertz, identification of the need for resonance between transmitter and receiver by Lodge and finally Marconi's successful practical application and "invention".

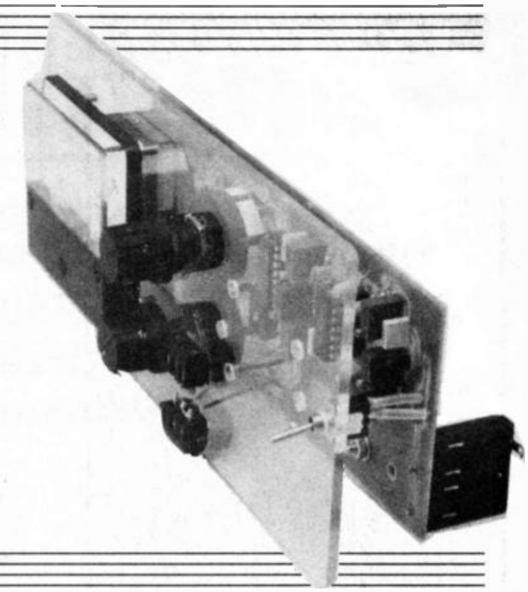
Mr. Garratt was an Assistant Keeper at the Science Museum in London for most of his career, he joined the Museum in 1934. Unfortunately he died in 1989 before completing the book and the last chapter, on Marconi, was prepared by his daughter from his notes and a lecture her father gave in 1972.

The book makes fascinating reading and gives many details about early experiments on the "pre-history" of wireless telegraphy. It covers a number of important early experiments and experimenters that I was not previously aware of. Gerald Garratt has kept the human interest in the account of these early radio pioneers but also covers in detail, the facts on their experiments, with many interesting excerpts from early papers and letters.

The book can be highly recommended to anyone interested in technology, it is perhaps unfortunate that the publishers, the IEE in association with the Science Museum, have priced it at £19. However, although it is only 96 pages, it is in hardback and in my opinion worth the outlay. *M.K.*

Constructional Project

CAPACITANCE/ INDUCTANCE METER



DOUG KENNEDY

Identify those unmarked capacitors and inductors with this useful low-cost piece of test gear. Measures capacitors from 10pF to 10µF and inductors 1µH to 1H.

CAPACITOR values are marked either with the standard colour code, or number and letter codes. The capacitive values are often difficult to decipher (see *Circuit Surgery* and *Techniques*), especially when the values on the miniature types or the coloured banded ones are printed badly. Inductor values can be even more confusing as many are unmarked. The Capacitance/Inductance Meter should be useful when confronted with these problems.

This project when constructed and calibrated will display with reasonable accuracy values of capacitors from 10pF to 10µF and inductors from 1µH to 1H. All components are easily obtainable at reasonable cost. The accuracy when using standard components for calibration should be sufficient to satisfy most project work. For more precise measurements ±1% or 2% tolerance components can be used for initial calibration.

CIRCUIT DESCRIPTION

A 74HC14 TTL Hex schmitt trigger IC1 (Fig. 1) uses each gate to generate a square-wave signal of approximately five volts peak-to-peak. The oscillators are designed to output the following frequencies. No. 1. 1MHz. No. 2. 100kHz. No. 3. 10kHz. No. 4. 1kHz. No. 5. 100Hz and No. 6 10Hz. Each signal is fed to a MOS 4050 (IC2) Hex buffer gate to isolate the medium input impedance of the following transistor stage from distorting the output of the oscillators. This, however, reduces the output of each gate to approximately two volts peak-to-peak.

From the buffer gates a choice of frequency is selected by the range switch S1. Which is fed to the base of transistor amplifier TR1 via resistor R8. Capacitor C10 is connected in parallel with R8 to obtain a steep rise time on the square wave input to the base of TR1. The reduction of amplitude due to the buffer stage is restored by the transistor amplifier TR1 to approximately five volts peak-to-peak.

With switch S2 in the Capacitor Test position a capacitor on test is inserted between the emitter of TR1 and the positive terminal of the 100µA meter ME1. Diode D2 ensures a steady positive potential is present at the positive terminal of the meter. Therefore the meter needle indicates in a forward direction.

Resistor R7 is the collector load resistor of the transistor. Capacitor C9 is included to dampen the meter movement and VR8 is adjusted to limit full scale deflection (f.s.d.) on all capacitor test ranges.

With switch S2 in the Inductor Test position an inductor is connected in the collector load in series with R7. The collector of TR1 is also connected to preset VR7 and then to the positive terminal of the meter. VR7 is adjusted for a full scale reading on all inductor test ranges.

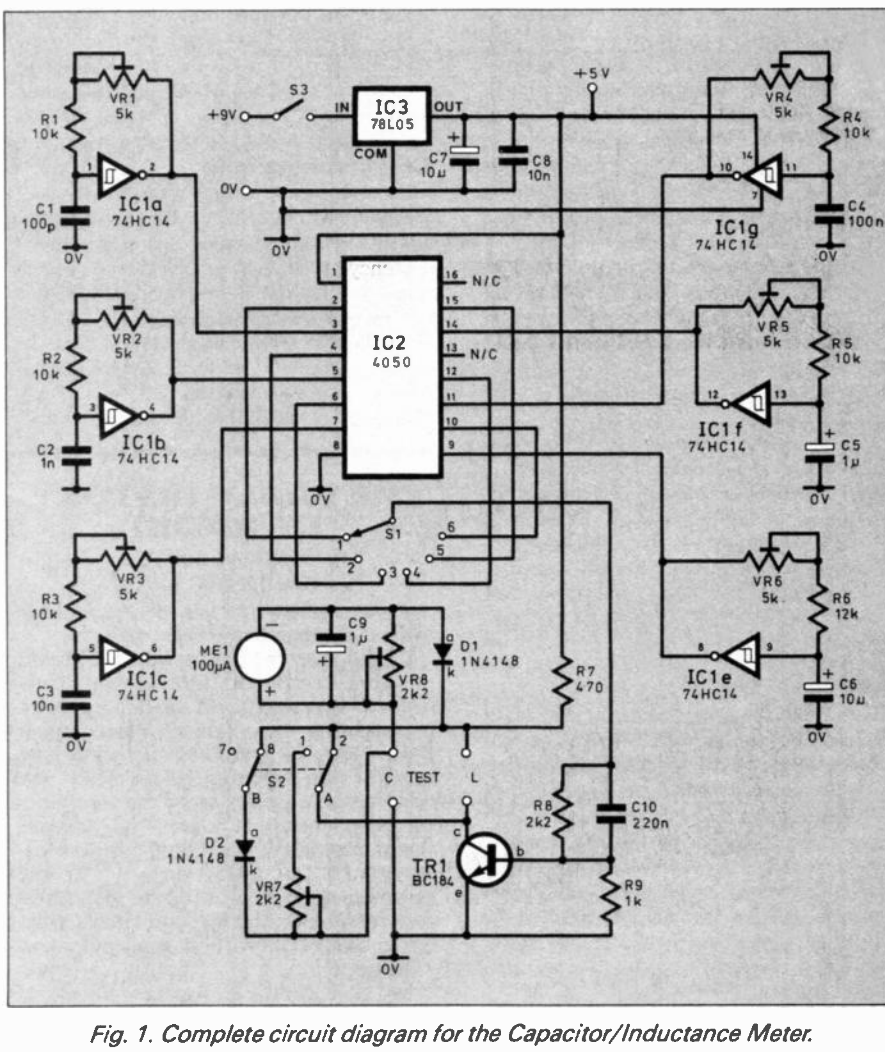


Fig. 1. Complete circuit diagram for the Capacitor/Inductance Meter.

COMPONENTS

Resistors
R1 to R5 10k (5 off)
R6 12k
R7 470
R8 2k2
R9 1k
All ¼ ±5% carbon film

Potentiometers
VR1 to VR6 5k multiturn cermet preset (5 off)
VR7, VR8 2k2 miniature preset (2 off)

Capacitors
C1 100p ceramic
C2 1n mini-polyester
C3, C8 10n mini-polyester (2 off)
C4 100n mini-polyester
C5 1µ tantalum
C6, C7 10µ elect. 15V (2 off)
C9 1µ elect. 15V, axial
C10 220n mini-polyester

Semiconductors
D1, D2 1N4148 signal diode
TR1 BC184 *npn* transistor
IC1 74HC14 Hex Schmitt trigger
IC2 4050 Hex buffer
IC3 78L05 5V regulator

Switches
S1 1-pole 12-way rotary
S2 2-pole 6-way rotary
S3 s.p.s.t. toggle

Miscellaneous
ME1 100µ A panel meter
14-pin d.i.l. socket; 16-pin d.i.l. socket; 3-way terminal block; PP3 battery holder; PP3 battery; printed circuit board, available from the *EPE PCB Service*, order code 876; plastic case; knobs (2 off).

A selection of capacitors and inductors for test purposes is also required.

Approx cost guidance only **£25**

Diode D1 makes sure current flows in the same direction through the meter as when testing capacitors. Diode D1 also protects TR1 from damage due to high value transients (back e.m.f.), a danger when checking inductors.

The project is powered with a PP3 nine volt battery mounted in the battery holder on the printed circuit board. A 78L05 regulator IC3 reduces the battery voltage to five volts. A separate power-supply can be used, but it is advisable to include the 78L05 as the maximum power supply voltage for the TTL 74HC14 IC1 is six volts. A stable voltage is also important to prevent frequency drift of the oscillators.

Table 1. Range Switch Readings

Switch S1. position	1	2	3	4	5	6
Oscillator Frequency	1MHz	100kHz	10kHz	1kHz	100Hz	10Hz
Capacitor max. reading on meter. Also circuit values of	100pF C1	1nF C2	10nF C3	100nF C4	1µF C5	10µF C6
Inductor max. reading on meter	10µH	100µH	1mH	10mH	100mH	1H

DESIGN CONSIDERATIONS

Many capacitance and inductive measuring instruments utilise one single oscillator test frequency or the 50Hz mains frequency to generate a pulsed waveform. Using a single frequency can often limit the range of components to be measured. The problems that arise are shown in the following examples.

The impedance (Z) of a 100pF capacitor at 50Hz is virtually an open circuit.

Example:

$$Z = \frac{1}{2\pi \times \text{frequency} \times \text{value of capacitor}}$$

$$= \frac{1}{6{\cdot}28 \times 50 \times 100 \times 10^{-12}} = 31{\cdot}8 \times 10^{6}$$

$$= 31{\cdot}8 \text{ megohms}$$

With the same value capacitor and a frequency of 1MHz:

$$Z = \frac{1}{6{\cdot}28 \times 1 \times 10^{6} \times 100 \times 10^{-12}} = 1592\Omega$$

A similar problem when testing inductors can be shown.

Example:

The impedance of a 10µH inductor at a frequency of 50Hz is:

$$Z = 2\pi \times \text{frequency} \times \text{value of inductor}$$

$$= 6{\cdot}28 \times 50 \times 10 \times 10^{-6} = 0{\cdot}00314\Omega$$

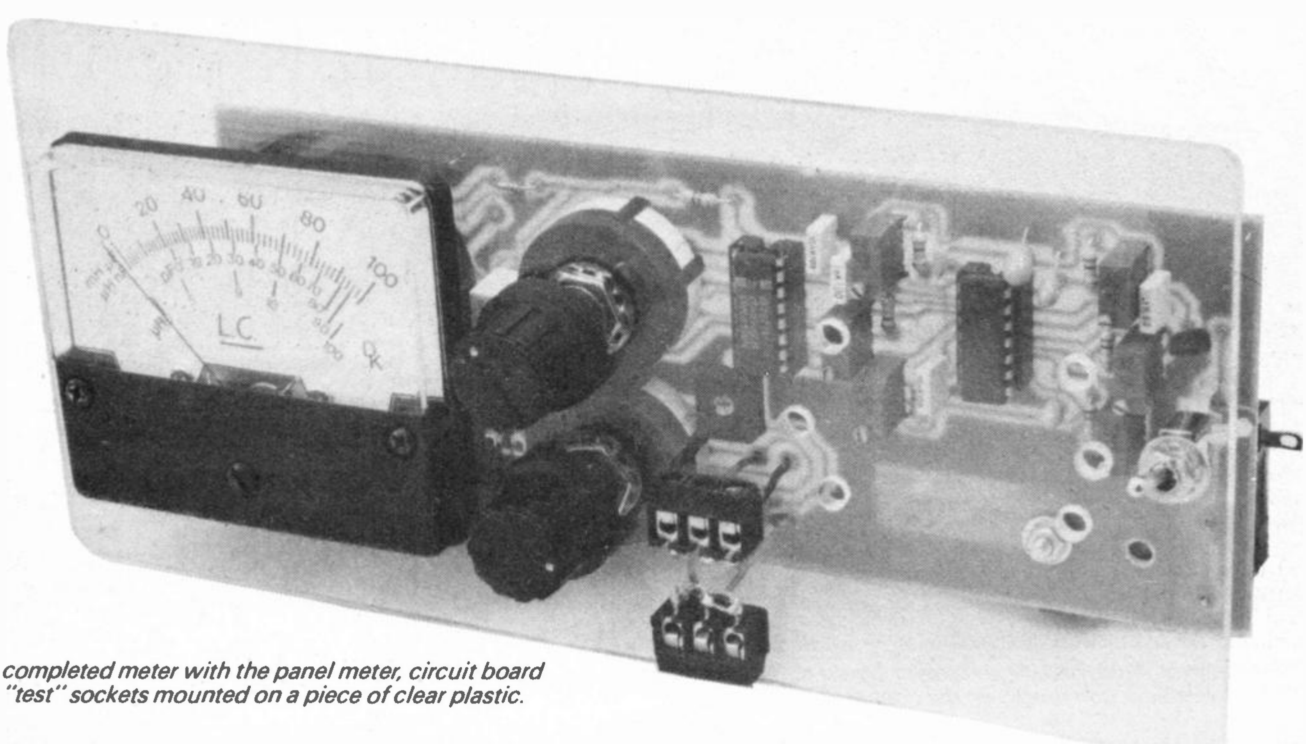
In this project the impedance of components tested at the maximum value on each range will be identical. By calculation the impedance for inductors is 62·6Ω for capacitors it is 1592Ω. Resulting in a constant level load on TR1. It also provides the meter with a linear and direct display reading.

Table 1 above shows the relationship between frequency, inductance, capacitance and the range switch S1 positions.

HOW IT WORKS

A square wave, of a frequency selected by the range switch S1 generates a pulsed current, this passes through the inductor inserted in "L" test socket. This changing rate of current creats an induced voltage which is sampled and monitored on the meter.

A capacitor when inserted in the "C" test socket is also connected to a pulsed waveform with the meter monitoring the average charge and discharge in the capacitor. This process is repeated at a frequency selected by the range switch S1. The meter displays a direct linear reading in both test modes.

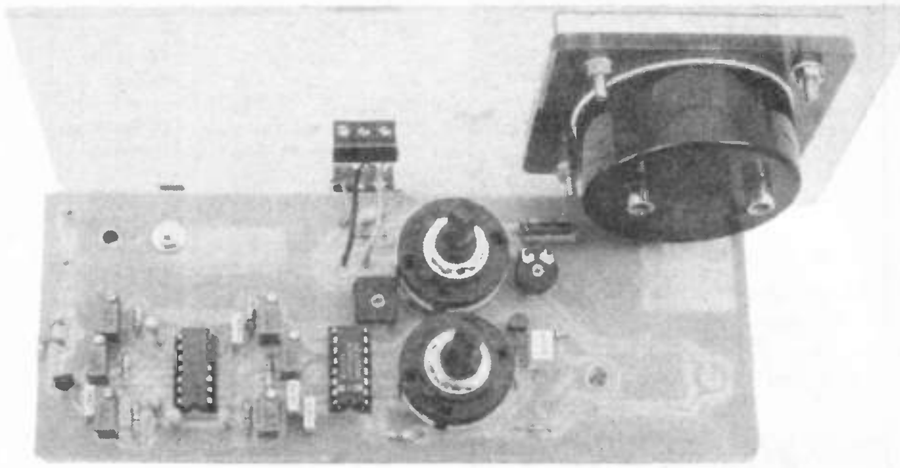


The completed meter with the panel meter, circuit board and "test" sockets mounted on a piece of clear plastic.

CONSTRUCTION

The meter movement listed for this project will fit neatly on the printed circuit board and matches the facia panel. It is possible, of course, to use other types of 100µA movement. However, the reason for mounting the meter on board is to minimise stray capacitance and this is obviously important on the lower value ranges. The test connectors are also attached to the panel, using super glue. Fig. 2 shows the p.c.b. (available from the *EPE PCB Service*, order code 876) and the layout and mounting of all the components, even the battery holder is wired directly on the board (copper side). The panel artwork Fig. 3 can be photocopied (enlarged), attached to the front panel and used as a drilling template.

There could be slight differences in the stray capacitance between different units, if so: photocopy and remove only the 100pF and 10µH range (Fig. 4) and paste to existing meter scale, in new calibrated position.



Completed p.c.b. removed from the meter mounting to show the component layout.

CALIBRATE

If the constructor has easy access to an oscilloscope or frequency meter. The unit may be calibrated using the following procedure:

a. Connect oscilloscope or frequency meter test leads to "C" test socket.
b. Set all oscillator frequencies by adjusting VR1 to VR6 to those shown in the table.
c. Set switch S2 to "C" and switch S1 to 10nF position.
d. Insert a 10nF capacitor in "C" test socket.
e. Adjust VR8 preset to read full scale on meter.
f. Set S2 to position "L"
g. Insert a 1mH inductor in "L" test socket.
h. Adjust VR7 preset to read full scale on meter.

All capacitor and inductor ranges should be correct.

NOTE: The meter will read approximately 21pF on the 100pF range. This is the

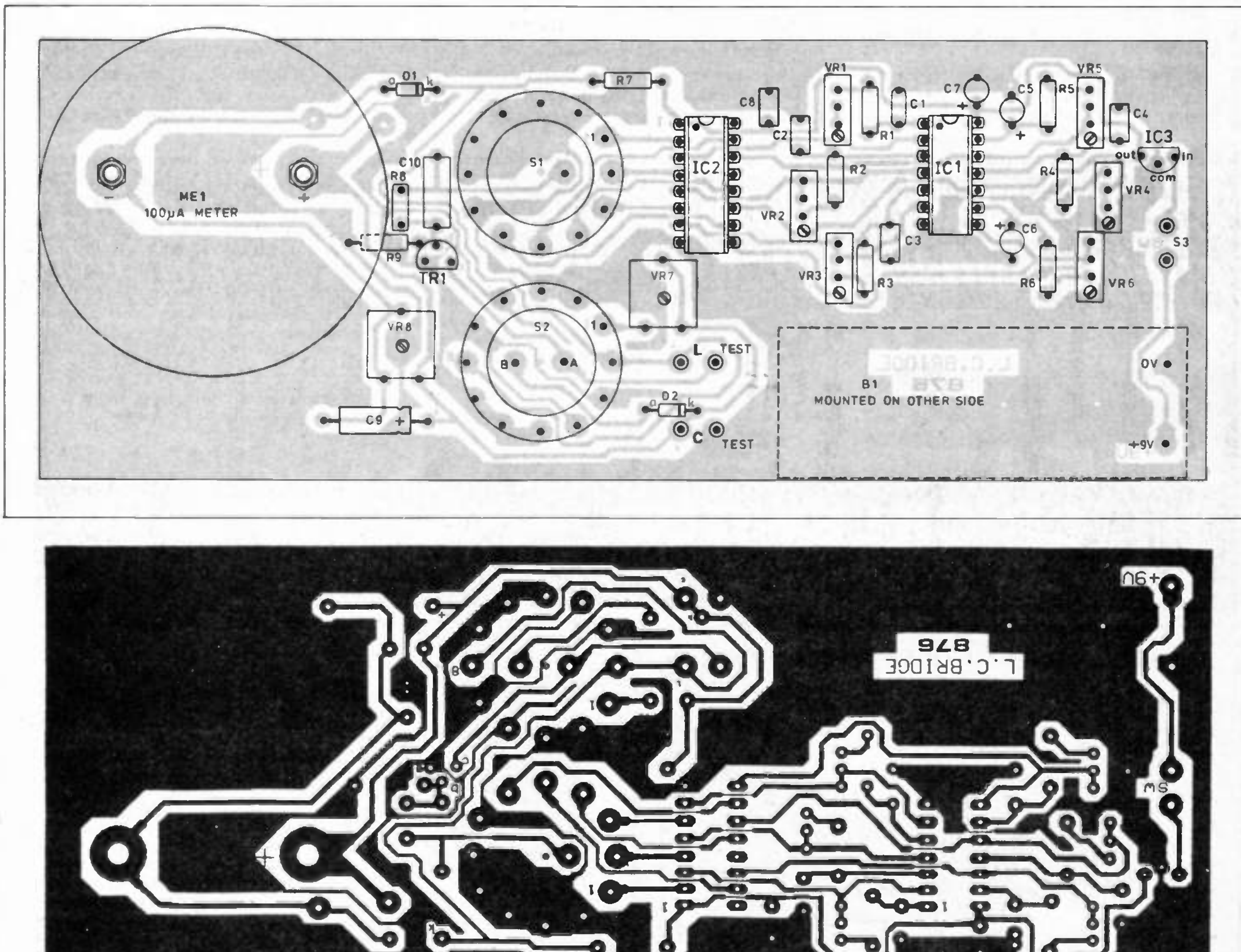


Fig. 2. Printed circuit board component layout and full size copper foil master pattern for the Capacitance and Inductance Meter. The battery holder is mounted on the copper side of the p.c.b.

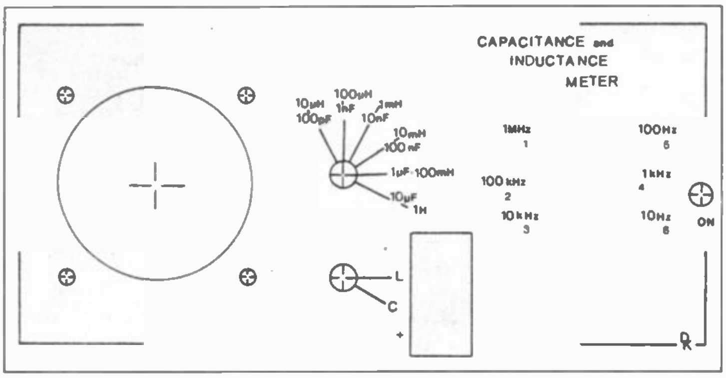


Fig. 3. Suggested front panel layout and lettering (half-size). This can be enlarged, copied and used as a template.

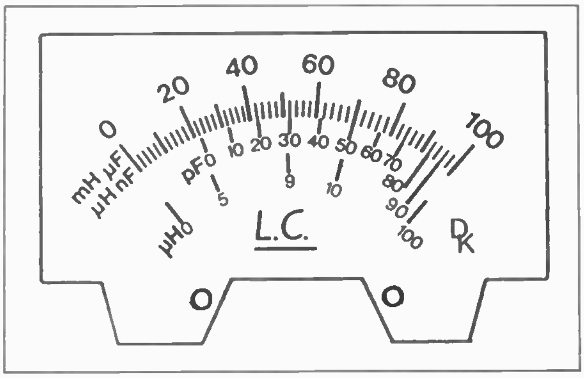


Fig. 4. Full size modified meter scale. This can be photocopied and stuck on the meter scale.

inherent stray capacitance of the circuit. Subtract this value from the main scale, or attach a modified meter scale (Fig. 4).

It is possible to calibrate the meter by using a digital multimeter. A trimming tool is needed for VR7 and VR8 and a small screwdriver for VR1 to VR6. To do this the following sequence should be followed:

a. The power switch must be in the "off" position.
b. Set the multimeter to read kilohms.
c. Connect one lead to pin 1 (gate 1) of the 74HC14 IC1 and the other lead to pin 2.
d. Adjust VR1 for a resistance value of approximately 13k5
e. Proceed as above at the following test points.
f. Adjust VR2 and measure across gate pins 3 and 4 – 13k5
g. Adjust VR3 and measure across gate pins 5 and 6 – 13k5.
h. Adjust VR4 and measure across gate pins 10 and 11 – 13k5.
i. Adjust VR5 and measure across gate pins 12 and 13 – 13k5.
j. Adjust VR6 and measure across gate pins 8 and 9 – 13k5.
k. Set the power switch S3 to "on".
l. Place 100pF capacitor in "C" test socket.
m. Set the range switch S1 to position 1.
n. Adjust VR8 for meter needle to read "5" at centre of scale.
o. Trim VR1 pre-set to read "5" on meter scale.
p. Adjust other ranges, as above with appropriate test capacitors.
q. Adjust VR8 preset for meter needle to read full scale.

NOTE: As the 10µF range operates on a slow pulse of 10Hz, the maximum deflection of the meter needle will display the maximum value of the test capacitor.

r. Switch S2 to "L" and fit a 1mH inductor to test socket "L".
s. Move range Switch S1 to position 3 the 1mH position.
t. Adjust VR7 to read full scale on meter.

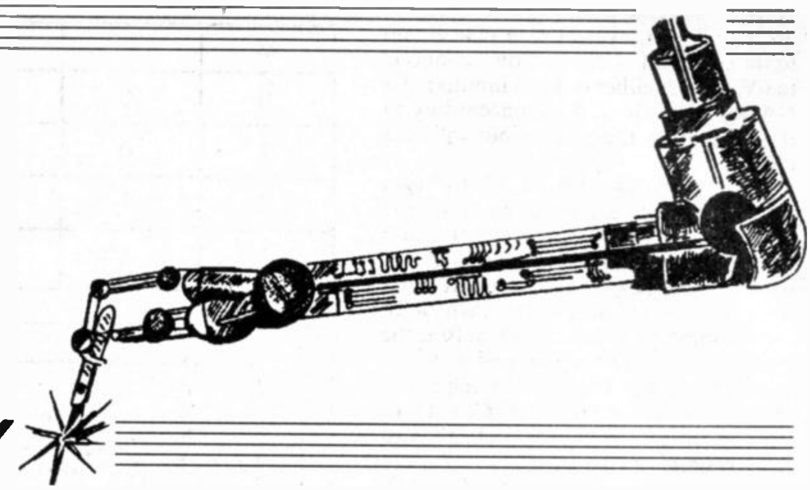
All capacitor and inductor ranges should now read correctly.

TYPICAL TOLERANCE

The wide tolerance of the off-the-shelf inductors and capacitors does not usually affect most electronic projects. Where accuracy is required circuit design usually incorporates a variable trimming capacitor or a variable inductor.

Polystyrene capacitors claim a tolerance of ±5%. Miniature polyester ±10%. But electrolytics including tantalum bead only ±20%, some electrolytics are even +100% −50%. The tolerance expected for inductors is ±10% to ±20%. □

CIRCUIT SURGERY



ALAN WINSTANLEY

Welcome to our monthly column to help readers with puzzling problems in the field of electronics. This month we unscramble capacitor markings and we help students to probe logic bistables in a little more depth.

Cat. Flap

I am grateful to *Mr. H. Key* of Sutton-in-Ashfield who contacted me asking for help in identifying some curious capacitors – a fairly widespread cause for confusion.

I've been reading electronics magazines for over fifty years but as regards capacitors, I have never read how to decipher a capacitor marked with just a number and a letter. These capacitors are widely available. Recently I spotted some advice on this topic in the Maplin catalogue on Page 448 – but could you please explain how according to their data, a figure of 449 means 1000pF?

No criticism of Maplin, their excellent catalogue has an innocent misprint. Maplin told me that the value shown as "449" in Maplin's example should actually state 102; they were aware of the misprint which was identified some time ago, and it will be corrected in the next catalogue issued.

However, their advice is perfectly correct: some capacitors – notably ceramic disc types (and also polyester) – may be marked only with three digits with an additional letter indicating the percentage tolerance. The first two digits of the code show the numerical value of the capacitance. The third digit is a *multiplier*, in ***picoFarads.*** It's actually the number of zeroes following the value, which should then be read off in "pF."

For example, a marking of "102" means 1000 picoFarads (10 plus two zeroes, pF). Otherwise that value of 449 would imply a 44,000µF capacitor (44 $\times$ 10^{9} $\times$ 10^{-12} Farads), rather large for a ceramic disc! This leads me to my next point.

There is actually another clue to determine whether you are barking up the wrong tree when deciphering a dubious capacitor. Just like resistors, capacitor values are always based on a range of ***preferred values.*** Manufacturers produce a variety of capacitors starting at 1pF upwards, but their values will nearly always be based on one of the following preferred values: 1, 1·5, 1·8, 2·2, 2·7, 3·3, 3·9, 4·7, 5·6 and 6·8. Checking through any catalogue, you will find that just about every capacitor you can buy has a value in this list.

Of course, you need to multiply the value according to the capacitance of the component – so you might see a 470µF electrolytic, a 22nF polyester or a 33pF silver mica capacitor – but you won't see a "44" value anywhere. Fig. 1 illustrates some typical marking methods for some otherwise anonymous capacitors. (Who remembers the colourful Mullard C280 polyester types?)

Sometimes you see a value such as "22n" printed on the body instead, see Fig. 1a. The *n* is actually the multiplier (nanoFarads in this case) and it also represents the position of the decimal point – so it's a 22nF capacitor. By the same token a part marked as "47p" would be a 47 picoFarad type, and "µ22" would be 0·22µF.

We use the same system (multiplier in place of the decimal point) in our *circuit diagrams* because the reader can see the values more clearly, rather than trying to read a barely visible decimal point which may not reproduce very well after we've reduced the diagrams photographically.

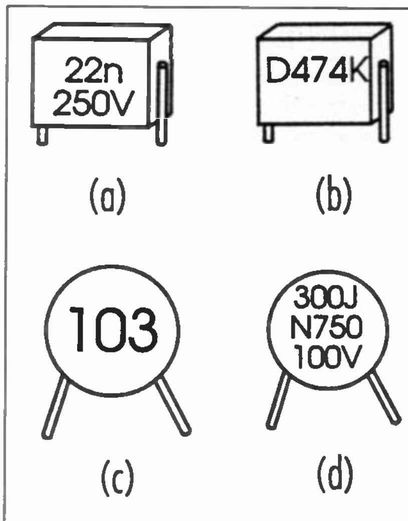


Fig. 1. A selection of some typical capacitor markings.

A capacitor similar to some which arrived with a recent delivery is shown in Fig. 1b – it's actually a 0·47µF (circuit diagram 0µ47) polyester type (presumably the second "4" denotes a multiplier of 10,000 picoFarads, since 470,000pF would be 470nF or 0·47µF). Fig. 1c is a 10,000pF or 10nF ceramic disc. Mr. Key actually possesses a mica disc capacitor as shown in Fig. 1d. Perhaps it's a 30pF type ±5% – but possibly it's a 0·75nF type instead – neither value is standard! My guess is the latter, but what do readers think?

Bistable Briefing

Our Education Service has been introduced to support those who are actually involved with *teaching* GCSE, GCE "A" Level or similar Electronics Syllabuses such as the electronics content of CDT courses. My thanks to ***Mr. R.T. Giles,*** Head of Science at Bedminster Down School in Bristol who suggested just such a topic for us to investigate:

One section of our GCSE Science Syllabus deals with Feedback and Control. The electronics content is mainly "logic gates" and this can be explored by quite young students using systems such as the Unilab MFA (Microelectronics for All) System in the school lab.

The Syllabus requires students to be able to describe the function in a control circuit of a bistable latch. *It would aid student understanding of this topic if you could design some hands-on demonstrations of "a control circuit using a bistable latch" to support the Syllabus.*

The circuit schematic of a typical bistable, which has been assembled from individual logic gates is shown in Fig. 2. In this case, two NAND gates of a 7400 i.c. were used. You can see the classic "cross-over" configuration where the output of each gate is connected to one input of the other gate. The output of the bistable can be observed at *either* of the gate outputs (read on). A 5V supply is required, connected to pins 14 (+5V) and pin 7 (0V). It works as follows.

The *truth table* of the NAND gate (Table 1) plots all possible combinations of logic inputs and outputs. A logic "1" or "high" is equivalent to a connection to the +5V rail, a "0" or "low" connects to 0V. Thus if either or both input(s) of a NAND gate is logic 0 then according to the truth table, the gate output will be a logic 1.

Ignoring the switches S1, S2 to begin with, R1 and R2 are so-called "pull-up" resistors which ensure that pins 1 and 5 are normally held at logic 1 (high). Starting with gate IC1a, assuming that pin 2 is at logic 1 to start with, then IC1a output must be a *logic 0*. Therefore the inputs of IC1b are 1 (pin 5) and 0 (pin 4), so IC1b output would be a *logic 1* – which is fed back to pin 2 of IC1a. Thus, the bistable is locked or "latched" with pin 3 low and pin 6 high.

If instead IC1a pin 2 had been at logic 0 to begin with, IC1a output would be *logic 1*. This is connected to pin 4 of IC1b whose output would have to be *logic 0* – which again is fed across to pin 2 of IC1a. Now the bistable would be latched with pin 3 high and pin 6 low.

The two outputs are always the opposite or *complement* of each other, without exception. The output is often designated "Q" and its complementary output called "NOT Q or $\overline{Q}$." The term ***bistable*** refers to the fact that this circuit has ***two*** stable states. It remains latched until forced to change over, and the bistable or "flip-flop" acts like a simple memory which stores one binary digit – displayed at the output – so it's a *one-bit latch*.

Adding the two push switches S1 and S2 enables us to change over the state of the bistable latch. Temporarily closing either switch will send a logic 0 to its associated gate input pin. If the bistable is latched as initially described (with IC1a output at logic 0) then closing S1 will send pin 1 "low". IC1a output changes over to a *logic 1*. This causes the other gate to change to logic 0 output, the complement of pin 3.

By closing each switch in succession, the bistable can be forced to change states in the manner described – a change in one gate's output causes a change at the opposing gate's input which forces a change onto that gate's state too. Pressing *both* switches produces a forbidden or indeterminate state. NOR gates could be used in a similar arrangement, using "pull-down" resistors with the switches, instead.

Design Problem

A design problem is that TTL (transistor-transistor logic) gates are not very good at supplying current and they prefer to sink it into the output terminals instead. Just because a gate output is "high" does not mean that there is plenty of current available to power a load! A higher current drive is available by *sinking* into a logic 0 output.

In order that the bistable can operate a load, a driver or buffer is needed. Two simple drivers are given in Fig. 3, which can be used with the NAND bistable (or any logic gate for that matter).

In Fig. 3a a MOSFET transistor TR1, coupled to the bistable circuitry, is used to drive a lamp. This static-sensitive

Table 1: NAND Gate Truth Table

A	B	OUT
0	0	1
1	0	1
0	1	1
1	1	0

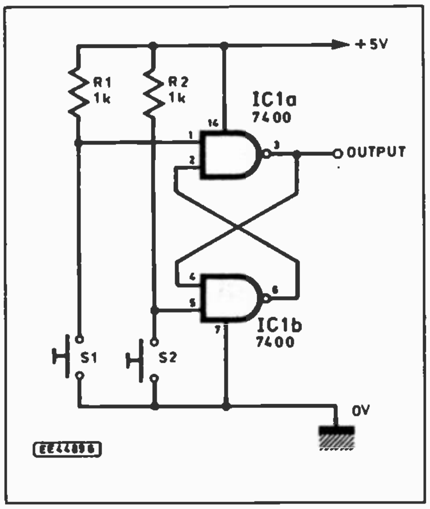


Fig. 2. A bistable latch construed from NAND gates.

device will handle about 500mA. It needs no gate current and it really is as easy to use as that! Pressing switches S1 (on) and S2 (off) will control the lamp, which lights when the bistable output is logic 1.

In Fig. 3b a *pnp* Darlington transistor TR2 drives a small model electric motor (say 3V to 4·5V d.c.). This time the transistor, being a *pnp* type, conducts when the bistable output is logic 0. The switches start (S2) and stop (S1) the motor accordingly.

The power transistor recommended is rugged (10 Amps), but the motor needs suppressing as shown – I found that noise and spikes created by the motor affected the bistable latch undesirably. Alternatively the motor could be replaced by a relay coil to control other loads.

Suggestions: Adding a second push switch in series with the Motor Start button will give you a simple two-handed safety switch, where both hands would be needed to start the motor – just like industrial machinery. Perhaps configure the switches so that *both* start switches need to be operated, but *either* of two stop buttons (two parallel switches) would halt the motor as a safety feature. More elaborate control systems could be constructed using further logic gates.

A text-book application for a bistable is as a switch debouncing circuit. Mechanical switches have spring-metal contacts which bounce a few times before finally making contact. This can play havoc with digital systems which can operate so quickly that the switch's transitions cause several signals to be generated instead of just one.

By inserting a bistable between the switch and the digital system, the first contact bounce causes the bistable to latch, which sends only one signal to the digital circuit. The bistable ignores any further contact movement.

This is less straightforward to demonstrate meaningfully. A digital counter such as the CMOS 4017 has ten output pins. Each will go high in sequence, upon receipt of a clock pulse. A row of filament lamps or l.e.d.s could be driven by suitable buffers.

By using a "noisy" switch to deliver a clock pulse, the display will advance erratically. Using a bistable instead to clock the 4017 would force the counter to advance more predictably – to change or "toggle" the bistable, perhaps use a double-pole changeover switch commoned to 0V, in place of the two push switches detailed earlier.

Further guidance is available by writing to *Circuit Surgery*. Incidentally, we managed to capture and print out some contact bounce waveforms as part of our *Teach-In '93* series (EPE May 1993).

Shock Horror

A regular *Circuit Surgery* correspondent, ***Mr. H.R. Smith*** of Wallington, Surrey comments:

I have just read the "Safety First" *articles and a horrible thought struck me*

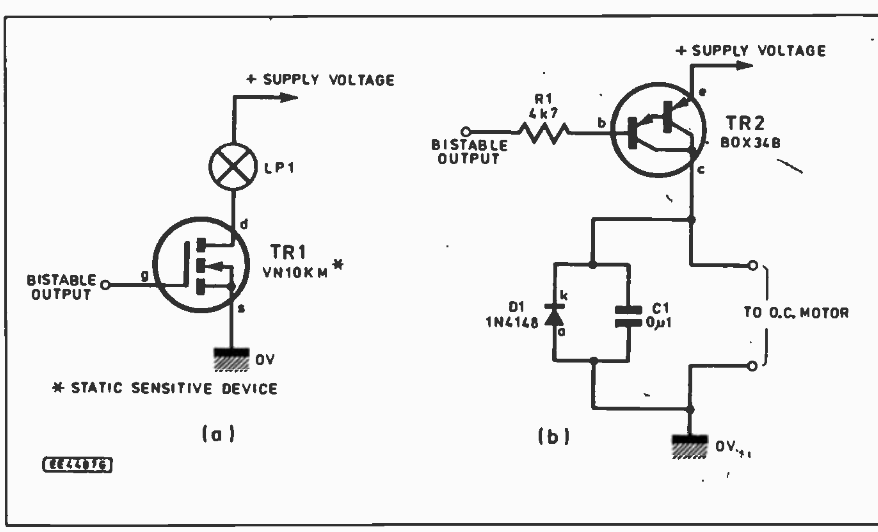


Fig. 3. Bistable output load drivers. (a) Lamp driver using a MOSFET transistor and (b) low-voltage d.c. motor driver using a pnp *Darlington transistor.*

concerning the final part on fuses! Mains adapters are widely used for powering radios, computers etc. and it occurred to me that all those which I have seen are not fuse protected. This only leaves the 30A ring main fuse as protection. It seems to me that they could become extremely hot if a fault developed – just how safe are they?

I think it's a rare adapter that doesn't have at least *some* form of fault protection. Many adapters are sealed for life and are tamperproof, and although a fuseholder may not be evident from the outside, the better ones should generally contain an internal quick blow fuse perhaps soldered in-line, though there's no guarantee.

Alternatively, a *thermal* fuse will disconnect the supply if the transformer temperature becomes excessive. A rupture temperature of about 125°C seems commonplace. Check by examining the markings on the adapter itself, which may bear the symbol(s) depicted in Fig. 4.

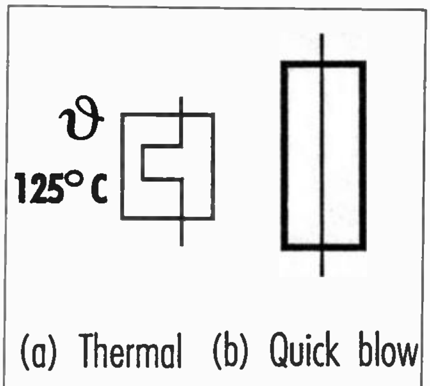


Fig. 4. Fuse symbols that may be found on mains adapter units.

Recently I unplugged an adapter which powers a laptop computer. To my "shock" (almost), the plastic cover broke off in my hands, leaving the adapter chassis still firmly plugged into the mains socket, with live mains terminal aglow! The plastic rivets holding the casing together had broken off.

The same problem recently resulted in a recall by a well-known manufacturer. So check those plastic casings, especially if the adapter is used by youngsters and has been subjected to rough handling.

Next Month: For boat owners, an Experimental Bilge-Pump Controller, with other potential level-detection applications. It switches on a pump once the water level has risen above a certain height. Don't forget, I'm still looking for all those circuit and construction hints and tips to publish as a special round-up. Keep them coming!

If you have any queries, comments or suggestions for inclusion in this column, please write to me: Alan Winstanley at *Circuit Surgery*, 6, Church Street, Wimborne, Dorset, BH21 1JH. **Please note,** I cannot guarantee an individual reply but I read every letter and will try to help if possible.

SHOP TALK
with David Barrington

Simple TENS Unit

Not to many "painful" experiences should be faced by readers shopping for parts for the *Simple TENS Unit*. It is most important however that the "160V working" polypropleyne capacitor C5 or the suggested 100V polyester alternative be ordered. Also, keep to the one per cent types were specified.

The single-sided printed circuit board is available from the *EPE PCB Service*, code 875 (see page 399). The small handheld case, to take the p.c.b., was purchased from **Maplin** and is their HH2 type, code ZB16S. Most of our advertisers should also be able to offer a suitable plastic box.

Finally, a supplier of suitable 45mm square electrodes is: **Spembley Medical Ltd, Dept EPE, Newbury Road, Andover, Hants, SP10 4DR**. The item required is a "pack of four self-adhesive *Pulsar* electrodes," size 45mm x 45mm. At the time of writing we understand that they can supply these for the sum of £7.76, including VAT and p&p.

L.E.D. Matrix Message Display

Amongst all the components needed to complete the *L.E.D. Matrix Message Display*, the only items that can be classed as being really "special are the surface mount devices and the pre-programmed 2756 EPROM. However, the surface mount devices are now appearing in most component suppliers stocks and should not prove too troublesome to find. The same applies to the computer type plugs and sockets. Don't forget to ask for a bulk price for the l.e.d.s.

This just leaves the EPROM. The pre-programmed EPROM, together with a detailed operation manual is available from the authors, price £10, by writing to them at **28 Blisworth Close, Yeading, Hayes, Middx. UB4 9RF.**

The Display board (code 870) and CPU board (code 871) are available from the *EPE PCB Service*, see page 399. The Display copper foil master is to large to be included in the article but a photostat copy is available from EPE by sending a large s.a.e.

Some hot news we have just received. We understand that **Greenweld, 27D Park Road, Southampton, Hants, SO15 3UQ,** (☎ *0703 236363*), are preparing kits and readers should contact them for details

Stereo Noise Gate

All components required to build the *Stereo Noise Gate* appear to be readily obtainable and should be stocked by your local supplier. The compander i.c. type NE571 is certainly listed in most suppliers components catalogues.

The U-shaped printed circuit board (p.c.b.) was designed to fit the metal case (type AB10), but other *metal* cases can, of course, be used and the p.c.b. need not be cut to this shape. The p.c.b. shown in the diagrams is available from the *EPE PCB Service*, code 873 (see page 399).

Remember to specify "log" types when ordering the potentiometers.

Dual Stepping Motor Driver for PC Computers

Looking through the list of components for the *Dual Stepping Motor For PCs*, nothing stands out as being "out of the ordinary," except perhaps the stepper motors.

A complete kit of parts, including two 200 step motors and a silk-screened printed circuit board, with component positions clearly marked, is available from **Magenta Electronics**. The kit cost £62.99 plus £3 carriage and packing charge, and includes an easy-use PC software package. Note that the printed circuit board is not available separately.

Magenta Electronics, Dept EPE, 135 Hunter Street, Burton-on-Trent, Staffs, DE14 2ST. (☎ *0283 65435*). Quote kit code 846.

MARCO TRADING IN LIQUIDATION

We regret to inform readers that after 20 years of trading Marco have gone into liquidation. No further orders should be sent to Marco Trading (Minicost Ltd.). Any reader with a claim against the company should contact the liquidator Mr. D. G. Richardson of Muras Baker Jones & Co., Bradburn House, 42-46, Darlington Street, Wolverhampton, WV1 4NN. Tel: (0902) 29811. Fax: (0902) 772156. Unfortunately it would appear that unsecured creditors will not receive any payment after the liquidation.

Capacitance/Inductance Meter

The main problem to be resolved when purchasing components for the *Capacitance/Inductance Meter* is the sourcing of the panel meter. Apart from the 100µA movement, which is fairly readily available, the mounting terminals of the meter must match up with the fixing holes and copper pads on the p.c.b.

The meter used in the model was obtained by the author from **Rapid Electronics** (☎ *0206 751166*), code 48-0305. Unfortunately, we understand that they will not supply components to individuals. However, we feel sure that some of our advertisers will be able to offer a suitable replacement meter, provided you keep the meter terminal spacing of 28mm (fixing centres) in mind.

The Meter printed circuit board is available from the *EPE PCB Service*, code 876 (see page 399).

PLEASE TAKE NOTE

MOSFET MkII Variable Bench Power Supply ***(April '94)***

Page 267, Fig. 6. The two output leads from the Red and Black terminal have been transposed at the printed circuit board connections. The red lead should be connected to the plus (+) point at the right corner of the board, and the black lead should go to the minus (−) point below this – see Fig. 4.

Also, the type number of the thyristor CSR1 has been omitted from the circuit diagram and components list. This should be the TIC V106D type. The V denotes the plastic package device.

CCD TV Camera – Frame Grab ***(April '94)***

Fig. 20. The "Component Side" copper track of the double-sided p.c.b. version requires correction. The single-sided layout, using link wires, in Fig. 21 is correct.

We will be happy to send details to any readers who require this information.

THE BEST OF BRITISH

TERRY de VAUX-BALBIRNIE

Where is Britain's place in the world scene?

This is the second in a four-part series about the British electronics industry. Last month we explored some British companies producing software for computer-aided p.c.b. design and robots for education and instruction purposes. This month we shall examine British audio products.

IF YOU look in any high street TV/Audio store, you will see the familiar big-name products manufactured in the Far East and sold to the mass market. If you want a *British* designed and built product you would need to look a little further. However, you would be rewarded with *real* quality – some of the best in the business. In the UK, we manufacture a range of audio equipment which is second to none and exported to all parts of the world.

Special interest

The TGI group is of special interest. This was formed in 1987 by the merger of two existing UK audio companies – *Goodmans Loudspeakers Ltd.* and *Tannoy* both famous in their own right. The loudspeaker manufacturer *Mordaunt-Short* had been acquired previously by GLL so this too became part of the group. Three companies were added later – *Audix* in 1989, *Martin Audio* in 1990 and *Creek* who joined Tannoy in 1991.

Tannoy loudspeaker columns.

The group as a whole manufactures loudspeakers and high-quality amplifiers, tuners and other audio equipment some of broadcast quality. In fact, ***TGI Group*** is the largest loudspeaker designer and manufacturer in the UK. Through its various component companies, the group manufactures loudspeakers of all types. These range from professional studio monitors, automotive types and domestic models. They also include the rugged variety used in public address systems and those designed for transporting from place to place for live performances.

Over the Tannoy

Having been in the audio market for 65 years ***Tannoy*** has acquired one of the most respected brand names in the industry. To the public, the company name is synonymous with "public address systems" as in "the message came over the Tannoy".

This notion is so firmly established that it is not generally known that Tannoy no longer design and install PA equipment at all. This work is now carried out by sister company Audix of which more will be said presently. Since 1976, the centre of Tannoy operations has been situated in central Scotland on a seven-acre site close to major transportation networks.

Tannoy are now involved in the design and manufacture of high-quality studio monitor loudspeakers and the large types used in theatres, cinemas, nightclubs and similar places. However, anyone wishing to buy Tannoy loudspeakers will not necessarily have to pay the earth for them because they manufacture some inexpensive domestic models too. Prices range from around £120 to over £13,000 a pair.

They currently export 75 per cent of production and their loudspeakers are the UK's best selling brand. In the field of studio monitoring, the company enjoys a prominent position in North America. Tannoy have also penetrated the Japanese market where they are leaders in imported high-fidelity equipment.

Integrated speaker

Complementing the Tannoy range, ***Mordaunt-Short*** produce a range of low to mid-price high-fidelity loudspeakers. The top end of the market is characterised by traditional cabinet designs which are particularly popular with overseas purchasers.

One interesting feature of some of the Mordaunt-Short range is the use of shielded magnets which allows them to be operated close to magnetic field-sensitive equipment without causing problems such as distortion of TV pictures. Thus, the loudspeakers can be made part of an integrated audio system with television, computer monitor, etc. Export of Mordaunt-Short loudspeakers accounts for 50 per cent of total production with over half being in the £100 to £200 per pair price bracket.

High quality mix

Two other members of TGI group are interesting – ***Martin Audio*** and ***Audix***. Martin Audio have had over 20 years' experience in the manufacture of the larger type of rugged high quality loudspeakers used for live performances in fixed installations and for touring. Currently, 90 per cent of production is exported with a particularly strong following in the United States.

Over the years Audix have manufactured amplifiers, radio receivers and loudspeakers chiefly for the commercial rather than the domestic market. However, during the '80s the company began to centre its attention on public address systems and broadcast mixers. With Audix taken into the TGI group in 1989, Tannoy's public address interests were absorbed and added to their own. Audix PA systems are now found all over the world in conference halls, shopping centres, airports (including all of London's terminals) and sports complexes.

In the field of audio mixers, Audix have supplied equipment to BBC local radio stations, the BBC World Service, ITV, independent radio stations and to broadcast companies in many parts of the world. Among recent projects has been the re-equipping of the National Radio Station in Djakarta, Indonesia following destruction of the original by fire.

This project involved equipping nine continuity studios, fifteen general purpose studios, ten edit dubbing suites, a master control room, a news room, three outside broadcast vehicles and a full standby power system, A system of radio links between transmitter and outside broadcast vehicles is also part of the installation.

High quality T40 stereo FM Tuner from Creek, part of the Tannoy group.

Good ones

Goodmans Loudspeakers Ltd. has been long established in the UK as a loudspeaker manufacturer – with 65 years of design experience. This company is chiefly concerned with the high-volume end of the market with their six production lines able to manufacture six million units per year on a single shift.

Although GLL manufacture a range of domestic hi-fi loudspeakers, their chief interest now is in the smaller ones used in cars and those for TV and radio receivers. Automotive loudspeakers must be rugged and able to withstand constant vibration and distortion of the frame as well as wide changes in temperature and humidity.

Tests on the loudspeakers are therefore carried out between – 40°C and 180°C and with relative humidities between 20 per cent and 98 per cent. Extremes of infra-red, ultra-violet, vibration and shock are also applied to test any new design.

This type of loudspeaker needs to be constantly developed to keep up with the needs of the consumer. Not very long ago a simple A.M. radio, possibly with a basic cassette player built in, was all that the motorist could expect. With improved technology, allowing FM stereo broadcasts to be received in the car, the possibility of true hi-fi sound was made possible.

Mordant-Short loudspeakers and enclosures. Some of their range of speakers have "shielded" magnets.

Today, in-car audio systems often rival their home-based counterparts in terms of fidelity with high-quality cassette equipment and compact disc players becoming increasingly common. The power output of a car-based installation – often several tens of watts – surpasses that of a medium-sized domestic system. The demands placed on the loudspeakers are therefore higher than ever requiring a combination of ruggedness, small size, high power and good quality.

Creek, part of the Tannoy company, produce high quality amplifiers, tuners and other pieces of audio equipment including further loudspeakers. Before joining Tannoy, Creek already had a digital electronics development section. This, it is thought, will bring benefits to the group in the next generation of digital audio products.

Some of the Audix studio mixing equipment in action.

Gas stove amplifier

The company now called ***Quad Electroacoustics*** was founded by Peter Walker as ***The Acoustical Manufacturing Company*** in 1936. In 1941, having been bombed out of the original London premises, the company moved to Huntingdon where it exists to this day.

Originally, Acoustical was concerned with the design and manufacture of public address systems. There was no hi-fi market in those days but research into better quality PA amplifiers was to prove important to home audio in later years. The occasional "gas stove" domestic amplifier was built but large scale manufacture of quality household units awaited the public demand and this was not to emerge until after World War II.

During the war, non-essential manufacturing stopped but in the early post-war years production commenced once again – often using war surplus parts! The public were now beginning to seek better quality sound from domestic audio installations and Acoustical were ready to meet the challenge.

A range of new and technically advanced equipment appeared in 1949. The *corner ribbon speaker* was innovative and well ahead of its time. Its design, using a moving coil bass unit and horn-loaded ribbon tweeter, easily out-performed rival loudspeakers of the day. It is a tribute to the design that many of these are still in use today.

Hiss and rumble

In the same year, the HR1 radio tuner appeared – long and medium wave only, of course – VHF/FM not yet being broadcast. The QA12/P *(Quality Amplifier 12 watt with Preamplifier)* also appeared in 1949. This was originally designed for laboratory and studio applications but was quickly taken up by audio enthusiasts for domestic use. During its two years of production, 1000 units were sold.

In 1951 the QA12/P developed into the Acoustical Q.U.A.D (note how the *QUAD* brand was beginning to creep in). In this, the control unit was separate from the power amplifier and had switchable filters designed to cut out much of the hiss and rumble which was painfully evident in early record reproduction.

The classic QUAD II power amplifier and matching QC II control unit were introduced in 1953. The control unit had push button selection of input source and equalisation for different record characteristics. The QUAD II was manufactured unchanged for eighteen years with 90,000 units sold to virtually every country in the world.

Based on valve technology (the output valves were a pair of KT66's) rather than *transistors*, many of these units are still in use today and much-loved by their owners. A matching tuner appeared in 1955 and an outboard stereo decoder in 1965 with the introduction of stereo broadcasting. In 1968 this was replaced by the hybrid valve/transistor FM II tuner. Meanwhile, Quad had discontinued all public address and contract work in favour of developing the hi-fi line.

Walker's little wonder

In 1956, Quad demonstrated the world's first full-range electrostatic loudspeaker (ESL) and the company is still the acknowledged world leader in this field. It is said that every loudspeaker manufacturer of note has used a Quad ESL as a laboratory reference standard and one against which his efforts could be compared. The 1956 model described by a contemporary reviewer as "Walker's Little Wonder", set standards for the next quarter century. More will be said about the ESL presently.

In 1958, with the introduction of stereo records, there was a demand for a stereo control unit and matching stereo decoder. This was marketed as the *QUAD 22* Control Unit driving two separate Quad II power amplifiers.

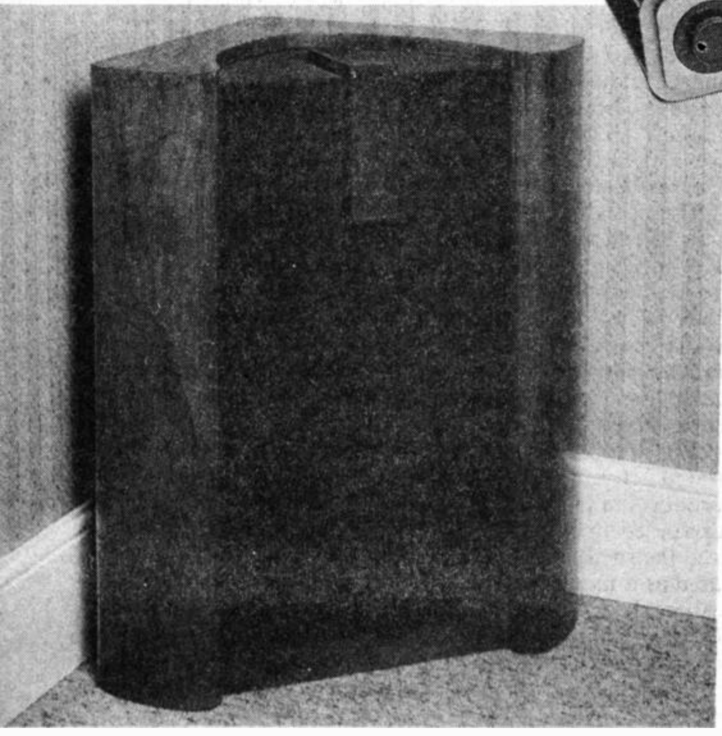
The year 1967 saw a monumental change in the product range with the introduction of the *QUAD 303* power amplifier and 33 control unit. This was Quad's first *transistorised* system. The *FM3* matching all-transistor tuner appeared three years later. Discontinued in 1982 this is still a firm second-hand favourite.

In 1975, the company presented a paper to the *50th International Convention of the Audio Engineering Society* on a technique named by Quad as "Current Dumping". Here, the linearity of the output transistors (current dumpers) does not rule the overall amplifier performance. This is determined solely by a very low power, very high quality current-controlled amplifier using error correction techniques.

Current Dumping made it possible to design a very high performance amplifier without the need for carefully matched output transistors. This avoids problems of cross-over biasing and the need for accurate setting-up at manufacture. Any subsequent repairs requiring the fitting of a new component may be carried out cheaply since the need for re-aligning is eliminated.

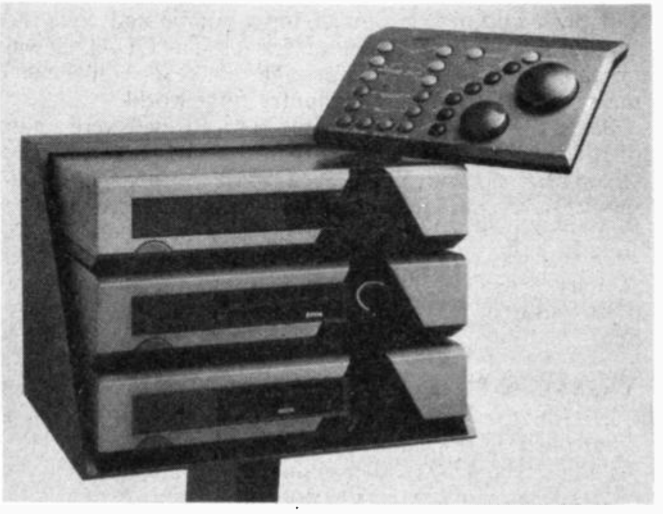
The 405 current-dumping power amplifier introduced in 1975 brought with it the Queen's Award for Technological Achievement – Quad is the only hi-fi company ever to have been given this award. The 405 quickly became the best selling amplifier in the world – including Japan – with 64,000 units produced.

The *QUAD 44* control unit introduced in 1979 provided complete flexibility of inputs by a system of replaceable modules. This used other innovative techniques such as electronic switching and a new approach to tone control.



The Corner Ribbon Loudspeaker. The horn-loaded ribbon tweeter and folded horn low-frequency unit were unrivalled in their day.

The classic Quad II Power Amplifier and QCII Control Unit. Manufactured unchanged for 18 years.



The 66 series Remote Control, CD Player, Tuner and Amplifier from Quad Electroacoustics.

(Right): The Quad ESL63 electrostatic took 18 years to develop.

In 1982, the QUAD 33 and FM3 tuner were replaced by completely new products – the 34 preamplifier and the *FM4* tuner using the latest technology. The FM4 used microprocessor control making it very simple to use yet offering unparalleled performance. In 1986, the current-dumping 306 and 606 amplifiers replaced the 303 and complementing the 405-2.

The latest *QUAD 66* series is a further step forward with an ergonomically advanced remote-control system. It continues the Quad philosophy of manufacturing technically advanced systems which are extremely easy to use.

Quad (the name derives from *Quality Unit Amplifier Domestic*) has become famous for a range of very high quality audio products which includes loudspeakers, amplifiers and tuners. However, the company is still particularly noted for its electrostatic loudspeaker design with the current model, the *ESL-63* having taken 18 years to develop. Known fondly as *FRED* (Full Range Electrostatic Doublet), care in design means that one unit is virtually identical to any other with manufacturing tolerances being virtually eliminated.

The Quad Electrostatic Loudspeaker is found in recording studios and broadcast companies as well as in the homes of music lovers all over the world. Quad have an impressive list of celebrities who use their equipment. Up to 1990, nearly 31,000 ESL-63's were sold.

Compact disc

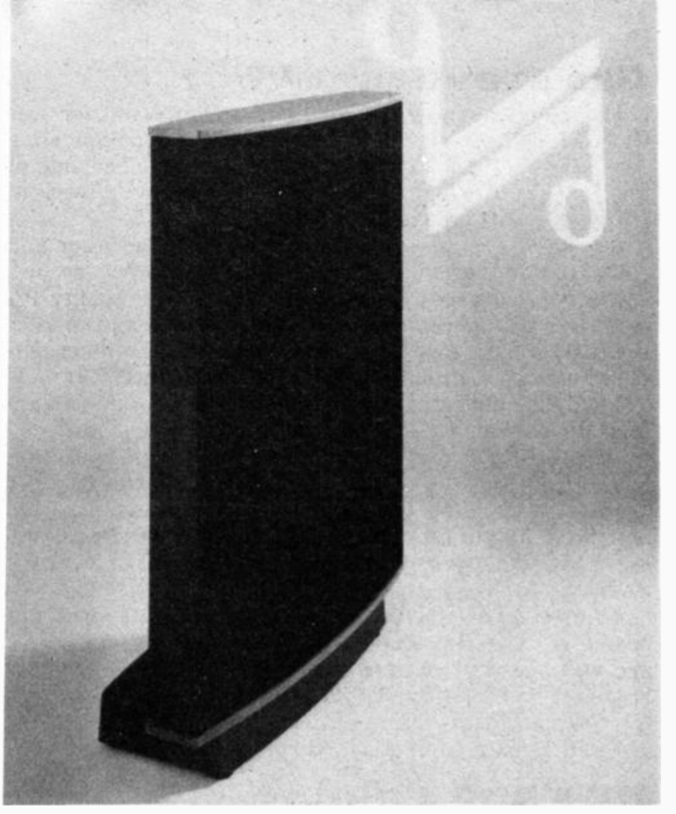
Electrostatic loudspeakers produce vibrations in the air but rely on a different principle to the conventional moving-coil unit. In the ESL an electrically charged membrane, one-tenth of the thickness of a human hair, is suspended between two acoustically transparent electrodes.

The electrical input causes a varying *electrostatic field* to be developed between them. The membrane is electrostatically charged and this interacts with the varying field. This causes the membrane to move alternately backwards and forwards in sympathy with the sound.

The membrane in an electrostatic loudspeaker is extremely light so has very little inertia. It is therefore able to follow rapid movements much more faithfully and hence reproduce the full range of sound perception using only one unit.

With the appearance of the Compact Disc in the mid-80's, there are now far greater demands placed on audio equipment since this medium is a virtually perfect input source. Any audible imperfections are therefore likely to be due to the system. Enthusiasts know this and are less forgiving of the manufacturer.

Quad philosophy is one of providing technical excellence resulting from a scientific approach to problem-solving.



However, all products are designed to look good too and much effort is put into the feel for a product. In fact, as many prizes have been awarded for the design aspect as for technical innovation.

Another aspect of Quad philosophy is that they will continue to service all their equipment whatever the year of manufacture. This is important because many users acknowledge that 1950's Quad equipment still out-performs the high street volume products on sale today.

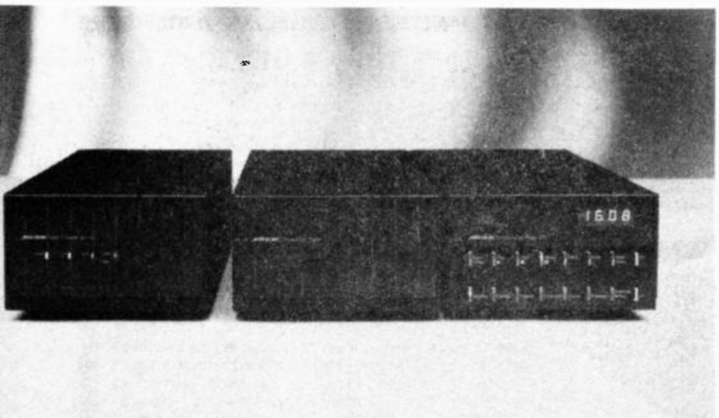
The company currently exports 65 per cent of output with products sold to 65 countries with major markets in Europe, Canada, Korea and Japan. The company employs 140 workers in a 3,000m^2 factory producing a product every 150 seconds. The founder, Peter Walker, was awarded the OBE in 1990 for his contribution to the audio industry and was conferred the honorary degree of Doctor of Science by Keele University in 1992.

Meridian line

The company *Boothroyd Stuart* was established in 1977 by Allen Boothroyd and Bob Stuart. The two had met in the early 1970's as consultants working on high performance audio products for clients. They felt that there would be great benefit and more freedom to express their own ideas if they set up their own manufacturing base. They were already established designers having won a Design Council Award for the Lecson Amplifier System in 1974.

The brand name chosen for Boothroyd Stuart products was ***Meridian*** (the original premises were in the town of St. Ives in Cambridgeshire which is on the meridian line of 0 degrees longitude). Meridian have become well-known for their digital technology and for *Active Loudspeakers* (of which more will be said presently). However, there is a much wider product range than this with the company designing and manufacturing the whole range of audio equipment.

The first product to bear the Meridian brand name was the *M1 Active Loudspeaker*. There followed a whole line of products in the late '70s called the 100 series. The company expanded their range of active loudspeakers with the *M2* and the smaller *M3* unit. In its latest form – the *M30* – it is used as a monitor speaker by broadcasting companies and others. In 1982, the two founders won their second British Design Award for the new Modular Amplifier System. This enabled a wide variety of units to be assembled using plug-in components – the idea was to accommodate new equipment such as for CD and digital processing.



The 200 series Digital Converter and CD Player from Meridian.

The Meridian Argent loudspeaker range.

Latest DSP5000 Active Speaker System from Meridian.

In 1983 Bob Stuart began his involvement with CD and developed a close association with Philips in Holland. In 1984, the MCD CD player was introduced. Physically based on the Philips machine, this was enhanced in performance by redesigning and replacing the analogue audio circuitry.

In 1985 a more advanced version was introduced for professional users – the MCD-Pro. This has been used by recording companies for evaluating CD's. Probably not in the domestic domain but certainly of interest is the CD-R compact disc recorder. This is used as a master recorder by leading British record companies. Unfortunately, the cost – £4,500 – puts it out of the reach of most amateurs.

The first 200 series product was introduced at the *CES* (Consumer Electronics Show) Chicago in 1986 – the 207 two-box CD player. The 201 Preamp Control Unit was introduced in the same year. The 204 FM tuner and 205 Power Amplifier followed in 1987 and, in 1988, the 200 series won the third British Design Council Award – the first design team to win this on three occasions.

Augmenting the 200 series, Meridian introduced the 600 range of "high end" products in 1990. In the same year, conventional passive loudspeakers were marketed for the first time – the Argent range. This puts a Meridian system within reach of the serious enthusiast with Argent 1 costing around £1,000. The Meridian 605 150W power amplifier with MOSFET output was introduced in 1992.

Passive and active

A *passive* loudspeaker is familiar to most of us as simply a speaker – or a group of speakers – in a cabinet. This is connected to the amplifier using a length of twin wire. In a conventional multi-speaker system, a crossover network comprising capacitors, inductors and resistors is used.

Inevitably, the frequency bands overlap and degrade the performance. In a Meridian active system, there is a separate power amplifier for each loudspeaker and these are built into the cabinet along with the speakers themselves. Active filters separate the frequency bands much earlier in the circuit giving greatly improved performance.

In 1989, the *D600 Digital Active Loudspeaker* was introduced – this allowed for the first time a 3-way speaker system with amplifiers, preamps, volume control and digital conversion on-board. Crossover filtering can then, with advantage, be performed on the digital signal. As well as electrical and optical digital inputs, the D600 is fitted with an analogue input port.

The D6000 loudspeaker system was introduced at the *Chicago CES* in 1990. This builds on the D600 and is designed to accept a digital signal only. Unfortunately, the D600 is out of the reach of most enthusiasts at £2950 a pair and the D6000 still more so at £7650. For those who cannot afford this but who still want an active system, the M30 system price tag is £950 and for the M60, £1950. Latest in the line of Digital Active Speakers – the DSP5000 – was introduced at the San Francisco *Stereophile Show* in March, 1993.

Expensive business

Designing and manufacturing quality audio equipment is an expensive business and proved beyond the financial resources of the original investors. In 1987 Boothroyd Stewart was acquired by AGI (Electronics); the owners of KEF.

However, in 1991, AGI group went into receivership. Under a Management Buyout Plan, the company assets and property were acquired with a deal completed in May 1992. Now *three* companies – Meridian Audio, Digital Gramophone and Wireless (the development and manufacturing company) and Meridian America – the organisation operates as ***The Meridian Group of Companies***. Once again in the hands of the original management, it is totally independent.

That's all for this month. Next time we shall look at manufacturers of test instruments and soldering equipment chiefly of the kind used for amateur and educational purposes.

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HART KITS give you the opportunity to build the very best engineered hifi equipment there is, designed by the leaders in their field, using the best components that are available.
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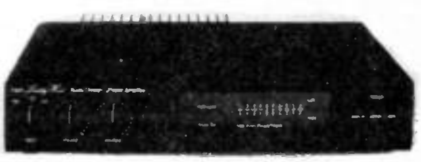

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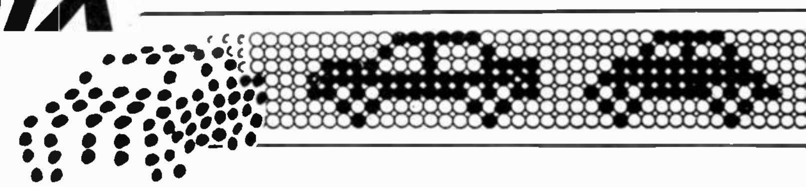
L.E.D. MATRIX MESSAGE DISPLAY UNIT



JULYAN ILETT and BRETT GOSSAGE

A versatile display unit with moving messages and graphics. A host of features include manually keyed or library messages

MESSAGE displays are in widespread use and are a very effective medium for attracting attention. This unit can be used for a variety of applications including retail advertising in shop windows, at discos, parties and weddings for entertainment purposes, and for warning or security messages.

The ability to design your own messages is included, and graphics characters enhance the visual effect. Also, no message display would be complete without the facility for it to be under computer control. So, a follow up interface add-on unit will be described next month which will enable the Matrix Display to be connected to a PC, further expanding its versatility.

This display unit consists of an array of standard 5mm red l.e.d.s arranged in 64 columns of seven rows (approx 51mm x 482mm) mounted on a 102mm x 584mm display Printed Circuit Board (p.c.b.). Control of this p.c.b. is achieved with a Z80A microprocessor on a compact 76mm x 165mm CPU p.c.b., together with EPROM, static RAM and a handful of discrete logic i.c.s.

Messages are entered via a remote hand-shaped five-key keypad connected to the CPU p.c.b. via ribbon cable. All three component parts are constructed on single-sided p.c.b.s and the complete unit is easily transportable provided a suitable 8V to 12V power supply is available. Some of the features of the L.E.D. Matrix Message Display Unit are shown in the "Specification" panel.

COMPONENTS

As far as possible the project has been designed to use readily available components. Full price l.e.d.s can be used, but as there are so many in this project, 448, each penny saved on the price of an l.e.d. will reduce the overall project cost by nearly £5.

Try and get the best deal on l.e.d.s by going to several suppliers, some of which usually have special bargain offers. The average new red l.e.d. price is about 12p, but it should be possible to get bargain l.e.d.s for 5p or less. Care should be taken when buying the l.e.d.s, it is quite important to buy them in one batch, plus a few spare just in case!

Check the physical characteristics of a few in the batch, to ensure they all have similar properties and will make an even display when mounted in a large matrix. Also check that the legs of each l.e.d. are greater than 10mm in length and will fit through a 1mm hole. Remember, the l.e.d.s do not have to be red, but the higher price and reduced availability of other colours may cause difficulties.

The only other special component is the EPROM. A pre-programmed 27256 EPROM, together with a detailed operation manual is available from the authors, price £10, see *Shoptalk* page.

The hand-shaped keypad is slightly unusual, but was found to be a practical alternative to a full "Qwerty" keyboard. This was chosen for several reasons: With only five keys, the project cost is greatly reduced. It also simplifies the circuitry.

With a little practice, the character codes can be easily remembered. The authors found that after only an hour or so, they were able to key "The quick brown fox" etc. without any assistance from Fig. 13 (next month), the keying codes. High speed accurate keying is possible once these codes have been mastered.

Specification . . .

- Large bright l.e.d. display
- Long range visibility
- Self-contained unit with built-in Z80A CPU
- Low cost project with performance comparable to commercial units
- Single 8V to 12V power supply required
- Easy to use 5-key keypad for message input and control
- Four built-in message libraries, each containing about 50 messages
- Manual keying of user messages
- Quick library message access
- Message search facility using a "string" of characters
- Many message display style options
- Message sequencing
- Four fonts (type styles)
- Eight animation styles
- Graphic characters and punctuation in each font
- One-shot or continuous message display facility
- Long message handling (word breaking or whole message scrolling)
- Piezo sounder to assist with key operation and error reporting

CHARACTERS, FONTS AND GRAPHICS

The idea of representing characters as a series of dots, or "pixels" is very common in todays digital society. It is used in printing, facsmilie, even television.

Displays using l.e.d.s in this way are always quite large as each l.e.d. represents one pixel, the smallest part of a character or graphic. Because of this, these displays are best viewed from a distance, as the pixels then merge into their respective characters. However, the real advantage of a computerised display such as this, is that the characters can be made to move, and it is this aspect alone

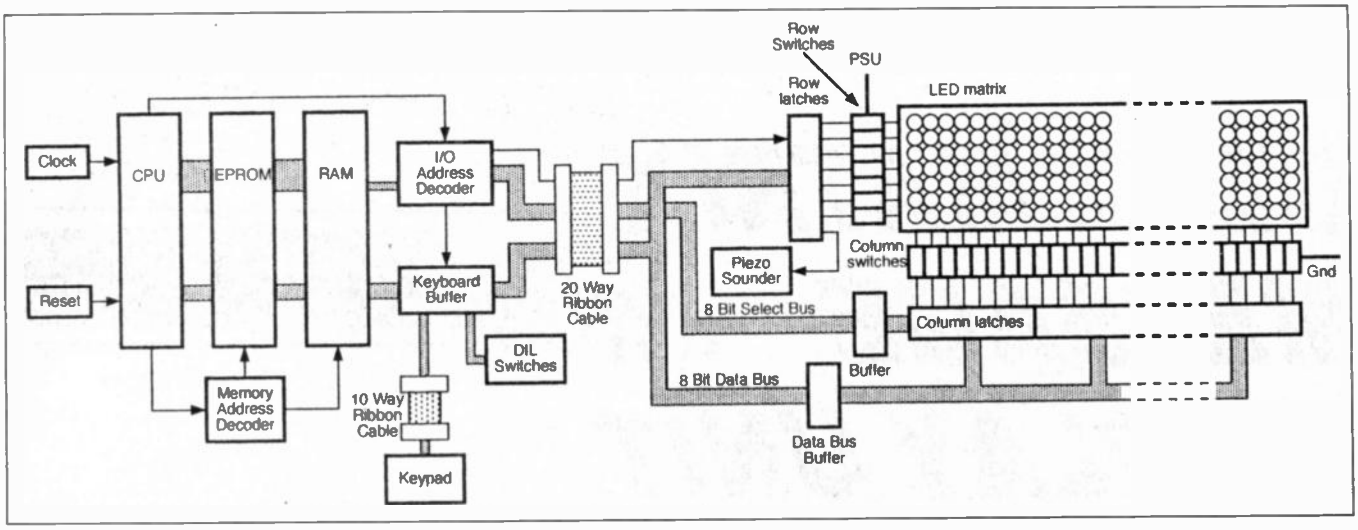


Fig. 2. Block schematic diagram for the L.E.D. Matrix Message Display Unit.

that makes these displays more interesting than static illuminated displays.

There are limitless ways in which the characters and messages can be made to move on the display, restricted only by the software. These movements are often referred to as "animations". In the same way that it has been possible to represent all the numerals on 7-segment displays, it has been found that all English alpha characters can be represented on a standard "matrix" of seven pixels (l.e.d.s) high, by five pixels wide. Any fewer pixels, and the characters start to become unrecognizable.

This project uses four sets of characters or "fonts", each of which contains all 26 upper case alpha, 10 numeral, 12 punctuation and 4 graphic characters. This obviously adds to the flexibility of any display system, allowing messages to vary in their style.

An example of the four "styles" is shown in Fig. 1a. The first font (Font 1) is made up using the general 7 x 5 l.e.d. arrangement with the noticeable exception of the "I" character which is only three l.e.d.s wide. These differing character widths make each word more compact and pleasing to the eye when displayed.

Font 2 introduces a narrower character font, but as stated above, this introduces problems. The upright of a character such as the "T" must be in the centre of the character, so it can only have an odd number of l.e.d.s that make up its width. Here the normally 4-l.e.d. wide character is replaced by the standard 5-l.e.d. wide one. The advantages of the narrow font are obvious in that more characters, and therefore longer words can be shown on the display in one go.

Fonts 3 and 4 are "bold" versions of fonts 1 and 2 respectively (See Fig. 1a). This is achieved within the software. Each character to be displayed has a bit-map (stored in the EPROM) which is a series of consecutive bytes that represent the columns of each character. These are then read out to the display, duplicating each column of each character to create the bold effect. This means that the majority of the characters are 10 and 8 pixels wide in fonts 3 and 4 respectively.

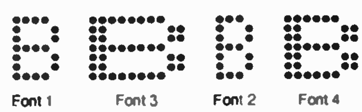


Fig. 1a Font Examples

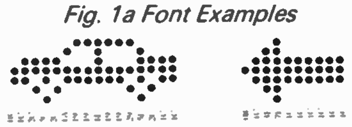


Fig. 1b Graphic Examples

For the purposes of the program, each column of l.e.d.s that make up a character is a byte in memory. The top l.e.d. is bit 0 and the bottom is bit 6 (Bit 7 is used for other purposes). Fig. 1b shows how the bytes represent the various columns of a character. A byte of 7FH represents all l.e.d.s on, and this is shown in the "arrow" character.

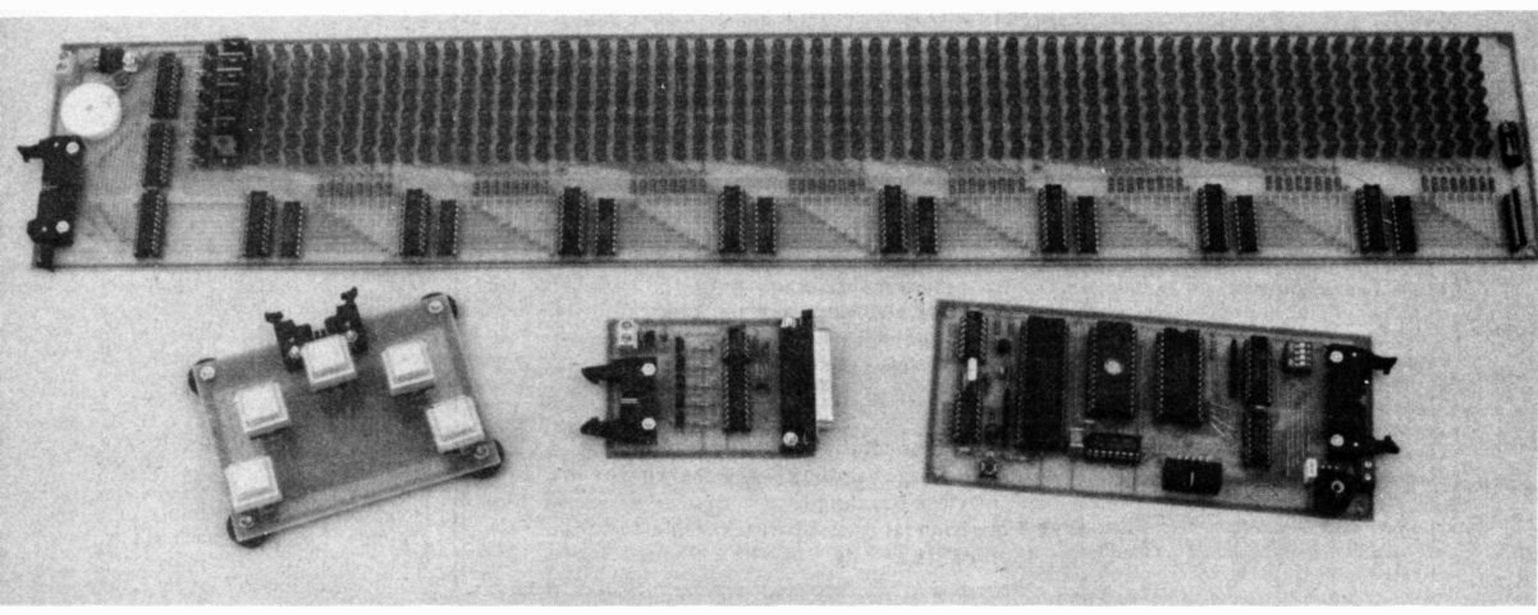
The graphics are treated as single characters although they can be as big as the entire display area. Any picture or graphic can be created, but the limit of seven l.e.d.s in a column does pose a restriction on height.

HOW IT WORKS

A block diagram of the message display unit is shown in Fig. 2. On the right of the diagram is the l.e.d. matrix which consists of seven rows of 64 l.e.d.s. Each of the rows has a switch circuit, which supplies current from the power supply when activated.

These row switches are controlled by a set of seven latches which receive data from the data bus. An eighth latch is used to activate the piezoelectric sounder circuit.

The completed Display board and, left to right, the Keypad, Computer Interface and CPU boards.



The columns also have switch circuits, these being designed to sink current to ground when activated. The column switches are also controlled by latches, arranged in eight groups of eight.

Each group can be written to from the data bus under the control of eight column group select lines which make up the select bus. Both the data and select busses are buffered before connection to the column latches.On the left side of Fig. 2. is the CPU circuitry. The clock circuit provides the master timing reference, while the reset circuit ensures that the CPU starts executing program instructions from the beginning when power is first applied. The EPROM and RAM are connected to the CPU via common address and data busses and are selected under the control of the memory address decoder circuit.

The I/O (Input/Output) address decoder circuit uses control signals from the CPU to select the row latches, the column latches and the keyboard buffer. The keyboard buffer reads both the keypad and the DIL switches simultaneously. The data bus, select bus and the row latch signals are connected to the display section via a 20-way ribbon cable, while a 10-way ribbon cable is used to connect the keypad to the keyboard buffer.

MATRIX THEORY AND MULTIPLEXING

The matrix configuration used in this design allows all 448 l.e.d.s to be controlled with a total of just 71 switches. Turning on both a row switch and a column switch, completes a circuit and current flows through the l.e.d. at their intersection (see Fig. 3). The arrangement does however, impose restrictions on the combinations of l.e.d.s that may be switched on simultaneously.

Imagine that just two l.e.d.s are to be illuminated, and that they are positioned diagonally adjacent to each other. Both of the rows to which they are connected would need to be switched on, so too would both of the columns. It quickly becomes apparent that this would result in a block of four l.e.d.s all being lit up. Clearly, individual l.e.d.s are not individually controllable, and a special technique is required in order to make them appear so.

To effectively control the l.e.d. matrix, a multiplexing technique must be employed. All the appropriate l.e.d.s along one row, (the top row for example), are selected by turning on the corresponding column switches. The row switch is then turned on for a short, but carefully measured period of time.

With the row switch turned back off again, the column switches are altered to reflect the pattern of l.e.d.s to be illuminated on the next row down. This next row is then switched on for the same short period of time. The remaining rows are activated sequentially in the same manner until all seven have been displayed. The entire "frame" is then re-displayed from the top.

Remarkably, this complex sequence of row and column switching, if carried out at sufficient speed, results in a completely stable display, with all l.e.d.s capable of individual control. With the frame repetition rate at about 50 frames per second, the human eye fails to keep pace with the rapid switching and interprets the light output as constant; an effect known as "persistence of vision".

At this point, it may seem that multiplexing is a rather complicated way of controlling a large number of l.e.d.s. This might be a valid argument, if it were not for the inevitable presence of a microprocessor in the design. This sort of high-speed, repetitive task is highly suited to the microprocessor and imposes little additional burden upon it.

Multiplexing is generally considered preferable to the alternative method which involves driving each l.e.d. from a separate latch. Wiring up 448 latches could become a little unwieldy, and the cost would be considerable. Both methods do, however, have their advantages and disadvantages.

The multiplexed display suffers from the fact that each l.e.d. is only switched on for one seventh of the frame time which could result in reduced brightness, although this can be compensated for by increasing the current that flows through the l.e.d.s. Overdriving the l.e.d.s is perfectly safe as long as the multiplexing system keeps running and does not stop for any reason. There is a danger that a row of l.e.d.s could be left switched on if the program were to crash and so the matrix must be fitted with row protection circuits that switch off the row after a certain maximum time.

Multiplexing also creates some curious effects when words or messages are animated. Characters that are moving appear to lean slightly in the direction of movement (assuming that the matrix is scanned from top to bottom). This effect is not necessarily a disadvantage though, as the slant adds a certain "dynamic" appearance to the animation.

DISPLAY CIRCUIT

The circuit diagram of the Display is shown in Fig. 3. The Z80A CPU (see Fig. 4) writes data to the row latches (IC1) by holding the $\overline{CE}$ (Enable) input, pin 1, low while a low going pulse is applied to the CK (Clock) input, pin 11.

Seven identical row switch circuits are connected between the latch outputs and the l.e.d. matrix. The diagram shows just one of these circuits, which operates as follows:

The output of the latch is coupled to the base (b) of *npn* transistor TR1 via capacitor C1 and resistor R72, which under normal conditions, will turn on the transistor whenever the latch output is high. If the latch output stays high, however, a potential will start to develop across C1 returning the base of TR1 to 0V after about 5ms. In this way, the row switches are prevented from being turned on continuously, thus protecting the l.e.d.s from damage. When the latch output goes low, diode D1 holds its side of capacitor C1 at 0V ensuring it is discharged and ready for the next pulse.

The *pnp* Darlington power transistor TR8, turns on whenever TR1 is switched on, and supplies current to the row. Although this power transistor must be capable of providing enough current for all 64 row l.e.d.s, not all of them will be on all the time. Additionally, each row is only switched for one-seventh of the total frame time, so the maximum current requirement of over six amps is reduced to an average of well below one amp, allowing the transistors to be operated without heatsinks.

Column data is written into the eight groups of column latches (IC5 to IC12), one group at a time, by applying a low going select pulse to each of the eight clock (CK) inputs in turn. The select bus and data bus signals are buffered using HCT devices (IC2 and IC3) which convert TTL signals from the CPU to CMOS compatible signals for the column latch chips, while at the same time providing the necessary output current to drive the long bus lines. The column switches (IC13 to IC20) are simply *npn* Darlington transistors in packs of eight, and are directly connected to the outputs of the column latches.

Each column of l.e.d.s requires a current limiting resistor (R1 to R64) connected in series. Each of the l.e.d.s in the column uses this resistor in turn, so that in practice, it is only ever in series with one l.e.d. at any one time.

To compensate for the multiplexing system and to ensure a high brightness display, the l.e.d.s are operated at 100mA, over three times their normal maximum current rating. The maximum recommended l.e.d. supply voltage is 12V, but at least 2V is lost in the Darlington transistor junctions and the l.e.d. itself which leaves about 10V across the series resistor.

From this information, Ohms law can be used to determine the value of the resistor by applying the formula:

$R = V/I$.

$R = 10/0{\cdot}1 = 100$ ohms

The power dissipation requirement of the resistor can be calculated using:

$P = I^2R$.

$P = (0{\cdot}1)^2 \times 100 = 1$ Watt

Unfortunately, one Watt resistors tend to be both fairly large and fairly expensive. Since 64 of them are needed, and they are quite closely spaced, it was decided that 0·6W metal film types would be used instead. Since not all of the l.e.d.s in each column are likely to be on all the time, the resistors are unlikely to get very hot.

Finally, a simple oscillator circuit is constructed around a 7555 CMOS timer chip (IC4). Germanium diode D9, ensures minimum breakthrough from the piezo sounder WD1 when the circuit is gated off.

CPU CIRCUIT

The Central Processing Unit (CPU) circuit diagram is shown in Fig. 4. The CPU is clocked at 4MHz using a standard crystal oscillator X1/IC1, with an additional active pull-up circuit comprising transistor TR1, resistor R1, R2 and R3, and capacitor C2. This is the recommended clock circuit for operation of the Z80A at 4MHz.

The reset circuit consists of a simple *RC*-network with the electrolytic capacitor C11 charging up via a resistor in SIL1; an 8-way resistor array. The Schmitt trigger inverters (IC2) are used to ensure a clean reset pulse and to provide separate outputs for the Reset l.e.d. and the CPU. The l.e.d. lights for half a second or so during the reset period but stays switched off during normal operation.

Unused Z80A inputs $\overline{BUSRQ}$ (Bus Request), $\overline{NMI}$ (Non Maskable Interrupt), $\overline{WAIT}$ and $\overline{INT}$ (Interrupt) are connected to the 5V line via separate resistors within resistor pack SIL1. Unused outputs are left unconnected.

The Z80A microprocessor has a good number of control signals which makes connecting memory and I/O devices very simple. When the Z80A needs to *read* data from either memory device (IC4, IC5), it first places the desired address on the address bus, then lowers both the RD (Read) line and the MREQ (Memory Request) line. The CPU writes data by

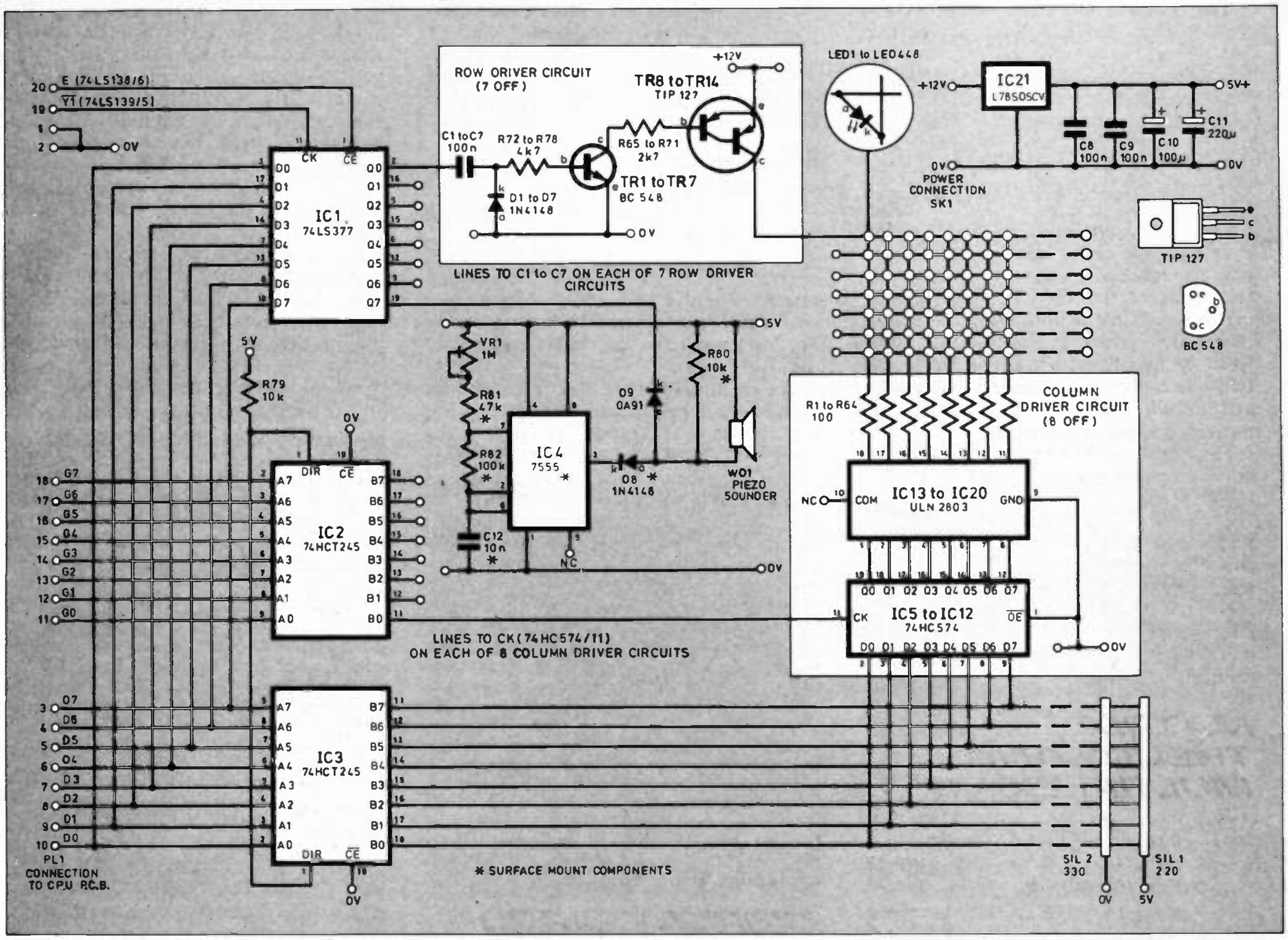


Fig. 3. Circuit diagram of the display section of the Message Display Unit.

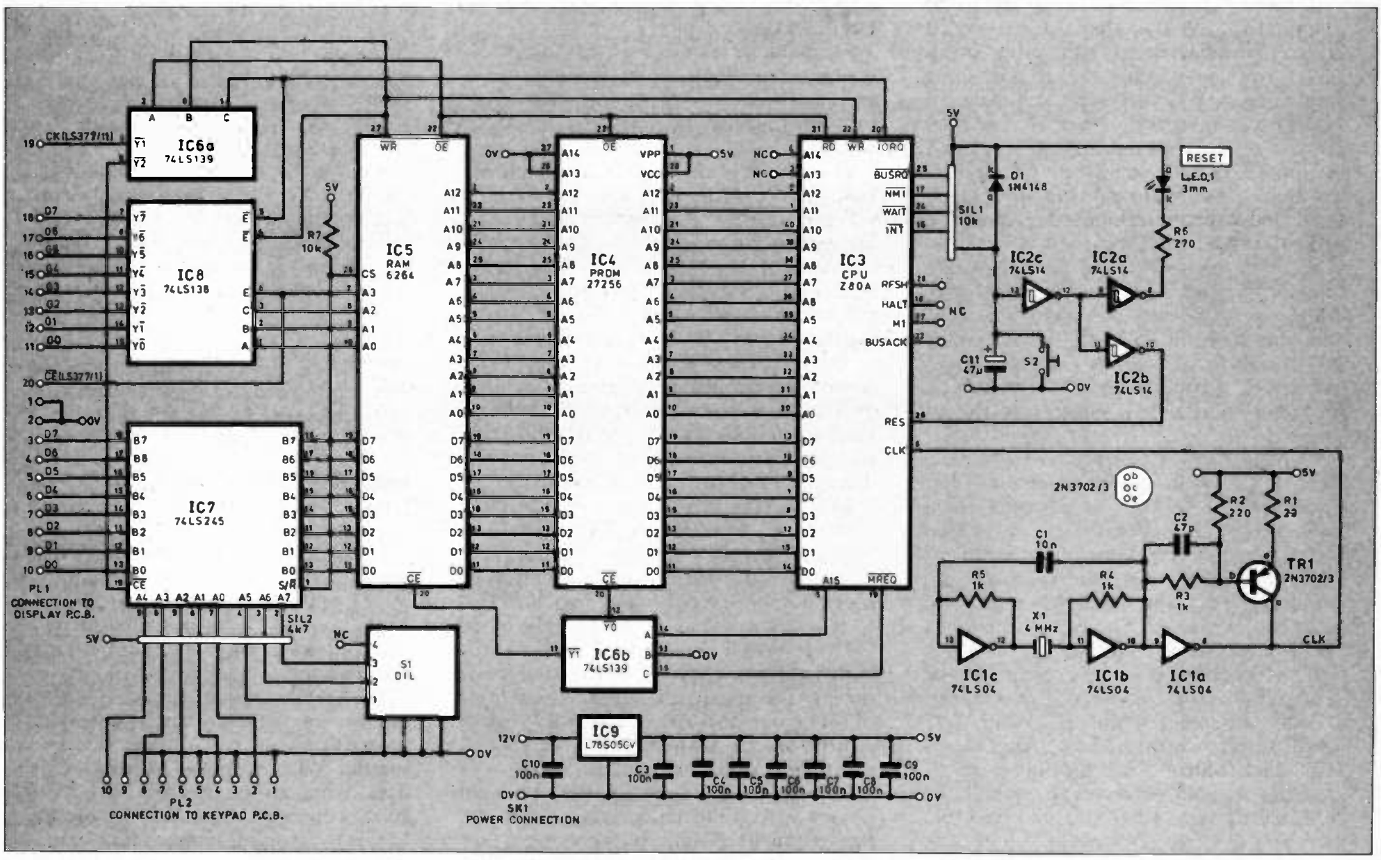


Fig. 4. Circuit diagram of the Z80A CPU section of the Display Unit.

I/O Address Decode

DIL/Keypad	IORQ . RD . XXXX XXXX
Column	IORQ . WR . XXXX1NNN
Row/Sounder	IORQ . WR. XXXX0XXX

Fig. 5. Input/Output (I/O) address decode

Listing 1: Main Program Loop

```
MAIN:       CALL KEYTEST
            CALL NZ,KEYPROC
            CALL DISPLAY
            CALL C, ANIMATE
            CALL SOUNDER
            JR MAIN
```

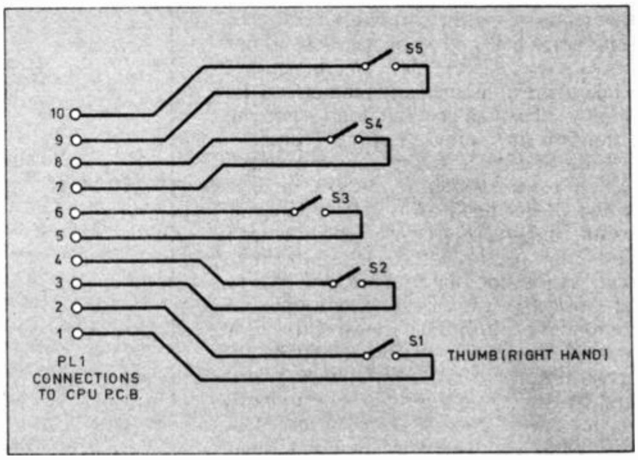


Fig. 6. Circuit diagram for the five "key" keypad.

lowering both $\overline{WR}$ and $\overline{MREQ}$. (Note: Most of the Z80A control signals are active when they are low. Active low signals are indicated by the inversion "bar" across the top of the signal's name).

The Z80A's $\overline{RD}$ output (pin 21) is connected to the $\overline{OE}$ (Output Enable) pin (22) on both memory devices, but only the one whose $\overline{CE}$ (Chip Enable) input (pin 20) is also low, will actually output data. The 2 to 4 line decoder IC6b performs the memory address decoding necessary to select either the EPROM (IC4) or the RAM (IC5).

With IC3's $\overline{MREQ}$ low, address line A15 selects the EPROM when low, and the RAM when high. As a result, the EPROM responds to addresses between 0000H and 7FFFH and the RAM to addresses between 8000H and FFFFH.

The memory address decoder performs only partial decoding. This means that the RAM contents (8K bytes) appear four times within the 32K address range mentioned above.

In the case of the EPROM, the situation is complicated further. For a start, only a quarter of the EPROM is accessible since its top two address lines, A13 and A14, are tied to the 0V line. The remaining three quarters of the EPROM are completely unused.

This situation is not as wasteful as it sounds though, as EPROMS of different sizes are all much the same price anyway. This 8K quarter of EPROM also appears four times within its decoded address range.

The Z80A communicates with I/O devices by lowering the $\overline{IORQ}$ (Input/Output Request) line together with either $\overline{RD}$ or $\overline{WR}$. IC6a performs the simple decoding required to read the keypad buffer IC7. Since none of the address lines is decoded, an I/O read of any of the Z80A's 256 I/O addresses will result in the keypad buffer being read.

The 3 to 8 line decoder IC8 is responsible for decoding the eight column latch select lines from eight consecutive I/O write addresses. Address line A3 is used to select the column latch decoder when high, and the row latch when low. Fig. 5 details all I/O addresses used.

KEYPAD

The circuit diagram of the Keypad is shown in Fig. 6. The circuit consists of five push-to-make key switches (S1 to S5), each connected to one pair of pins on the 10 way ribbon cable connector. Switch S1 (located on the left side of the p.c.b.) is normally operated by the right hand thumb and produces the "space" character when pressed on its own. When the keypad is read by the CPU, switches S1 to S5 represent data bits D0 to D4 respectively.

SOFTWARE

Although it is not possible to describe all the software in detail, it is probably worth taking a look at the main program loop, which gives a good insight into how the various tasks of the system are managed. The main program loop is reproduced in Listing 1.

The keyboard testing subroutine KEYTEST, reads the keyboard port noting any changes since the last time it was read. Only when the keyboard data returns to zero, does the subroutine evaluate what combination of keys has been pressed. This explains why the CPU responds to keyboard codes not when the keys are pressed, but when they are *released.*

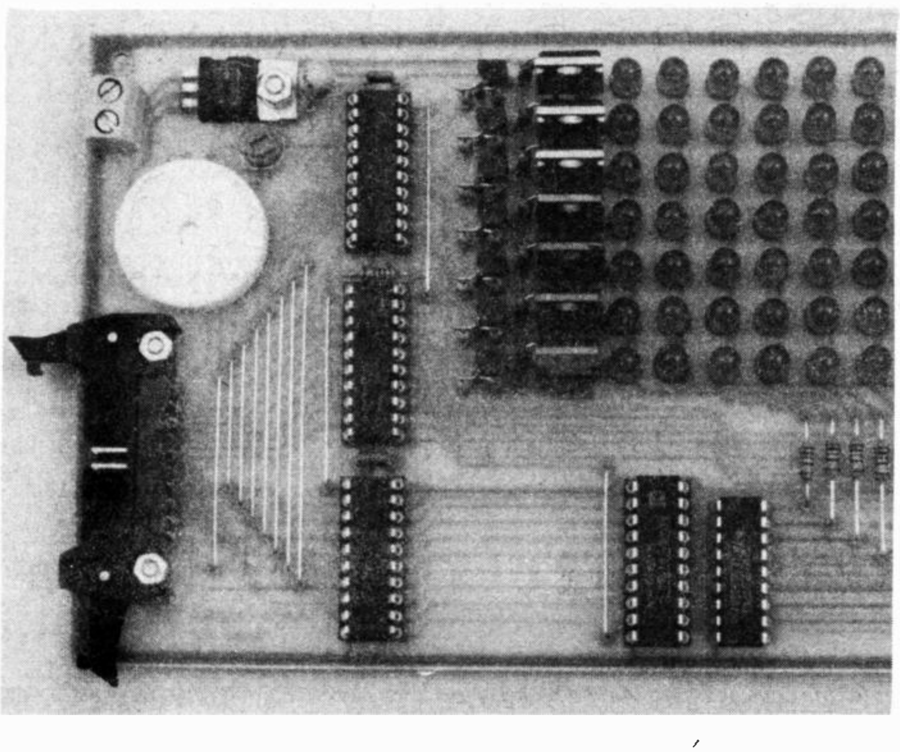
When a keyboard code has been detected, a "not zero" "carry" (c) flag condition is signalled, and the keyboard processing routine KEYPROC is called. This subroutine checks to see whether the key code is a character or a command. Characters are entered into an ASCII text buffer whereas commands call up additional subroutines setting various tasks into action.

The DISPLAY subroutine controls the multiplexing system by turning off the currently displayed row, compiling column data for the next row down and then turning that row on. Only when the DISPLAY routine turns on the seventh row (the bottom row), is the "carry" (c) flag condition signalled which indicates that the ANIMATE subroutine is to be called. In this way, animation only takes place once the display routine has finished each complete frame.

ANIMATION

The ANIMATE subroutine is by far the largest element in the software, and is responsible for controlling the way in which words or messages move into and out of the display area. The subroutine has to maintain a number of counters and memory address pointers and calls several different subroutines of its own in order to produce the various different animation effects, e.g. scrolling left, right, up and down.

Each time the ANIMATE subroutine is called, only a single pixel move is performed in order that the main program loop can be kept cycling at a suitably rapid rate. This execution of several subroutines, a bit at a time and at high speed, gives



the impression of performing several tasks simultaneously and explains how a new message can be keyed in on the keypad while a previous message remains on the display. The main program loop represents a simple form of multi-tasking software.

The SOUNDER subroutine simply checks to see whether the piezo sounder is to be switched on or off, or left unchanged.

Other major software elements include a SEARCH routine which scans the message libraries looking for matching character strings. Even if a match is found, the remainder of the library is also searched in order to determine whether the string appears more than once. A QUICK search routine is also incorporated which simply locates one of the first 26 messages in the library (not including the start-up message) when the search string consists of just one character between A and Z.

A CONVERT subroutine produces graphical bitmaps of the character codes in the ASCII text buffer by referring to one of the font tables held in the EPROM. These bitmaps are placed in the bitmap RAM with a single blank column between them. Four blank columns are inserted where a "space" character is read from the text buffer.

The memory map in Fig. 7 shows how the EPROM and RAM addresses are allocated to the various data areas used by the message display unit.

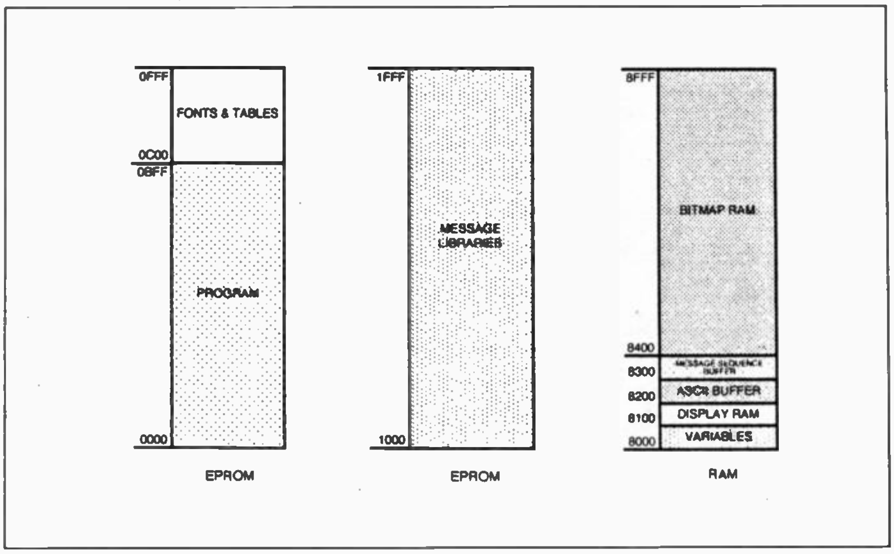


Fig. 7. Memory map showing how the EPROM and RAM addresses are allocated.

CONSTRUCTION - Display Board

The L.E.D. Matrix Message Display Unit project is built on three printed circuit boards and these are available as a set of three from the *EPE PCB Service*, codes 870 (Display), 871 (CPU) and 872 (Keyboard). The component layout for the Display p.c.b. is shown in Fig. 8.

With over 2,000 solder joints to be made, construction of the Display p.c.b. is not something that can be undertaken in a hurry. There are also a couple of unusual construction techniques involved, particularly with the "surface mount" components, and so a little forward planning is recommended. Take the time to read this section thoroughly before commencing.

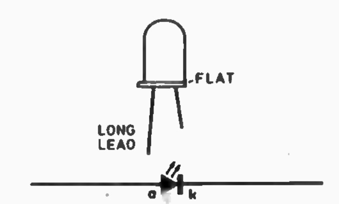


Fig. 9. L.E.D. pinout identification details.

The first stage of construction is to insert the 448 l.e.d.s. It is important that the l.e.d.s are inserted in the correct sequence, one column at a time, starting at the end where the power transistors will be positioned. It is also important that the l.e.d.s are inserted the correct way round!

Start by soldering in the first column of just seven l.e.d.s, using the identification diagram (Fig. 9) to make sure that they are inserted correctly.

DO NOT cut off the legs of the l.e.d.s at this point. Connect up a battery and resistor in series (a PP3 and 470 ohm resistor is ideal) and attach the negative battery terminal to the column track on the p.c.b.. The positive battery terminal should be connected via the resistor to each l.e.d. anode (a) in turn, making sure they all light up.

Once tested, the l.e.d. cathode legs

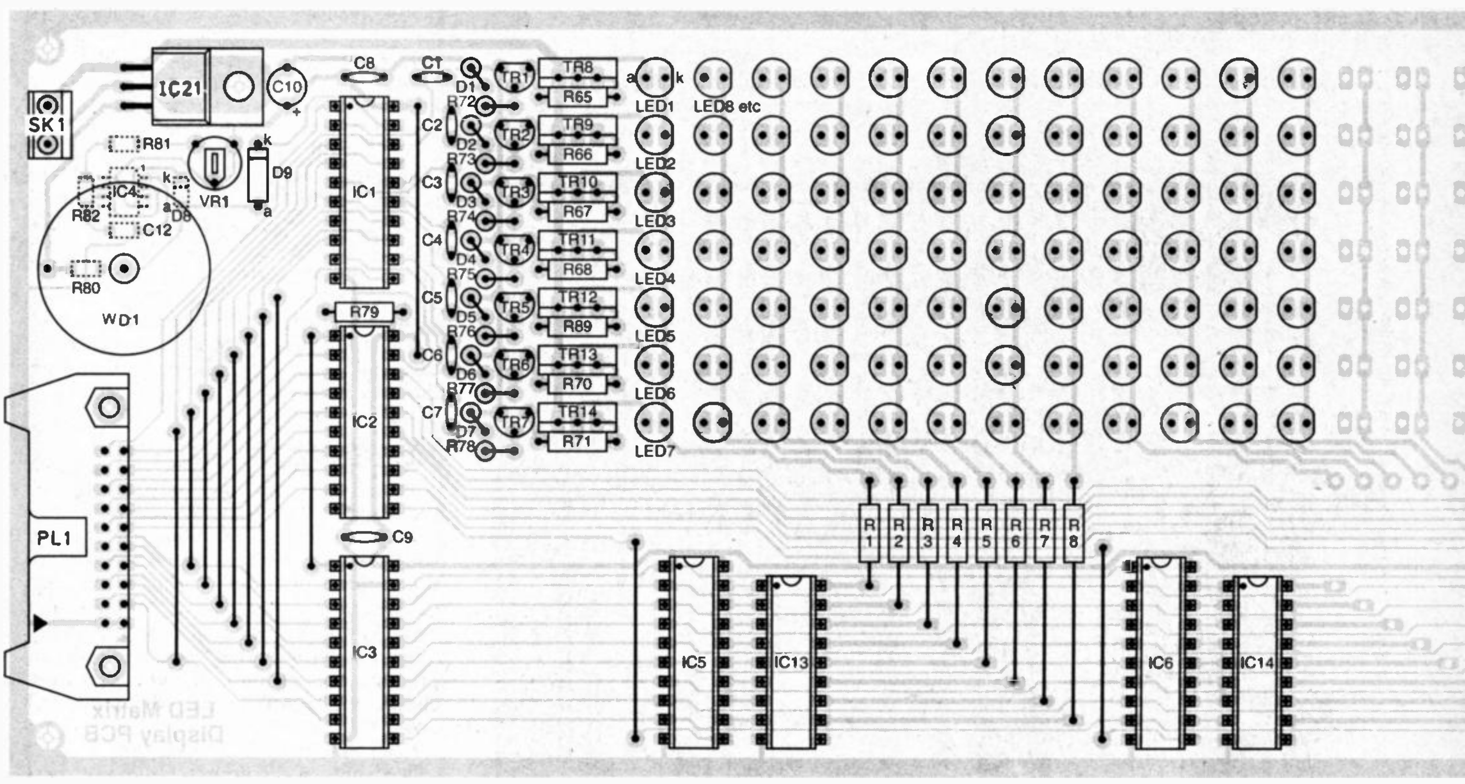


Fig. 8. Printed circuit board component layout for the Display board. As the board is too large to be included fully, we are only able to show the two ends (see next page) of the board; the middle section is a repeat of the l.e.d. layout.

should be cut down. *UNDER NO CIRCUMSTANCES* should the l.e.d. anode legs be cut, as these are needed to support the row wires. Remember, only the l.e.d. cathode (k) legs, those connected to the column tracks on the p.c.b., should be cut.

Additional columns of l.e.d.s may now be fitted, until all 64 columns have been completed. Avoid any temptation to deviate from a strict column-by-column sequence, otherwise difficulty will be experienced when cutting the component legs.

It may be helpful to hold the p.c.b. face down on a piece of foam rubber, while soldering in the l.e.d.s, in order to get them to lie as flat against the p.c.b. as possible. Some of the l.e.d.s will inevitably require additional attention in order to get them to line up properly.

With all the l.e.d.s in place (an achievement certainly worth celebrating), the seven row wires should now be attached. Cut off a two foot length of tinned copper wire and weave it in and out of the 64 protruding l.e.d. legs that make up a row.

Push the wire down using the shank of a small screwdriver until it is suspended about 5mm above the surface of the p.c.b. along its whole length. It may help to wind the wire around the two end l.e.d. legs, to hold it in place. Now solder the wire to all 64 l.e.d. legs and then cut off the excess leg lengths. Fit the remaining six row wires in the same manner.

With the l.e.d. matrix now complete, most of the remaining components can be fitted. Start with the 18 wire links, making them as tight and as straight as possible as some of them lie quite close to each other. Continue with the 64 current limiting resistors positioned immediately below the l.e.d. matrix and then fit the 11 i.c. sockets for the various latch and buffer chips.

The i.c.s should not be inserted into their sockets until after the p.c.b. has been tested. The eight ULN2803A driver chips should be soldered onto the p.c.b. without using i.c. sockets as they handle a fairly high current and would not benefit from the extra resistance that a socket introduces.

All the remaining components should now be fitted, with the exception of the voltage regulator IC21, leaving the surface mount components until last. See Fig. 10 for details on how to attach the surface mount components.

Prior to soldering, position the surface mount device on the p.c.b. and hold it in place with a weighted object. Solder just one terminal, remove the weight, then solder the remaining terminals.

Use a very small soldering iron bit, preferably pointed at the tip. Also use the finest solder available, fine silver solder is recommended. It may help when soldering, to use a magnifying glass.

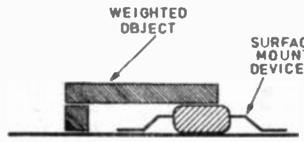
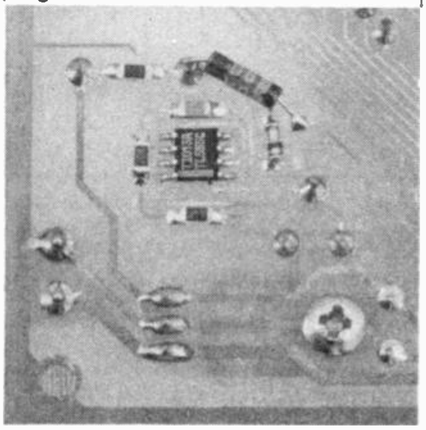


Fig. 10. Soldering the surface mount devices on the track side of the board.



Surface mount components on track side of board.

COMPONENTS

DISPLAY

Resistors

R1 to R64	100 (64 off)
R65 to R71	2k7 (7 off)
R72 to R78	4k7 (7 off)
R79	10k
*R80	10k surface mount
*R81	47k surface mount
*R82	100k surface mount
SIL1	220 SIL 8-way resistor array
SIL2	330 SIL 8-way resistor array

All 0·6W metal film, except where indicated

See SHOP TALK Page

Potentiometer

VR1	1M cermet preset, lin.

Capacitors

C1 to C9	100n disc ceramic (9 off)
C10	100µ min. radial elect. 16V
C11	220µ axial elect. 16V
*C12	10n surface mount

Semiconductors

LED1 to LED448	5mm red light emitting diode (448 off)
D1 to D7	1N4148 signal diode (7 off)
*D8	1N4148 surface mount signal diode
D9	OA91 germanium signal diode
TR1 to TR7	BC548 *npn* silicon transistor (7 off)
TR8 to TR14	TIP127 *pnp* power Darlington transistor (7 off)
IC1	74LS377 octal flip-flop
IC2, IC3	74HCT245 octal bus transceiver (2 off)
*IC4	7555 CMOS timer, surface mount
IC5 to IC12	74HC574 octal D-type flip-flop (8 off)
IC13 to IC20	ULN 2803A Octal Darlington driver (8 off)
IC21	L78S05CV +5V 2A voltage regulator

Miscellaneous

SK1	2-way power connector
PL1	20-way R/A IDC plug
SK2, SK3	20-way IDC socket (2 off)
WD1	Piezoelectric transducer

Printed circuit board (set) available from the *EPE PCB Service*, code 870 (Display); 20-pin d.i.l. socket (11 off); 20-way ribbon cable, one metre; single-core wire for links; multistrand connecting wire; M3 6mm bolt and nut; M2·5 12mm bolt and nut (2 off); optional case to choice; solder etc.

Note: Components marked with an asterisk are "surface mount" items.

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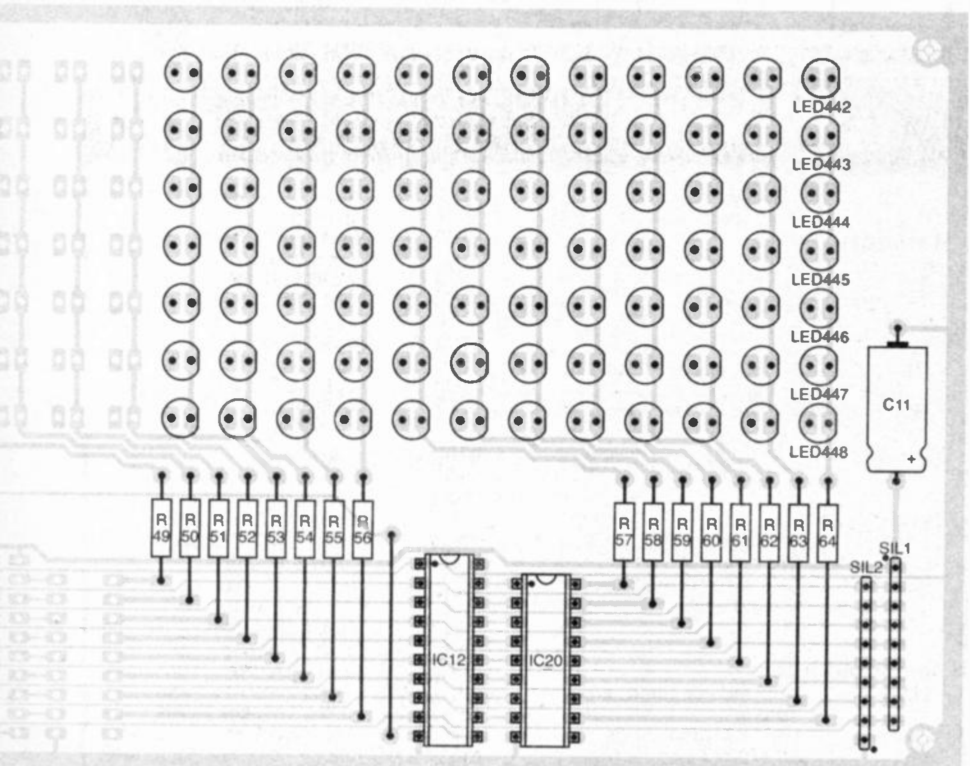


Note: A full size photostat copy (in two sections) of the copper foil master pattern for the Display p.c.b. is available from the EPE Editorial offices by sending a large S.A.E.

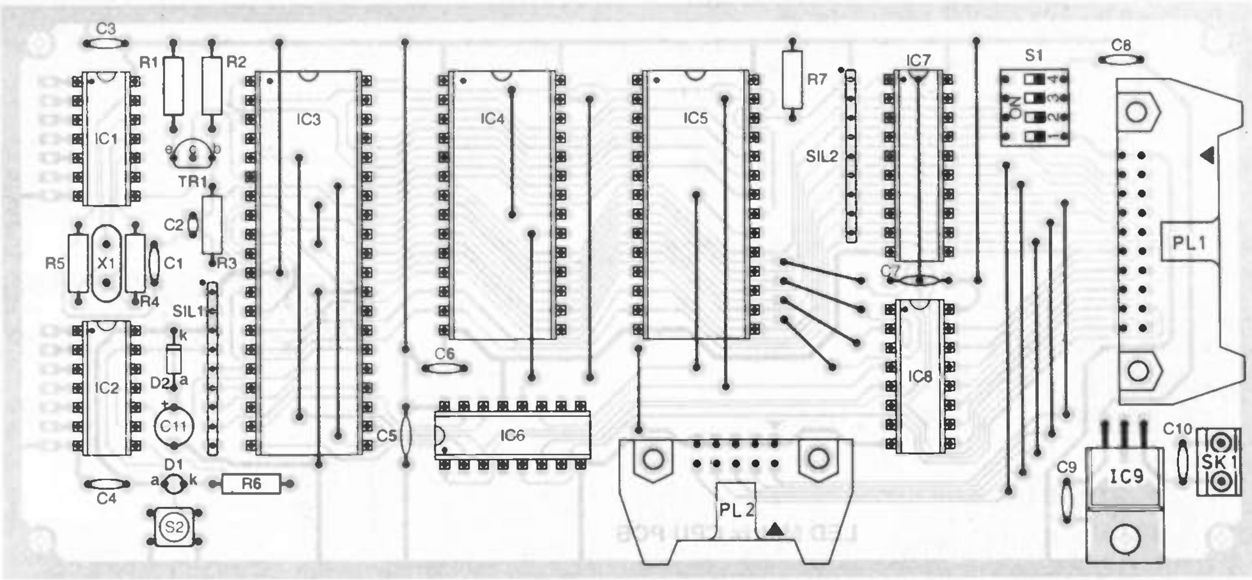
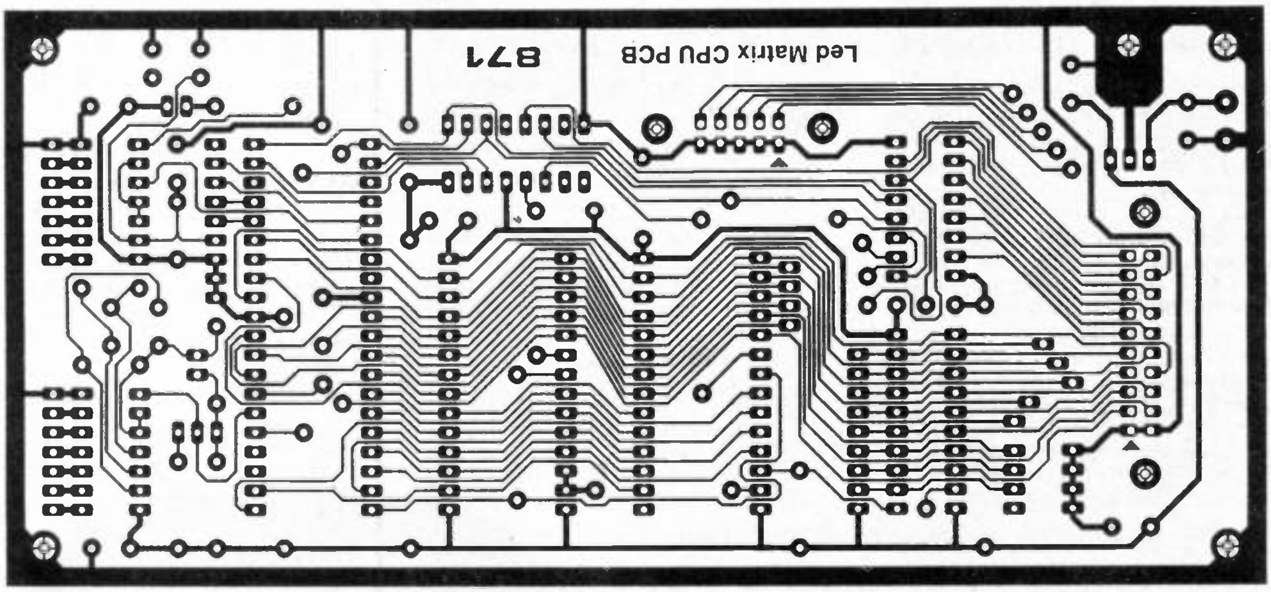


Fig. 11. Printed circuit board component layout and full size underside copper foil master pattern for the CPU board.



CONSTRUCTION - CPU Board

The CPU printed circuit board (p.c.b.) topside component layout and full size underside copper foil master pattern is shown in Fig. 11. Construction of the CPU board is relatively straight forward, although there are a couple of points that should be considered before commencing.

It is very important that the 23 wire links are soldered in first, as some of them lie beneath i.c. sockets. Sockets should be used for all the i.c.s, turned pin types being well worth the extra expense. The remaining components can be fitted in any order, although the i.c.s should be left out of their sockets until after the board has been tested.

The heatsink for the voltage regulator IC9 is fitted in a slightly unusual manner, being first slid over a half-inch long M3 threaded spacer, which is then used instead of a nut to hold the regulator on the p.c.b.

Next Month: Keypad construction, system testing, message sending and details of an Add-On Computer Interface.

COMPONENTS

Approx cost guidance only **£30**

CPU

Resistors

R1	22
R2	220
R3 to R5	1k (3 off)
R6	270
R7	10k
SIL1	10k SIL 8-way resistor array
SIL2	4k7 SIL 8-way resistor array

All 0·6W metal film, except where stated

Capacitors

C1	10n ceramic
C2	47p ceramic
C3 to C10	100n disc ceramic (8 off)
C11	47µ radial elect. 25V

Semiconductors

LED1	3mm red light emitting diode
D1	1N4148 signal diode
TR1	2N3702/3 *pnp* silicon transistor
IC1	74LS04 hex inverter
IC2	74LS14 hex Schmitt inverter
IC3	Z80A CPU (Central Processor Unit)
IC4	27256 EPROM (see text)
IC5	6264 CMOS static RAM
IC6	74LS139 2 to 4 line decoder
IC7	74LS245 octal bus transceiver
IC8	74LS138 3 to 8 line decoder
IC9	L78S05CV +5V 2A voltage regulator

Miscellaneous

X1	4MHz crystal
SK1	2-way power connector
PL1	20-way R/A IDC plug
PL2	10-way R/A IDC plug
S1	4-way d.i.l. switch
S2	Sub. min pushbutton reset switch

Printed circuit board (set) available from the *EPE PCB Service*, code 871 (CPU); 14-pin d.i.l. socket (2 off); 16-pin d.i.l. socket (2 off); 20-pin d.i.l. socket; 28-pin d.i.l. socket (2 off); 40-pin d.i.l. socket; TO18 style heatsink; M3 12mm spacer; M3 6mm bolt (2 off); M2·5 12mm bolt and nut (4 off); solder etc.

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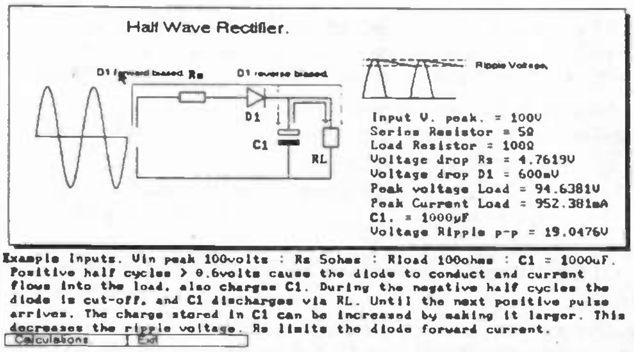

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STEREO NOISE GATE

JOHN CHATWIN

Clean up your act! Create the sounds you want, or listen to your favourite tapes in "silence"!

IF YOU are into any kind of music electronics, perhaps recording or using effects units with a guitar or synthesiser, you'll be very familiar with the problems of unwanted noise, be it mains hum picked up on a microphone lead or background hiss rushing in to ruin quiet parts of a performance.

The unit described here can go a long way towards cleaning up unwanted noise and will find a home in small recording set-ups as well as on stage.

OPERATION

Because it was originally intended for use between two tape decks, the Noise Gate has two identical channels that can be turned on and off independently making for stereo operation. Having two channels also means that it can be very versatile in "On-stage" situations. One channel could be used by, say a guitar player cleaning up his effects units and feeding his amplifier, while the other could take a vocal mic. or group of mics. and feed the PA.

This type of "Dynamic" noise gate works by reducing or expanding the dynamic range of the signal fed into it depending on the level of the input. The lowest level at which the unit or gate starts to open and let signals pass can be set manually so that it is just above the level of the noise you want to exclude.

This means that during periods of high level input, loud music for instance, the gate is fully open and has full dynamic range, any background noise being masked by wanted signals. When things quieten down or fall silent, the gate shuts down to the preset level excluding the unwanted background noise.

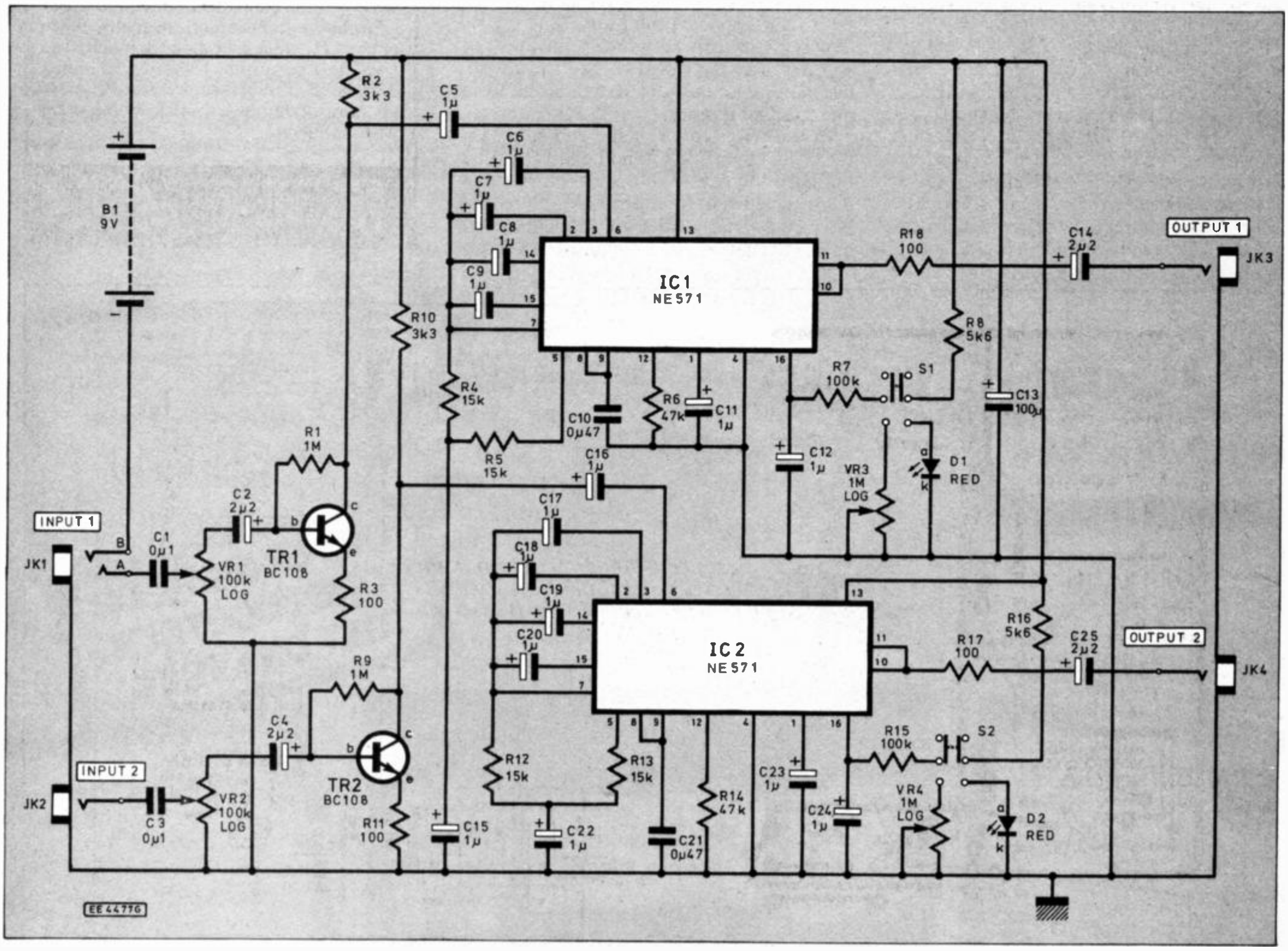


Fig. 1. Complete circuit diagram of the Stereo Noise Gate.

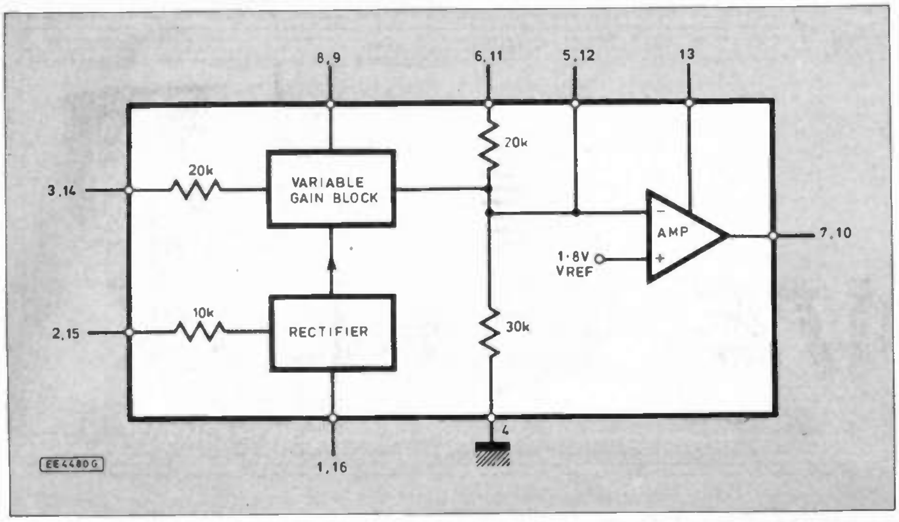


Fig. 2. Block diagram of the NE571 compander i.c.

CIRCUIT DESCRIPTION

The full circuit diagram for the Stereo Noise Gate is shown in Fig. 1. The "gate" consists of two identical halves that are independent from each other apart from sharing the power supply rails. As the two halves of the circuit are identical the operation of only one will be considered here.

Signals enter the circuit via socket JK1 and can be attenuated by VR1 to eliminate clipping if they are at a high level. Transistor TR1 forms a high impedance buffer which helps to overcome any input loading that may occur and also gives a little gain so that the unit can be used as a signal booster with the gate effect turned off.

The output signal from TR1 now enters the "gate" section via capacitor C5. This part of the circuit is based around an NE571 compander IC1 which does most of the work. The i.c. (see Fig. 2) has two sets of gain control circuits which can be wired as dynamic range expanders or compressors.

In this application the signal is first fed into a 2:1 compression network formed by one half of IC1 and its associated components. The capacitors are used to decouple the different parts of the i.c. and set "attack/decay" levels in the variable gain control section. Resistors R4, R5 and R6 set the required bias levels.

The compressed signal now enters the other half of IC1 which expands it back to its original state. Control VR3 is used to set the level of attenuation in the expanders gain control network, creating a cut-off point below which any signal present (noise) has its dynamic range reduced.

Switch S1 is used as an "effect by-pass" and disconnects the effect level potentiometer VR3, letting the unit work with full dynamic range, but at the same level as set by the input attenuation. This means that the gate can be switched in and out without affecting signal levels or introducing more noise into the system in the form of clicks and thumps.

Resistor R7 works as an "end stop" for the effect control VR3 and l.e.d. D1 comes on when the gate is in operation. Resistor R8 is the current limiter for D1. Note that both l.e.d.s (D1, D2) come on when their half of the gate is operational.

COMPONENTS

Resistors

R1, R9	1M (2 off)
R2 R10	2k2 (2 off)
R3, R11, R17, R18	100 (4 off)
R4, R5, R12, R13	15k (4 off)
R6, R14	47k (2 off)
R7, R15	100k (2 off)
R8, R16	5k6 (2 off)

All 0·25W carbon film

Potentiometers

VR1, VR2	100k rotary carbon, log. (2 off)
VR3, VR4	1m rotary carbon, log. (2 off)

See SHOP TALK Page

Capacitors

C1, C3	0µ1 polyester (2 off)
C2, C4, C14, C25	2µ2 tantalum bead, 35V (4 off)
C5 to C9, C11, C12, C15 to C20, C22 to C24	1µ tantalum bead, 35V (16 off)
C10, C21	0µ47 polyester (2 off)
C13	100µ radial elect

Semiconductors

D1, D2	3mm red l.e.d (2 off)
TR1, TR2	BC108 *npn* silicon transistor (2 off)
IC1, IC2	NE571 compander (2 off)

Miscellaneous

JK1 to JK4	¼ inch jack socket (4 off)
B1	9V battery (PP3) and clips

Printed circuit board available from *EPE PCB Service*, code 873; metal case (AB10), size approx 135mm x 102mm x 38mm; 16-pin d.i.l. socket (2 off); plastic control knobs (4 off); connecting wire, solder etc.

Approx cost guidance only **£25**

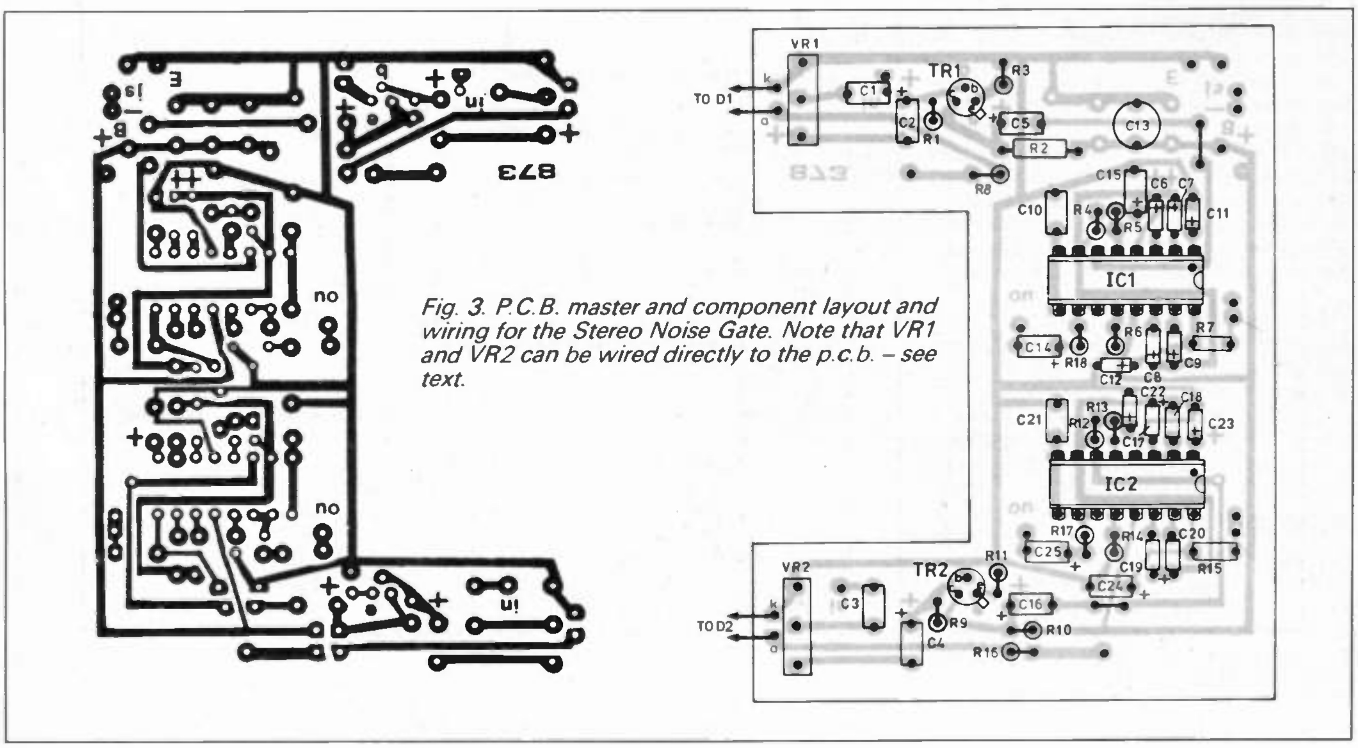


Fig. 3. P.C.B. master and component layout and wiring for the Stereo Noise Gate. Note that VR1 and VR2 can be wired directly to the p.c.b. – see text.

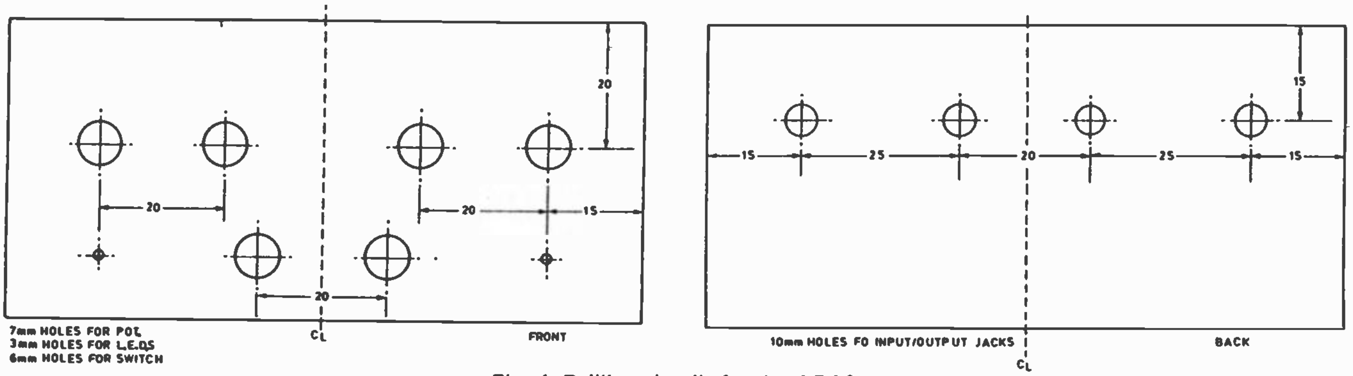


Fig. 4. Drilling details for the AB10 case.

Outputs from the unit are through decoupling capacitors C14 and C25. Smoothing capacitor C13 is connected across the supply rails, and overall on/off switching is achieved when a normal mono jack plug is pushed into socket JK1. This connects the negative terminal of the battery to the negative supply rail.

CONSTRUCTION

The Stereo Noise Gate is built on a small single-sided printed circuit board (p.c.b.) and the component layout and underside copper foil master pattern is shown in Fig. 3. This board is available from the *EPE PCB Service*, code 873.

The p.c.b. for the unit was made so that it would fit a certain type of case, but it can obviously be used in other situations and need not be cut to this shape. The board mounted potentiometers and l.e.d.s could also be removed and connected to the circuit using wires.

When assembling the p.c.b. make sure that all the polarised components are positioned correctly. This circuit uses over 20 capacitors and most of them have to be the right way round.

When soldering in the components, start with the wire links, the resistors and i.c. sockets. Leave the semiconductors until last so that they do not get damaged by heat or static. As always, beware of solder bridges between tracks and always check everything you do at least a couple of times.

CASE DETAILS

The prototype model was was built to fit in an aluminium case that measured approx. 133mm × 102mm × 38mm, with the p.c.b. held in position by the two input level potentiometers. Hole measurements, drilling diameters and component positions are shown in Fig. 4. The l.e.d.s, switches and effect controls are mounted on the front panel which makes wiring up quite easy with everything in position, see Fig. 5.

All the jack sockets were mounted at the back so that the unit could sit on top of a guitar amplifier or effects rack. If you are going to use another type of case, or even mount the unit inside other equipment, make sure that it is well screened or you may end up creating worse noise problems than you started with.

OPERATION

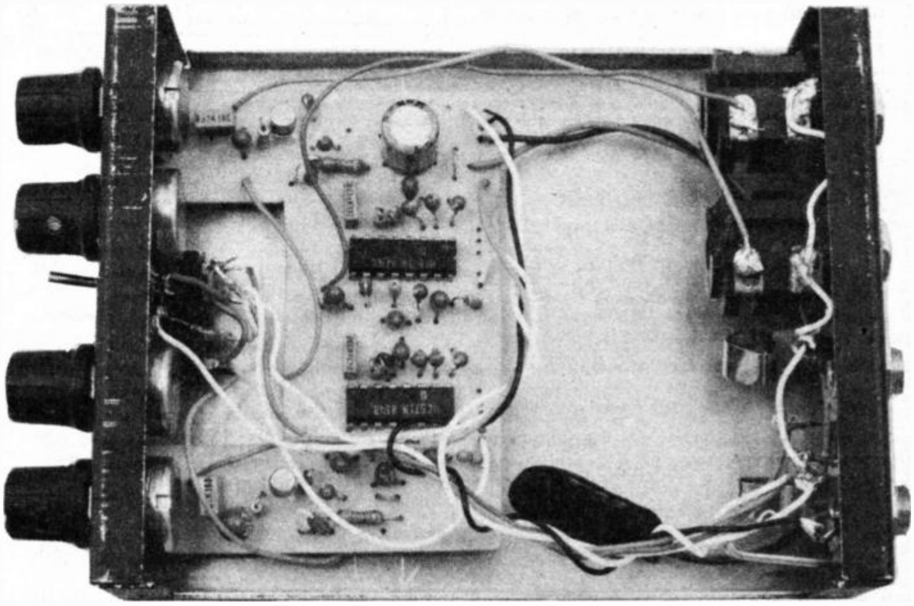
The Stereo Noise Gate is simple to use and should be connected to the output of whatever it is that you want to "gate". The output of the unit can then feed other equipment, such as amplifiers or tape decks, with a noise free signal.

To test the circuit, start with all the level controls right down, and switch on by putting a jack into the input of Channel 1. Check that the effect l.e.d.s light up when the switches S1 and S2 are operated.

If they do, by-pass the unit and connect some noisy instrument or effects pedal to the input. A signal played through the unit should be unaffected except that you will have control over its level.

Set the "effect" control on Channel 1 fully clockwise and flick the by-pass switch. The gate should close down on any hiss or hum that is present. If it does you can bring the effect control back until it just cuts off the noise. Any louder wanted signals should pass through undistorted.

If Channel 1 is working, check Channel 2 out the same way, but remember to keep a lead plugged into socket JK1 so that the power remains connected. □



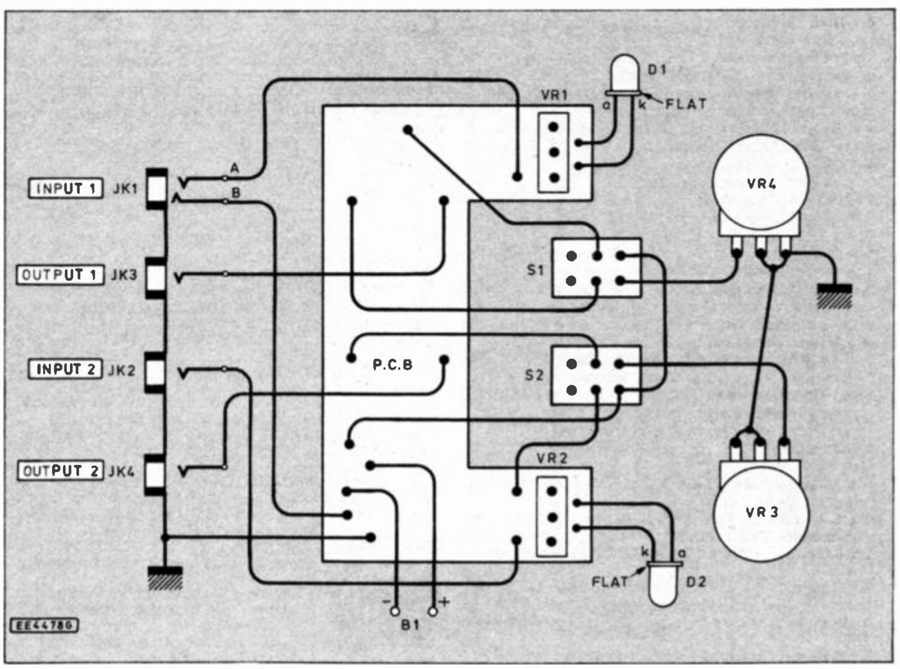


Fig. 5. P.C.B. and off board component wiring.

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2 x 5 amp Pull Cord Ceiling Switches. Brown. Order Ref: 921.
5 x reels Insulation Tape. Order Ref: 911.
4 x 14mm Ball-races. Order Ref: 912.
2 x Cord Grip Switch Lamp Holders. Order Ref: 913.
1 x DC Voltage Reducer. 12V-6V. Order Ref: 916.
1 x 10 amp 40V Bridge Rectifier. Order Ref: 889.
Lightweight Stereo Headphones. Moving coil so superior sound. Order Ref: 896.
2 x 25W Crossovers. For 4ohm loudspeakers. Order Ref: 22.
2 x NiCad Constant Current Chargers. Easily adaptable to charge almost any NiCad battery. Order Ref: 30.
10m Twin Screened Flex. White pvc cover. Order Ref: 122.
2 x White Plastic Boxes. With lids, approx. 3" cube. Lid has square hole through the centre so these are ideal for light operated switch. Order Ref: 132.
2 x Reed Relay Kits. You get 8 reed switches and 2 coil sets with notes on making relays and other gadgets. Order Ref: 148.
1 x Big Pull Solenoid. Mains operated. Has ½" pull. Order Ref: 871.
1 x Big Push Solenoid. Mains operated. Has ½" push. Order Ref: 872.
1 x Mini Mono Amp. 3W into 4 ohm speaker or 1W into 8 ohm. Order Ref: 268.
1 x Mini Stereo 1W Amp. Order Ref:870.
1 x In-Flight Stereo Unit is a stereo amp. Has two most useful mini moving coil speakers. Made for BOAC passengers. Order Ref: 29.
1 x 0-1mA Panel Meter. Full vision fact 70mm square. Scaled 0-100. Order Ref: 756.
2 x Lithium Batteries. 2·5V penlight size. Order Ref: 874.
2 x 3m Telephone Leads. With BT flat plug. Ideal for 'phone extensions, fax, etc. Order Ref: 552.
1 x 12V Solenoid. Has good ½" pull or could push if modified. Order Ref: 232.
4 x In-Flex Switches. With neon on/off lights, saves leaving things switched on. Order Ref: 7.
2 x 6V 1A Mains Transformers. Upright mounting with fixing clamps. Order Ref: 9.
2 x Humidity Switches. As the air becomes damper, the membrane stretches and operates a micro switch. Order Ref: 32.
5 x 13A Rocker Switch. Three tags so on/off, or changeover with centre off. Order Ref: 42.
2 x Flat Solenoids. You could make your multi-tester read AC amps with this. Order Ref: 79.
1 x Suck or Blow-Operated Pressure Switch. Or it can be operated by any low pressure variation such as water level in tanks. Order Ref: 67.
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2 x Stripper Boards. Each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc. Order Ref: 120.
12 Very Fine Drills. For PCB boards etc. Normal cost about 80p each. Order Ref: 128.
5 x Motors for Model Aeroplanes. Spin to start so needs no switch. Order Ref: 134.
6 x Microphone Inserts. Magnetic 400 ohm, also act as speakers. Order Ref: 139.
6 x Neon Indicators. In panel mounting holders with lens. Order Ref: 180.
1 x In-Flex Simmerstat. Keeps your soldering iron etc always at the ready. Order Ref:196.
1 x Mains Solenoid. Very Powerful as ½" pull, or could push if modified. Order Ref: 199.
1 x Electric Clock. Mains operated. Put this in a box and you need never be late. Order Ref: 211.
4 x 12V Alarms. Makes a noise about as loud as a car horn. All brand new. Order Ref: 221.
2 x (6" x 4") Speakers. 16 ohm 5 watts, so can be joined in parallel to make a high wattage column. Order Ref: 243.
1 x Panostat. Controls output of boiling ring from simmer up to boil. Order Ref: 252.
2 x Oblong Push Switches. For bell or chimes, these can switch mains up to 5A so could be foot switch if fitted in pattress. Order Ref: 263.
50 x Mixed Silicon Diodes. Order Ref: 293.
1 x 6 Digit Mains Operated Counter. Standard size but counts in even numbers. Order Ref: 28.
2 x 6V Operated Reed Relays. One normally on, other normally closed. Order Ref: 48.
1 x Cabinet Lock. With two keys. Order Ref: 55.
1 x Magnetic Brake. For stopping a motor or rotating tool. Order Ref: 66.
1 x Shaded Pole Mains Motor. ¾" stack, so quite powerful. Order Ref: 85.
2 x 5 Aluminium Fan Blades. Could be fitted to the above motor. Order Ref: 86.
1 x Case. 3½ x 2¼ x 1¾ with 13A socket pins. Order Ref: 845.
2 x Cases. 2½ x 2¼ x 1¾ with 13A pins. Order Ref: 565.
4 x Luminous Rocker Switches. 10A mains. Order Ref: 793.
4 x Different Standard V3 Micro Switches. Order Ref: 340.
4 x Different Sub Min Micro Switches. Order Ref: 313.

BARGAINS GALORE

Medicine Cupboard Alarm. Or it could be used to warn when any cupboard door is opened. The light shining on the unit makes the bell ring. Completely built and neatly cased, requires only a battery, £3. Order Ref: 3P155.
Don't Let It Overflow! Be it bath, sink, cellar, sump or any other thing that could flood. This device will tell you when the water has risen to the pre-set level. Adjustable over quite a useful range. Neatly cased for wall mounting, ready to work when battery fitted, £3. Order Ref: 3P156.
Very Powerful Mains Motor. With extra long (2½") shafts extending out each side. Makes it ideal for a reversing arrangement for, as you know, shaded pole motors are not reversible, £3. Order Ref: 3P157.

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45A Double Pole Mains Switch. Mounted on a 6 x 3½ aluminium plate, beautifully finished in gold, with pilot light. Top quality, made by MEM, £2. Order Ref: 2P316.
Amstrad 3" Disk Drive. Brand new and standard replacement for many Amstrad and other machines, £20. Order Ref: 20P28.
High Quality Key Switch. This is a single pole, 2 position switch, changeover or on/off. With 2 keys. Good British make, normally retails at £3, our price £1.50. Order Ref: 1.5P12.
Movement Alarm. Goes off with the slightest touch. Ideal to protect car, cycle, doorway, window, stairway, etc. Complete with Piezo shrieker, ready to use, only £2, (PP3 battery not supplied). Order Ref: 2P282.
AM-FM Radio Chassis. With separate LCD module to display date and time. This is complete with loudspeaker, £3.50. Order Ref: 3.5P5.
2, 3 and 4 Way Terminal Blocks. The usual grub screw types. Parcel containing a mixture of the 3 types, giving you 100 waves for £1. Order Ref: 875.
12/24 DC Solenoid. The construction of this is such that it will push or pull. With 24V this is terrifically powerful but is still quite good at 12V, £1. Order Ref: 877.
20 W 5" 4 Ohm Speaker. Mounted on baffle with front grille, £3, Order Ref: 3P145. Matching 4 ohm 20W tweeter on separate baffle, £1.50. Order Ref: 1.5P9.
Ultra Thin Drills, actually 0.3mm. To buy these regular costs a fortune. However, these are packed in half dozens and the price to you is £1 per pack. Order Ref: 797B.
You Can Stand On It! Made to house GPO telephone equipment, this box is extremely tough and would be ideal for keeping your small tools in. Internal size approx. 10½" x 4½" x 6" high. Complete with carrying strap, price £2. Order Ref: 2P283B.
Ultra Sonic Transducers. Two metal cased units, one transmits, one receives. Built to operate around 40kHz. Price £1.50 the pair. Order Ref: 1.5P/4.
Safety Leads. Curly coil so they contact but don't hang down. Could easily save a child from being scalded, 2 core, 5A, extends to 3m, £1. Order Ref: 846. 3 core, 13A, extends to 3m, £2 each. Order Ref: 2P290.
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Philips 9" High Resolution Monitor. Black and white in metal frame for easy mounting. Brand new, still in maker's packing, offered at less than price of tube alone, only £15. Order Ref: 15P1.

> **LCD 3½ Digit Panel Meter**
> This is a multi range voltmeter/ammeter using the A-D converter chip 7106 to provide 5 ranges each of volts and amps. Supplied with full data sheet. Special snip price of £12. Order Ref: 12P19.

Insulation Tester with Multimeter. Internally generates voltages which enable you to read insulation directly in megohms. The multimeter has four ranges. AC/DC volts, 3 ranges DC milliamps, 3 ranges resistance and 5 amp range. These instruments are ex-British Telecom but in very good condition, tested and guaranteed OK, probably cost at least £50, your for only £7.50 with leads, carrying case £2 extra. Order Ref: 7.5P/4.
Mains 230V Fan. Best make "PAPST", 4½" square, metal blades, £8. Order Ref: 8P8.
2MW Laser. Helium neon by Philips, full spec. £30. Order Ref: 30P1. Power supply for this in kit form with case is £15, Order Ref: 15P16, or in larger case to house tube as well £18, Order Ref: 18P2. The larger unit, made up, tested and ready to use, complete with laser tube £69, Order Ref: 69P1.
⅛hp 12V Motor – The Famous Sinclair C5. Brand new, £18. Order Ref: 18P7.
Solar Charger. Holds 4AA NiCads and recharges these in 8 hours, in very neat plastic case £6. Order Ref: 6P3.
Ferrite Aerial Rod. 8" long x ⅜" diameter, made by Mullard. Complete with two coils, 2 for £1. Order Ref: 832P.
Air Spaced Trimmer Caps. 2-20pf, ideal for precision tuning UHF circuits, 4 for £1. Order Ref: 818B.
Mains Isolation Transformer. Stops you getting "to earth" shocks. 230V in and 230V out. 150 watt, £7.50. Order Ref: 7.5P/5 and a 250W version is £10. Order Ref: 10P97.
Amstrad Power Unit. 13·5V at 1·9A or 12V at 2A encased and with leads and output plug, normal mains input, £6. Order Ref: 6P23.
Atari 65XE. At 65K this is quite powerful, so suitable for home or business, unused and in perfect order but less PSU, only £19.50. Order Ref: 19.5P/5B.
80W Mains Transformer. Two available, good quality, both with normal primaries and upright mounting, one is 20V 4A, Order Ref: 3P106, the other 40V 2A, Order Ref: 3P107, only £3 each.

BARGAINS GALORE

40W-250W Light Dimmers. On standard plate to put directly in place of flush switch. Available in colours, green, red, blue and yellow, £2.50, Order Ref: 2.5P9. Or on standard 3x3 cream metal switch plate, £3, Order Ref: 3P174.
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Telephone Extension Wire. 4 core correctly coloured coded, intended for permanent extensions, 25m coil, £2. Order Ref: 2P339.
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15W 8 Ohm 8" Speaker & 3" Tweeter. Made for a discontinued high quality music centre, gives real hi-fi and only £4 per pair. Order Ref: 4P57.
Water Pump. Very powerful, mains operated, £10. Order Ref: 10P74.
0-1mA Full Vision Panel Meter. 2¾" square, scaled 0-100 but scale easily removed for re-writing, £1 each. Order Ref: 756.
VU Meter. Illuminate this from behind becomes on/off indicator as well, 1½" square, 75p each. Order Ref: 366.
1 RPM Motor. This is only 2W so will not cost much to run. Speed is ideal for revolving mirrors or lights. £2. Order Ref: 2P328.
Battery Quick Charger. Into a flat battery to about 5A the charging rate would be 8-10A, this would fall away as the battery charges up or it can be switched to a lower rate. Complete kit includes mains transformer, rectifier, capacitor, switch and metal case, £7.50. Order Ref: 7.5P20.
15V PSU. Mains operated, nicely cased, adequately smooth DC output, £1. Order Ref: 942.
Mains Filter. Resin impregnated, nicely cased, pcb mounting. £2. Order Ref: 2P315.
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220VA Mains Transformer. Secondary voltages 8V-0-8V. So you could have 16V at 12A or 8V at 25A. Could be ideal for car starter charger, soil heating, spot welding, carbon rod welding or driving high powered amplifiers etc. £15. Order Ref: 15P51.
Fully Enclosed Mains Transformer. On a 2m 3 core lead terminating with a 13A plug. Secondary rated at 6V 4A. Brought out on a well insulated 2 core lead terminating with insulated push on tags, £3. Order Ref: 3P152.
Ditto but 8A, £4. Order Ref: 4P69.
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Sinclair 9V 2·1A Power Supply. Made to operate the 138K Spectrum Plus 2, cased with input and output leads. Originally listed at around £15, are brand new, our price is only £3. Order Ref: 3P151.
Amstrad Keyboard Model KB5. This is a most comprehensive keyboard, having over 100 keys including, of course, full numerical and qwerty. Brand new, still in maker's packing, £5. Order Ref. 5P202.
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Techniques

ACTUALLY DOING IT!

by Robert Penfold

THERE is an old adage about "familiarity breeding contempt". I suppose that this applies to many things, including electronics. Those of us who have been building electronic projects for more years than we care to remember tend to grab components from the workbench and fit them onto circuit boards, barely giving them a first look, let alone a second glance. There is no need for an "old hand" to work out the colour coding for a 4k7 resistor, because he or she knows what a 4k7 resistor looks like, and can soon sort one out from a group on the bench.

IDENTIFICATION

For the beginner identifying components is a much slower operation, and one that should *not* be rushed. Getting a couple of components swopped over is almost certain to prevent the finished project from working, and if you are unlucky it could even result in damage to some of the components. Never fit components to a circuit board unless you are sure you know which component is which.

Sorting components into general types (resistors, electrolytic capacitors, integrated circuits, etc.) is not too difficult. The article describing the project should have photographs and illustrations which will help in this respect. Photographs in component catalogues are also a very useful aid to general component identification.

The main problem is likely to be when trying to sort out a 10k resistor from the twenty other resistors you ordered, the two 100n ceramic capacitors from the two dozen assorted capacitors used in the project, and so on. In some cases there will be markings that will make the values of the components fairly obvious. Electrolytic capacitors for example, are usually just marked with their value and voltage rating (e.g. 100µF 10V).

CRYPTIC MESSAGES

Non-electrolytic capacitors tend to be a little more difficult, and some types have decidedly cryptic value markings. Some are actually quite straightforward, and are simply marked with values as they would appear on a circuit diagram. The value might also be accompanied by the maximum operating voltage and (or) a tolerance rating (e.g. "2n2 63V", "330p 5%", etc.).

Capacitors sometimes have additional markings, but these are usually of no consequence to the user. These extra markings are also to be found on many semiconductors, where they can be rather more confusing.

Apparently they do actually mean something to those at the factory where the components were produced. They are usually just batch numbers, or the date of manufacture in some highly cryptic form. You soon get used to picking out the important lettering.

Many capacitors have the value marked using a method that is something less than immediately obvious, but which is quite easy to use once you understand the way it operates. The value is marked in the form of a three digit number. The first two digits are simply the first two digits of the value. The third digit is a multiplier which indicates the number of zeros to be added to the first two digits. This gives the value in picofarads.

For example, suppose that a capacitor is marked "473". The first two digits of the value are 4 and 7, and three zeros must be added to these. The value is therefore 47000 picofarads. In order to obtain an answer in nanofarads divide the value by one thousand, or by one million to obtain the value in microfarads. In this example the value of the capacitor is therefore 47n, or 0·047µ. This method of coding mainly seems to be used on ceramic capacitors having values from 1n to about 470n. Table 1 should help to clarify this method of value coding.

TO THE LETTER

Several types of capacitor, but particularly certain ceramic types and most polystyrene capacitors, have a letter after the type number which indicates the tolerance rating. This will often be of no consequence, but it is worth checking that the right code letter is present if you have ordered high quality capacitors having close tolerances. Table 2 shows the corresponding tolerance figure for each code letter.

Table 1

CODE	VALUE (pF)	VALUE (nF)	VALUE (µF)
102	1,000	1	0·001
222	2,200	2·2	0·022
332	3,300	3·3	0·033
472	4,700	4·7	0·047
103	10,000	10	0·01
223	22,000	22	0·022
333	33,000	33	0·033
473	47,000	47	0·047
104	100,000	100	0·1
224	220,000	220	0·22
333	330,000	330	0·33
473	470,000	470	0·47

Table 2

CODE LETTER	TOLERANCE RATING
F	1%
G	2%
H	2·5%
J	5%
K	10%
M	20%

READING THE BANDS

Resistors are probably the components that give beginners the most problems. Some resistors are simply marked with a value and tolerance rating such as "27k 5%". However, it is mainly high power resistors which are marked in this way, and these are little used in electronic projects. The small resistors you will use in every project are only marked with a few coloured bands. These indicate the value and tolerance.

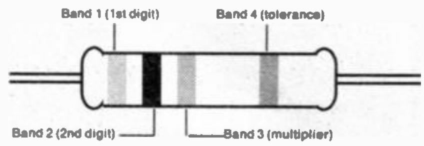

Fig. 1. Standard four band resistor colour coding.

The basic method of coding uses four coloured bands. The first three bands carry the value coding, and the fourth indicates the tolerance rating. When reading colour codes it is essential to read the bands in the right order. This should not give any major difficulties because the fourth band is well separated from the other three (Fig.1). the gap from band 4 to its end of the body is slightly larger than the gap from band 1 to the opposite end of the body. On modern resistors the difference is very small (or non-existent), but the wider gap between bands 3 and 4 should be pretty obvious.

The value coding works in a manner which is similar to the three digit capacitor method described previously. The first two colours denote the initial two digits of the value, and the third colour is a multiplier which indicates the number of zeros which must be added in order to give the full value. The fourth band uses a separate method of coding to indicate the tolerance rating. Table 3 shows the meaning of each colour in the four bands.

As an example, suppose a resistor is coded red, violet, orange, gold. The red and violet bands indicate that the first two digits of the value are 2 and 7. The orange band indicates that the first two digits must be multiplied by 1,000 (i.e. add three zeros). This gives a value of 27,000 ohms. Divide by one thousand to produce an answer in kilohms (k), or one million to give an answer in megohms (M). The example value of 27,000 ohms would normally be expressed as 27k. The gold fourth band indicates that the value has a tolerance of ±5% (i.e. it is within 5% of the marked value).

Resistors having five band codes

seem to be with us once again, which has to be regarded as a pity. Having a spares box which contains resistors using the four colour code and two different five colour codes is, to say the least, a bit confusing!

One of these five band codes is actually quite easy to deal with. The first three bands indicate the value in the normal way. The fifth band, which is offset from the other four, denotes the tolerance rating in the usual fashion. The fourth band indicates the temperature coefficient, and is of no importance. Therefore, if you ignore the fourth band, the remaining four colours are effectively a normal four band colour code.

The other five band method of coding operates in a manner which is very similar to the normal four band type, but the fifth band does have to be taken into account. Fig.2 explains the way in which this system operates. It only differs from the standard coding in that the first three bands give the first three digits of the value, rather than just the first two bands giving the first two digits. The last two bands carry the usual multiplier and tolerance codes.

Table 3

COLOUR	1st/2nd DIGIT	MULTIPLIER	TOLERANCE
Black	0	X1	
Brown	1	X10	1%
Red	2	X100	2%
Orange	3	X1,000	
Yellow	4	X10,000	
Green	5	X100,000	
Blue	6	X1,000,000	
Violet	7		
Grey	8		
White	9		
Gold		X0·1	5%
Silver		X0·01	10%
None			20%

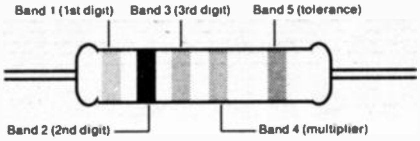

Fig. 2. One of the five band resistor colour code systems.

The point of this type of five band code is that it accommodates close tolerance resistors having odd values. In practice you will not be using non-standard values such as 29·4k, and the third band will always be black (0). A value such as 390k (1%) would therefore have the colour code orange, white, black, orange, and brown. Orange, white, and black indicate that the first three digits of the value are 3, 9, and 0. The orange multiplier band shows that this value must be multiplied by 1,000 (add three zeros), giving a final value of 390,000 ohms, or 390k. The brown fifth band shows that the tolerance is 1%.

CHOKED UP

At one time the C280 style polyester capacitors were invariably marked with a colour code. This gained them the nickname "liquorice allsorts". Colour coding capacitors is a practise that has largely died out, and most C280 style capacitors simply have the value, tolerance, and maximum voltage ratings written on the top edge of the body. Colour coding is still used for some C280 style capacitors though.

The top three bands are the important ones, as they denote the value of the component in picofarads using the standard resistor method. For instance, if from the top downwards the colours are brown, black, and yellow, the first two digits of the value are 1 and 0. The multiplier is 10,000 (add four zeros), and the value is therefore 100,000p (100n, or 0·1µ). The fourth band denotes the tolerance and is usually either black (20%) or white (10%). There is a fifth band which indicates the voltage rating. This is either red (250V) or yellow (400V).

Some other components "borrow" the resistor colour coding, and it is often used on small inductors (r.f. chokes). The value is coded in standard four band resistor format, but it is in microhenries rather than ohms. Dividing the answer by one thousand gives the value in millihenries.

Colour codes are to be found on other components, such as some preset resistors. These are sometimes marked with three coloured dots. The dots indicate the value in the same way as the first three bands of a standard resistor colour code. If you understand the standard resistor coding, it is not usually too difficult to fathom out the colour coding.

New Technology Update

Ian Poole investigates the latest research developments in disk drive technology and digital audio conversion.

IN RECENT years the size and complexity of computer software has increased markedly. This places ever more stringent requirements on computer technology. Processing speeds must be increased, along with greater requirements for memory and a host of other requirements.

In addition to this there is a growing tendency for computers to be made smaller. Lap-top computers as well as note book versions are becoming more widespread and ordinary desk-top computers are becoming more compact. To achieve this basic computer technology has needed to improve. Low 3·3V i.c.s are now widely used and even larger scales of integration are being used.

Hard disk drive technology has made equally major advances. Drives measuring as little as 1¼ inches are available. Data capacities have been increased and access times have been reduced to meet the requirements of the computer hardware itself.

Resistive Head

In order to be able to meet all these requirements many new ideas have been developed for use in disk drives. The media, read and write heads, and most of the internal electronics have all been improved.

One major development involves a new type of head called a magneto-resistive (MR) head. This enables data to be read faster and more accurately than before.

Although magneto-resistive heads are not widely used in disc drives yet, all the major manufacturers are planning to introduce them in the foreseeable future. Currently the most common type of head uses a coil in which an e.m.f. is induced as the flux from the disc changes. However, to make them small enough thin film technology is used.

The MR heads are fundamentally different. They contain a resistive element which changes its resistance with the flux from the disc. As the flux increases so does the resistance of the element.

Using this effect a larger signal can be generated. In addition to this the level of the signal is constant regardless of the speed of the disc.

With a conventional head the level of the signal is proportional to the rate of change of flux. This means that the faster the disc rotates the larger the signal which is obtained.

By using MR heads the disc can rotate slower and still give a readable signal. This has the advantage that discs can rotate slower saving considerable amounts of power. This is of particular importance on the smaller discs where high speeds have to be used to maintain a given linear velocity in view of the small radius.

Another advantage of the MR head is that it permits narrower tracks to be used. This obviously allows for a much greater data density to be obtained.

Complications

Whilst the MR head offers many advantages there are naturally a number of problems which are being overcome. In the first instance they can only be used to read data from a disc and they cannot write data onto it.

To overcome this a separate thin film head is embodied into the same structure to perform the write operation. At first sight this may appear to be a disadvantage, but it does allow for each head to be optimised for its particular operation.

Possibly the major problem with MR heads is that they require a more complicated preamplifier. One reason is that the head only produces a change in resistance. This has to be converted into a voltage change so that it can be electronically processed.

To accomplish this a very carefully controlled current source is required. It contains filtering to prevent power supply noise giving erroneous data, and circuitry to prevent temperature changes affecting the operation of the circuit. A one degree change in temperature gives the same change in resistance as the data from the disc!

All of this extra circuitry naturally increases the cost, and this is of great importance in a corner of the market which is very competitive. Despite this MR heads give a much better performance than conventional ones, and it is expected that by the turn of the century most drives will be using this technology as standard.

Digital Audio Conversions

Like virtually every other area of electronics, audio technology is fast converting to digital techniques wherever possible. The first digital system to hit the consumer end of the market was the now familiar CD. This was followed by Digital Audio Tape (DAT).

Now the Philips Digital Compact Cassette (DCC) and the Sony Minidisc (MD) are fighting it out in the market place for supremacy in a corner of the market where the ordinary Compact Cassette has reigned supreme for many years. In addition, television audio is now available in a digital format as Nicam digital audio.

If this was not enough there are likely to be more digital audio systems available in the years to come. One example is digital audio broadcasting which is likely to start in a few years time.

Digital systems bring many advantages, but they also have a few disadvantages. One is interfacing between the variety of different standards and sampling rates.

The CD uses a sampling rate of 44·1kHz whilst DAT can use any one of three, 48kHz, 44·1kHz and 33kHz. If this was not enough some PC sound systems use a sampling rate of 22·01kHz.

To try to transfer audio from one system to another is not always easy. The obvious method is to reconstitute the analogue audio and then re-digitise it.

This approach is easy to set up but it removes many of the advantages of having a digital system in the first place. It is far better if the audio can be retained in its digital form and modified to suit the new format.

Professional sample rate converters are available now. However they are very expensive, far beyond what any domestic user would pay. With the proliferation of digital audio standards for domestic use it is likely that converters will be needed here in the next few years.

Seeing this need Analog Devices, a semiconductor manufacturer based in the USA, have introduced two new devices which perform just this function. Two types are available. One accepts up to 20-bit words and is aimed at the professional market, whilst the other one accepts up to 16-bits and it is aimed more at the consumer end of the market.

Polyphase Filtering

To achieve all of this on one chip Analog Devices have used a number of very innovative ideas. They are quite complicated, using many of the techniques used in digital signal processing.

One is a little known system called "polyphase filtering". This reduces the number of samples which have to be generated in the chip as well as the memory which is needed.

Another idea uses a digital servo loop to compute the exact ratio between the two sample rates, and there are also various techniques used to prevent a problem called "aliassing" which can occur.

The i.c.s are available now. In view of the complicated nature of their function and operation they are quite expensive. However like many other new i.c.s at the forefront of technology the cost is likely to fall as the demand rises.

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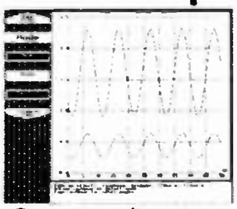
PICOTECHNOLOGY

PicoScope



'Virtual instrument' software package. Storage oscilloscope with trigger, timebase, rulers and offset functions. Real time spectrum analysis with mi/max frequency options and signal averaging. Multiple meters on screen (digital and bargraph). Printer and file handling support

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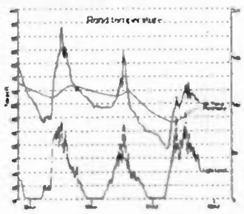

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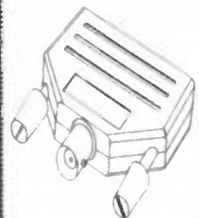
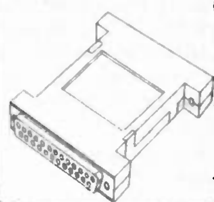
ADC-10



- Up to 24kHz sampling rate from a 386/33MHz machine
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection
- Includes PicoScope software

Single Channel 8 bit ADC

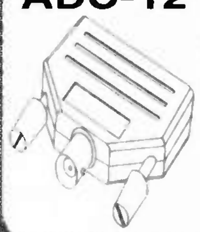
ADC-11



- 15K samples per second
- 0-2.5V Input range
- Digital output
- D25 input connector
- 30V overload protection
- Parallel port connection

11 Channel 10 bit ADC

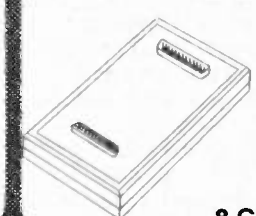
ADC-12



- Up to 18kHz sampling rate
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection

Single Channel 12 bit ADC

ADC-16



- Software selectable single ended or differential inputs
- Resolution programmable between 8 and 16 bits + sign
- ±2.5V input range
- 5V reference output
- Connects to serial port
- Includes PicoLog software

8 Channel 16 bit + sign ADC

Typical application	ADC -10	ADC -11	ADC -12	ADC -16
Oscilloscope	●	●	●	
Voltmeter	●	●	●	●
Spectrum analyser	●	●	●	
Audio sampling	●	●	●	
Chart recorder emulation		●		●
Temperature measurement	●	●	●	●
Pressure measurement	●	●	●	●
Automotive monitoring		●		●
Medical research		●	●	●
Education	●	●	●	●

Prices

ADC-10 with PicoScope	£49
ADC-10 with PicoScope and PicoLog	£59
ADC-11 with PicoScope	£85
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ADC-12 with PicoScope	£85
ADC-12 with PicoScope and PicoLog	£95
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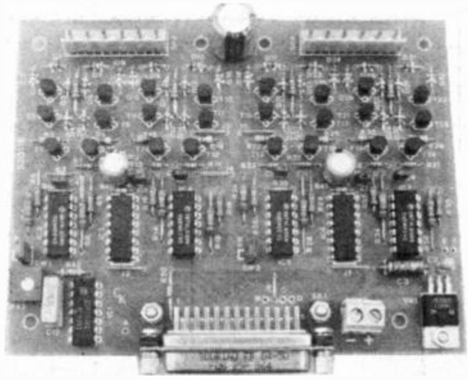
DUAL STEPPING MOTOR DRIVER FOR PC COMPUTERS



MARK STUART

Control two stepping motors via the parallel printer port of a PC and this single board driver.

STEPPING motors have featured many times in this magazine. They offer an effective way to produce controlled, precise movement where power and speed are not critical. Their most familiar application is in computer printers, where it is usual to find at least two motors, one driving the carriage and the other driving the paper feed roller. There are many other common applications in such things as fax machines, photocopiers, disk drives, and plotters.

This project allows two stepping motors to be driven independently under the control of a PC computer. It operates from the parallel printer port and so does not need any interface cards, and can be connected and disconnected instantly. Software is supplied which runs under MS-DOS and allows each motor to be started, stopped, reversed, and run in half-step and full-step modes for selected numbers of steps at a range of speeds.

Tables of instructions can be entered so that the motors can either execute single sequences of operations, or cycle repeatedly looping through sets of movements. The software is simple to use, operating on a Menu basis. Routines can be Loaded, Edited, Saved, and Run as required. There is also a "Direct Drive" mode which allows the motors to be operated in "Real Time" from the keyboard. Advanced computer users should be able to experiment with their own software, driving the parallel port directly and controlling the motors.

MOTORS

Most stepping motors can be driven by this circuit, providing they have operating voltages in the range of 9 to 24 volts and

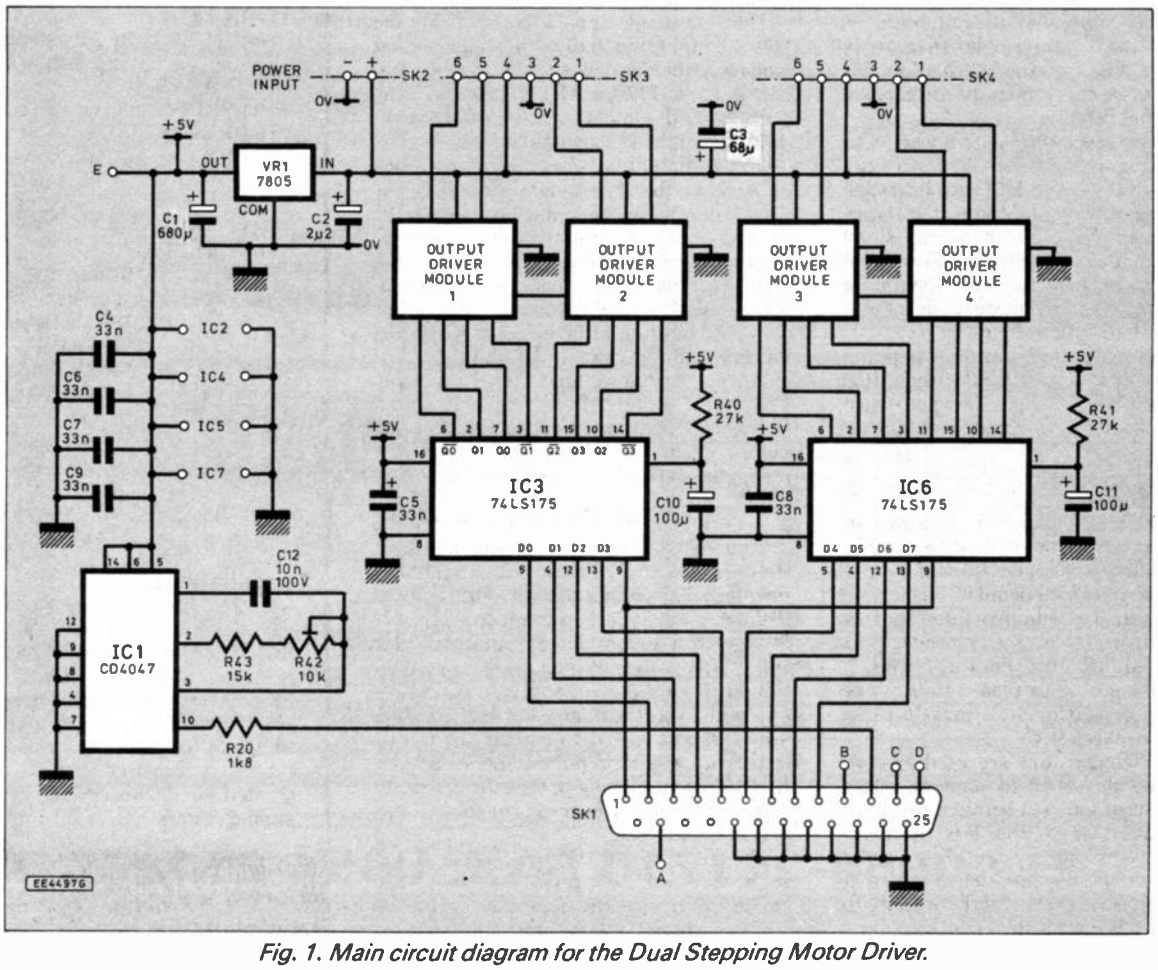


Fig. 1. Main circuit diagram for the Dual Stepping Motor Driver.

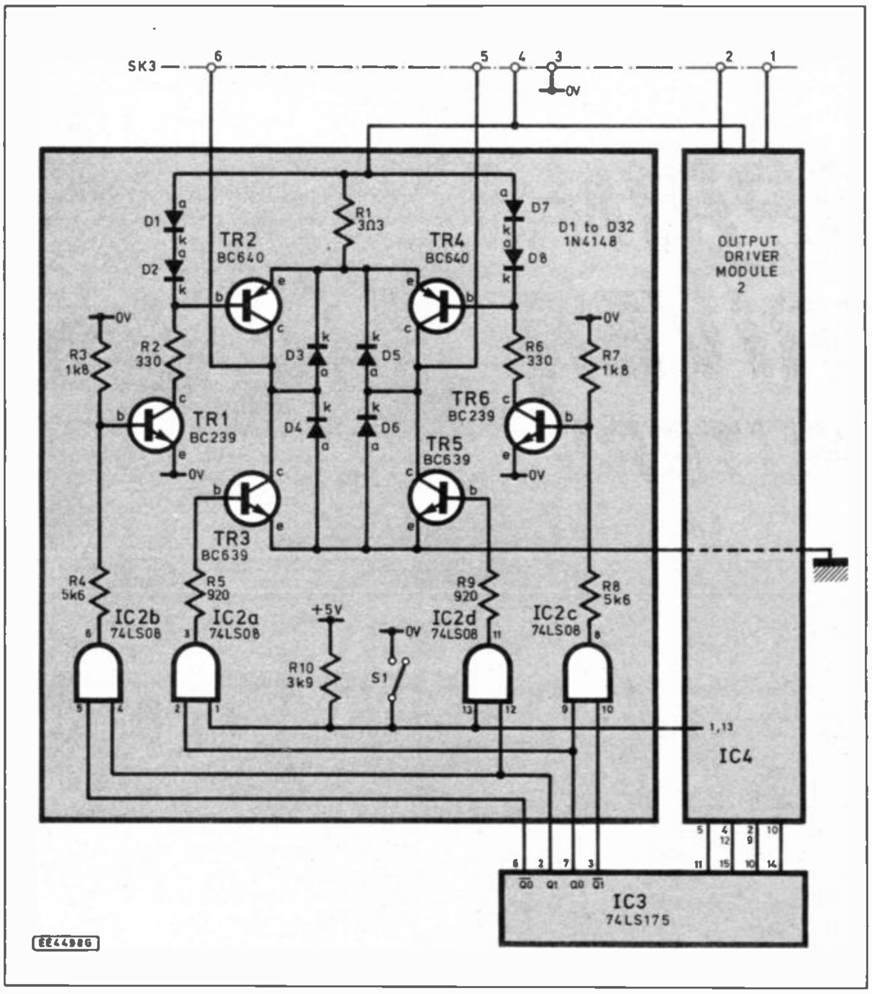


Fig. 2. Motor drive circuit for modules 1 and 2. Modules 3 and 4 are identical.

require less than 350mA per winding. The drive can be configured to suit both bi-polar (four wire) and uni-polar (five or six wire) motors. Links on the board allow this option to be set independently for each of the two output stages.

The kit (see *Shoptalk*) is supplied with two high quality bi-polar 200 step per revolution motors, with ball race bearings, and mounting brackets. Many other types of motor can be used including small 48 step per revolution types. For small motors, the torque and the maximum stepping rate are limited more by the choice of motor than the drive circuit.

Compared with d.c. motors, stepping motors have limited speed and torque. It is their controlability – right down to zero speed – that makes stepping motors so special.

CIRCUIT

The main circuit diagram is shown in Fig. 1. As there are four identical output driver modules, these have been shown in block form here, and in detail in Fig. 2.

If we look at the computer interface section first, the lead from the computer port has eight parallel data lines D0 to D7. These are connected to pins 2 to 9 of the 25-way "D" connector SK1. Pins 18 to 25 are ground connections.

The other connections are used to control the data flow and to send messages (such as "out of paper") between the computer and the printer. Pin 1 is the Data Strobe pin. This pin is pulsed low by the computer to tell the printer when the eight data lines have been set up and are ready to be read. In this circuit the eight data lines are connected to two latches. D0 to D3 are connected to IC3, and D4 to D7 to IC6.

The data strobe signal is connected to the "clock" input (pin 9) of both latches so that whenever the computer sends a strobe signal, data on D0 to D7 is latched in. The outputs of the latches consist of the eight data bits, and eight inverted data bits.

The availability of the inverted data bits as well as the direct data simplifies the driver modules which must translate the data into the appropriate drive sequences for the motor windings. The flow of data from the computer must be controlled, otherwise streams of data and strobe pulses would be sent out at high speeds which the motors could not possibly follow. To deal with this, the connection to pin 11 is made. This is the "Printer Busy" line, and is used to signal from the interface to the computer. When this line is held high, the computer waits and does not send any data.

In normal applications with a printer, the "Printer Busy" line is used to stop and start the data flow to the printer's internal buffer memory. This circuit uses the line in a less orthodox way. IC1 is a free running oscillator with a square wave output at 1kHz which drives the "Printer Busy" line continuously via R20. The software reads this line and uses it not just to stop the data flow, but as a clock, to control the timing of the motor control pulses, and sequences. By relating everything to this, the computer software does not have to run time loops and so is simplified.

The frequency of the pulses from IC1 is set by C12, R43, and preset R42 which can be set up against the computer crystal by using a special utility program provided with the software. Additional components

COMPONENTS

Resistors

R1, R11, R21, R31	3Ω3 ¼ Watt carbon film 5% (4 off)
R2, R6, R12, R16, R22, R26, R32, R36	330 (8 off)
R3, R7, R13, R17, R20, R23, R27, R33, R37	1k8 ⅛Watt (9 off)
R4, R8, R14, R18, R24, R28, R34, R38	5k6 (8 off)
R5, R9, R15, R19, R25, R29, R35, R39	920 (8 off)
R42	15k
R10, R30	3k9 (2 off)
R40, R41	27k (2 off)
R42	10k horizontal trimmer

Capacitors

C1	680µ radial elect. 25V
C2	2µ2 tantalum bead 25V
C3	68µ axial elect. 16V
C4 to C9	33n polyester or ceramic 50V (6 off)
C10, C11	100µ radial elect. 10V (2 off)
C12	10n polyester film 100V

Semiconductors

D1 to D32	1N4148 diodes (32 off)
TR1, TR6, TR7, TR12, TR13, TR18, TR19, TR24	BC239 or BC549 *npn* transistor (8 off)
TR2, TR4, TR8, TR10, TR14, TR16, TR20, TR22	BC640 *pnp* transistor (8 off)
TR3, TR5, TR9, TR11, TR15, TR17, TR21, TR23	BC639 *npn* transistor (8 off)
VR1	7805 voltage regulator
IC1	4047B CMOS multivibrator
IC2, IC4, IC5, IC7	74LS08 LS TTL quad input AND gates (4 off)
IC3, IC6	74LS175 quad latch (2 off)

Miscellaneous

S1, S2	Two pin headers with shorting links
SK1	Male 25-way 90 deg. "D" connector
SK2	Two way mains terminal block
SK3, SK4	Six way plug-in terminal block connectors

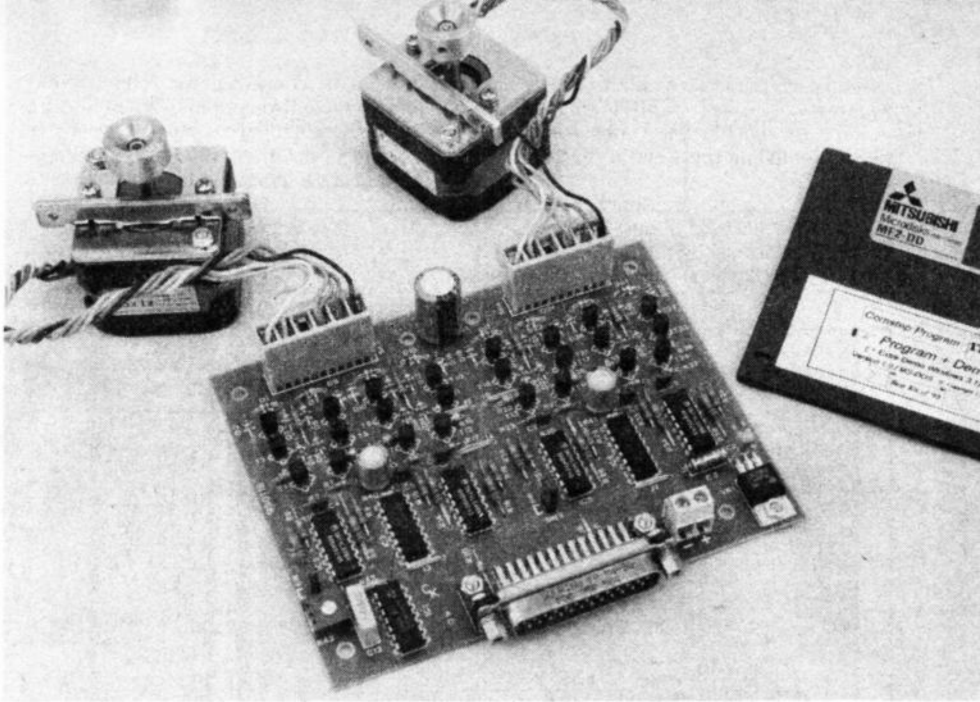
Printed circuit board (see *Shoptalk*); stepping motors.

Approx cost guidance only **£63** *including motors*

TRUTH TABLE – DRIVER MODULE

DATA INPUTS		OUTPUTS – SK3			
		S1 OPEN		S1 CLOSED	
Q^0	Q^1	PIN 6	PIN 5	PIN 6	PIN 5
0	0	X	X	X	X
0	1	H	L	H	X
1	0	L	H	X	H
1	1	L	L	X	X
		BI-POLAR MODE		UNI-POLAR MODE	

R40, C10, and R41, C11 hold the "clear" pins of the latches down for a brief time following switch on so that the circuit starts from a known state, with both motors free.



MOTOR DRIVE MODULES

The circuit diagram of each motor drive module is shown in Fig. 2. Four inputs to each module are connected via ICs 2, 4, 5, and 7. These are LS TTL AND gates.

In driver module 1 the gate outputs drive four transistors TR1, TR3, TR5, and TR6. Of these TR3 and TR5 drive the output pins (pins 6 and 5 of SK3) directly, pulling the pins to ground when they are turned ON. TR1 and TR6 drive *pnp* transistors TR2 and TR4 which pull the output pins up to the positive motor supply when they are turned on.

A simplified truth table (above) shows the levels of Q0 and Q1 (the latched equivalents of D0 and D1) and the associated outputs on SK3. Note that in many cases all transistors are turned off (indicated by an X in the truth table), and the motor current is therefore zero.

Bi-polar and uni-polar motors need different drive states. In particular, uni-polar motors do not require TR3 or TR5 to be turned on, as their winding centre taps are permanently connected to ground. The truth table shows that when S1 is closed (uni-polar mode), neither output is ever grounded. When S1 is open (bi-polar mode), both outputs can be switched between the motor positive supply and ground so that current can flow either way through the whole winding.

Uni-polar motors can be used as bi-polar motors simply by ignoring their centre taps. In most cases this will result in better performance (as long as the voltage and current ratings are appropriate) as the entire winding space is used, instead of only half. Fig. 3 shows the connections of the two types of motor to SK3 and SK4.

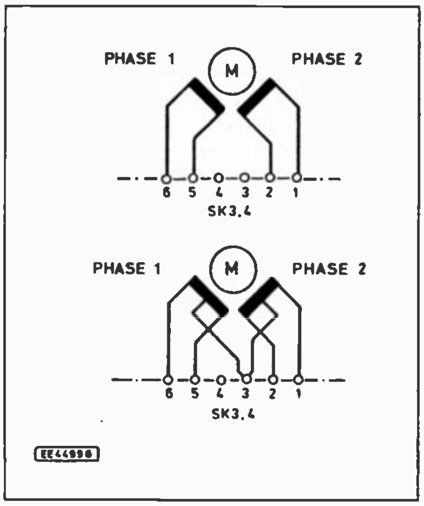


Fig. 3. Connections to bi-polar and uni-polar stepping motors.

Diodes D1, D2, D7, and D8 set the bias voltage for TR2 and TR4, and in combination with resistor R1 provide a simple current limiting action which protects all parts of the output circuitry. The other diodes, D3, D4, D5, and D6 protect the output transistors by providing alternative paths for the winding current during switching so that excessive "back e.m.f." voltages do not occur.

There are two output driver modules per motor, one to drive each winding. The sequences of energisation for the coils is determined by the computer software which switches the four data lines in the appropriate combinations. Stepping motor principles have been covered in detail from time to time in this magazine, and so will not be repeated here.

The software supplied with the kit produces the sequences for half and full stepping automatically. Programming from scratch is possible, and depends largely on having a good understanding of the parallel port operation.

POWER SUPPLIES

The interface requires a suitable source of power for the motors. The logic part of the circuit uses the same supply, reduced to 5 volts via voltage regulator VR1. The usual operating voltage will be 12 volts, but the circuit will run with any motor supply from 9 to 24 volts. A simple unregulated 12 volt one amp supply will be fine for most applications.

CONSTRUCTION

A single printed circuit board holds all of the components. The track foil pattern and component layout are shown in Fig. 4. The board supplied has all of the component positions marked to ease assembly.

Begin by fitting all of the resistors, and then the diodes. Note that the diodes have a broad yellow band to indicate the cathode, which corresponds to the straight bar on the p.c.b. symbol. There are a number of wire links which should be made with tinned wire – the resistor lead offcuts are ideal. As the links are short there is no need to insulate them.

The capacitors can be fitted next, taking care that C1, C2, C3, C10, and C11 are the right way round. The transistors should be fitted one type at a time to minimise the chance of error. Make sure that the outline corresponds to the shape printed on the board.

The voltage regulator, should have its leads bent back carefully and fitted into their connecting holes and then the fixing nut and screw should be used to fasten the tab to the board *before* soldering the three leads.

The 25-way "D" connector (SK1) needs a little skill to get all of the leads into their p.c.b. holes properly before screwing it to the board with the nuts, screws, and locking washers provided. Once in place the pins are easy to solder.

The power connector SK2 should be fitted as shown with its wire entries to the edge of the board. SK3 and SK4 should be fitted with their straight side nearest to the board edge.

The final components to fit are the i.c.s. All except IC1 are LS TTL types, and so are not prone to static damage. IC1 should be handled a little more carefully. All are fitted the same way round with their notched (pin 1) end as shown on the board symbol. The main thing is to be sure that the soldering iron used is adequately isolated or earthed. I.C. sockets are not necessary as the circuit puts very little stress on the i.c.s which are extremely unlikely to fail.

TESTING

Before applying power to the board, give it a thorough inspection. Look for solder whiskers, dry joints, and above all for reversed or incorrectly fitted components. Once everything looks satisfactory the circuit can be powered. Do not connect the motors or computer, but apply 12 volts to SK2 via a current limiting device such as a bulb or a 47 ohm resistor.

If all is well the current will remain low, and the output from VR1 will read 5 volts. Next check that the Q outputs of IC3 and IC4 are low, and that the 'NOT Q' outputs are high. Measure the voltage on SK3 pins 6, 5, 2, and 1, first in relation to the negative supply (ground, SK3 pin 3), and then in relation to the motor positive supply (SK3 pin 4). Repeat these checks on SK4. There should be no readings in any positions if the circuit is correct and if IC3 and IC6 have cleared properly following switch on.

If an oscilloscope is available check for a square wave on pin 10 of IC1. An analogue multimeter will indicate roughly half supply (2.5 volts) on this point if the oscillator is running.

The stepping motors supplied with the kit are wire-ended, and must be terminated in the plugs provided to mate with SK3 and SK4. For uni-polar operation the wires should be connected as follows: pin 1 Black: pin 2 Brown: pin 3 No connection: pin 4 Red, Red: pin 5 Orange: pin 6 Yellow.

Connect the motors to the control board and select uni-polar mode by fitting the two jumpers on S1 and S2 so that the pins are shorted together. Switch the interface on, and check that the two motors can be turned freely by hand.

The next step is to connect the computer and load the software. A fully wired parallel printer lead is required with 25-pin "D" connectors at each end. The computer parallel connector is usually a female one and the interface has a male connector, so a straight 25-way pin to pin male – female lead is needed. Computers do vary, and so it is possible that a female – female may be required, or a gender changer could be useful.

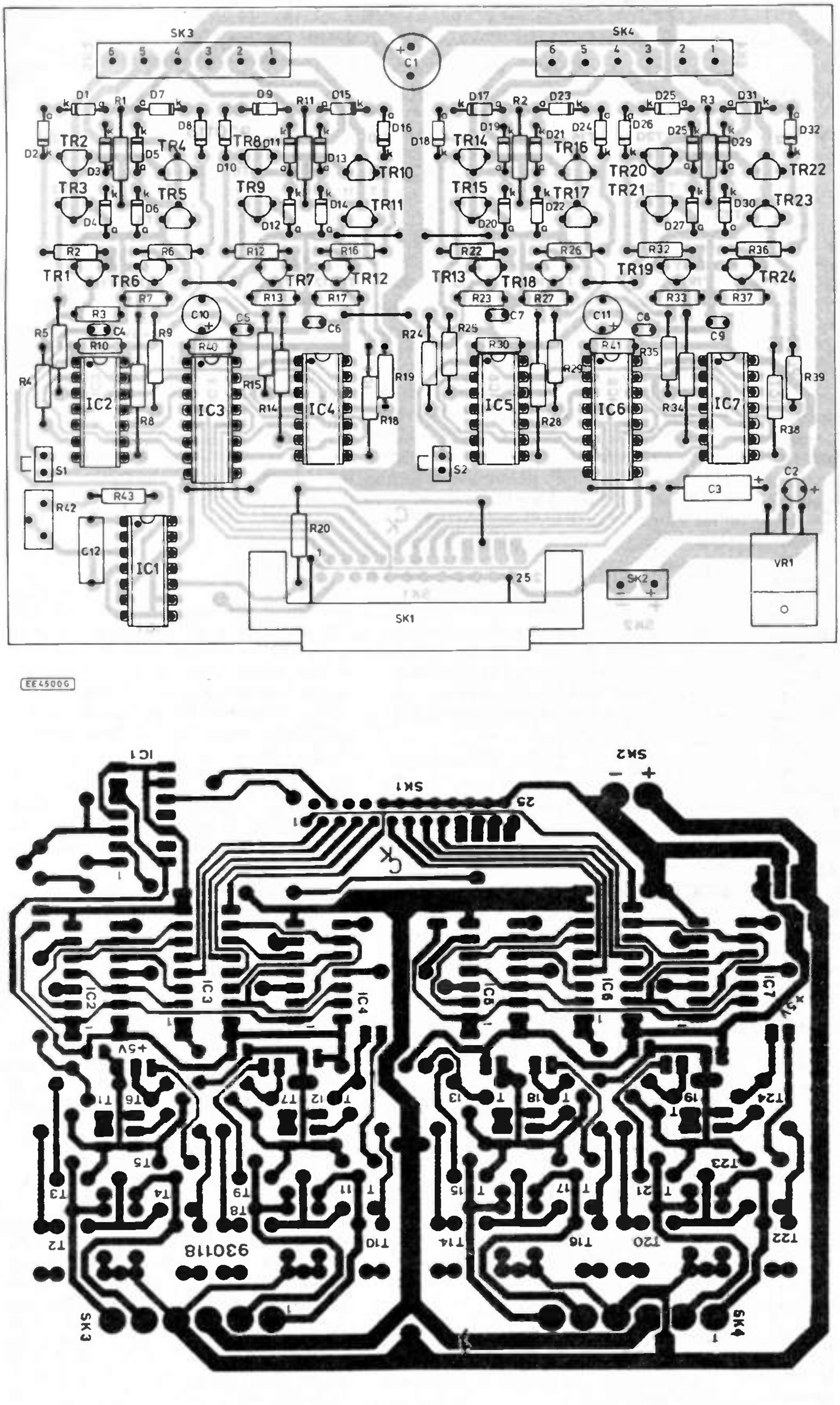


Fig. 4. P.C.B. Layout and wiring for the Dual Stepping Motor Driver.

SOFTWARE

The software is supplied as standard on a 3·5 inch double density disk to run under MS-DOS. Insert the disk, select the appropriate drive (A: 'return') and then type MOTOR. The computer screen then prompts for display type. Enter your display and the screen will open out into the main control page.

Select the CONFIG option, either by using F10 and the cursor arrows, or by entering the 'control' X sequence required. The drop down box will now show SET PARALLEL PORT, and ADJUST CLOCK. Select adjust clock and if the board oscillator is running it should be possible to set up the 1kHz required by adjusting preset R42.

Exit the ADJUST CLOCK menu, and proceed to the EDIT menu. From the drop down box select GET DEMO. The two motor columns will fill with the instructions of the motor demonstration program.

Press F10 move the cursor to RUN and the drop down box will show RUN MOTORS 1&2, RUN MOTOR 1, RUN MOTOR 2, INTERACTIVE. Select RUN MOTOR 1, and if all is well the first stepping motor should start its demonstration routine. Follow this with RUN MOTOR 2, and then RUN MOTORS 1&2.

Once the motors are running correctly, all that remains is to play around with the software, modifying the demonstration commands to become familiar with the various key options, and then beginning to write short routines from scratch. Routines can be saved and recalled, run, and edited as required. The software is self explanatory and can be picked up very quickly.

Finally the motors are ready to be put to use. Models, mechanisms, and other devices which need movement can be brought to life with this system. It is also the ideal way to introduce stepping motors into classroom projects, and should be a source of many good teaching and project ideas. □

INTER FACE

Robert Penfold

WHEN interfacing a peripheral circuit to a computer there is usually no problem if the peripheral is connected direct to a port of the computer. It is not always acceptable to do this though, and earthing problems can arise.

The most common cause of the problem is a lack of "earth connections" on mains powered equipment. The problem is most severe when both the computer and the peripheral device are mains powered, but neither has an earthed chassis. Use of the double insulation technique rather than an earthed chassis is now quite widespread.

On the face of it there is no problem with a setup of this type, but in practice there is often quite a high voltage between the chassis of the two circuits. Although this voltage is at a high impedance, it is capable of damaging most semiconductors. When dealing with modern circuits it should be remembered that while semiconductors are usually unharmed by brief current overloads, they are very intolerant of high voltages.

Damaging components due to earthing problems is not a purely theoretical problem. I, and many others, have damaged computer ports when ignoring this potential problem. If in doubt it is better to include an isolation circuit rather than taking the "suck it and see" approach.

There can be other advantages in adding an isolation circuit. They provide one way around the problem in any situation where there is a potential difference across the earth connections. In audio applications an isolation circuit helps the avoidance of "hum" loops, and can also prevent digital noise from finding its way into the audio signal path.

Analogue Isolation

Probably the most common form of isolation circuit is the optically coupled variety. Opto-isolators represent a very simple and inexpensive means of coupling digital signals, and their only major drawback is a lack of speed by normal digital standards. However, their operating speed is perfectly adequate for most applications.

Opto-isolators are less suited to the transfer of analogue signals. This is simply due to their rather poor linearity. A severe lack of linearity is of no consequence when transferring digital signals, but it is essential to virtually every analogue application.

One way around this problem is to encode the analogue input signal into some form of digital signal, transfer the digital signal through the opto-isolator, and then convert the digital signal back to an analogue type. Pulse width modulation is one way of achieving this, and this is a subject which has been covered in previous articles.

There is an alternative method which is based on two opto-isolators and non-linear feedback over an operational amplifier. Fig. 1 shows the basic scheme of things used in a circuit of this type. D1 and D2 are the l.e.d.s inside the opto-isolators, and these are both driven from the output of the operational amplifier via a current limiting resistor (R3).

The operational amplifier IC1 is used as what is effectively a non-inverting amplifier having unity voltage gain. Resistor R1 biases the non-inverting input to the 0V "earth" rail and sets the input resistance of the circuit.

Feedback

Although the circuit may seem to lack a negative feedback path from the output of IC1 to the inverting input (−), the feedback is provided via an indirect route. D1 is the photodiode in one of the opto-isolators. For an opto-isolator which has a phototransistor rather than a diode, the collector-emitter terminals of the transistor would be connected in place of D1.

With a small positive input voltage applied to the circuit there is no negative feedback, and IC1 has its full open loop voltage gain. This results in the output going strongly positive, since the non-inverting input is taken positive of the inverting input. The latter is biased to the 0V supply by resistor R2.

The output of IC1 swings positive until the two l.e.d.s are brought into conduction. Light from one of the l.e.d.s produces increased leakage through D1, and provides a feedback signal to the inverting input.

The circuit functions in what is basically the same fashion as a normal non-inverting amplifier, with the feedback balancing the two input voltages to IC1. If the input is taken more positive, a higher l.e.d. current flows, the leakage through D1 increases, and the potential at the inverting input is raised to a level that matches the voltage at the non-inverting input. The large amount of negative feedback applied to IC1 ensures the voltage at the inverting input is always accurately matched to the input voltage.

The photodiode D4 is in the second opto-isolator, and R4 is its load resistor. If R2 and R4 have exactly the same value, and the characteristics of the two opto-isolators are accurately matched, the voltage across R4 should always be the same as that across R2, which is in turn equal to the input voltage. The circuit therefore provides a linear transfer from the input to the output, but with no direct connection between the two.

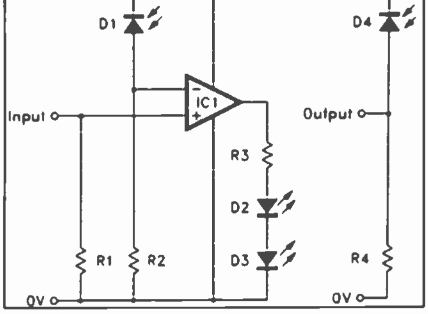


Fig. 1. Using two opto-isolators to obtain a more linear transfer characteristic.

Dual Isolator

Unfortunately, practical circuits do not achieve theoretical perfection, and there is usually a certain amount of non-linearity through the system. The main problem is in getting two accurately matched opto-isolators. Experiments with circuits based on "bog standard" opto-isolators produced rather disappointing results.

Improved results are obtained using higher quality opto-isolators having tighter tolerances, but significant imbalances can still occur. Circuits of this type can certainly be made to work, and a practical design appeared in the July 1988 issue of *Everyday Electronics* ("Isolink" by Andy Flind).

There is now an opto-isolator which is specifically designed for use in linear circuits. The basic idea is very simple, and the device consists of one l.e.d. driving two accurately matched photodiodes. The opto-isolator in question is the IL300, and it has the pinout configuration shown in Fig. 2. There are no connections internally to pins 7 and 8.

The IL300 is designed for use in a circuit of the type described previously, but the operational amplifier only has to drive the single l.e.d. The use of one l.e.d. to drive both photodiodes, plus the use of two matched photodiodes, ensures a reasonably high level of performance is obtained.

The circuit diagram for a d.c. coupled opto-isolator circuit based on the IL300 is shown in Fig. 3. On the input side the circuit uses the configuration described previously. Resistor R1 sets the input resistance of the circuit at 100 kilohms, but this can be set at any desired figure by using the appropriate value for R1.

On the output side R4 is the load resistor for the photodiode (IC2b), and IC3 acts as a buffer amplifier. With the IL300s I tried there was something less than unity voltage gain through the circuit.

If necessary, preset VR1 can be adjusted to provide a certain amount of voltage gain to compensate for the losses through the main circuit. The amplifier has unity voltage gain with the wiper of VR1 at the top end of the track. Moving the wiper down the track gives increased voltage gain.

Note that the CA3140E used for IC1 and IC3 is a type which can operate as a d.c. amplifier using a single supply rail. Most other operational amplifiers (μA741C, LF351N, TIL81CP, etc.) will not operate properly in this circuit unless they are powered from dual balanced supplies. Even if dual balanced supplies are used, the circuit can only couple positive input voltages. The circuit should work well with input voltages of up to at least five volts.

The performance of the circuit is quite good, and the linearity is very respectable at input voltages of between one and five volts. At input voltages of less than one volt

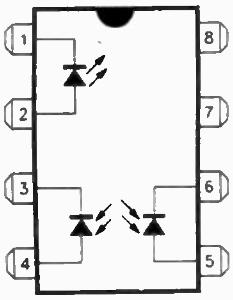


Fig. 2. Pinout details for the IL300.

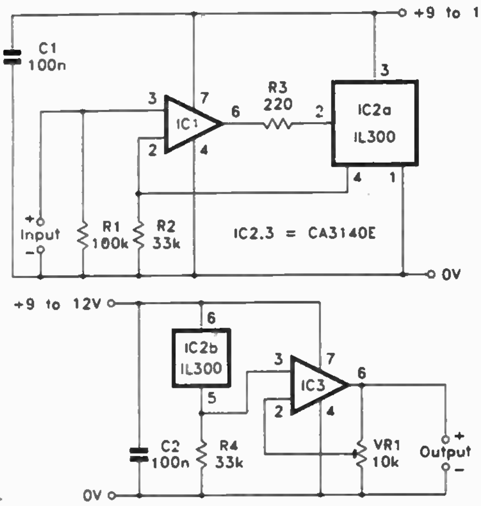


Fig. 3. The d.c. coupled opto-isolator circuit.

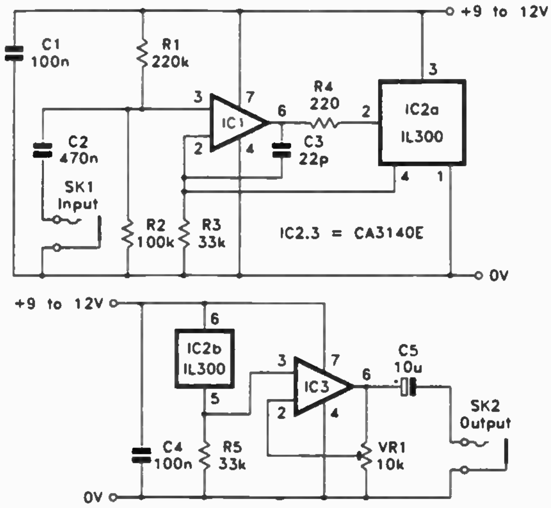


Fig. 4. The a.c. coupled version of the opto-isolator circuit.

it is not quite as impressive, but the linearity is adequate for non-critical applications.

Audio Isolator

The circuit has quite a wide bandwidth, and in this respect it is more than adequate for coupling audio frequency signals. With pulse width modulation and similar methods of opto-coupling audio signals it can be difficult to obtain sufficient bandwidth.

Also, it is usually necessary to resort to some fairly comprehensive lowpass filtering in order to obtain an output signal having good suppression of the clock frequency. With this circuit there is no need for any lowpass filtering at the output, and at about 200kHz the bandwidth is some ten times wider than the audio band.

An a.c. coupled version of the circuit, which has been modified for audio frequency use, is shown in Fig. 4. The main difference between the d.c. coupled version is that the input has been biased to about one third of the supply voltage, and coupling capacitors have been added at the input and the output.

The only other change is the addition of feedback capacitor C3 which provides a small amount of high frequency roll-off to IC1. This was found to be necessary in order to give good stability with the audio version of the circuit, even though the d.c. circuit showed no signs of instability. Preset control VR1 should be adjusted to give about one third of the supply voltage at the output (pin 6) of IC3.

While true hi-fi performance cannot be claimed for this circuit, for such a simple device it does provide surprisingly good results. Input signals of up to about 5V peak-to-peak can be accommodated.

With some opto-coupled audio circuits the signal to noise ratio is quite low due to noise generated in the opto-isolator itself. Noise does not seem to be a problem in this case, and the background noise level of the circuit is negligible. This method of opto-isolation is very simple and inexpensive, and almost certainly represents the most cost effective solution where very high levels of linearity are not essential.

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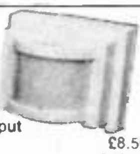

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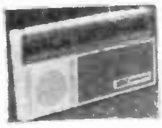

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The City & Guilds introduction to module 726/301 reads: "A candidate who satisfactorily completes this module will have a competence to identify basic components and digital integrated circuits and connect them together to form simple working circuits and logic units." This provides an excellent introduction to the book.
112 pages (A4 size) Order code TI4 **£2.95**

ELECTRONICS TEACH-IN No.5 GUIDE TO BUILDING ELECTRONIC PROJECTS
Published by *Everyday Electronics*
Due to the demand from students, teachers and hobbyists we have put together a range of articles from past issues of *Everyday Electronics* that will assist those involved with the construction of electronic projects.
The book contains the complete *Project Development for GCSE* series.
Contents: Features – First Steps in Project Building; Building with Vero; Project Development for GCSE; Getting your Projects Working; Guide to Printed Circuit Boards; Choosing and Using Test Equipment – The Multimeter, The Oscilloscope, P.S.U.s, Logic Probes, Digital Frequency Meters, Signal Generators, etc; **Data** – Circuit Symbols; Component Codes; Resistors; Identifying Components; Capacitors; Actually Doing It – Understanding the Circuit Diagram, Component Codes, Mounting circuit boards and controls, Understanding Capacitors; **Projects** – Lie Detector; Personal Stereo Amplifier; Digital Experimentsr's Unit; Quizmaster; Siren Effects Unit; UV Exposure Unit; Low-cost Capacitance Meter; Personal Radio.
88 pages (A4 size) Order code TI5 **£2.95**

ELECTRONICS TEACH-IN No. 6 DESIGN YOUR OWN CIRCUITS (Published by *Everyday with Practical Electronics*)
Mike Tooley B.A.
This book is designed for the beginner and experienced reader alike, and aims to dispell some of the mystique associated with the design of electronic circuits. It shows how even the relative newcomer to electronics can, with the right approach, design and realise quite complex circuits.
Fourteen individual p.c.b. modules are described which, with various detailed modifications, should allow anyone to design and construct a very wide range of different projects. Nine "hands-on" complete DIY projects have also been included so readers can follow the thinking behind design, assembly, construction, testing and evaluation, together with suggested "mods" to meet individual needs. The practical projects have each been designed to stand on their own as complete items of equipment. P.C.B.s for all the modules and projects are available by mail order.
The subjects covered in each chapter of the book are: Introduction and Power Supplies; Small Signal Amplifiers; Power Amplifiers; Oscillators; Logic Circuits; Timers; Radio; Power Control; Optoelectronics.
The nine complete constructional projects are: Versatile Bench Power Supply; Simple Intercom; Bench Amplifier/Signal Tracer; Waveform Generator; Electronic Die; Pulse Generator; Radio Receiver; Disco Lights Controller; Optical Communications Link.
136 pages Order code TI6 **£3.45**

DIRECT BOOK SERVICE

The books listed have been selected by Everyday with Practical Electronics editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page. For another selection of books see next month's issue

TESTING, THEORY AND REFERENCE

PRACTICAL ELECTRONICS HANDBOOK – Third Edition
Ian Sinclair
A completely updated and revised third edition of this popular title. It still contains a carefully selected collection of standard circuits, rules-of-thumb, and design data for professional engineers, students and enthusiasts involved in radio and electronics, but is now over one hundred pages bigger..
The book covers many areas not available elsewhere in such a handy volume, and this new edition now includes chapters on: **Microprocessors and microprocessor systems:** The instruction register, Clocking, Memory, Read-write memory, The buses, Reading and writing actions, Three-state control, The control bus, Timing and bus control, The PC register and addressing, Addressing methods, Interrupts, Inputs and outputs, Port, Keyboard interfacing, Video interfacing. **Digital-analogue conversions:** Analogue-to-digital conversion, Sampling and conversion, Digital-to-analogue conversion, Current addition methods, Conversion problems, Bitstream methods, Computer plug-in boards. **Computer aids in electronics:** The computer, Linear circuit analysis by computer, The menus, Circuits and nodes, PCB layouts, Circuit diagrams, The Public Domain Software Library. **Hardware components and practical work:** Hardware, Video connectors, Control knobs and switches, Switches, Cabinets and cases, Packages for semiconductors, Integrated circuit packages, Constructing circuits, Surface mounting, testing and trouble-shooting, Practical work on microprocessing equipment, Instruments for digital servicing work, Logic analysers.
Other chapters cover Passive Components, Active Discrete Components, Discrete Component Circuits, Linear ICs, Digital ICs, Transferring Digital Data and Computer Aids in Electronics
338 pages Order code NE19 **£14.95**

MORE ADVANCED USES OF THE MULTIMETER
R. A. Penfold
This book is primarily intended as a follow-up to BP239, (see above), and should also be of value to anyone who already understands the basics of voltage testing and simple component testing. By using the techniques described in chapter 1 you can test and analyse the performance of a range of components with just a multimeter (plus a very few inexpensive components in some cases). Some useful quick check methods are also covered.
While a multimeter is supremely versatile, it does have its limitations. The simple add-ons described in chapter 2 extended the capabilities of a multimeter to make it even more useful.
84 pages Order code BP265 **£2.95**

ELECTRONIC TEST EQUIPMENT HANDBOOK
Steve Money
The principles of operation of the various types of test instrument are explained in simple terms with a minimum of mathematical analysis. The book covers analogue and digital meters, bridges, oscilloscopes, signal generators, counters, timers and frequency measurement. The practical uses of the instruments are also examined.
Everything from Audio oscillators, through R, C & L measurements (and a whole lot more) to Waveform Generators and testing Zeners.
206 pages Order code PC109 **£8.95**

A REFERENCE GUIDE TO BASIC ELECTRONICS TERMS
F. A. Wilson
The wonders of electronics multiply unceasingly and electronic devices are creeping relentlessly into all walks of modern life. As with most professions, ours too has a language of its own, ever expanding and now encompassing several thousands of terms. This book picks out and explains some of the more important fundamental terms (over 700), making the explanations as easy to understand as can be expected of a complicated subject and avoiding high-level mathematics.
Through its system of references, each term is backed up by a list of other relevant or more fundamental terms so that a chosen subject can be studied to any depth required.
472 pages Order code BP286 **£5.95**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold
This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.
In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.
96 pages Order code BP239 **£2.95**

ELECTRONICS-BUILD AND LEARN
R. A. Penfold
The first chapter gives full constructional details of a circuit demonstrator unit that is used in subsequent chapters to introduce common electronic components – resistors, capacitors, transformers, diodes, transistors, thyristors, fets and op amps. Later chapters go on to describe how these components are built up into useful circuits, oscillators, multivibrators, bistables and logic circuits.
At every stage in the book there are practical tests and experiments that you can carry out on the demonstrator unit to investigate the points described and to help you understand the principles involved. You will soon be able to go on to more complex circuits and tackle fault finding logically in other circuits you build.
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ELECTRONICS – A "MADE SIMPLE" BOOK
G. H. Olsen
This book provides excellent background reading for our *Introducing Digital Electronics* series (Teach-In No.4 above) and will be of interest to everyone studying electronics. The subject is simply explained and well illustrated and the book assumes only a very basic knowledge of electricity.
330 pages **Temporarily out of print**

PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE
F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.
Bridges the gap between complicated technical theory, and "cut-and-tried" methods which may bring success in design but leave the experimenter unfulfilled. A strong practical bias – tedious and higher mathematics have been avoided where possible and many tables have been included.
The book is divided into six basic sections: Units and Constants, Direct-current Circuits, Passive Components, Alternating-current Circuits, Networks and Theorems, Measurements.
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NEWNES ELECTRONICS TOOLKIT
Geoff Phillips
The author has used his 30 years experience in industry to draw together the basic information that is constantly demanded. Facts, formulae, data and charts are presented to help the engineer when designing, developing, evaluating, fault finding and repairing electronic circuits. The result is this handy workmate volume: a memory aid, tutor and reference source which is recommended to all electronics engineers, students and technicians.
Have you ever wished for a concise and comprehensive guide to electronics concepts and rules of thumb? Have you ever been unable to source a component, or choose between two alternatives for a particular application? How much time do you spend searching for basic facts or manufacturer's specifications? This book is the answer, it covers resistors, capacitors inductors, semiconductors, logic circuits, EMC, audio, electronics and music, telephone, electronics in lighting, thermal considerations, connections, reference data.
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COMPUTING

INTERFACING PCs AND COMPATIBLES
R. A. Penfold

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This book gives you: A detailed description of the lines present on the PC expansion bus. A detailed discussion of the physical characteristics of PC expansion cards. The I/O map and details of the areas where your add-ond can be fitted. A discussion of address decoding techniques. Practical address decoder circuits. Simple TTI 8-bit input and output ports. Details of using the 8255 parallel interface adaptor. Digital to analogue converter circuits. Analogue to digital converter circuits. In fact everything you need to know in order to produce successful PC add-ons.

80 pages Order code BP272 **£3.95**

HOW TO CHOOSE A SMALL BUSINESS COMPUTER SYSTEM
D. Weale

This book is for anyone intending to buy an IBM compatible computer system, whether it is their first system or a replacement. There are sections on hardware, application and systems programs, and how to actually make your choice as well as sections on the law, ergonomics and a glossary or common terms. The text contains many useful tips and some warnings (which could save much effort and expense). After having read this book you should have a better idea of what is suitable for your needs, how to obtain it and how to ensure that the system is operated with the minimum of difficulty.

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R. A. Penfold

Not only are PC and compatible computers very expandable, but before long most users actually wish to take advantage of that expandability and start upgrading their PC systems. Some aspects of PC upgrading can be a bit confusing, but this book provides advice and guidance on the popular forms of internal PC expansion, and should help to make things reasonably straightforward and painless. Little knowledge of computing is assumed. The only assumption is that you can operate, a standard PC of some kind (PC, PC XT, PC AT, or a 80386 based PC).

The subjects covered include: PC overview; Memory upgrades; Adding a hard disk drive; Adding a floppy disk drive; Display adaptors and monitors; Fitting a maths co-processor; Keyboards; Ports; Mice and digitisers; Maintenance (including preventative maintenance) and Repairs, and the increasingly popular subject of d.i.y. PCs.

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The PRE-BASIC BOOK
F. A. Wilson, C.G.I.A., C.ENG., F.I.E.E., F.I.E.R.E., F.B.I.M.

Another book on BASIC but with a difference. This one does not skip through the whole of the subject and thereby leave many would-be programmers floundering but instead concentrates on introducing the technique by looking in depth at the most frequently used and more easily understood computer instructions. For all new and potential micro users.

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AN INTRODUCTION TO 6502 MACHINE CODE
R. A. & J. W. Penfold

No previous knowledge of microprocessors or machine code is assumed. Topics covered are: assembly language and assemblers, the register set and memory, binary and hexadecimal numbering systems, addressing modes and the instruction set, and also mixing machine code with BASIC. Some simple programming examples are given for 6502-based home computers like the VIC-20, ORIC-1/Atmos, Electron, BBC and also the Commodore 64.

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N. Kantonis

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The book explains: what hardware requirements you need in order to run Windows 3.1 successfully, and how to install, customise and fine-tune the program, and how to optimise your system resources. How to manipulate Windows screens and how to run Windows and DOS applications under the Windows Graphical User Interface (GUI) environment. How to use the Windows triple Management system; Program Manager, File Manager and Print Manager to advantage. How to use the word processor accessory Write to type, edit, format, print and save documents.

How to use Paintbursh and its tools to draw and edit drawings, and how to set up, sort and search a Cardfile database and exploit its autodial feature. How to use the Windows Calendar to enter appointments, add special times and alarms. How to use the Terminal accessory to connect to remote systems, specify terminal emulation preferences, communications setting, telephone number and prepare files for transfer. How to use the Notepad, Macro Recorder, PIF Editor and Calculator.

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Mike Tooley BA

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A CONCISE USER'S GUIDE TO MS-DOS 5
N. Kantonis

If you are a PC user and want to get the most out of your computer in terms of efficiency and productivity, then you must learn the intricacies of its MS-DOS operating system. With this book you will learn to do just that in the shortest and most effective way.

The book explains: The enhancements to be found in MS-DOS version 5, over previous versions of the operating system. How the DOS operating system is structured so that you can understand what happens when you first switch on your computer. How directories and subdirectories can be employed to structure your hard disc for maximum efficiency. How to use the DOS Shell program (a menu-driven graphical interface) to perform various house-keeping operations on your disc. How to manage disc files, and how to use the MS-DOS Editor to fully configure your system by writing your own CONFIG.SYS and AUTOEXEC.BAT files. How to optimise your system by either increasing its conventional memory or increasing its speed. How to write batch files to automate the operation of your system

A summary of all DOS commands, illustrated with examples, is given in the penultimate chapter, which turns it into a useful reference guide.

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CIRCUITS AND DESIGN

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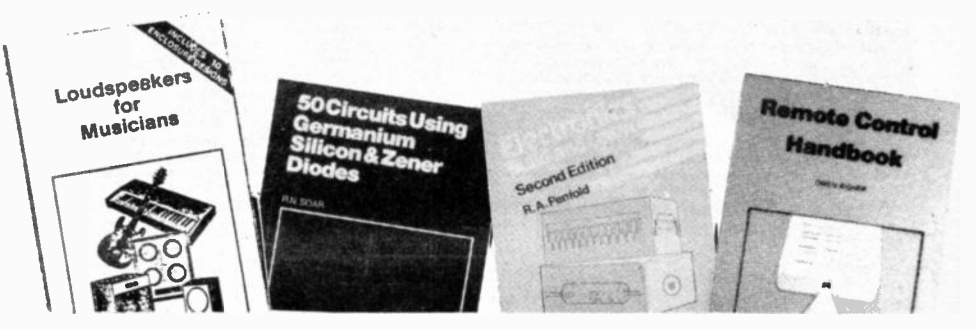

A BEGINNERS GUIDE TO CMOS DIGITAL ICs
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Getting started with logic circuits can be difficult, since many of the fundamental concepts of digital design tend to seem rather abstract, and remote from obviously useful applications. This book covers the basic theory of digital electronics and the use of CMOS integrated circuits, but does not lose sight of the fact that digital electronics has numerous "real world" applications.

The topics covered in this book include: the basic concepts of logic circuits; the functions of gates, inverters and other logic "building blocks"; CMOS logic i.c. characteristics, and their advantages in practical circuit design; oscillators and monostables (timers); flip/flops, binary dividers and binary counters; decade counters and display drivers.

The emphasis is on a practical treatment of the subject, and all the circuits are based on "real" CMOS devices. A number of the circuits demonstrate the use of CMOS logic i.c.s in practical applications.

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R. M. Marston

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The first part of this book covers standard operational amplifier based "building blocks" (integrator, precision rectifier, function generator, amplifiers, etc), and considers the ways in which modern devices can be used to give superior performance in each one. The second part describes a number of practical circuits that exploit modern operational amplifiers, such as high slew-rate, ultra low noise, and low input offset devices. The projects include: Low noise tape preamplifier, low noise RIAA preamplifier, audio power amplifiers, d.c. power controllers, opto-isolator audio link, audio millivolt meter, temperature monitor, low distortion audio signal generator, simple video fader, and many more.

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All the circuits have been designed, built and fully evaluated by the author; all use inexpensive and internationally available devices.

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Waveform generator circuits may be built using transistors, op-amps, standard digital ICs, or dedicated waveform or "function" generator ICs.

The manual is divided into eleven chapters, and presents over 300 practical circuits, diagrams and tables. The subjects covered include: Basic principles; Sine wave generators; Square wave generators; Pulse generator circuits; "Timer IC" generator circuits; Triangle and sawtooth generators; Multi-waveform generation; Waveform synthesizer ICs; Special waveform generators; Phaselocked loop circuits; Miscellaneous "555" circuits.

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AF Generator, Capacitance Meter, Test Bench Amplifier, AF Frequency Meter, Audio Millivoltmeter, Analogue Probe, High Resistance Voltmeter, CMOS Probe, Transistor Tester, TTL Probe.
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AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold
The purpose of this book is to provide the reader with a wide range of preamplifier and power amplifier designs that will, it is hoped, cover most normal requirements.
The preamplifier circuits include low noise microphone and RIAA types, a tape head preamplifier, a guitar preamplifier and various tone controls. The power amplifier designs range from low power battery operation to 100W MOSFET types and also include a 12 volt bridge emplifier capable of giving up to 18W output.
All the circuits are relatively easy to construct using the p.c.b. or stripboard designs given. Where necessary any setting-up procedures are described, but in most cases no setting-up or test gear is required in order to successfully complete the project.
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AUDIO AND MUSIC

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Vivian Capel
This book contains all that a working musician needs to know about loudspeakers; the different types, how they work, the most suitable for different instruments, for cabaret work, and for vocals. It gives tips on constructing cabinets, wiring up, when and where to use wadding, and when not to, what fittings are available, finishing, how to ensure they travel well, how to connect multi-speaker arrays and much more.
Ten practical enclosure designs with plans and comments are given in the last chapter, but by the time you've read that far you should be able to design your own!
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Clive Brooks
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INTRODUCTION TO DIGITAL AUDIO
(Second Edition)
Ian Sinclair
Digital recording methods have existed for many years and have become familiar to the professional recording engineer, but the compact disc (CD) was the first device to bring digital audio methods into the home. The next step is the appearance of digital audio tape (DAT) equipment.
All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.
This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product.
128 pages Order code PC102 £7.95

MIDI SURVIVAL GUIDE
Vic Lennard
Whether you're a beginner or a seasoned pro, the MIDI Survival Guide shows you the way. No maths, no MIDI theory, just practical advice on starting up, setting up and ending up with a working MIDI system.
Over 40 cabling diagrams. Connect synths, sound modules, sequencers, drum machines and multitracks. How to budget and buy secondhand. Using switch, thru and merger boxes. Transfer songs between different sequencers. Get the best out of General MIDI. Understand MIDI implementation charts. No MIDI theory
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Analysis of the sound wave and an explanation of acoustical quantities prepare the way. These are followed by a study of the mechanism of hearing and examination of the various sounds we hear. A look at room acoustics with a subsequent chapter on microphones and loudspeakers then sets the scene for the main chapter on audio systems – amplifiers, oscillators, disc and magnetic recording and electronic music.
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DATA

PRACTICAL ELECTRONIC DESIGN DATA
Owen Bishop
This book is a comprehensive ready-reference manual for electronics enthusiasts of all levels, be they hobbyists, students or professionals. A helpful major section covers the main kinds of component, including surface-mounted devices. Foe each sort, it lists the most useful and readily available types, complete with details of their electronic characteristics, pin-outs and other essential information. A special feature of this section are the easily followed charts and tables which advise the reader on how to select the best type of component for any particular puspose.
Basic electronic units are defined, backed up by a compendium of the most often required formulae, fully explained. There are five more extensive sections devoted to circuit design, covering analogue, digital, radio, display, and power supply circuits. Over 150 practical circit diagrams cover a broad range of functions. The reader is shown how to adapt these basic designs to a variety of applications. Many of the circuit descriptions include step-by-step instructions for using most of the standard types of integrated circuit such as operational amplifiers, comparators, filters, voltage converters and switched-mode power supply devices, as well as the principal logic circuits.
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A. Michaels
Helps the reader to find possible substitutes for a popular selection of European, American and Japanese transistors. Also shows material type, polarity, manufacturer and use.
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RADIO/TV

SETTING UP AN AMATEUR RADIO STATION
I. D. Poole
The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.
Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.
An essential addition to the library of all those taking their first steps in amateur radio
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H. C. Wright
Although nearly a century has passed since Marconi's first demonstration of radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour.
The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc. These materials are, in general, cheap to obtain and easily worked with simple tools, encouraging the trial-and-error philosophy which leads to innovation and discovery.
Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.
72 pages Order code BP278 £3.50

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Joe Pritchard G1UQW
Part One covers the "science" side of the subject, going from a few simple electrical "first principles", through a brief treatment of radio transmission methods to simple receivers. The emphasis is on practical receiver designs and how to build and modify them, with several circuits in the book.
Part Two covers the use of sets, what can be heard, the various bands, propagation, identification of stations, sources of information, QSLing of stations and listening to amateurs. Some computer techniques, such as computer morse decoding and radio teletype decoding are also covered.
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FOX REPORT

by Barry Fox

Secure – Sure?

A little knowledge can be a dangerous thing. But so can too much specialist knowledge. Sometimes it pays to know a bit about a lot of things. Stray facts are more likely to fit together.

National Westminster Bank told me it has "high confidence" in the security of its new electronic alternative to cash, the Mondex card. NatWest has been working on Mondex for nearly four years, hopes to make it a global standard and already has the backing of the Midland Bank and British Telecom.

In its basic form Mondex will be no more secure than cash. It relies on a conventional smart card, made to ISO standard 7816, with inbuilt memory chip and computer processor which store cash credits, and external contacts to connect with a card reader. Anyone can use the card to make a purchase from any shop which has a reader at the till. The user's only security is to use an electronic wallet to lock, and unlock, the card's memory with a Personal Identification Number. Many users will still be their own worst enemy and write their secret PIN number on the card.

The conceptual breakthrough claimed by NatWest is in the method of proofing the card against counterfeiting, so that criminals cannot make copies of cards or tamper with the memory and credit transfer signals, to create money from thin air. Tim Jones, NatWest's Head of Information Technology Policy and Strategy, says Mondex is "extraordinarily secure". But court actions brought recently by satellite broadcaster BSkyB reveal that smart cards can be a lot less secure than those who rely on them previously thought.

Credits are loaded into the Mondex card memory or sucked out to make payments, when the card is slotted into a reader. Shops will have readers so that customers can pay for purchases with their cards. British Telecom will provide payphones with readers.

Both National Westminster and Midland Bank will provide hole-in-the-wall readers which let cardholders refresh cards by loading credits into the memory, while debiting their accounts. NatWest, Midland and BT plan to start a service in 1995. BT is already designing a domestic "smart" telephone which will let cardholders refresh them from home by calling their bank.

NatWest knows that Mondex is an open invitation to criminals who will try to print money by copying cards or pirating the signals which transfer cash from one memory to another.

Says the ubiquitous PR spokesman for NatWest "Yes we are definitely confident on security. We realise that Mondex will be targeted by criminals. There are many levels of protection against counterfeiting".

Tim Jones, is more guarded. He explains that the system checks the integrity of the money signal passing from "purse" to "purse", or source and destination, to ensure that a cardholder does not tamper with the digits and so make a transfer of £10 register as £1000. Mondex also checks that each signal only registers once, to stop the same £10 transfer notching up five times to become £50. The system continually checks the validity of each purse, to ensure that the owner of one card cannot suck money from someone else's account.

Card Clones

All the time I keep thinking about satellite broadcaster BSkyB. Four years ago Sky was equally confident in security when it began using the VideoCrypt scrambling system developed by French electronics company Thomson Consumer Electronics, and News Datacom, a subsidiary of Rupert Murdoch's News International. VideoCrypt relies on a decoder which is activated by a smart card which stores secret codes. And Thomson was fully confident in Videocrypt's strength, too.

For three years the VideoCrypt system remained largely secure against piracy. But over the last year computer hackers have found a way of copying or cloning cards, by taking the secret code from one legitimate card and loading it into many blank cards. So one subscription buys viewing for many others.

Pirate cards sell for £200. The pirates have also successfully cloned the smart cards for another, supposedly equally secure, scrambling system called Eurocrypt which is used by Swedish satellite station TV1000.

Although the satellite industry has long known about cloning, the broadcasters have kept silent, for fear of publicising the availability of pirate cards. So did the press.

BSkyB tries to invalidate pirate cards by transmitting blocking signals with the programmes, but still has to issue every legitimate subscriber with a new card twice a year.

In late October 1993 BSkyB finally went public, branding card pirates as "common thieves" and pledging to pursue them in both civil and criminal actions. The broadcaster has now won injunctions against Hi-Tech Innovation of Camberley, Surrey, Satellite Communications of Chorley, Lancashire and card production company RSD of Stirling in Scotland. BSkyB has also sued Satellite Decoder Systems of Warrington, Cheshire, and another supplier in Camberley.

In November, in a separate move, lawyers for TV1000 won a preliminary injunction against Hi-Tech, banning the sale of pirate smart cards for viewing the Swedish station.

Find the right person inside the Rupert Murdoch empire (which owns both Sky and News Datacom, a small company in Israel that worked with Thomson on the encryption) and they will admit that VideoCrypt has been compromised and the future lies in new encryption systems for all-digital TV.

Pirates who have found out how to crack the satellite systems with viewing cards will find it much more rewarding if they can now turn their talent to making cards which function as hard cash.

Talking Camera

"Daft", I thought when I first saw Polaroid's new single-use 35mm talking camera ("Sidekick") at the Winter *Consumer Electronics Show* in Las Vegas. "Try one" said the demonstrator. Back home in Britain I have been trying it out on people ever since. And it works.

Although Polaroid made its name selling instant picture cameras and film, Sidekick uses conventional snapshot film, pre-loaded into a camera which the processing laboratory breaks open and recycles. What makes Sidekick special is a little box, alongside the lens. This contains a speech synthesis chip, pre-programmed memory, amplifier and loudspeaker, all powered by a button cell. Before pressing the camera shutter release the snapshooter presses a similar control for the speech chip. This starts the camera talking, in a silly voice.

There are four different cameras, each with two messages, like "Smile, say cheese", "C'mon, look happy" and "It'll be over in a flash".

At worst, anyone hearing the camera's voice smiles. At best they collapse into laughter, just as the snapshooter presses the picture button.

Sidekick will cost around $14. Polaroid keeps the cost low by recycling the speech units intact, but with fresh button cells. But I confess that I shall strip out the talking section and stick to the side of my 35mm SLR.

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REPORTING AMATEUR RADIO

Tony Smith G4FAI

OPERATION MAQUIS 1994

Associated with the 50th anniversary of D-Day this year there will be a special event by French radio amateurs to commemorate the clandestine radio links between France and Britain during WW2.

Agents of the Resistance were in contact with control stations here throughout the occupation. Miniaturised radio equipment was used, often carried in suitcases or disguised in some other way to avoid detection. Many agents were caught and died, and it is to honour the memory of these incredibly brave men and women that a number of special French stations will be on the air during the weekend 11-12th June 1994.

They will be using low power war-time equipment, for example the famous "B2" suitcase set designed by the late John Brown, G3EUR. This equipment will be operated on the 40 metre band, while modern equipment will be used on other bands. There will be special QSL cards, and possibly a certificate, for those contacting the commemorative stations.

An invitation has been made to UK amateurs suggesting they also set up special stations, using either wartime or modern equipment, to contact the French stations. All operation will be in CW (Morse), the mode principally used for clandestine operations.

If any radio amateur readers of this column haven't yet heard about *"Operation Maquis"*, there is still time for them, or their local clubs, to take part in this special commemoration. For further details, write to: ***Jean-Jacques Legrand F5SMR, 11 chemin de Bonneau, Le Mesnil, 45110 Germigny Des Pres, France.***

Coincidentally, in the April issue of Morsum Magnificat, the Morse magazine, there is an article by Pat Hawker, G3VA, describing his experiences at the Liberation of Paris, and some of the clandestine operations in France prior to that. Copies of this issue (MM33) can be obtained from *G. C. Arnold Partners, Ref EPE, 9 Wetherby Close, Broadstone, Dorset, BH18 8JB,* price £2.20.

RADIO BY SUITCASE

The spy suitcase sets are probably better known today than they were in the war. They have featured in a number of films and TV series, illustrating their use in clandestine operations. There were several different types but the one usually referred to today is the Type III MkII, popularly known as the B2.

After the war a number of these sets were made available to radio amateurs who found they could be readily used for CW on the 80m, 40m and 20m amateur bands without modification. At the same time, articles appeared in the amateur press explaining how the transmitter could be modified for other types of modulation.

Over the years most have disappeared but a number still exist and are operated regularly by individual amateur stations. There also feature in demonstration stations run by museums or other organisations concerned with some aspect of wartime activity.

In Norway, the Norsk Radiohistorik Forening (Norwegian Radio Historical Association) has an annual field-day commemorating WW2 resistance activities, with a B2 set as its main station. In Denmark, the Museum of Danish Resistance has an amateur station, OZ5MAY, commemorating the Danish liberation date of 5th May 1945.

This operates around noon most weekdays and some weekends, on 20m. It uses WW2 equipment and particularly welcomes calls from those using B2 sets.

Although once readily available on the surplus market, the B2 is a collector's item today. The wonderful thing about it, though, is that if the collector is also a radio amateur it can still be used.

Sitting in a darkened shack at night, tapping out messages on the miniature B2 key (made by Multitone for the whole series of SOE W/T sets designed by John Brown), it is possible to imagine at least something of the atmosphere and tension experienced by their original operators when these sets were on "active service".

SAREX MOSCOW CONTACT

The Space Shuttle *Discovery*, STS-60, launched on February 3rd, was the first US-Russian shuttle flight, and included cosmonaut Sergei Krikalev, U5MIR, as one of the six crew members. Of the remaining American crew, two members were also licensed radio amateurs, namely Commander Charlie Bolden KE4IQB, and Mission Specialist Ron Sega KC5ETH.

As usual, the secondary payload was SAREX, the Shuttle Amateur Radio Experiment, and five school groups, four in America and one in Russia, were scheduled for contacts with the shuttle via amateur radio.

Of great interest this time was the contact with the House of Science and Technology for Youth in Moscow, Russia. At 10·42 UTC on February 6th, Sergei Krikalev spoke directly to the school and answered students' questions about the shuttle.

This was the first time a cosmonaut on a US space shuttle had communicated with Russian citizens, and the contact was broadcast live throughout Russia on the amateur HF bands (80, 40 and 20 metres) as well as on VHF. *(W5YI Report).*

RADIO STATIONS IN THE UK

The 1994 edition of *Radio Stations in the United Kingdom* has recently been published by the British DX Club. Following the successful format of previous years, it also has several new features, including FAX numbers, RDS (Radio Data Service) IDs and a full list of Irish radio stations.

Completely revised and updated, it includes the latest available information on frequency changes, plus all the new stations that have opened in the last year. All AM and FM stations in the UK are listed in frequency order, with power of transmitter, location of station and parallel frequencies.

A separate section gives the address, telephone and FAX number of each station, cross-referenced with the frequency list. There is a summary of the various BBC and Radio Authority services and their future plans; information about Restricted Service Licences (special event stations); and advice on how to send reception reports to local radio stations heard from a distance.

This useful booklet (38 pages x A5) costs £2.50 UK, or 6 x IRCs (or 4 US dollar bills) overseas, including postage, and can be obtained from the *British Dx Club, Ref EPE, 54 Birkhall Road, Catford, London SE6 1TE.* Cheques payable to "British DX Club".

Changes to entries in the booklet are included in the BDXC's monthly bulletin *Communication.* A sample copy of this publication and further information about BDXC, can be obtained by sending two first class stamps (UK) or 2 x IRCs (overseas) to the above address.

EMERGENCY OPERATIONS

Two natural disasters in particular have hit the headlines recently and in both cases amateur radio emergency organisations have assisted where official communications systems were put out of action or were unable to cope with the extra demands made on them.

During the Los Angeles earthquake, according to the *W5YI Report*, they provided communications for Salvation Army and Red Cross emergency workers. An amateur repeater in Southern California handled most of the Red Cross health and welfare traffic, and amateur operators were stationed at a number of Red Cross shelters.

Southern California amateurs also handled hundreds of incoming health and welfare calls because they could dial within the local area when callers outside California could not get through.

In Australia, WICEN (Wireless Institute Civil Emergency Network), helped provide communications for firefighters in the NSW bush fires and I hope to report on this operation later.

In many parts of the world, radio amateurs prepare and train regularly to help whenever such emergencies arise and there is a need for supplementary communications. This includes the UK of course although, thankfully, the emergency situations here are seldom on such a large scale as in the USA or Australia.

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