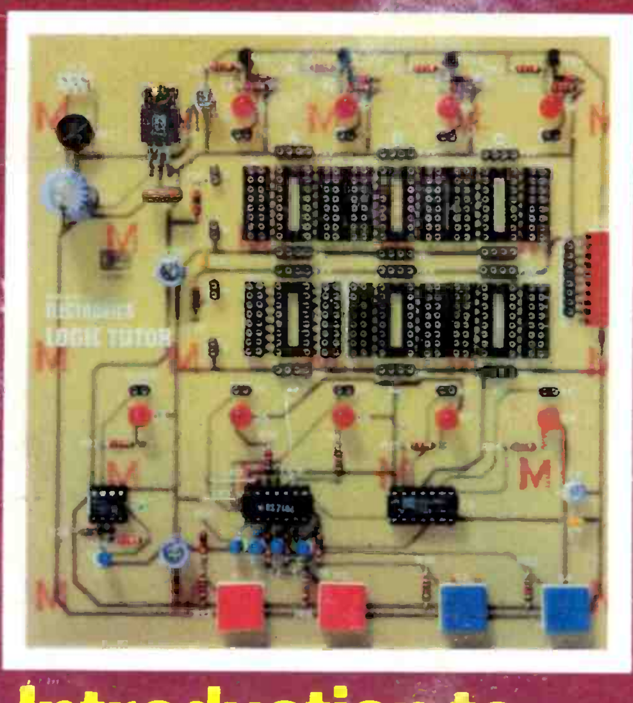
Australia $1.50 New Zealand $1.60 Malaysia $4.95 IR £1.30 (inc. VAT)

PRACTICAL ELECTRONICS

OCTOBER 1983

90p

EXPANDING the VIC 20



ELECTRONICS in PHOTOGRAPHY

Introduction to DIGITAL ELECTRONICS

O & A LEVEL Part One

RELAXOMETER

4½ DIGIT PANEL METER

PRACTICAL

ELECTRONICS

VOLUME 19 No. 10 OCTOBER 1983

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL SUPPLEMENT

OUR NOVEMBER ISSUE WILL BE ON SALE FRIDAY, OCTOBER 7th, 1983
(for details of contents see page 11/6 Micro-file)

SPEAKERS

8Ω, 0·3W, 2"; 2·25", 2·5", 3"	80p
0·3W, 2·5" 40Ω; 64Ω or 80Ω	80p

DIODES

AA119	15
AA129	20
AAY30	15
BA100	15
BAX13	20
BY100	24
BY126	12
BY127	12
CRO33	250
OA9	40
OA47	12
OA70	12
OA79	15
OA81	20
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	15
1N5404	16
1N5406	17
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

BRIDGE RECTIFIERS
(plastic case)

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	56
VM18	50

ZENERS
Range: 2V7 to 39V 400mW **8p each**
Range: 3V3 to 33V 1·3W **15p each**

VARICAPS

MVAM2	166
BA102	30
BB105B	40
BB106	40

TRIACS

3A/100V	48
3A/400V	56
3A/800V	85
8A/100V	60
8A/400V	69
8A/800V	115
12A/100V	78
12A/400V	82
12A/800V	135
16A/100V	103
16A/400V	105
16A/800V	220
25A/400V	185
25A/800V	295
25A/1000V	480
30A/400V	525
T2800D	120

SCR's Thyristors

0·8A-100V	32
5A/300V	38
5A/400V	40
5A/600V	48
8A/300V	60
8A/600V	95
12A/100V	78
12A/400V	95
12A/800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5064	38
2N4444	130

SOLDERCON PINS

100	75p
500	370p

DIAC
ST2 25

VERO WIRING PEN and Spool 350p
Spare Wire (Spool) **75p**; Combs **6p** ea.
Wire Wrapping Stakes 100 250p

OPTO

LEDS Including Clips	
TIL209 Red 3mm	10
TIL211 Green 3mm	14
TIL212 Yellow	14
TIL220 ·2" Red	12
0·2" Yel, Grn, Amber	14
Rectangular LEDs with two part clip. R, G & Y	29
Rectangl. Stackable LEDS	18
Triangular LEDs R&G	18
0·2" Flashing LED Red	56
0·2" Bi colour LEDs Red/Green	65
Green/Yellow	80
0·2" Tri colour LEDs Red/Green/Yellow	85
0·2" Red High Bright	59
High Bright Green or Yellow	65
LD271 Infra Red (emit)	46
TIL32 Infra Red (emit)	52
SFH205 (detector)	118
TIL78 (detector)	54
TIL38	45
TIL81 82; TIL100	90

7 Segment Displays

TIL321 ·5" C.An	115
TIL322 ·5" C.th	115
DL704 ·3" C.Cth	99
DL707 ·3" C.Anod	99
FND357 or 500	120
·3" Green C.A.	140
±1 ·3" Red or Green	150
Bargraph 10 seg. Red	225
Bargraph NSM3914	500

0·5" LIQUID CRYSTAL DISPLAYS

3½ digit	495
4 digit	530
6 digit	625

BPX25	195
BPW21	295
BPX65	270
IL74	45
ILD74	99
ILQ74	185
ILCT6 Darlington Isolator	135
TIL111	65
OCP71	120
ORP12	78
2N5777	45
4N33	135
Pin diode	610

OPTO SWITCH
Reflective TIL139 170
Slotted similar to RS 186

FERRIC CHLORIDE
Crystals 1lb
195p + 50p p&p

DALO ETCH RESIST
Pen plus spare tip 100p

ALUM.BOXES

4×2¾×2"	85
4×2¾×2½"	103
4×4×2½"	120
5×4×2"	105
5×2½×1½"	90
5×2½×2½"	130
5×4×1½"	99
5×4×2½"	120
6×4×2"	120
6×4×3"	150
7×5×3"	180
8×6×3"	210
10×4½×3"	240
10×7×3"	275
12×5×3"	260
12×8×3"	295

COPPER CLAD BOARDS

Fibre Glass	Single-sided	Double-sided	SRBP 9·5"×8·5"
6"×6"	100p	125p	110p
6"×12"	175p	225p	

VEROBOARDS 0·1"

	Clad	Plain
2½×3¾"	85p	—
2½×5"	100p	—
3¾×3¾"	100p	—
3¾×5"	115p	95p
3¾×17"	390p	275p
4¾×18"	495p	—
Pkt. of 100 pins	55p	
Spot Face Cutter	150p	
Pin Insertion Tool	185p	

'VQ' Board	180
'DIP' Board	374
Vero Strip	144

PROTO-DECs

Veroblock	405
S-Dec	350
Eurobreadboard	520
Bimboard 1	695
Superstrip SS2	£13

VOLTAGE REGULATORS

1A T0220 Plastic Casing

	+ve		−ve	
5V	7805	40p	7905	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p		

100mA T092 Plastic Casing

5V	78L05	30p	79L05	60p
6V	78L62	30p		—
8V	78L82	30p		—
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

ICL7660	248	LM317K	320
78H05 5V/5A	550	LM317P	99
78H12 12V/5A	580	LM323K	500
78HG+5 to		LM337T	175
+24V 5A	599	LM723	35
79HG −2.25V to		TBA625B	75
−24V 5A	685	RC4194	375
LM309K	120	RC4195	160

SWITCHES

SLIDE 250V

1A DPDT	14
1A DPDT C/OFF	15
½A DP on/on/on	40

PUSH BUTTON
Spring loaded
Latching or Momentary 6A

SPDT c/over	99
DPDT c/over	145

MINIATURE
Non Locking

Push to make	15p
Push break	25p

TOGGLE 2A 250V

SPST	33
DPDT	44
4 pole on off	54

SUB-MIN TOGGLE 2 amp

SP changeover	60
SPST on off	54
SPDT c/off	85
SPDT Biased	105
DPDT 6 tags	75
DPDT C/OFF	88
DPDT on/on/on	185
DPDT Biased	145
3 pole c/over	205

ROTARY: (Adjustable Stop Type)
1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way 45p

ROTARY: Mains 250V AC, 4 Amp 64p

DIL SWITCHES: (SPST) 4 way **65p**; 6 way **80p**; 8 way **87p**; 10 way **100p**; (SPDT) 4 way **190p**.

AMPHENOL PLUG

	IDC	Solder
24 way IEEE	475p	450p
36 way Centronics	525p	485p

ASTEC UHF MODULATORS

6MHz Standard	325p
8MHz Wideband	450p

DIL SOCKETS

	Low profile	Wire wrap
8 pin	8p	25p
14 pin	10p	35p
16 pin	10p	42p
18 pin	16p	52p
20 pin	20p	60p
22 pin	22p	65p
24 pin	25p	70p
28 pin	28p	80p
40 pin	30p	99p

ZIF DIL SOCKET

24 way	575p
28 way	750p
40 way	975p

DIL PLUGS (Headers)

Pins	Solder	IDC
14	38p	95p
16	42p	100p
24	88p	138p
28		140p
40	195p	218p

RIBBON CABLE
(price per foot)

Ways	Grey	Colour
10	15p	28p
16	25p	40p
20	30p	50p
26	40p	65p
34	60p	85p
40	70p	90p
64	100p	135p

'D' CONNECTORS:

Pins	9 way	15 way	25 way	37 way
MALE				
Solder	80p	110p	160p	240p
Angle	150p	210p	250p	355p
Strait	170p	160p	220p	310p
FEMALE				
Solder	105p	160p	200p	338p
Angle	165p	215p	290p	440p
Strait	175p	200p	300p	420p
COVERS	80p	75p	75p	90p

IDC 25 way Plg. **385p**, Skt **450p**

SIL Sockets
0.1"
20 way **65p**
32 way **95p**

EDGE CONNECTORS

	1"
2×18 way	180p
2×22 way	199p
2×23 way	170p
2×25 way	225p
2×28 way	210p
2×30 way	245p
2×36 way	295p
2×40 way	315p
2×43 way	395p
2×75 way	550p

25 WAY 'D' CONNECTORS (RS232)

Jumper lead Ribbon Cable

18" Single End Male	475p
18" Single End Female	510p
36" Double Ended M/M	995p
36" Double Ended F/F	£10
36" Double Ended M/F	£10

IDC CONNECTORS (Speed block type)

2 rows	PCB Male with latch Strt. Pins	PCB Male with latch Angle Pins	Female Header Socket	Female Card-Edge Connector
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	195p
20 way	145p	166p	125p	240p
26 way	175p	200p	150p	320p
34 way	205p	236p	169p	340p
40 way	220p	250p	190p	420p
50 way	235p	270p	200p	470p

EURO CONNECTORS
Gold flashed contacts

	FEMALE SOCKETS Strt.	FEMALE SOCKETS Angle	MALE PLUGS Strt	MALE PLUGS Angle
DIN 41617 31 way	170p	—	—	175p
DIN 41612 2×32 way	275p	320p	220p	285p
DIN 41612 2-3×32 way	295p	340p	240p	300p
DIN 41612 3×32 way	360p	385p	260p	395p

TRANSFORMERS (mains Prim. 220-240V)
3-0-3V, 6-0-6V 100mA; 9-0-9V 75mA; 12-0-12V 75mA; 15-0-15V 75mA **98p**
6VA: 2x6V-·5A; 2x9V-·4A; 2x12V-0·3A; 2x15V-·25A **220p**
12VA: 2x4V5-1·3A; 2x6V-1·2A; 2x12V-·5A; 2x15V-·4A **295p** (35p p&p)
24VA: 6V-1·5A 6V-1·5A; 9V-1·2A 9V-1·2A; 12V-1A 12V-1A; 15-·8A 15-·8A; 20V-·6A 20V-·6A **330p** (60p p&p)
50VA: 2×6V-4A; 2×9V-2·5A; 2×12V-2A; 2×15V-1·5A; 2×20V-1·2A; 2×25V-2A; 2×30V-0·8A **465p** (60p p&p)
100VA: 2×12V-4A; 2×15V-3A; 2×20V-2·5A; 2×30V-1·5A; 2×40V-1·25A; 2×50V-1A **920p** (60p p&p)

JUMPER LEADS Ribbon Cable Assembly
DIL Plug (Headers)
Single Ended Lead, 24" long

Length	14pin	16pin	24 pin	40 pin
24"	145p	165p	240p	325p
Double Ended Leads				
6"	185p	205p	300p	465p
12"	198p	215p	315p	490p
24"	210p	235p	345p	540p
36"	230p	250p	375p	595p

IDC FEMALE RECEPTACLE Jumper Leads 36"

	20pin	26pin	34pin	40pin
1 end	160p	200p	260p	300p
2 ends	290p	370p	480p	525p

COMPUTER CORNER

- **SEIKOSHA GP100A** – Unihammer Printer, normal & double width characters, dot resolution graphics 10" Tractor feed, parallel interface standard. **FREE 500 Sheets** **£175**
- **SEIKOSHA GP 250X** Printer **£230**
- **SEIKOSHA GP-700** The 7 colour graphic printer at the price of a standard Dot matrix printer. A unique 4 hammer method enables text & high res graphics to be drawn in 7 basic colours or 30 shades. 7 × 8 matrix. Up to 106 char. per line at 50 CPS. Variable line spacing to 1/120". Tractor or Friction feed. Centronix interface standard. **£399**
- **SOFTY – 2.** The complete Microprocessor development system. Accepts any 24 pin 5V EPROM. **£169**
- **ZENITH 12" Hi-RES,** Green Monitor 40/80 column select switch, value for money. **£75**
- **MICROVITEC 14"** colour monitor. RGB input. Lead incl. **£249**
- **TEX EPROM ERASER.** Erases up to 32 ICs in 15-30 min. **£33**
- **TEX EPROM ERASER** with the Solid-State 30 minute Electronic Timer. **£43**
- **SOLID STATE** 30 minute Electronic **TIMER** for above UV Erasors **£14**
- **Spare** 'UV lamp bulbs **£9**
- **POWER SUPPLY** Regulated, Variable from +5V to +15V. 4A. Fully Cased **£39**
- **MULTIRAIL PSU KIT.** Output: +5V/5A; +12V; +25V; −5V; −12V @ 1A. **£40**
- **4 × 4 matrix keypad** (reed switch assembly) **£4**
- **C12 COMPUTER Grade BASF Cassettes** in Library Cases **40p**
- **8½" & 9½" Fan fold paper** (1000 sheets) **£7** **(150p)**
- **Teleprinter Roll** (no VAT) **£3.50**

(P&P on some of the above items is extra)
Call in at our shop for demonstration of any of the above items. Be satisfied before you buy.

NEW BROTHER 8300 DAISEY WHEEL PRINTER/ TYPEWRITER

Provides very high quality type in any six interchangeable styles including Italics, Script and 4 conventional typefaces. Ideal for business use. Connects directly to a BBC Micro via standard centronics interface or can be used as a stand alone typewriter. As typewriter, has a built in timing function to measure the operator's speed making it ideal for teaching or invoicing jobs correctly. Friction feed; 11 CPS; 12" max width; 5 different colour ribbons. Hard top cover/carrying case. **Only: £399.**

- **EPSON FX80 10"** 160cps, Tractor/Friction, Bi-directional, logic seeking, 9 × 11 matrix, Hi-res bit image, normal, italic & elite char. Super & subscript. Proportional spacing. Underlining. **£388** (£7 carr.)

ANTEX Soldering Irons

C15W	495
G517W	495
G18W	520
XS25W	525
Spare bits	85
Elements	225
Iron stands	175
Heat Shunt	30

Access
Just phone your order through, we do the rest. 0923-50234

CRYSTALS

32·768KHz	100
100KHz	235
200KHz	268
455KHz	370
1MHz	275
1·008M	275
1·28MHz	392
1·5MHz	420
1·6MHz	395
1·8MHz	395
1·8432M	200
2·0MHz	225
2·4576M	200
2·5MHz	225
2·56250M	220
3·2768M	150
3·57954M	98
3·6864M	300
4·0MHz	150
4·032MHz	290
4·194304M	200
4·433619M	100
4·608MHz	200
4·80MHz	200
5·0MHz	160
5·185MHz	300
5·24288M	390
6·0MHz	140
6·144MHz	150
6·5536MHz	200
7·0MHz	150
7·168MHz	250
7·68MHz	200
8·0MHz	150
8·08333M	395
8·867237M	175
9·00MHz	200
9·375MHz	350
10·0MHz	175
10·5MHz	250
10·7MHz	150
10·24MHz	200
12·0MHz	175
12·528MHz	300
14·31818M	170
14·7456M	175
14·765MHz	250
15·0MHz	200
16·0MHz	200
18·0MHz	180
18·432M	150
19·968MHz	150
20·0MHz	200
24·0MHz	170
24·930MHz	325
29·695MHz	150
26·670MHz	325
27·125MHz	295
27·145M	190
27·648MHz	300
38·66667M	175
48·0MHz	175
55·5MHz	400
100MHz	295
116·0MHz	300
145·8MHz	225

BBC MICROCOMPUTER

Model A **£299;** Model B **£399** (incl. VAT). We stock the full range of BBC Micro peripherals, Hardware & Software like, Disc Drives (Top quality Cumana & Mitsubishi), Diskettes, Printers, Printer Paper, Interface Cable, Dust Covers, Cassette Recorder & Cassettes, Monitors, Connectors (Ready made Cables, Plugs & Sockets), Plotter (Graphic Tablet) EPROM Programmer, Lightpen Kit, Joysticks, Sideways ROM Board, EPROM Eraser, Machinecode ROM, The highly sophisticated Watford's 16K BEEB DFS, WORDWISE, BEEBCALC, Software (Educational Application & Games), BOOKS, etc. etc. Please send SAE for our descriptive leaflet.

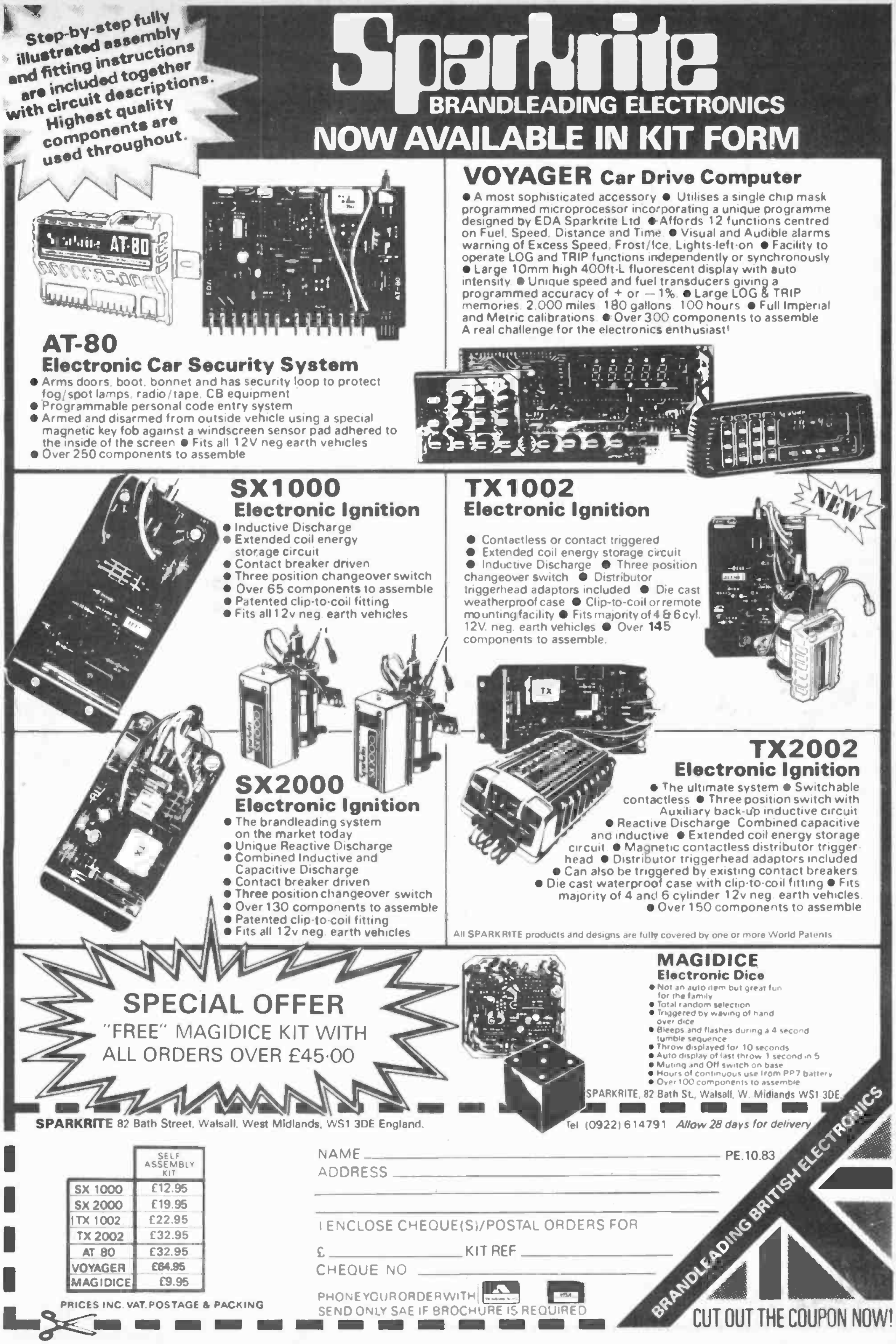
DISC DRIVES FOR BBC MICRO

- **CS50A – TEAC** Cased with own Power Supply, S/S, 40 track, 5¼", 100K **£170**
- **CD50A – TEAC** Twin Cased with own PSU, S/S, 40 track, 5¼", 200K **£330**
- **CS50E – TEAC** Single Cased with own PSU, S/S, 80 track, 5¼", 200K **£250**
- **CD50E – TEAC** Twin Cased with own PSU, S/S, 80 track, 5¼", 400K **£475**
- **SINGLE MITSUBISHI** Slim line – Cased with own PSU, DS/DD, 1 Megabytes (400K with BBC) **£275**
- **TWIN MITSUBISHI** Slim line – Cased with own PSU, DS/DD, 2 Megabytes (800K with BBC) **£535**
- Single Drive Cable for BBC Micro **£8**
- Twin Drive Cable for BBC Micro **£12**

(5 year warranty on VERBATIM Diskettes)
- 10 Verbatim Diskettes, 5¼". S/S **£20**
- 10 Verbatim Diskettes, 5¼", D/S **£30**

(2 year warranty on WABASH Diskettes)
- 10 WABASH Diskettes, 5¼", S/S **£15**
- 10 WABASH Diskettes, 5¼", D/S **£25**

WATFORD ELECTRONICS
Tel. (0923) 40588 **Telex. 8956095**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NOW AVAILABLE IN KIT FORM
AT-80
AT-80
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● Arms doors, boot, bonnet and has security loop to protect fog/spot lamps, radio/tape, CB equipment
● Programmable personal code entry system
● Armed and disarmed from outside vehicle using a special magnetic key fob against a windscreen sensor pad adhered to the inside of the screen ● Fits all 12V neg earth vehicles
● Over 250 components to assemble
VOYAGER Car Drive Computer
● A most sophisticated accessory ● Utilises a single chip mask programmed microprocessor incorporating a unique programme designed by EDA Sparkrite Ltd ● Affords 12 functions centred on Fuel, Speed, Distance and Time ● Visual and Audible alarms warning of Excess Speed, Frost/Ice, Lights-left-on ● Facility to operate LOG and TRIP functions independently or synchronously ● Large 10mm high 400ft-L fluorescent display with auto intensity ● Unique speed and fuel transducers giving a programmed accuracy of + or − 1% ● Large LOG & TRIP memories 2,000 miles 180 gallons 100 hours ● Full Imperial and Metric calibrations ● Over 300 components to assemble
A real challenge for the electronics enthusiast!
SX1000
Electronic Ignition
● Inductive Discharge
● Extended coil energy storage circuit
● Contact breaker driven
● Three position changeover switch
● Over 65 components to assemble
● Patented clip-to-coil fitting
● Fits all 12v neg. earth vehicles
TX1002
Electronic Ignition
● Contactless or contact triggered ● Extended coil energy storage circuit ● Inductive Discharge ● Three position changeover switch ● Distributor triggerhead adaptors included ● Die cast weatherproof case ● Clip-to-coil or remote mounting facility ● Fits majority of 4 & 6 cyl. 12V. neg. earth vehicles ● Over 145 components to assemble.
NEW
TX
SX2000
Electronic Ignition
● The brandleading system on the market today
● Unique Reactive Discharge
● Combined Inductive and Capacitive Discharge
● Contact breaker driven
● Three position changeover switch
● Over 130 components to assemble
● Patented clip-to-coil fitting
● Fits all 12v neg. earth vehicles
TX2002
Electronic Ignition
● The ultimate system ● Switchable contactless ● Three position switch with Auxiliary back-up inductive circuit ● Reactive Discharge Combined capacitive and inductive ● Extended coil energy storage circuit ● Magnetic contactless distributor trigger head ● Distributor triggerhead adaptors included ● Can also be triggered by existing contact breakers ● Die cast waterproof case with clip-to-coil fitting ● Fits majority of 4 and 6 cylinder 12v neg. earth vehicles. ● Over 150 components to assemble
All SPARKRITE products and designs are fully covered by one or more World Patents
SPECIAL OFFER
"FREE" MAGIDICE KIT WITH
ALL ORDERS OVER £45·00
MAGIDICE
Electronic Dice
● Not an auto item but great fun for the family
● Total random selection
● Triggered by waving of hand over dice
● Bleeps and flashes during a 4 second tumble sequence
● Throw displayed for 10 seconds
● Auto display of last throw 1 second in 5
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Twyford ELECTRONICS LTD

Tel:- 0734 340333

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We are situated 200 yards from Twyford BR Station.

Access VISA

ANTEX

Model (C) 15 Watt	4.60
Model (CS) 17 Watt	5.00
Model (X25) 25 Watt	5.20
Spare Bits	.70
Elements	2.10
Iron Stands	1.70

TOOLS & ACCESSORIES

Desoldering pump	6.50
Spare Nozzle	.90
Desolder Braid	.90
PLIERS:	
Fine Tweezer	3.50
Short fine nose	3.50
Long fine nose	3.50
CUTTERS:	
Miniature side	3.50
Serrated scissor	3.50
Angled side	3.50
12v EXPO DRILL	7.00
Hand Vice	4.70
Plastic tweezers	.33
Etch resist pens	.90
HSS TWIST DRILLS	
1/16"	.40
1/8"	.40
1/4"	1.00
5/16"	1.20
1.0mm	.45
1.50mm	.45
1.80mm	.40
2.00mm	.40
Helping Hands vice	5.20

RESISTORS

Carbon Film 5%		
¼ Watt	E24	2p
½ Watt	E12	2p
1 Watt	E12	8p
1% Metal Film	E24	6p

CAPACITORS

ELECTROLYTICS 16 Volts

10uF/22uF/47uF	.10		
100uF	.11	1000uF	.27
220uF	.14	2200uF	.47
470uF	.21		

25 Volt Range

10uF/22uF	.9	1000uF	.45
47uF/100uF	.10	2200uF	.55
220uF	.27	4700uF	1.00
470uF	.31		

63 Volt Range

1uF/2.2uF/4.7uF	.09		
10uF	.10	100uF	.23
22uF	.12	220uF	.36
47uF	.14	470uF	.50

100 Volt Range

10uF	.15	100uF	.40
22uF	.17	150uF	.49
47uF	.36	220uF	.53

METALLISED POLYESTER

0.01/0.015/0.022uF	.07		
0.033/0.047/0.068uF	.08		
0.1uF	.09	0.68uF	.22
0.15uF	.11	1uF	.25
0.22uF	.12	1.5uF	.40
0.33uF	.15	2.2uF	.46
0.47uF	.18		

POLYSTYRENE 160 Volts

10pF-1800pF	.09
2200pF	.10
2700pF	.09
3300pF	.12
3900pF	.11
4700/5600pF	.12
6800/8200pF	.15
10,000pF	.18

SILVER MICA 350 Volts

2.2pF-68pF	.15
82pF-180pF	.18
220pF	.20
270pF-560pF	.26
680pF-820pF	.30
1000pF-1500pF	.35
1800pF	.36
2200pF	.55
3600pF	.60
4700pF	.70

PLATE CERAMIC

2.2pF-47pF	.06
68pF	.08
100pF	.10
150pF-220pF	.14

TANTALUM BEAD

0.1/35v	.15	10/16v	.18
0.22/35v	.15	10/25v	.26
0.33/35v	.15	22/6.3v	.42
0.47/35v	.16	22/25v	.50
1/35v	.16	33/6.3v	.42
2.2/25v	.16	33/25v	.50
3.3/25v	.18	47/6.3v	.50
4.7/16v	.18	47/10v	.48
4.7/35v	.22	100/3v	.50
6.8/16v	.18	100/10v	.55
6.8/35v	.22		

TRANSISTORS

BC107	.10	BC559C	.17
BC107A	.12	BC560	.32
BC107B	.12	BC560B	.16
BC108A	.12	BCY70	.16
BC108B	.12	BCY71	.16
BC108C	.12	BCY72	.16
BC109	.10	BD131	.44
BC109B	.12	BD132	.44
BC109C	.12	BD135	.40
BC140	.30	BD136	.40
BC141	.30	BD137	.42
BC142	.30	BD138	.40
BC154	.27	BD139	.40
BC160	.45	BD140	.40
BC161	.45	BD239	.57
BC167	.10	BD241	.60
BC167A	.10	BF177	.25
BC167B	.10	BF178	.30
BC168	.10	BF240	.38
BC168B	.10	BF244A	.35
BC169	.10	BF244B	.39
BC169B	.10	BF244C	.40
BC169C	.10	BF245A	.30
BC170	.15	BF245B	.51
BC170B	.15	BF245C	.55
BC170C	.15	BF247A	.54
BC171A	.11	BF247B	.55
BC171B	.11	BF256B	.48
BC172	.11	BF256C	.62
BC172A	.11	BF257	.30
BC172B	.11	BF336	.40
BC172C	.11	BFR39	.25
BC173	.11	BFR40	.25
BC173B	.11	BFR41	.25
BC178	.16	BFR80	.25
BC178A	.16	BFR81	.25
BC179	.20	BFX29	.26
BC179A	.20	BFX30	.27
BC179B	.20	BFX86	.28
BC179C	.20	BFX87	.30
BC182	.10	BFX88	.30
BC182B	.10	BFY50	.23
BC182L	.10	BFY51	.23
BC182LA	.10	BFY52	.23
BC182LB	.10	BFY53	.32
BC183	.10	BU105	1.70
BC183C	.10	BU108	2.95
BC183L	.10	BU205	1.75
BC183LA	.10	BU208	1.98
BC183LB	.10	MPSA05	.23
BC184	.10	MPSA06	.25
BC184B	.10	MPSA12	.29
BC184C	.10	MPSA13	.48
BC184L	.10	MPSA14	.46
BC187	.26	MPSA43	.49
BC207	.26	MPSA55	.28
BC208	.26	MPSA56	.30
BC212	.10	MPSA66	.47
BC212A	.10	MPSA70	.45
BC212B	.10	MPSA92	.39
BC212LA	.10	MPSA93	.39
BC212LB	.10	TIP29A	.32
BC213	.10	TIP30A	.35
BC213B	.10	TIP31	.38
BC213C	.10	TIP31A	.38
BC213LB	.10	TIP32B	.38
BC213LC	.10	TIP32C	.42
BC214	.10	TIP34A	.74
BC214B	.10	TIP35A	1.09
BC214C	.10	TIP36A	1.30
BC214L	.10	TIS43	40
BC214LC	.10	TIS88A	62
BC237	.14	2N697	23
BC237A	.14	2N930	35
BC237B	.14	2N1893	30
BC238	.14	2N2102	39
BC238A	.14	2N2218	33
BC238B	.14	2N2218A	25
BC239	.14	2N2219	27
BC239B	.14	2N2219A	28
BC239C	.14	2N2220	22
BC300	.45	2N2221	22
BC301	.44	2N2221A	23
BC302	.43	2N2222	24
BC303	.47	2N2904	26
BC307	.14	2N2904A	28
BC308	.16	2N2905	28
BC327	.16	2N2905A	28
BC328	.14	2N2906	25
BC337	.15	2N2906A	30
BC338	.15	2N2907	25
BC440	.32	2N2907A	26
BC460	.32	2N2925	15
BC461	.33	2N2926	10
BC516	.40	2N3053	27
BC517	.40	2N3055	55
BC547	.13	2N3109	45
BC547A	.14	2N3702	10
BC547B	.14	2N3703	10
BC548	.12	2N3704	10
BC548A	.13	2N3705	10
BC548B	.13	2N3706	10
BC548C	.13	2N3707	10
BC549	.13	2N3708	10
BC549B	.13	2N3709	10
BC550	.14	2N3710	10
BC557	.15	2N3711	10
BC557A	.16	2N3819	25
BC557B	.16	2N3903	15
BC558	.14	2N3904	15
BC558B	.16	2N3905	15
BC559	.15	2N3906	15
BC559B	.15	2N4036	58
		2N4037	43

2N4440	.15
2N4401	.15
2N4402	.30
2N4403	.30
2N5086	.15
2N5087	.39
2N5088	.37
2N5089	.37
2N5401	.35
2N5447	.18
2N5448	.20
2N5457	.29
2N5458	.29
2N5459	.29
2N6126	.71
2N6130	.93

DIODES

BY126	.12
BY127	.12
IN914	.04
IN916	.05
IN4001	.05
IN4002	.05
IN4003	.06
IN4004	.06
IN4005	.06
IN4006	.07
IN4007	.07
IN4148	.04
IN5400	.15
IN5401	.15
IN5402	.20
IN5403	.16
IN5404	.16
IN5405	.17
IN5406	.17
IN5407	.18
IN5408	.19

ZENER DIODES

BZX61C 1.3W 4.7-75v	.16
BZY88C 400mW 2.7v-30v	.10

VOLTAGE REGULATORS

ML7805	.40
ML7805A	.40
ML7812	.40
ML7812A	.40
ML7815	.40
ML7815A	.40
ML7818	.40
ML7818A	.40
ML78L05	.26
ML78L05A	.26
ML78L12	.26
ML78L12A	.26
ML78L15	.26
ML78L15A	.26

BRIDGE RECTIFIERS

W0-01	.20
W0-02	.28
W0-04	.28
W0-06	.35
W0-08	.40

TRIACS

3A/200v	.58
3A/400v	.58
8A/400v	.75
12A/200v	.85
12A/400v	.90
15A/400v	.90

THYRISTORS

4A/50v	.50
4A/400v	.60
4A/600v	.70
8A/100v	.85
8A/600v	.85
12A/100v	1.20
12A/400v	1.35
12A/800v	1.95
C106	.45
2N5064	.45
2N4444	1.40

DIAC

ST2	.28

TTL74

7400	.11	7412	.18
7401	.11	7413	.18
7402	.11	7414	.24
7403	.12	7416	.20
7404	.13	7417	.20
7405	.15	7420	.15
7406	.20	7421	.20
7407	.20	7422	.20
7408	.14	7423	.20
7409	.14	7425	.20
7410	.14	7426	.18
7411	.16	7427	.15
		7428	.26
		7430	.14
		7432	.22
		7433	.22
		7437	.25
		7438	.22
		7440	.15
		7441	.55
		7442	.32
		7443	.90
		7444	.90
		7445	.55
		7446	.60
		7447	.40
		7448	.45
		7450	.16
		7451	.16
		7453	.16
		7454	.16
		7460	.16
		7470	.35
		7472	.24
		7473	.26
		7474	.20
		7475	.25
		7476	.25
		7480	.48
		7481	1.20
		7482	.65
		7483	.38
		7484	.70
		7485	.80
		7486	.20
		7489	1.70
		7490	.20
		7491	.35
		7492	.25
		7493	.25
		7494	.35
		7495	.35
		7496	.35
		7497	.90
		74100	.80
		74104	.50
		74105	.55
		74107	.20
		74109	.25
		74110	.35
		74111	.55
		74112	1.70
		74116	.50
		74118	.55
		74119	.60
		74120	.50
		74121	.25
		74122	.35
		74123	.35
		74125	.35
		74126	.35
		74128	.35
		74132	.30
		74136	.28
		74141	.55
		74142	1.75
		74143	2.10
		74144	2.10
		74145	.50
		74147	.75
		74148	.60
		74150	.50
		74151	.40
		74153	.40
		74154	.55
		74155	.40
		74156	.40
		74157	.30
		74159	.80
		74160	.60
		74161	.40
		74162	.40
		74163	.40
		74164	.40
		74165	.48
		74166	.48
		74167	1.50
		74170	1.25
		74172	2.50
		74173	.60
		74174	.54
		74175	.55
		74176	.40
		74177	.45
		74178	.80
		74179	.80
		74180	.40
		74181	1.15
		74182	.60
		74184	.90
		74185	.95
		74188	2.50
		74190	.48
		74191	.48
		74192	.46

74193	.45
74194	.40
74195	.40
74196	.46
74197	.40
74198	.80
74199	.84
74221	.54
74246	1.20
74247	1.20
74248	1.20
74249	1.20
74251	.65
74259	1.50
74265	.55
74273	1.50
74276	1.20
74278	1.00
74279	.50
74283	.50
74284	1.55
74285	1.55
74290	1.05
74293	.80
74297	2.36
74298	1.00
74351	1.95
74365	.30
74366	.30
74367	.30
74368	.30
74390	.75
74393	.90
74490	.95

74S SERIES

74S00	.30
S02	.30
S03	.30
S04	.30
S05	.60
S08	.60
S20	.40
S32	.70
S74	.75
S86	.65
S112	.80
S114	.80
S132	1.10
S133	.60
S138	1.00
S139	1.15
S157	2.25
S158	2.10
S188	1.40
S189	1.40
S194	1.95
S195	1.95
S201	2.50
S225	2.40
S241	2.50
S244	2.90
S251	1.70
S257	1.70
S262	8.50
S287	2.25
S289	2.00
S301	3.50
S412	3.80
S470	3.20
S471	6.20
S472	11.50
S475	8.00
S571	6.20

74LS SERIES

LS00	.11
LS01	.11
LS02	.11
LS03	.12
LS04	.12
LS05	.13
LS08	.12
LS09	.12
LS10	.13
LS11	.13
LS12	.13
LS13	.20
LS14	.28
LS15	.13
LS20	.13
LS21	.12
LS22	.12
LS26	.14
LS27	.13
LS28	.14
LS30	.13
LS32	.13
LS33	.15
LS37	.15
LS38	.15
LS40	.13
LS42	.28
LS47	.35
LS48	.45
LS49	.50
LS51	.14
LS54	.14
LS55	.14
LS63	1.20
LS73	.18
LS74	.18
LS75	.20
LS76	.18

LS78	.18
LS83	.36
LS85	.42
LS86	.16
LS90	.24
LS91	.60
LS92	.32
LS93	.23
LS95	.40
LS96	.95
LS107	.40
LS109	.23
LS112	.22
LS113	.20
LS114	.22
LS122	.36
LS123	.36
LS124	.90
LS125	.24
LS126	.25
LS132	.30
LS133	.30
LS136	.24
LS138	.25
LS139	.28
LS145	.70
LS147	1.00
LS148	.75
LS151	.40
LS153	.40
LS155	.30
LS156	.38
LS157	.25
LS158	.30
LS160	.32
LS161	.37
LS162	.35
LS163	.35
LS164	.43
LS165	.50
LS166	.52
LS168	.84
LS170	.70
LS173	.50
LS174	.36
LS175	.36
LS181	.90
LS183	1.05
LS190	.36
LS191	.36
LS192	.36
LS193	.37
LS194	.35
LS195	.35
LS196	.45
LS197	.45
LS200	2.75
LS202	2.75
LS221	.55
LS240	.55
LS241	.55
LS242	.55
LS243	.55
LS244	.55
LS245	.70
LS247	.50
LS248	.55
LS249	.55
LS251	.30
LS253	.32
LS257	.30
LS258	.35
LS259	.55
LS260	.22
LS261	1.00
LS266	.20
LS273	.54
LS275	1.25
LS279	.30
LS280	.90
LS283	.40
LS290	.40
LS293	.40
LS295	.75
LS298	.80
LS299	1.50
LS300	1.75
LS302	1.75
LS322	2.00
LS323	1.60
LS324	1.68
LS325	2.95
LS326	2.40
LS327	2.40
LS347	.95
LS348	.90
LS352	.62
LS353	.62
LS363	7.50
LS364	1.50
LS365	.30
LS366	.32
LS367	.30
LS368	.35
LS373	.65
LS374	.65
LS375	.50
LS377	.85
LS378	.80
LS379	1.10
LS384	3.95
LS385	2.50
LS390	.50
LS393	.45

LS395	1.25
LS399	1.50
LS445	1.00
LS471	6.50
LS490	2.00
LS541	1.20
LS640	1.80
LS641	1.80
LS645	1.80
LS668	1.25
LS669	1.20
LS670	1.00
LS673	5.50

CMOS

4000	.12
4001	.12
4002	.13
4006	.50
4007	.14
4008	.40
4009	.24
4010	.24
4011	.12
4012	.16
4013	.20
4014	.46
4015	.40
4016	.20
4017	.36
4018	.45
4019	.25
4020	.42
4022	.40
4023	.14
4024	.35
4025	.13
4026	.60
4027	.20
4029	.45
4028	.39
4030	.18
4041	.42
4042	.40
4043	.40
4044	.40
4046	.46
4049	.25
4050	.25
4060	.45
4069	.16
4070	.14
4071	.14
4072	.14
4081	.14
4082	.14
4093	.20
4510	.46
4511	.45
4514	1.15
4516	.55
4518	.55
4520	.50
4543	.80
4583	1.00

LINEAR

741	.14
748	.28
AY3-8910	3.50
AY3-8912	6.25
CA3019	.80
CA3028	.70
CA3046	.70
CA3080	.70
CA3086	.48
CA3089	2.00
CA3090	4.00
CA3130	.90
CA3160	1.00
CA3161	1.50
CA3162	4.50
CA3189	3.00
LF356	.95
LM101	3.25
LM301	.25
LM311	.70
LM324	.30
LM339	.50
LM348	.65
LM358	.60
LM381	1.80
LM393	1.00
MC3401	.65
MC3403	.75
NE555	.16
NE556	.45
NE567	1.40
TBA800	.80
TBA801	1.00
TBA820	.80
TCA210	3.50
TCA220	3.50
TDA1022	5.00
TDA1024	1.20
TDA1170	3.00
TL010	.39
TL061	.29
TL062	.49
TL064	.98
TL071	.29
TL072	.47
TL074	1.00

TL081	.26
TL082	.46
TL084	1.58
TL091	.40
TL092	.59
TL094	1.34
TL487	.62
TL489	.62
TL494	1.63
TL496	.60
ULN2003	.85
ULN2004	.90

MEMORIES

2708	2.95
2716	3.50
2732	3.45
4118	3.25
4164	5.00
6116	4.20

CPUs

Z80ACPU	3.50
Z80AP10	3.00
Z80ACTC	3.00
Z80ADART	7.50
6800	2.75

OPTO

LEDs	.125
TIL209	.10
TIL211	.14
TIL212	.15
LEDs	.2
TIL220	.12
TIL222	.14
TIL228	.15
DISPLAYS	
TIL312	1.05
TIL313	1.05
TIL321	1.15
TIL322	1.15
LDRs	
ORP12	.90

CRYSTALS

Freq MHz	
1.000	4.20
1.8432	3.20
2.000	3.20
2.4576	2.80
3.000	2.80
3.5795	1.70
3.6864	2.30
4.000	2.30
4.194304	2.30
5.0688	2.30
6.000	2.30
6.144	2.30
6.880	2.30
8.000	2.50
10.000	2.50
15.625	3.50
15.7248	3.50
16.000	2.50
17.7345	2.50
18.432	2.50
19.6608	3.20
20.000	3.00
24.1488	3.00
27.000	2.50
48.000	2.50

RIBBON CABLE (Coloured)

10 Way	.20
16 Way	.30
20 Way	.38
24 Way	.48
34 Way	.58
40 Way	.70
50 Way	.80

per ft.

FERRITE

RM6 /160	1.40
RM6 /250	1.30
RM7 /250	1.45
RM10/250	2.10
RM10/400	2.10

TRIMMERS

40pF	.25
50pF	.35
2-10pF	.25
2-22pF	.30
5.5-65pF	.35

ACCESS or VISA

Just give us a Call

0734 340333

SIFAN COLLET KNOBS

S150	.54	SW210	.75
S151	.54	SW211	.80
SW150	.65	K210	.68
SW151	.75	K211	.75
K150	.60	W210	.75
K151	.62	W211	.85
S210	.65	W150	.75
S211	.75	W151	.75

CAPS Mixed Colours

C150	.10	C151	.10
C210	.10	C211	.10

TRANSFORMERS 3VA (printed circuit mounting)

6v-6v 0.25Amp	2.00
12v-12v 0.12Amp	2.00
15v-15v 0.1Amp	2.00
20v-20v 0.07Amp	2.00

6VA miniature

3v-3v 0.5Amp	2.70
6v-6v 0.5Amp	2.70
9v-9v 0.33Amp	2.70
12v-12v 0.25Amp	2.70

12VA (printed circuit mounting)

4.5v-4.5v 1.3Amp	4.00
6v-6v 1Amp	4.00
9v-9v 0.6Amp	4.00
12v-12v 0.5Amp	4.00
15v-15v 0.4Amp	4.00
20v-20v 0.3Amp	4.00

MINIATURE LOUDSPEAKERS

1½in/8ohms	.65
2in/8ohms	.90
2½in/64ohms	.90
3in/8ohms	.90

NICKEL CADMIUM BATTERIES

Pencell, HP7, Size AA	1.20
HP11, Size C	2.50
HP2, Size D	3.60
PP3	5.00

PLUGS

2.5mm Jack Plugs (mono)	.15
3.5mm Jack Plugs (mono)	.15
6.3mm Jack Plugs (mono)	.35
6.3mm Jack Plugs (stereo)	.47
Phono Plugs	.15
5 pin DIN Plug	.24
PL259 Plugs	.75
reducer	.20
2 pin DIN Plugs	.18
Co-axial Plug	.40

DIL SOCKETS

(Low profile)		(Wire Wrap)	
8 pin	.08	8 pin	.30
14 pin	.10	14 pin	.35
16 pin	.12	16 pin	.40
18 pin	.15	18 pin	.50
20 pin	.20	20 pin	.60
22 pin	.23	22 pin	.65
24 pin	.25	24 pin	.70
28 pin	.29	28 pin	.80
40 pin	.32	40 pin	1.00

TERMINAL BLOCKS

2 way 20 3 way 30 4 way 50

IDC Plugs

(Straight pin)		(Angled pin)	
10 way	.90	10 way	.90
16 way	1.30	16 way	1.50
20 way	1.45	20 way	1.66
26 way	1.75	26 way	2.06
34 way	2.05	34 way	2.36
40 way	2.20	40 way	2.50
50 way	2.35	50 way	2.70

IDC Sockets

10 way	.95	34 way	1.70
16 way	1.10	40 way	1.95
20 way	1.20	50 way	2.10
26 way	1.50		

COPPER CLAD BOARD

Fibre glass 6×3 single sided	.70
Fibre glass 6×3 double sided	.90

BIM BOXES

BIM1005	1.70
BIM4003	1.20
BIM2002/12	1.10
BIM2003/13	1.25
BIM2004/14	1.30
BIM2005/15	1.50
BIM2006/16	2.50

BREADBOARDS

Euro Breadboard 607	6.00
BIM Board 1 601	6.50
Vero Bloc	4.30
Panel for above	.46

VERO PRODUCTS

Veroboard (small)	.87
Veroboard (medium)	1.00
Veroboard (large)	3.03
Wiring Pens	3.77
Wiring Combs (25)	1.50
Wire for pen (2)	1.42
Terminal Pins S/S	2.38
Vero Pins S/S	.52
Vero Pins D/S	.52
Vero Case (small)	3.48
Vero Case (medium)	4.32
Vero Case (large)	4.76
Battery Box case	4.32
Flip Top Box (small)	2.52
Flip Top Box (large)	3.29

TAG STRIPS

Standard .35 Miniature .32

POTENTIOMETERS

1K-2M2 LOG & LIN	.35
1K-2M2 Switched LOG & LIN	.85
1K-2M2 Ganged LOG & LIN	.95

SWITCHES

MINIATURE PRESS BUTTON (momentary)

Push to make	.15
Push to break	.25

SLIDE SWITCHES

Miniature DP-DT	.16
Standard DP-DT	.16

TOGGLE SWITCHES 250v 1.5A

SP-ST .33 DP-DT .44

SUB-MINIATURE TOGGLE 240v 2A

SP-ST .54 SP-DT .65
DP-DT .75

MINIATURE TOGGLE SWITCHES 240v 2A

SP-DT centre off	.88
DP-DT centre off	.88

ROTARY WAFER SWITCHES single bank

1 pole × 12 way	.82
2 pole × 6 way	.82
3 pole × 4 way	.82
4 pole × 3 way	.82

ENAMELLED COPPER WIRE 2oz Reels

SWG 14-34	.88
36-38	.93
40-42	1.61
44	2.75

SUB-MINIATURE RELAYS

6v-100R coil	1.25
12v-400R coil	1.25
24v-1600R coil	1.35

WARNING DEVICES

P.C.B. Type 3-16v dc	3.60
Low profile 15v dc	1.90
Mini Buzzer 6v dc	1.10
Mini Buzzer 12v dc	1.20

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This ad only covers a small selection of our stock ranges. Please telephone, if you do not see the items you require. All stock items despatched same day. Express Mail order service to your door. Shop Hours 9.00-5.30 Monday/Thursday; 9.00-6.00 Friday; 9.00-4.00 Saturday. Ample free car parking.

PE

VOLUME 19 No. 10 OCTOBER 1983

NEW STYLE

FOR some time the editorial staff of *PE* have been discussing the pros and cons of our logic circuit symbols. The symbols were based on BS3939 of 1969 and were accepted practice for many years. While we are aware that for some time our symbols have not conformed to any of the various "standards" (BS having been revised many years ago), we have been reluctant to change until one system of identification became accepted. Our main problem being that we neither liked nor found many working examples of the later BS specification symbols.

Early this year when our *Introduction to Digital Electronics* series was being planned, it became obvious that if this series was to be readily accepted in education and of maximum benefit to hobbyists and students alike, the symbols used should conform to those generally accepted. Further investigation led to further confusion as the systems used in many schools and colleges and recommended by some examining boards do not conform to any other standard.

What we have found is virtual universal acceptance of the so called American Mil. Spec. for logic symbols in industry, and that this system is used in many educational establishments. This standard is also now used by virtually every other electronics publication.

It does seem rather silly that some UK educational establishments and examining boards use a system that is individual but then so did *PE* until now. No doubt they have suffered from the same problems as us.

From now on *PE* will use what is known as the Mil. Spec. standard for logic symbols. However, trying to get hold of a "Mil. Spec." proved difficult but, aided by the local library, we discovered the correct title is ANSI Y32 14–1973/IEEE Std 91–1973, the letters representing American National Standards Institute and The Institute of Electrical and Electronics Engineers. This standard is a revision of ANSI/IEEE of 1962 and MIL-STD-806B, MIL-STD-00806C (Ships) hence the Mil. Spec. title.

Both the ANSI/IEEE and BS documents refer to IEC (International Eurotechnical Commission) Publication 117-15, BS, claiming their symbols are identical to IEC and ANSI saying theirs are "substantially compatible". Investigation reveals that the American Standard gives two alternative symbols, one is a box which is virtually the same as IEC and BS, while the other is called the Distinctive-Shape Symbol and this is the one that has become universally adopted. So what is in use is probably not what was intended by IEC but it does seem to be easier to follow on a circuit diagram and more logical!

The industry has shown that it will not adhere to a system just because it is set as a standard, it also has to be representative of the needs of the users. Perhaps IEC and BS should now amend their symbols and fall in line with the users!

Comparisons of the old and new *PE* styles are shown elsewhere in this issue and Part 2 of *Introduction to Digital Electronics* will show comparisons of the Mil. Spec. "distinctive shapes" with BS boxes.

Mike Kenward

Technical *and* **Editorial** *queries and letters (see note below) to:*
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Phone: *Editorial* Poole 671191

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Items mentioned are available through normal retail outlets, unless otherwise specified. Prices correct at time of going to press.

New Computer Range

The latest home computer to enter the micro market is the MTX 500 from Memotech. The standard machine will have 32K of user RAM with a further 16K dedicated to video RAM. Also to be launched is a 64K user RAM version—the MTX 512. They will cost £275 and £315 respectively.

The 'all purpose computer' is the selling angle and indeed extra attention has been paid to the differing uses of the micro. As can be seen the keyboard is of the QWERTY type with a separate 12 key numeric cursor control and editing pad and an 8 key user definable function keypad. The unit is housed in an anodised aluminium case angled towards the user and is ergonomically high scoring.

Whether your needs are for personal programming, games playing, scientific or process control, educational or business use the machine is already capable or is easily adaptable to most applications boast the manufacturers. The 16K ROM contains several languages and routines. Standard languages being MTX BASIC, LOGO and NODDY, ROM routines include and ASSEMBLER/DISASSEMBLER with screen display of Z80 CPU registers, which can be manipulated from the keyboard. Other interesting features include an Add-on 80 column video board as opposed to the 40 column norm, twin RS232 interface ports and ultimate expansion to 512K.

With a programming speed of 2400 baud the quality of the cassette player used in conjunction with this machine will play an important role in accurate data transferal. Games, Educational and Business software will also be available produced in the main by Continental Software Ltd.

The New Steam Age

For those nostalgic of the ignifluous hearted, albescent breathed labourer of the permanent way, in short, the *steam locomotive* the news that living steam is to return to the railways of North America might come as a pleasant shock. But not the clanking, brass bell and smokestack machine. Instead, a loco' "heavily disguised" as a diesel unit with pistons on its wheels, manufactured by American Coal Enterprises, will beat through American suburbs where electrification infrastructure costs are prohibitive.

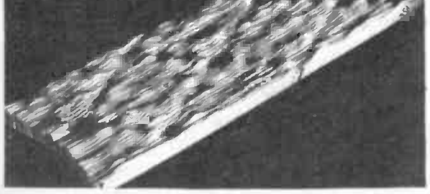
With a microprocessor for a firemen, efficiency of the locomotive is lifted from the 5 per cent of its ancestors, to 15 per cent. Whilst diesel may be 30 per cent efficient, this fuel costs four times as much as coal, and with a micro on the footplate to ensure minimum pollution in terms of gases and ash, the New Jersey company feels it has sparked off a good idea for the future. Production is expected to start soon.

IBM Breakthrough

IBM scientists have hit the news again; this time with a microscopy breakthrough at their Zurich Research Laboratory. An effect known as vacuum tunnelling has been successfully exploited to study surface topography down to atomic level — vertical differentiations of as little as 0.1 Angstroms, and horizontal differentiations of as little as 6 Angstroms (1 Angstrom unit equals 10^{-7} mm).

The tunnelling technique actually detects the electron clouds surrounding surface atoms, and as such, qualitatively reflects the atomic surface structure. In vacuum conditions a probe scans the specimen raster fashion, so that a 3-D facsimile is gradually built up. An electric current between the probe and surface is used to detect surface deviations. So sensitive is this technique that a distance the diameter of *one atom* changes the tunnel current by a factor of 1000.

The photograph shows an enlarged model of a silicon surface constructed from STM data. Two rhomboid-shaped unit cells are clearly visible. The individual "bumps", which are as little as 6 Angstroms apart, have never before been observed.



Mic on a Chip

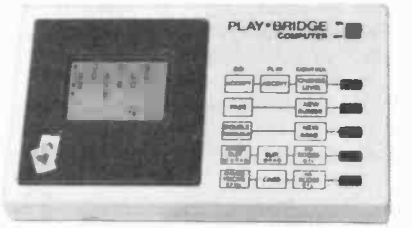
A new technology pioneered by Honeywell has led to the creation of the "mic on a chip"—a completely solid state microphone! Zinc oxide on a single silicon substrate offers a chip-sized microphone with significant advantages over the ceramic alternative; it responds to frequencies as low as 0·1Hz, as opposed to 20Hz. Honeywell's microphone is devoid of mechanically linked parts, and consequently far more reliable and robust. It is smaller and lighter too. The mic consumes a mere 40mW which makes it ideal for battery powered field work, and it is sensitive to as little as one microbar of pressure.

COMPUTER BRIDGE

The Systema BG1 Bridge Game is a simple computer, with control keys and display, designed so that one person can play Bridge, using the computer to play the roles of the other three persons.

The computer will deal new cards each time and you can choose between two levels of difficulty. It allows you to be dummy, declarer or defence. Between the hands, result of contract and vulnerability are displayed as well as below the line scores.

In each game you are able to bid and play your hand against the computer. During the auction, you make your own decisions as to what to bid, but the decisions of the other three players are made by the computer. The BG1 Bridge game is expected to retail at under £30.



MARKET PLACE

Briefly...

Five UK banks are to link together their 2,500 cash dispensers for shared customer use, by 1985. Bank of Scotland, Lloyds, Williams & Glyn's, Barclays and the Royal Bank of Scotland will be providing this common on-line facility to a total of 15 million customers.

● ● ● ●

Researchers at Battelle–Columbus have developed a low-cost, energy efficient method for coating plastics with metal. The technique is known as "in-mould" plating because unlike conventional deposition, the plastic component emerges from the mould with its metal coating. Processing costs are cut by over 30%, and the technique may well herald an era of lightweight production parts for automobiles, business equipment and plumbing fixtures.

● ● ● ●

W. H. Smith have opened three specialist computer shops at their branches in Birmingham, Bristol and Croydon. If these first efforts realise their predicted sales figures a national network will follow next year. The first special offer will be Mattel's new micro 'Aquarius' well before its official UK launch.

● ● ● ●

Socialist France has installed data links betweeen its treasury and its border posts. Electronic warrants enable emigration police to identify and jail immediately anyone who, upon trying to leave the country, owes money to the exchequer. Having fed the traveller's passport through a scanner terminal, the officer on duty is empowered to detain any offender until he/she pays up and wipes out the debt. In a matter of weeks of operation, hundreds of citizens had settled in cash rather than lose their connection.

● ● ● ●

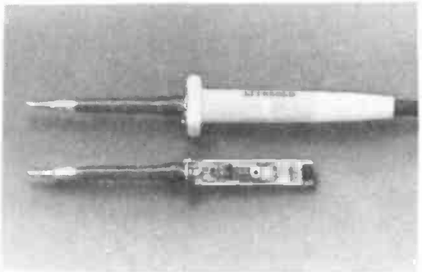
Maplin Electronics has introduced its Computer Aided SHopping by TELephone (CASHTEL) service, which allows owners of home computers with RS232 and modem facilities (CCITT 300 Baud) to link directly into its stock control computer. The user must have a customer number, and hold one of the major credit cards to be able to place an order, and may check that the components he/she requires are in stock. Maplin's computer is a DEC PDP11/70 with 2Mbytes of MOS memory and 200Mbytes of on-line disc. It is accessed by dialling 0702 552941.

LITESOLD

Litesold have just introduced a mains-voltage soldering iron.

The EC50 incorporates an electronic temperature control circuit mounted inside the handle, which operates in response to a thermistor fitted inside the bit-mount. Power to the 50 watt heating element is controlled by a triac operated by a zero-voltage switching i.c., to minimise spiking and RFI, and the iron is fully earthed so that it may safely be used on sensitive equipment and components.

A special feature of the design is that the low-voltage supply necessary for the control circuit is obtained by means (for which a patent is pending) which do not involve the fitting of a dropper resistor in or near the handle. This problem has previously prevented a mains iron of this type being made to run with a sufficiently cool handle.



Access is provided to the temperature control potentiometer, and settings may be varied from approximately 280 to 400°C. Standard setting is 370°C. The iron costs £28 + VAT and postage from Light Soldering Developments Ltd, 97/99 Gloucester Road, Croydon, Surrey, CRO 2DN. (01-689 0574).

FLASHBACK

Would you give a week's pay for a calculator with only the most basic of functions? The answer is yes if you bought one ten years ago. Before such technology was available to the general public, those in the know could purchase the Sinclair Cambridge for a staggering £43·95. The average weekly wage at that time was around £36 and the electronics world was celebrating the Silver Jubilee of the transistor. Such was the state of technology in 1973.

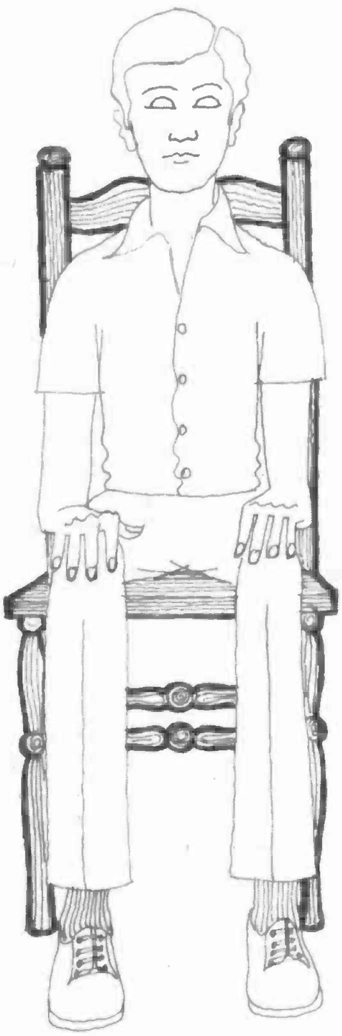
Nowadays the purchasing power of our weekly pay packet could run to three computers, ZX81's of course. With the microprocessor bandwagon well and truly rolling who knows what goodies will be around for our 1993 pay days?

Silicon News Corner

Bulletins announcing new semiconductor devices arrive at PE daily, so it is possible only to describe them briefly. Details of how to obtain further information are included, however.

Mullard ▶ Electronic humidity sensor (type 2322 691 90001) that operates between 10–90% relative humidity. Is a metallised film, capacitive cell. Worst case accuracy is 5%.
▶ AM/FM receiver TEA5570. Suitable for hifi, car radio and portable. S.w. to 30MHz.
▶ 128 × 8 bit static low-power RAM (type PCD 8571) in 8-pin d.i.l. package. Designed for battery back-up using only one ni-cad cell. Data transferred serially via I²C bus.
▶ High speed 8K PROM, type 82S181B (1024 × 8) and 82S185B (2048 × 4). Both 45ns access. Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.
Siemens ▶ 10kV rms opto-isolator HIL10 in 16-pin d.i.l. package.
▶ Claimed to be the world's smallest (match head sized) reflective opto switch, type SFH900. Very high dark/light ratio sensor. Emitter capable of 1·5A, 10µs pulse.
▶ 35 dot intelligent display, DLO 7135 series. 96 chars, ASCII format, µP compatible. Red, yellow, or green. Row/column addressing simplified by integral memory/decode/drive chip. Chars 0·68 in. high, with 75° viewing angle.
▶ Low power, 8-digit intelligent alphanumeric display, DL1814. 8 × 17 seg., 0·112 in. chars. Full ASCII/TTL compatibility through on-board memory/decode/drive. Synchro Services, High St., Harrold, Bedford.
Pronto ▶ A CMOS 2 µP with enhanced/extended instruction set. The SY65C02 works to 4MHz at current of 8mA (10µA standby).
▶ New series of extremely low noise, wide band op amps, the OP-27 is intended for instrumentation. Slew rate 2·8V/µs and low frequency noise corner frequency of 2·7Hz.
Synertek ▶ Low cost CRT controller with wide range of display features. The SY68045 is designed to interface 6500/6800 micro's raster scan CRT units.
Mostek ▶ The MK3801 Z80 STI contains a USART for serial communication, and reduces Z80 system chip-count. This multifunction device contains two binary, two full function timers, and eight general purpose bi-directional lines. 16 out of 24 internal registers are directly addressable. Pronto Electronic Systems Ltd., 466 Cranbrook Road, Gants Hill, Ilford, Essex 1G2 6LE.

A Safe Relaxometer...



RALPH LOVELOCK

ANYONE who has watched a very young baby acquiring manual skills such as reaching out and grasping a desired object, will have realised the complexity of the process. The hand first closes short of the object, then beyond it, then to one side of it, but once success has been attained, all further attempts are effortless and automatic. To the infant there is no comprehension of the physiological process, but the mind desires a certain end, the eyes feed back to it the results of trial and error, and the child 'learns' to use its body to perform the task.

Such knowledge continues with us into adult life, and without any conscious awareness of the individual electrical impulses which actuate the muscles, we can automatically learn, through feedback of the results of trials, from the five senses, from emotional reactions in the mind, and from the pleasure of attaining the desired end.

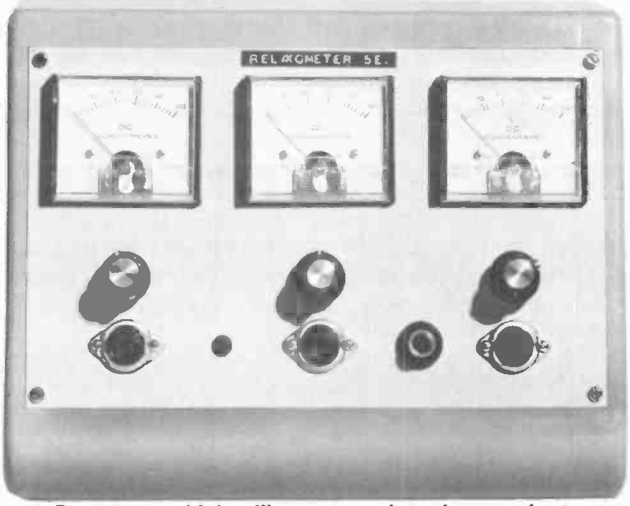
Much of the control and operation of bodily functions are exercised without conscious awareness. By fitting a suitable transducer to the body which will feed back to the mind through the senses an indication of state from moment to moment, the operation of such autonomic control is brought to the level of consciousness. This process has been named 'biofeedback', and through it it has been found possible to learn to raise or lower body temperature, blood pressure, rate of heart beat, and the operating mode of the mind itself.

One of the earliest applications of this process was in the American lie detector, which informed the questioner rather than the subject, of an emotional state. All well-equipped hospitals today employ many involved electronic machines to inform the doctor and nurses of the operational state of many bodily functions. This article is concerned with the development of the lie detector to respond to much more subtle states of mind, and feed back to the subject himself so that he may learn to control states beyond the level of consciousness. Such methods are being used currently in therapy of a number of psychosomatic conditions including cancer.

RELAXATION

It is common knowledge that worry, anxiety, sorrow, and emotional stress can all give rise to acute nervous tension. Some of our younger generation have sought relief from the pressures of Western civilisation by learning to relax under the guidance of Eastern religions. A regular entry into deep relaxation often accompanied by concentration on a fixed theme or phrase, as in transcendental meditation, can bring relief from such troubles, often allowing the operation of bodily functions below the level of consciousness to return to normal, and thus allow the natural responses of the body to meet and destroy any undesirable invasion.

Such relaxation is often accompanied by a brain wave known as 'alpha rhythm', and there has been an attempt in America to sell to the general public a cheap version of equipment to feed back to the patient the results of such electrical pulses by sound or sight, using biofeedback to learn control of the process. While such machines are in



Prototype which will accommodate three patients

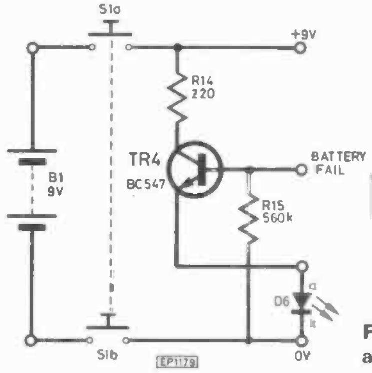
large scale use by medical staff to measure brain conditions in patients, the output is fed to the doctor, and not to the patient. Because sharp cut-off band pass filters are used which can be excited by electrical noise, such anomalous response can be very dangerous if fed back to the individual himself, occasionally resulting in epileptic seizure.

The electrical conductivity of the outer layers of the human skin has been the subject of much valuable research which has allowed a refined version of the lie detector to be used as a biofeedback machine to monitor, and teach to the private individual, the ability to develop deep relaxation, and by a type of transcendental meditation to receive therapy for his condition. The use of the skin conductivity machine by private individuals is quite safe, and can frequently be advantageous in improving the quality of life, although any sufferer from serious illness is well advised to seek the assistance of a trained therapist so that the state of relaxation can be advantageously utilised in therapy.

SKIN CONDUCTIVITY

These machines are often misnamed 'skin resistance meters', but such a designation is not true, because the relationship between applied voltage and resulting current is not linear, nor does the nature of conductivity variation with emotion remain similar over a wide range of voltage applied. In the normal process of living, the skin is being constantly abraded and replaced by new growth; on the surface is the debris of wear, beneath this is a complex outer layer, and beneath that the inner materials associated with the electrochemical organisation of life. It is in the outer layer of skin proper that the conductivity used occurs, while the surface debris offers an obstacle to measurement by injecting a high resistance limiting the effective area of electrode contact.

The conductance of the skin is not resistive because it is the result of electro-chemical transfer of charge through the walls of adjacent cells, and for the purpose of monitoring, relaxation research has indicated that potentials greater than 2V applied across electrodes will give anomalous results. The older method of obtaining a large effective area of conductance between electrodes and surface debris was to use a conducting jelly or fluid between electrode and skin (wet electrodes), but this introduces an uncontrollable variable into the system, which can mask some of the information desirable. With the wet electrodes, or with equally unsuitable metallic penetration of the debris by a layer of matted metallic fibres, effective resistance lay between five



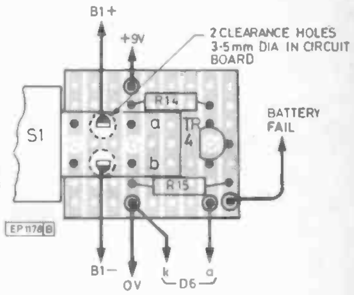


Fig. 1. Circuit of switch unit and board assembly

thousand and fifty thousand ohms, and such conductance was readily measured in a range of voltages below 2. With dry electrodes however, such as those described here, the effective resistance can rise to several megohms, and it was this limitation which was only overcome at a reasonable price when cheap versions of very high input resistance operational amplifiers became available. The instrument described here will allow an untrained person to adjust and monitor the conductance across the electrodes between five thousand ohms and fifty million ohms, a range of ten thousand to one, and involving the monitoring of changes in current of a few pica-amps.

In use, a needle moves across the scale of an instrument. With the electrodes applied to the skin, a knob is turned to increase the reading until it is approximately mid-scale. Any increase in nervous tension will cause the reading to increase, while a state of relaxation will cause it to fall back towards zero, the further the fall, the deeper the state. Apart from the difficulties of measurement in this range, a further difficulty was to use cheaply available components to obtain a smooth logarithmic variation of gain in the amplifier over such a wide range, without backlash or drift, such that an untrained person could easily operate it. Very early in the development it became obvious that the greatest operating cost was likely to be the destruction of sensitive meters through accidental overload, and in designing a meter protection circuit a means was found of obtaining a very desirable modification of input/output law over the working range.

CIRCUIT OPERATION

The meter protection circuit is shown in Fig. 2. The output of the amplifier is a voltage proportional to the current into the electrodes, and this is fed into the meter circuit. Since the purpose of the instrument is to 'teach' relaxation, there is no need for the reading to be a linear measure of conductance, but it is desirable that it shall have a large change of reading about the centre scale; this will enable a small start

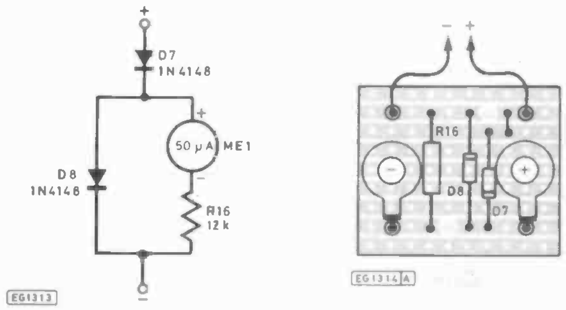
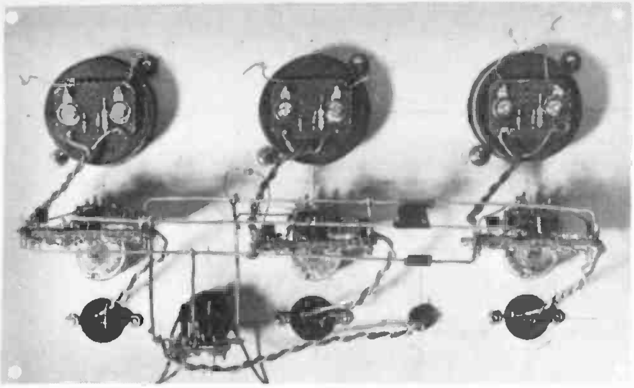


Fig. 2. Meter protection circuit and board assembly



towards relaxation to be clearly visible to the user, and thus encourage him to make further progress. The overall response of the circuit is shown in Fig. 5. D7 suppresses the zero, and D8 compresses the maximum reading, thus giving the expanded deflection around mid-scale which is desirable. In addition to this function, D7 masks the effects on meter reading of small offset voltage output from the amplifier, which varies from chip to chip, and also protects the meter from application of reverse polarity to the input. In addition to compressing scale reading, D8 protects the meter from damage due to too great an input of excessive voltage.

The switch unit circuit is shown in Fig. 1. Use of an indicator lamp to show that the instrument is switched on would be a waste of battery current, but lack of such an indication leads to run-down of batteries due to not switching off after use. To offset this problem a push switch is used which has an 'indicator' button; this button displays an indicating orange disk while on, which becomes invisible when off. It is very desirable however that when the battery has discharged to a voltage incapable of maintaining a constant voltage output from the regulator used in an amplifier, that a visible warning be given that performance is no longer reliable. When the switch unit is controlling a number of work units, such a failure must be detected from any one of the voltage controllers in that particular amplifier; this is accomplished by TR4, which in the absence of input to the battery fail line remains cut off due to R15, but when a failure drives the battery fail line positive, TR4 allows a limited current to flow, lighting D6 in the emitter circuit. There will still be enough output from the battery to continue lighting the lamp, and indicating that a new battery should be fitted.

The amplifier circuit is shown in Fig. 3. The voltage regulator section is designed to accept the output from the 9V battery at the collector of TR1 and deliver at the emitter a drive potential constant for varying load at a value between 5·5 and 6·5V. A value of 6V will cause a current of 0·104mA to flow through R4, R3 and R2, raising the base of TR2 to 0·07V which will leave it cut off in the absence of additional current through D5. If the battery voltage falls to such a level that D5 ceases to conduct, the voltage on the base of TR3 will fall to 0·17, it will also be cut off, its collector will rise to 6V, applying 5·3V through D1 to the fail line; although there may be up to nine more amplifiers connected to this line, each will have a diode in the same location, which will prevent them from shunting this voltage to zero, and the switch unit will light the alarm lamp. Until the battery voltage falls to too low a value to cause current to flow through D5, that additional current through R2 will rise until TR2 conducts, when feedback from R1 to TR1 will maintain a voltage just sufficient to cause around 0·5mA to flow through D5, and TR3 will conduct.

The amplifier section of the unit consists of a dual operational amplifier having input impedances around 1500 megohms and designed for single ended operation from 4–36V. The dual logarithmic potentiometer of 1M resistance is loaded so that the overall response of the amplifier to rotation of the control is very nearly logarithmic, and the response of a typical machine is shown in Fig. 6. A current of 0·93mA flows through D2, D3, D4, giving a ground line to the amplifier of 1·8V above the zero voltage input to it. This same current through R6, R7, R8, places a voltage across the potentiometer between 0·3 and 2·8V above the ground line. This is the voltage which should be applied across the electrodes, but their impedance is so low that the desired logarithmic control would not occur, and the first of the two operational amplifiers is used as a unity gain buffer of high input and low output impedances so that the required voltage is applied to the test terminals.

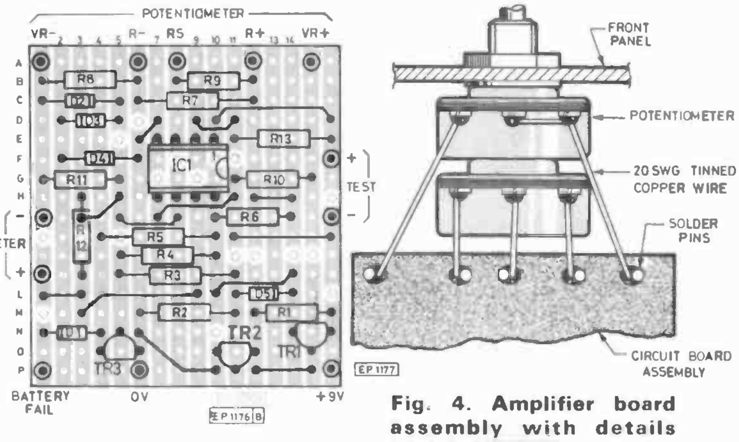
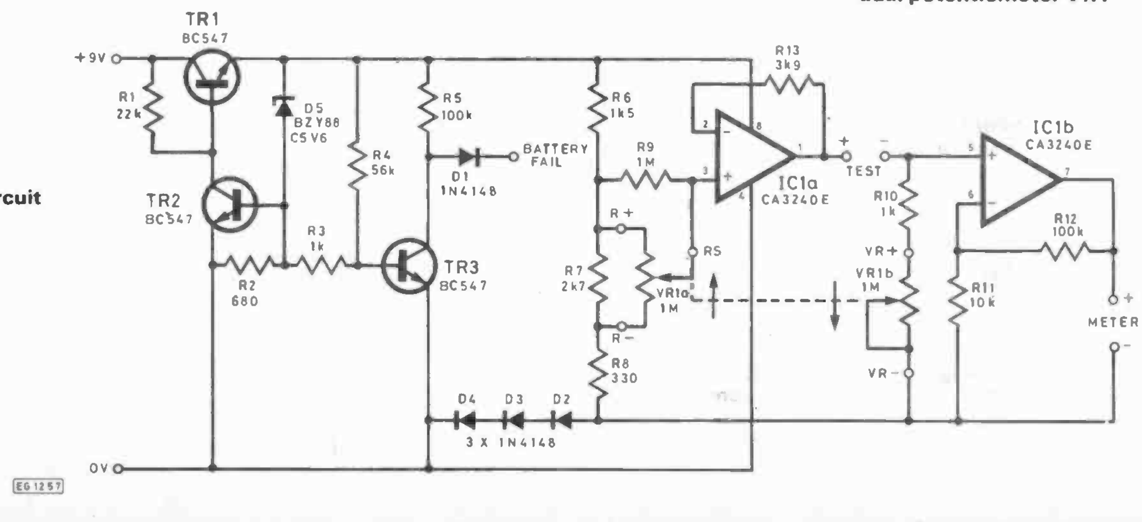


Fig. 4. Amplifier board assembly with details (right) for connecting the dual potentiometer VR1

Fig. 3. Amplifier circuit



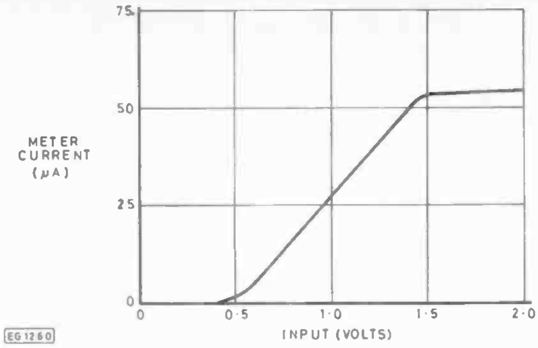


Fig. 5. Response graph of Relaxometer

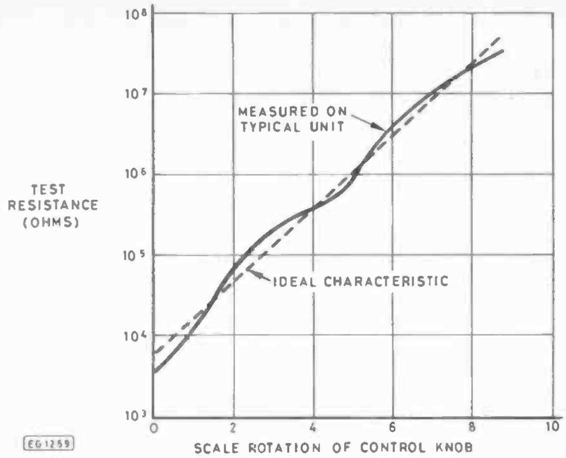


Fig. 6. Graph showing rotation of control knob to give mid-scale deflection of meter for resistance value across test terminals

The current flowing through the test terminals flows also through R10 and VR1b. The voltage developed across them is applied to the input of the second op amp. For very low values of skin resistance, not only is a lower voltage applied to limit current flow to the requisite low levels for significant response to tension, but the input resistance in the path of test negative to ground is also very low to prevent a masking of test variation by a significantly high resistance in series with the skin conductance. As the voltage is increased to give a test current which is low enough to register tension, but is also high enough to operate the amplifier above the 'noise' level when skin conductance is low, the value of the second potentiometer resistance is also increased for the same reason, and the combination of the two gives the overall logarithmic response which is shown in Fig. 6 and which also keeps the second op amp operating satisfactorily over the design range.

As far as the operator is concerned these various adjustments of condition are automatically performed and in turning the control knob from zero towards full scale, he sees a smooth increase of meter reading until it is half scale, at which point he leaves it there, and watches the needle for indication of relaxation or of tension.

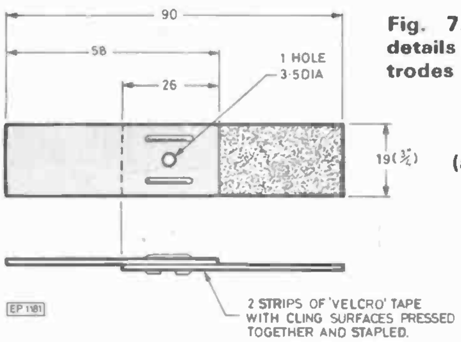
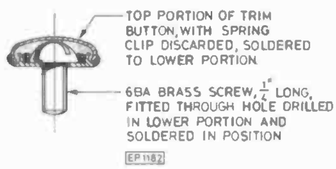
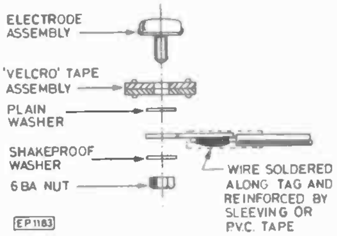


Fig. 7. Constructional details of finger electrodes

(a) Tape band

(b) (right) Electrode assembly where the two portions are pressed together





(c) (left) Showing assembly of electrode to band

PERSONAL USE

The instrument is basically of assistance in learning to relax. Most people think initially that if an effort of 'will' is made, and the mind concentrated on a firm intention of relaxing, that they succeed, and that the harder the mind is stressed in achieving the end, the deeper will be the relaxation. In practice, nothing could be more effective in preventing it; the very stress of concentration leads to tension, the very antithesis of the desired end.

COMPONENTS

Resistors

R1	22k
R2	680
R3	1k
R4	56k
R5	100k
R6	1k5
R7	2k7
R8	330
R9	1M
R10	1k
R11	10k
R12	100k
R13	3k9
R14	220
R15	560k
R16	12k

All resistors 0·4W metal film ±1% tolerance

Semiconductors

TR1–TR4	BC547 (4 off)
D1–D4	1N4148 (4 off)
D5	BZY88C5V6
IC1	CA3240E
D6	Red l.c.d.
D7–D8	1N4148 (2 off)

Potentiometer

VR1	1M log

Miscellaneous

B1	PP9
ME1	50μA meter
S1	Double pole indicating push button switch (RS 339–443)

Biofeedback is only one of many methods which have been used to train in relaxation, but it is probably the easiest, and certainly the most universally applicable, since it is the only one which is not tied to any one aim, but applicable alike to mystical, spiritual, religious, and medical assistance.

When commencing to use it, a number of sessions are normally needed before it becomes possible to rapidly relax. The difficulty or ease of learning depends in large measure on one's prior disposition and experience, and if one does not become discouraged, and gives the routine a fair trial, eventual success is certain. Many attitudes are currently adopted in relaxation, varying between standing on one's head, sitting cross-legged on the floor, lying on the floor, and sitting in a chair. A straight-backed chair is the easiest, and most effective to use, where the feet, when sitting upright, can rest comfortably on the floor.

The electrodes are attached to fingers or to the palm according to type, the unit switched on, and the meter adjusted to half-scale reading. The mind is gently diverted from surrounding objects and present interests, by slowly reviewing the bodily members, from feet, up legs, thighs, trunk, hands, arms, shoulders, gently relaxing all muscular tension in each in turn and leaving it in this state as attention is turned to the next. The breathing rate is dropped to about two-thirds of normal, but making each breath deep, slowly in, then *completely* expelling from the bowel upwards. Finally, the mind is detached from all the surroundings, and thought centred on a single matter (mental picture, or single syllable sound without rational meaning) and the needle idly watched with the full confidence that it is slowly going to drop towards zero.

The unit can be successfully used in private, in one's own home, but it is usually easier and more effective when done regularly in a group, from three up to six, all sitting around a table on which the machines rest. The location should be quiet, with no probability of external interruption, and duration from twenty to fifty minutes. It will be found that even if it takes a time to enter relaxation, to remain there for at least ten minutes will bring a feeling of great rest, and a peace which will remain for the remainder of the day. Even when able to relax with ease, it should be practised regularly, at least weekly, if possible more frequently, even perhaps daily. It will become possible with practice, to relax without a machine, but it is advisable to monitor occasionally with one to make certain that one is still relaxing; in any case the reassurance of seeing its existence will bolster confidence in its use.

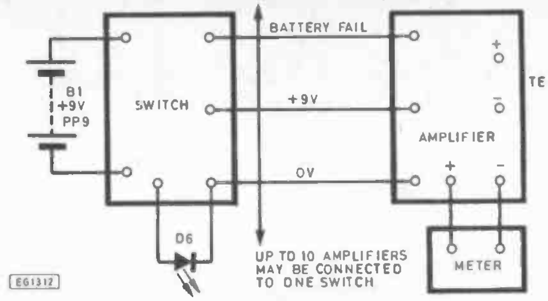


Fig. 8. Showing interconnection of board assemblies for complete Relaxometer

Finally, it should be noted that it is a complete mistake to think that sleep is a condition of deep relaxation. During a prolonged period of sleep, the brain experiences periods of intense activity in dreaming, with rapid eye-movements and other muscular activity. It is often found by patients that after a period of many minutes of noting the needle on zero, they have dropped off to sleep, and on waking have found the needle at full scale. ★

BAZAAR

WANTED Kodak Carousel projector type SAV 2000. Mr. B. R. Smith, 128 Eastbourne Rd., Southport, Merseyside PR8 4EA. Tel: 66316.

OSCILLOSCOPE wanted. Small, single beam, for use as vector graphics display. Offers less than £70 only. Mr. P. G. W. Beart, 11 Apthorpe St., Fulbourn, Cambridge CB1 5EY.

UK101 8K, BASIC 5, Mon 2 inst. manual, cased few software tapes plus 12 inch b/w TV £140 o.n.o. G. J. Garrett, Phone Luton (0582) 422147 after 6p.m.

WANTED good condition oscilloscope single or double beam. Preferably in Cleveland area. J. A. Talbot, 7 Barnard Avenue, Fairfield, Stockton-on-Tees, Cleveland TS19 7AB.

PRACTICAL Electronics Volume 1, bound yearly from 1964–1977 plus approx. 2 years unbound. S.A.E. with offers please. Mr. F. Allen, 34 Charlton Close, Cheltenham, Glos. GL53 8DJ.

ELECTRONIC piano kit, Wireless World, 51 Note Keyboard etc. As purchased. Cost £108 any reasonable offer? R. A. McCall, 20 Empress Ave., West Mersea, Colchester CO5 8EX. Tel: 0206 38 3039.

APPLE II Europlus 48K, 9 inch monitor, 1 disk drive, Silentype printer, private ownership hence v.g.c. £950. J. D. Dell, 'Cygnet', Norfolk Road, Buntingford, Herts SG9 9AN. Tel: 0763 72828.

TELEPRINTER Kode keyboard friction-feed paper punch + reader RS232–20mA good condition useful electric typewriter £75 o.n.o. H. H. Meinhardt, Morningside, Brereton, Heath Lane, Somerford, Congleton, Cheshire. Tel: 0477 35277 evenings.

MICROTAN with latest Tanbug and lower case chip. £60 bargain. Circuit diagram and manual included. M. Goonewardane, 241 Norbury Crescent, London SW16 4LF. Tel: 01 764 0839.

PRACTICAL TV 1958 June 1983. Electronics 1st issue to June 1983 £50. Tel: 01 874 6232. Mr. J. McGlynn.

DATA on cheap 1 to 2 second delayed flip flop from 12V d.c. wanted. M. Foster, 1 Buckles Way, Banstead, Surrey SM7 1HB.

EX COMPUTER power supplies −5 amp +5, +12, −12 £38. Gold edge connectors 2 × 36 £1.10 o.n.o. Tel: Cardiff (0222) 43015. Max Murison.

GUNSONS Sparktune Mk2 £5, 9 inch b/w monitor ITC—PM–910. Superb condition £55. B. M. Kermode, 56 Brantwood Road, Bradford 9, West Yorkshire.

PE VDU board £12 o.n.o. Elector 16K DRAM £15 o.n.o. Microtan 65 £25, SCMP/2 INS8154 £8 each d.i.l./plug in relays 75p/£1, MM5303 unused £5. G. Williams, 85 Salthouse Rd., Barrow-in-Furness, Cumbria LA13 9TN. Tel: 0229 29152.

FOR SALE, 7 TMS2516 EPROMS, 8 2114 RAM chips, 3 MPU's. Offers for lot. Will split. Tel: Chesterfield 825185.

QUANTITY magnetic tapes. Suitable computer programs. 30p each or £2.50 for 10 + postage. J. Harding, 30 Springhill, Upper Cam, Dursley, Glos GL11 5PF.

MONO DX–TV isolated chassis. All band tuner, audio/video in/out £25 o.n.o. or what have you! Mr. A. Bouskill, 129 Lyminster Rd., Sheffield, S. Yorks S6 1HY. Tel: 0742 311191 after 4.30p.m.

COSSOR monitor screen plus case £40. Some 74 series chips packed on p.c.b.'s offers. Mr. M. Faulks, 218 Watford Rd., Croxley Green, Rickmansworth, Hertfordshire WD3 3DD. Tel: (0923) 30584.

WILLIAM Stuart's "Big Ears" speech reconditioning system for UK101. Superboard, Nascom, Atom. £30. Call Chang. 041 332 7695 after 9p.m.

ATOM 13K+ 16K Utility 4A p.s.u. manuals leads etc., books, over £60 software Acorn tested £199. Mr. C. D. Bittlestone, 1 Beechcroft Ave., Dere Park, Brandon, Co. Durham DH7 8TF. Tel: Durham (0385) 780925.

RADIO controlled car cost £70 reluctant sale price £30. Tel: 01 504 0565. D. Snowdon, 124 Walpole Rd., South Woodford, London E18 2LL.

UK101 Cegmon 32 x 48 16K 1/2 300/600 green screen v.d.u. Manuals. Software various. £260 o.n.o. Tel: (0734) 501656, (0734) 22410. P. R. Border.

WANTED Everyday Electronics Feb 1979 or copy of correction to circuit for Solid State Roulette. D. S. Jackson, 13 Columbia St., Cheltenham, Glos GL52 2JR. Tel: (0242) 20770.

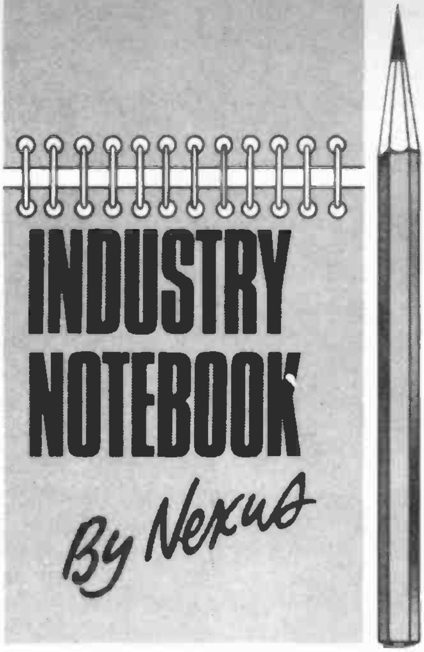
PRINZ Cruiser 8. Personal stereo radio cassette recorder, 1 month old, perfect in condition, with guarantee £60. Mr. Wing Lee, 5 Crown Street, Hebden Bridge, West Yorkshire HX7 8EH.

REALISTIC DX200 Receiver £70 and ZX81 Computer £30 o.n.o. Both in mint condition, possibly will deliver. Mr. S. Sagar, 293 Accrington Rd., Blackburn, Lancs. Tel: 65803.

SUPERBOARD 4K cased, modulator and power supply, 5 volt 3 amp £170. B. Hutchings, 19 Buckeridge Way, Bradwell-on-Sea, Essex. Tel: Maldon (0621) 76441.

WANTED vintage wireless sets and spares from the 1930's and before. Mr. S. Busbridge, 29 Clarence Drive, East Preston, Littlehampton, West Sussex BN16 1EJ. Tel: Rustington (09062) 5615.

WANTED urgent help needed to make my P.E. analogue board work. All replies answered, 'phone Gloucester 730919. Andy Bradley.



Who Pays?

The General Election, barely three months in the past, already seems light-years away. The result will affect industry and commerce until 1987/88. The opposition parties remain in disarray, divided and powerless. With hindsight It is now clear that the Conservatives fought on the Labour Manifesto rather than their own.

Whatever sins of omission or commission can be laid at the feet of Mrs Thatcher during her first term, she cannot be faulted for proclaiming an elementary truth. This is that governments don't pay wages. Neither do local councils or chairmen or managing directors of companies. They can only channel the money paid by customers and taxpayers. It is the latter who pay and loss of custom means less pay, ultimate unemployment. Taxpayers, too, need and demand value for money. The message is now taking hold.

Results

Nobody understands the principle of customer satisfaction better than Lord Weinstock who took over ailing GEC twenty years ago. Today GEC is second only to British Petroleum in stock market capitalisation. Trading results issued mid-year showed a turnover of £5·5 billion with profits up to £670 million from last year's £584 million. Moreover, cash at the bank and short-term investments rose to £1·34 billion from £1·04 billion. Of the £670 million profit, £224 million came from electronics. Order books are nine per cent up on the previous year.

Despite such apparently good results during the recession there are still hard times ahead. A climb out to improved growth could be painful. As Lord Weinstock observes, it is a mistake to imagine that recession is a prelude to boom and although the business outlook is improving there will be no sharp recovery in employment. Increased activity in high-tech manufacture could also precipitate a shortage in some of the more exotic i.c.s. This view adds weight to the rumour that Lord Weinstock has his eye on Inmos as a possible acquisition.

Another high-flyer is Sir Ernest Harrison heading up the Racal Group which, ten years ago, was not rated in the top 100 and is now in 19th spot. Racal boosted pre-tax profit to £114 million from £103 million last year but the City remains unimpressed, downgrading Racal from its former 'glamour' status. Those with the foresight to invest £1,000 in Racal shares when the company went public in 1961 and left them with dividends intact would find themselves today with a return of over £500,000. Well, you can't grow at that rate for ever and there are good reasons for the slow-down. Defence electronics in the Middle East is one of Racal's most profitable markets. The cut-back in oil prices in OPEC countries didn't help there. The data communications business in the USA ran into a price-cutting war and this didn't help, either. Then there was the problem of Decca, recently acquired, and needing turning round to profit. Borrowings soared to finance the Decca deal but these have now been paid off. So all-in-all the Racal Group looks set for further advances.

The three-year re-structuring of Decca and its integration into the Racal Group has now been virtually completed. Central to this task was David Elsbury, an old Racal hand and one of the earliest high flyers who has now returned to the centre as Deputy Chief Executive, second only to Sir Ernest in the hierarchy. Elsbury also has special responsibility for the Data Communications Group recently relinquished by D. Leighton Davies who has taken early retirement but remains a consultant to the company. A new promotion is that of Barton J. Clarke to chairman of Racal Radar Defence Systems Ltd. Clarke joined Decca in 1957 and in recent years succeeded in building up the company's electronics warfare business to world status. Now, within Racal, this EW group employs 1,800 people exporting to 30 countries.

The larger the company the harder it becomes to get dramatic growth in percentage terms. Thus Ferranti, almost a midget beside GEC, romped home with 31 percent increase in pre-tax profits to £31·5 million. Electronics again showed the sharpest advance, 49 percent up on the previous year. Order books for the current year are 20 percent up compared with a year ago.

STC, now British controlled (ITT retaining only a minority share), is also flying high as, indeed, are Plessey and Thorn-EMI.

Change

But to keep going means changing with the times, ditching old unprofitable lines, introducing new products at keener prices. So it was that GEC's telecommunications factory at Hartlepool which once employed 6,000 people is now reduced to a few hundred. Hardship for those displaced but it needn't be for ever. Remember Corby, 'crucified' by closure of British Steel with 6,000 people 'thrown on the scrap heap' three years ago? With government incentives, over 200 new firms have emerged not counting the great Wonderworld leisure complex yet to come with £200 million pounds investment and another 3,000 jobs. Corby hasn't yet solved its unemployment problem but has accepted the challenge of writing off steel in favour of a diversity of new enterprises. What should have been a Labour stronghold, fuelled on discontent, Corby with a vision of a new future ahead voted Conservative. But change is not all for the good. RS Components, for example, relocating at Corby means a loss of jobs in London.

Fruit Machines

Small computers named after fruits continue to proliferate but I should imagine that Lemon or even worse, Raspberry, models will not appear. We all know that the cost of computing is on a downward curve but it is still a surprise to learn that if aircraft fares had fallen at the same rate as computing power over the last 40 years you could fly the Atlantic for a penny! The comparison is based on the original Eniac at a then estimated cost of £10 million. The humblest micro will do more or less the same job today for a handful of notes.

The hardware may fall in cost but the software may not. It is conceivable that, like the Gillette safety razor once given free with a packet of blades, so the computer will come free with the software. But not yet. ACT, unveiling its new Apricot model at a basic £1,500, is decidedly up-market compared with, say, Sinclair, but even in this bracket there is an active price war with Apricot claimed to have the price edge through lower overheads, and might comfortably drop further when production speeds up to 4,000 machines a month early next year.

It is bad enough with genuine competition. The real trouble comes with illegally produced look-alikes, the cheap copies made in Hong Kong, Taiwan, Singapore, even, it is said, in Japan itself. Apple is the principal target, one machine being labelled Apollo (near enough to confuse) with other look-alikes with different names but boldly sub-titled Apple-compatible. One such is reported as being marketed in North America as the 'Orange'.

And how about software? Will computer software go the same pirating way as video tapes? There seems no reason why not while there is tainted money to be made. No, I'm not advocating the practice, just observing what could go wrong. The very prospect is terrifying the whole legitimate industry.

A possible countermeasure is the recent adoption by Japanese manufacturers of a common standard for both hardware and software for personal computers. Thus, any low-priced home computer will take any software. This could reduce prices to a level where it is not worthwhile for the copycats. On the other hand it sharpens up the existing price war to the point where only the strongest can survive. Looks like a re-run of the pocket calculator struggle. Perhaps we should forget the agonies of the manufacturers and concentrate on the benefit to the consumer.

PE LOGIC TUTOR

MICHAEL TOOLEY BA
DAVID WHITFIELD MA MSc CEng MIEE

THE PE Logic Tutor has been designed specifically for use with the series, 'Introduction to Digital Electronics' which commences in this issue of PE. The Logic Tutor provides the user with "hands-on" experience of digital circuits and numerous practical investigations have been included in the text. Furthermore, although primarily designed as a learning aid, the Logic Tutor can be used as a "breadboarding" system in its own right. It is thus eminently suitable for those readers engaged in the design and development of logic circuits. Indeed, it is envisaged that the newcomer will continue to find numerous applications for the Logic Tutor when the series has been completed.

LEARNING AIDS

There are, essentially, two distinct approaches to the problem of providing an effective digital logic learning aid. The first involves a fixed arrangement of logic gates wired permanently to a board with terminals to facilitate links between gates. Such an arrangement is ideal for a beginner but tends to be somewhat inflexible and often fails to reflect the "real-life" characteristics of integrated logic devices. The second approach involves the use of a "breadboard" area into which a wide variety of TTL and CMOS logic integrated circuits may be inserted. Such an arrangement is usually based upon a proprietary breadboarding system and is often lacking in such additional facilities as logic level generators of various types, a means of logic state indication, clocks and a power supply. Some, or all, of these items have to be provided by the user at additional cost and inconvenience.

The PE Logic Tutor combines both approaches; retaining the simplicity of the first method with the flexibility of the second. It is, therefore, adaptable and versatile, and furthermore is completely self-contained, requiring only a power source to be fully operational.

CIRCUIT DESCRIPTION

Logic State Indicators

The circuit diagram of the four logic state indicators is shown in Fig. 1. Each logic state indicator consists of a single npn silicon transistor operated in common emitter mode as a saturated switch. The l.e.d. connected in the collector of the transistor becomes illuminated whenever the transistor is in its conducting ('on') state. R1 and R2 set the input switching threshold and are arranged so that a logic '1' input state is recognised whenever the input voltage exceeds approximately 1·4V. The maximum input current drawn from the circuit under investigation is limited by R1 to below 1mA. Under the saturated condition in which TR1 is operated, R3 determines the 'on' state collector current and thus can be used to adjust the brightness of the l.e.d. Where desired, the value of R3 may be changed to increase or reduce the brightness of the l.e.d. The value specified should provide an adequately bright display under normal conditions of room illumination without excessive drain upon the supply. The minimum recommended value for R3 is 150ohm and, in this condition, the l.e.d.s will be operated with forward currents of approximately 20mA each. De-coupling of switching transients appearing upon the supply rail is provided by C1.

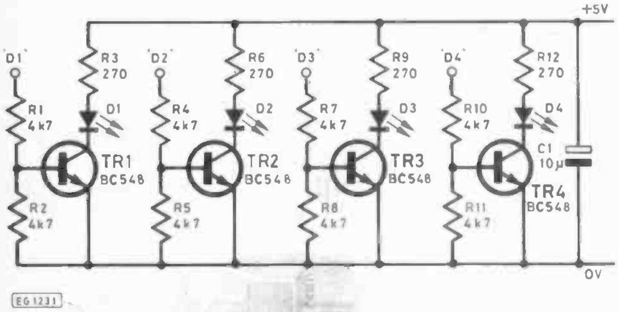


Fig. 1. Circuit diagram of the four logic state indicators

Logic Level Generators

Four switched logic level generators are provided. Two of these are momentary and two provide a latching action. Each switch is fully "debounced" (i.e. momentary switching transients due to contact bounce have been removed by means of appropriate circuitry). The output of each of the four logic level generators is fully TTL compatible in terms of the output voltage levels produced.

The circuit diagram of the two momentary switches, S1 and S2, is shown in Fig. 2. IC1 is a hex inverter (hex simply means that it incorporates six individual and identical logic gates).

Two inverters are used in each of the switch circuits; the first inverter provides the TTL compatible output whilst the second is used to complement the logic state and operate the l.e.d. R13, R14, and C2 perform the signal conditioning and de-bouncing necessary for S1. When S1 is closed, the input of IC1a (pin 1) will be at 0V (logic '0'). Due to the inverting action of IC1a, its output (at pin 2) will be at approximately +3·5V (logic '1'). TTL gates can usually sink very much more current than they can 'source' (this subject will be explained at greater depth in the Introduction to Digital

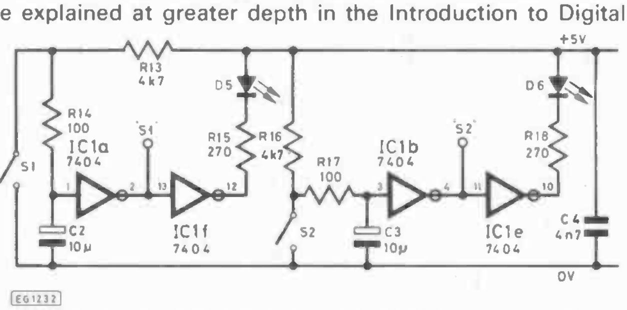


Fig. 2. Circuit diagram of the two momentary action logic level generators

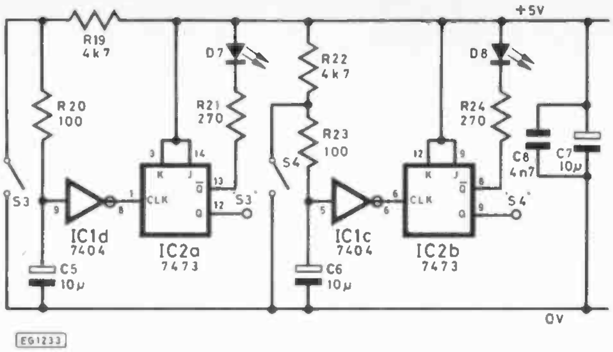


Fig. 3. Circuit diagram of the two latching action logic level generators

Electronics series). The second inverting stage, IC1b, is thus used to further invert the logic state such that the l.e.d. becomes illuminated when its output (at pin 12) is in the logic '0' condition.

The circuit diagram of the two latching action switches, S3 and S4, is shown in Fig. 3. The switch de-bouncing circuitry is the same as that used for the two momentary action switches. The output of the first inverting stage is, however, taken to a bistable stage which "remembers" the logic condition and remains in that condition until the switch is pressed a second time. The i.c. used is a dual J-K bistable (the significance of the term will again be explained in Introduction to Digital Electronics) and it offers two complementary (i.e. logically opposite) outputs which are labelled 'Q' and '$\bar{Q}$'. One of these, the Q output, is used as the TTL compatible output, whilst the second, $\bar{Q}$, output is used to 'sink' current for the l.e.d. indicator for the same reason as before.

Clock

The clock produces a low frequency square wave output at approximately 1Hz. The voltage levels produced by the clock are, again, TTL compatible. The circuit diagram of the clock is shown in Fig. 4. IC3 is a 555 timer connected in astable mode with timing components (R25, R26 and C10) chosen such that the output duty cycle (i.e. ratio of 'on' to 'on' plus

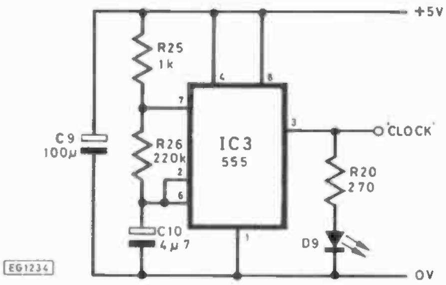


Fig. 4. Circuit diagram of the clock

'off' times) is very nearly 50%. The clock frequency may be increased or decreased simply by changing the values of either R26 or C10. Note that, to preserve the 50% duty cycle, it is essential to use a value for R25 which is very much less than that used for R26. C9 provides supply de-coupling and D9 is used to indicate the logical state of the clock output.

Power Supply

The circuit diagram of the power supply is shown in Fig. 5. The power supply comprises a bridge rectifier, REC1, and a monolithic integrated circuit voltage regulator, IC4. The

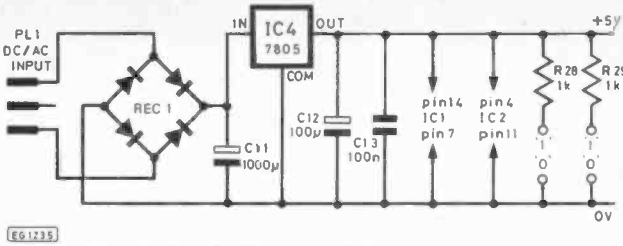


Fig. 5. Circuit diagram of the power supply

bridge rectifier has a dual function. When the Logic Tutor derives its power supply from a d.c. source (such as a 9V battery) the rectifier ensures that the supply polarity is always correct regardless of the actual polarity of the battery connections. When the Logic Tutor is to be operated from an a.c. mains adaptor (consisting of a 240V/6V step-down transformer) the bridge rectifier provides its normal function

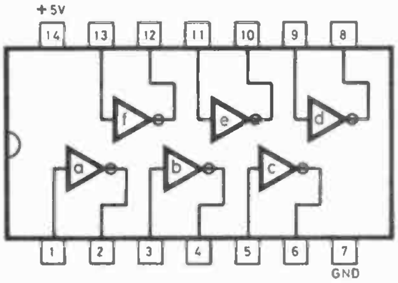


Fig. 6a. Pin configuration for the 7404

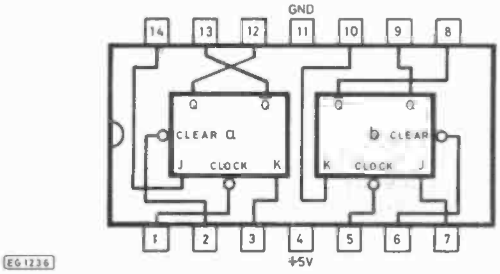
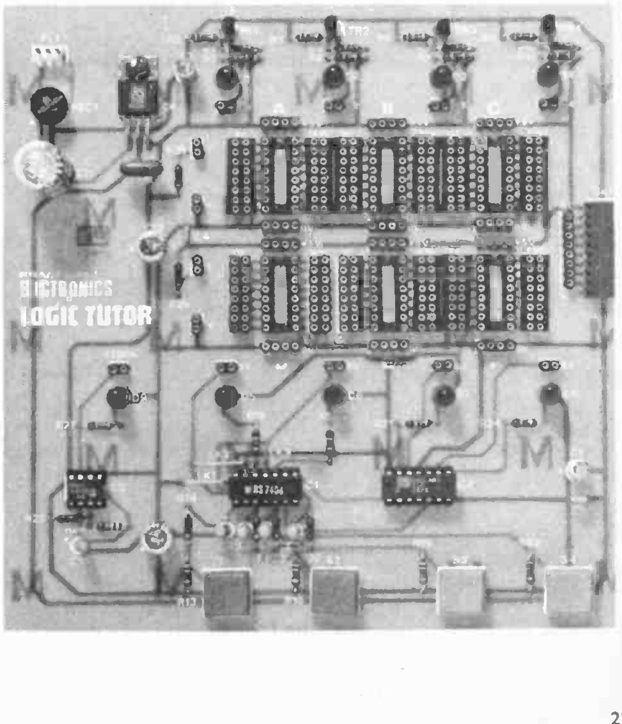


Fig. 6b. Pin configuration for the 7473



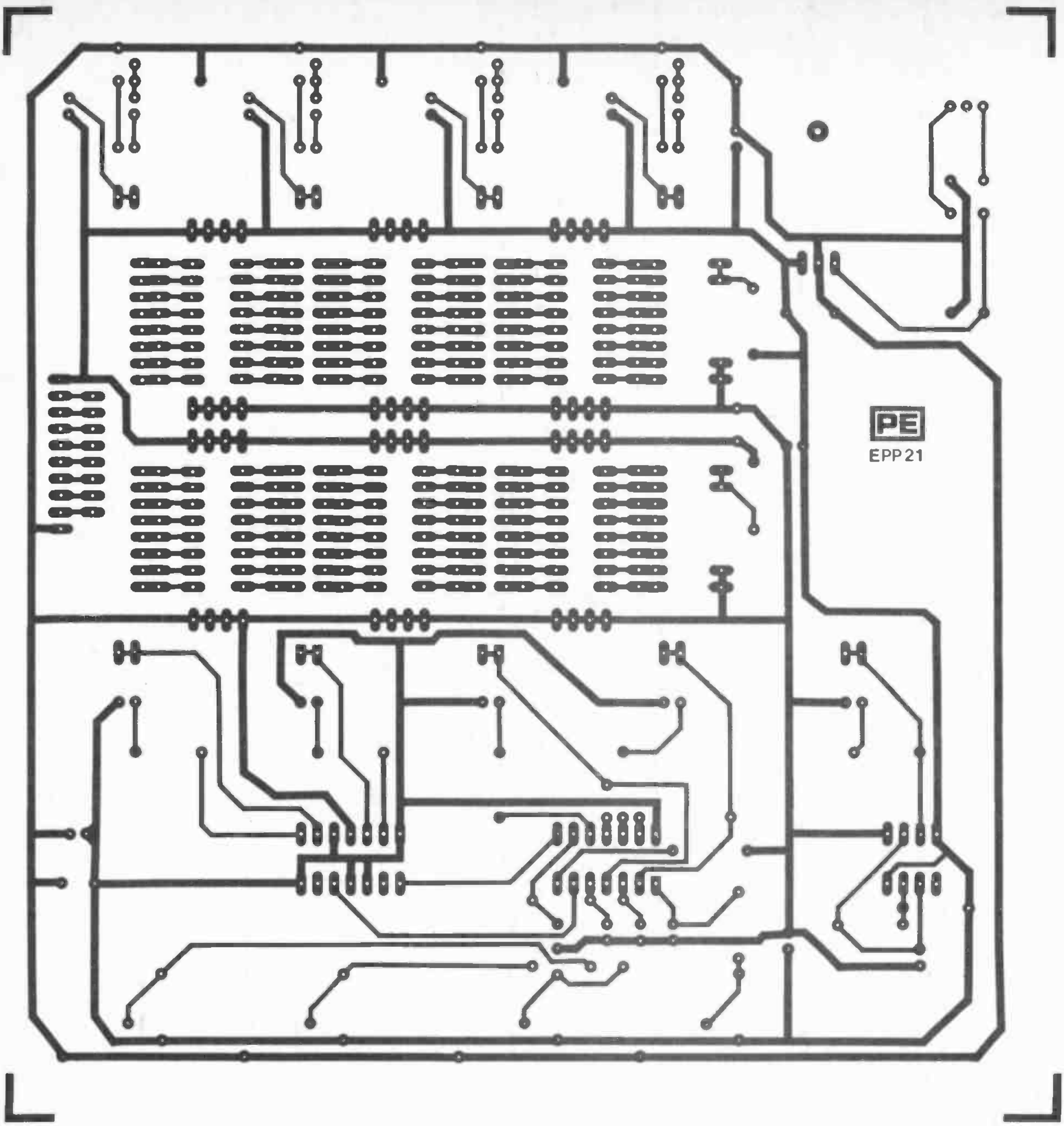


Fig. 7. P.c.b. design for the Logic Tutor board

of rectification and produces a 'raw' d.c. output which is developed across C11. A highly accurate and stable 5V output is produced by IC4. This supply is provided at various points throughout the breadboard area and is also taken to the other integrated circuits, IC1, IC2 and IC3. Two separate contact points are used to provide a logic '1' level. Resistors, R28 and R29, are connected in series with these points in order to limit the available current in the event of an inadvertent short circuit. The maximum current which can be sourced from either of the two logic '1' points being a modest 5mA. Further de-coupling is provided by C12 and C13. It is, incidentally, good practice to include a number of supply rail de-coupling capacitors in a digital logic system. These capacitors can often be instrumental in reducing the unwanted effects of supply borne transients and should always be distributed throughout the area occupied by the digital i.c.s.

CONSTRUCTION

The PE Logic Tutor is built on a single sided printed circuit board measuring approximately 163x172mm. The foil layout for the p.c.b. is shown actual size in Fig. 7 and the corresponding component layout on the top side of the p.c.b. is given in Fig. 8. The p.c.b. is available screen printed such that all components and connecting points are readily identifiable. Components should be fitted to the p.c.b. in the following order; i.c. sockets, connecting strip, connectors, resistors, capacitors, bridge rectifier, l.e.d.s, transistors and regulator. Care should be taken to correctly locate components prior to soldering them into place. Furthermore, it is particularly important to check the polarised components such as electrolytic capacitors, l.e.d.s and transistors.

The long term success of the Logic Tutor depends largely upon the ease with which reliable links can be made within

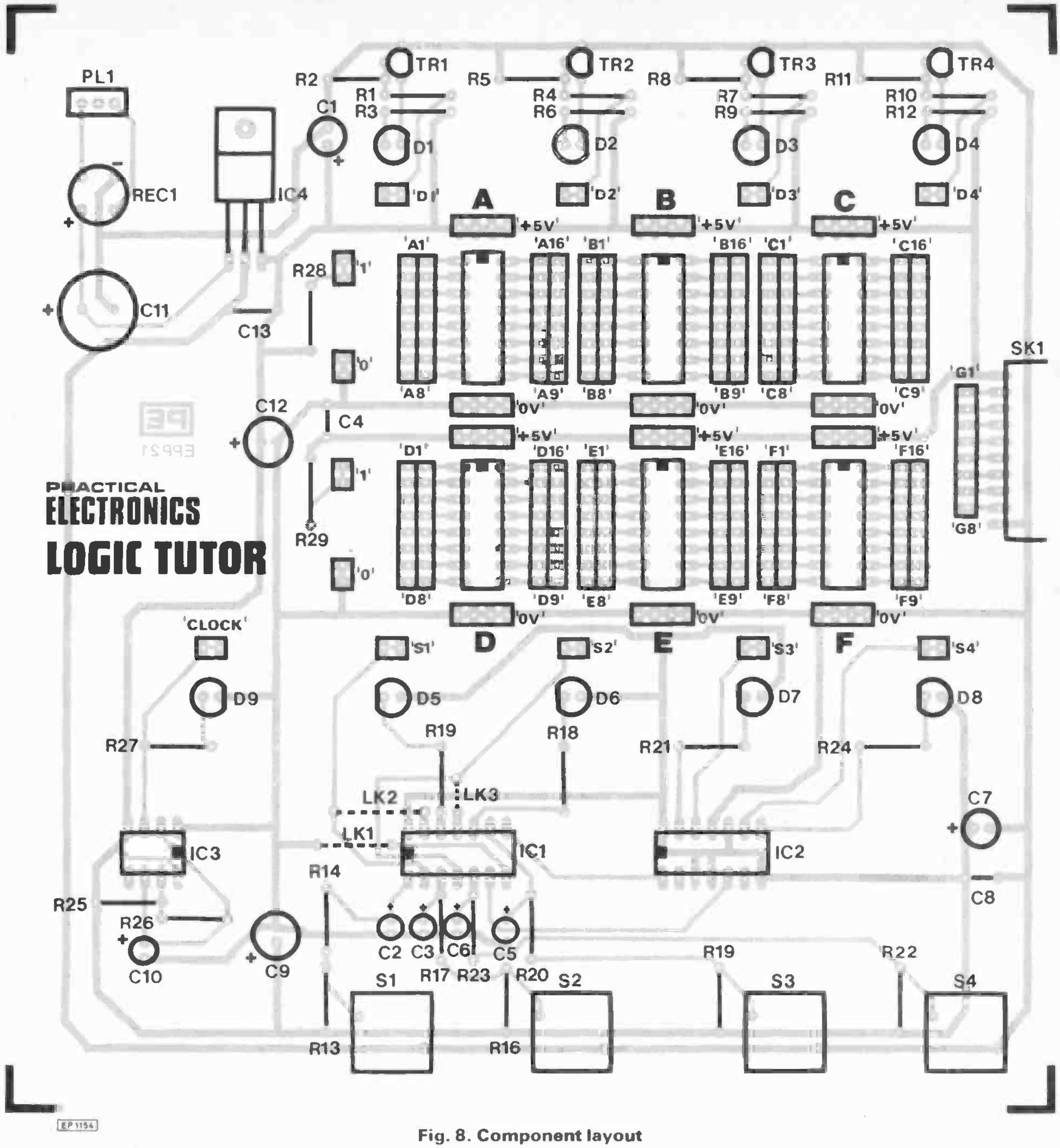


Fig. 8. Component layout

the breadboard area. It is, therefore, essential to use high quality connecting strip and i.c. sockets. The socket strip is supplied in 20-way lengths. These may be easily cut to produce any desired number of ways. The sockets themselves will accept connecting wires, or component leads, having diameters in the range 0·4 to 0·6mm. The sockets are of two-part machined construction with a four finger contact arrangement made from beryllium copper, gold plated over nickel. Such a high quality of construction does, unfortunately, carry a penalty! The i.c. sockets, and connecting strip, are relatively expensive, however it is felt that this is not too high a price to pay for reliability and ease of use.

When construction has been completed, carefully check the underside of the p.c.b. for dry joints and solder splashes between adjacent tracks. Finally, insert the integrated circuits into their respective holders taking care to observe the correct orientation of each device. Assembly is now complete and the Logic Tutor is ready for initial testing.

INITIAL TESTS

The following items of equipment are required in order to confirm that the Logic Tutor is fully functional:—

(1) d.c. multi-range meter of 10kohm/volt minimum

(2) regulated d.c. power supply

The power supply should preferably incorporate some form of short-circuit protection. If such a supply is not available, then a fuse of 500mA rating should be incorporated in the positive supply lead to offer a measure of protection in the event of an inadvertent short-circuit across the supply rails. Similarly, if a d.c. supply is unobtainable, then either a 9V dry battery (such as a PP9 or similar capable of delivering a

COMPONENTS . . .

Resistors

R1, R2, R4, R5, R7, R8, R10, R11, R13, R16, R19, R22	4k7 (12 off)
R3, R6, R9, R12, R15, R18, R21, R24, R27	270 (9 off)
R14, R17, R20, R23	100 (4 off)
R25, R28, R29	1k (3 off)
R26	220k

All resistors $\frac{1}{4}$W 5% carbon

Capacitors

C1, C2, C3, C5, C6, C7	10µ 16V p.c. elect. (6 off)
C4, C8	4n7 ceramic (2 off)
C9, C12	100µ 16V p.c. elect. (2 off)
C10	4µ7 35V tant
C11	1000µ 16V p.c. elect.
C13	100n polyester

Semiconductors

D1 to D9	red 0·2in l.e.d. (9 off)
TR1, TR2, TR3, TR4	BC548 (4 off)
IC1	7404
IC2	7473
IC3	555
IC4	7805
REC 1	50V 1A bridge rectifier

Miscellaneous

1 x 8-pin, 2 x 14-pin low profile d.i.l. sockets
6 x 16-pin high quality d.i.l. sockets (see text)
0·1" connector strip (appx. 15 x 20-way strips)
1 x 3-way 0·1" connector, 1 x 10-way 0·1" 90-degree connector
4 x miniature s.p.s.t. p.c.b. switches
Printed circuit board
Mains adaptor incorporating 6V 3VA transformer
Five stick-on rubber feet (for the rear of the p.c.b.)

load current of up to 100mA) or the recommended mains adaptor may be brought into service. In either case, however, it is essential to check for short circuits and correct orientation of the bridge rectifier *before* connecting the supply.

Set the d.c. supply to give an input of 12V d.c. and connect the meter in series with the positive supply lead in order to measure the supply current. Switch the supply 'on' and check that the supply current is in the range 30mA to 90mA. If the supply current is greatly in excess of 90mA, or the overload protection in the power supply operates, or the in-line fuse blows, then check for incorrectly located components and short circuits on the underside of the p.c.b. If the supply current is very much less than 30mA, or zero, then similarly check for incorrectly located components, open circuit connectors and dry joints. Assuming that the supply current is in the correct range, the next stage is to check the output voltage from the regulator. This is easily done by connecting the meter, on the 10V d.c. range, across the rails marked '+5V' and '0V'. The reading should be in the range 4·5V to 5·5V. If this is not the case, check the regulator and associated components.

Having established that the nominal 5V supply rail is correct, the next step is to check the low frequency clock. D5 should be flashing 'on' and 'off' at a rate of approximately one flash per second. If this is not the case then check IC3 and associated components. The logic level generators, S1 to S4, should now be checked. D6 and D7 should become illuminated when S1 and S2 respectively are depressed. The l.e.d.s should become extinguished when the switches are released, thus demonstrating the 'momentary' action of these switches. Depending upon the initial conditions, D8 and/or D9 may be illuminated. Depressing S3 and S4 should, however, change the state of D8 and D9 respectively. These l.e.d.s will remain in the illuminated or extinguished state until the appropriate switch is depressed again, thus demonstrating the 'latching' action of these switches. If the action of any of the switches is suspect, check IC1, IC2, and associated components. It is also worth checking that the l.e.d.s have been fitted with the correct polarity!

Finally, the logic state indicators should be tested. This is very simply accomplished by feeding a logic '1' (obtainable from the appropriate connecting point marked on the p.c.b.) to the input of each indicator, D1 to D4, in turn. In each case, the appropriate l.e.d. should become illuminated. If this is not the case check the polarity of the l.e.d., transistor, and associated components. This completes the construction and testing of the Logic Tutor. If desired, the protected d.c. power supply may be replaced with the recommended 6V/3VA a.c. mains adaptor. Details of the first practical investigation using the Logic Tutor will be found in Introduction to Digital Electronics elsewhere in this issue of PE. ★

LOGIC TUTOR BOARD KITS

Complete kits for the Logic Tutor are available from the following suppliers:

Howard Associates, 59 Oatlands Avenue, Weybridge, Surrey KT13 9SU (0932 42376)
Riscomp Limited, Electronic Component Distributors, 21 Duke Street, Princes Risborough, Bucks HP17 0AT (084 44 6326)
TK Electronics, 11 Boston Road, London W7 3SJ (01-579 2842)
Magenta Electronics Ltd., 135 Hunter St., Burton-on-Trent, Staffs DE14 2ST (0283 65435)
G. D. & P. Cowan Services, 9 Harcourt Terrace, Headington, Oxford (0865 60741)
Electronics World, 1C Dews Road, Salisbury SP2 7SN
Microstate Ltd., 5 Northfield Close, Fernhill Heath, Worcester WR3 7XB (0905 56322)
Bi-Pak, PO Box 6, Ware, Herts (0920 3182)

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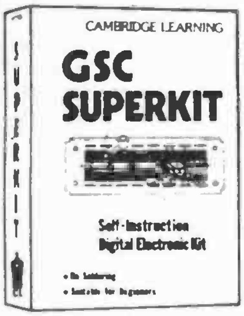

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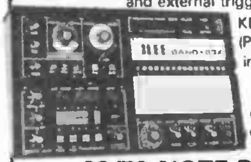

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LET it be known that there's nothing wrong with the Church's eyesight. Hot on the heels of my plea in an earlier issue of PE for our spiritual leaders to employ the bountiful blessings of electronic technology, comes news of a positive and encouraging response.

A church computer-users' group, with no less than 200 ministers of all denominations on its membership roll, is using computers to manage parish accounts and, among other functions, maintain records of its church's members. The Rev. Peter Goodlad, minister of the United Free Church at Seven Kings, Essex, is even harnessing video games to teach the old Bible stories. He's kicked off by reconstructing the rebuilding of the walls of Jerusalem by that pioneer of property development, Nehemiah. Mr. Goodlad is obviously a canny cleric, for he's fixed it so that Nehemiah always wins.

The idea is an inspired one. The colourful and enduring Bible tales lend themselves admirably to modern technological interpretation. But where does the good Mr. G. go from here?

May I suggest he casts a computerised eye at that notable encounter between David and Goliath. All kinds of angles could be brought in: weather, wind velocity, the weight and trajectory of David's projectile and so on. All good stuff.

The opening of the Red Sea would make another excellent subject. Among the various considerations here would be the likely effect of tidal variations and the danger of the odd bore (the kind they get down on the Severn, not the type you so often find getting into Parliament) turning up and altering the whole course of Hebrew history.

And what about the feeding of the 5,000? Leave the compilation of this game to a mixed bag of statisticians and bright young management trainees from Trust House Forte, and they'd probably be able to show, computerwise, they could have met double the catering requirement with half the materials, but plus VAT. The same may go for the changing of water into wine in Canaan.

Mr. Goodlad, you're still on the fringe.

★ ★ ★

We kids used to think my gran's doctor was about 100 years old. Gran herself used to reckon that he qualified around the time that Lord Lister—father of antisepsis—was sloshing the old carbolic around and turning major surgery from a likely death sentence into a sporting chance.

Dr. B. (I never found out his real name) wore a top hat and frock coat and carried a Gladstone bag. We firmly believed it contained babies. He was a traditionalist and even if electrical and electronic devices had been available then, he would have scorned them. Instead he stuck to standard remedies like purgatives, gaily-coloured tonics (which did wonders for the mind if nothing for the body) and evil-tasting expectorants. Ugly rumour had it that he even bred his own leeches in the scullery. When he died, a golden age died with him.

Mum's doctor was a different draught of syrup of figs. He was young and therefore, in the eyes of senior patients, not be trusted. He was also daft enough to adopt the scientific approach. Putting on his best bedside face, he'd first observe, then question and finally examine. This was foreign to the old hands. Dr. B. just used to look. He *knew* what was wrong with you. But my mother's doctor was a real progressive. He favoured X-rays both for diagnosis and therapy, infrared radiation for muscular ailments, ultraviolet for skin conditions and—though it was mentioned only in hushed whispers—electric shock treatment for mental disorders.

My doctor is a man of compromise. He is always prepared to prescribe ready-made medicines—selecting the latest from the manufacturers' catalogues like a gourmet choosing a celebration dinner. At the same time he's ever eager, indeed rabid, to call in such high-tech facilities as body-scanning, electrocardiography, encephalography, deep X-ray therapy, electron microscopy, laser techniques . . . the lot. Indeed, his attachment to these things is such that he didn't speak to his wife for a week when she presented him with a birthday gift of a knitted jumper instead of the electronic stethoscope he'd set his heart on.

But whatever their failings and foibles, these three brothers of the Hippocratic order were at least tangible. You could communicate with them on human terms. They had a ready supply of sympathy, understanding and reassurance. And they offered it in the kind of language you could understand. They were *people*.

This is why I get a touch of wind round the heart when I read the forecasts, by those who profess to know, about the way medicine is likely to go in the not-so-far-off future.

We all know today's pattern. You phone for an appointment, toddle along to the surgery, thumb through a vintage copy of Woman's Own or Menswear, enter the Presence when the buzzer buzzes, pour your heart out and then leave, bearing a slip of paper which is your passport to a return to health and vigour.

All that's going to change, say the pundits.

True, you'll still have to phone for an appointment, the date and time being determined by an electronically-controlled availability schedule. There will be no jolly mags to read while you're waiting (although, thanks to automated patient-traffic control, you won't have to). All you're going to have are uplifting works like Nature and New Scientist. And you can bet your last barbiturate they'll be current issues.

The most horrific change will be apparent when you sit before he who used to assure you that cremation wasn't around the corner and a couple of these three times a day would soon put you right. There will be no light preliminary chat about Arsenal's chances for the Cup or the price of fish. It will be straight down to business if your GP is to complete his quota as laid down by Those Above.

Fingers poised above his terminal keyboard, he will request you (in clipped Daleksque tones, I wouldn't wonder) to recite your symptons, which will be fed into a computer standing where the examination couch used to be. A short pause, and an allegedly infallible diagnosis will appear on the read-out (with increasing sophistication you might get the treatment as well). Mind you, things won't always be as straightforward. If the system's down you could sit there all night.

Apart from its total lack of soul, this frightening way of life—or, if the computer happens to be in a bad mood of unreliability—death, the system is highly-prone to the consequences of human error. Both on your part and that of the medico.

You may go along to your doctor feeling a bit under the weather, but perhaps unsure and not too explicit about the actual symptoms. Here lurks horror. One inaccuracy, one slip of the tongue, one ambiguity might spell the difference between a course of pep pills and a frontal lobotomy.

On the other hand your GP (who underneath is as mortal as you) may have been celebrating his latest pay rise the night before and be experiencing inescapable remorse in the form of the unsteady hand. Terminal buttons aren't all that big. Even total abstainers have been known to stab the wrong one. You know what I mean.

There is but one way to avoid this impending Armageddon. It can be expressed in seven simple words.

Come back Dr. B. We need you.

★ ★ ★

A few years back, until the cold wind of austerity began to blow up the commercial trouser leg, Mullard, the UK's biggest electronic components company, provided a unique educational service. It offered, sometimes free, sometimes at nominal cost, a vast range of aids for the teaching of electronics in schools, colleges and technical training centres. Its passing was universally mourned, though those who never heard the sad news still write in asking for help.

It was therefore heartening when in 1982 Mullard made a modest return to the educational field by sponsoring—jointly with PE's sister-journal Everyday Electronics—a Schools Electronic Design Award Competition (SEDAC). It was a huge success and was repeated this year. The standard of entries—and the level of knowledge and innovation displayed—surpassed even that of 1982. In fact two of the judging panel, Andy Beer and Terry Giles, both top Mullard IC men, are said to be fearing for the future of their jobs!

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DUAL SLOPE CONVERSION

Fig. 2 shows a successive integration waveform. To understand this it is first necessary to appreciate how a normal dual slope converter works. The simplest form consists only of an integrator, into which either the unknown input voltage or a known reference voltage can be switched, a comparator, a continuously running counter, and some simple logic. Starting with the integrator output at zero, the unknown signal is applied to the integrator for a fixed number of clock periods (determined by the counter). The integrator output will ramp away from zero at a rate directly proportional to the input voltage, and at the end of the integrate period will have reached a voltage directly proportional to the input voltage and the integration period, but inversely proportional to the integrator R-C time constant. Next, the reference voltage (which must be of opposite polarity to the unknown) is applied, causing the integrator to ramp linearly back towards zero. The time taken to reach zero will be directly proportional to the starting voltage, but inversely proportional to the reference voltage and the R-C time constant. The point at which the ramp returns to zero is detected by the comparator, and the logic registers the number of counts (i.e. the time) taken. It should by now be clear that this is proportional to the ratio of unknown and reference voltages, and is independent of the R-C time constant and of the frequency at which the counter is clocked. This digital count is the required output.

SUCCESSIVE INTEGRATION

The integrate and DE1 phases shown in Fig. 2 are therefore the classical dual slope waveform. In practice, however, it is necessary in all dual slope converters to detect the zero crossing synchronously with the clock, to overcome the effects of clock noise on the integrator output. Zero crossing is therefore not actually detected until the next clock edge after zero crossing occurs, and by this time the integrator will have overshot zero by an amount proportional to the fraction of a count by which the input value exceeds the registered result. The ICL7129 cunningly uses this fact to increase its accuracy. The DE1 phase gives a digital result essentially accurate to 3½ digits, then the residual integrator voltage is multiplied by −10, and de-integrated a second time. Now the accuracy has increased to 4½ digits. The residual is once again multiplied and de-integrated to yield a final resolution of 5½ digits.

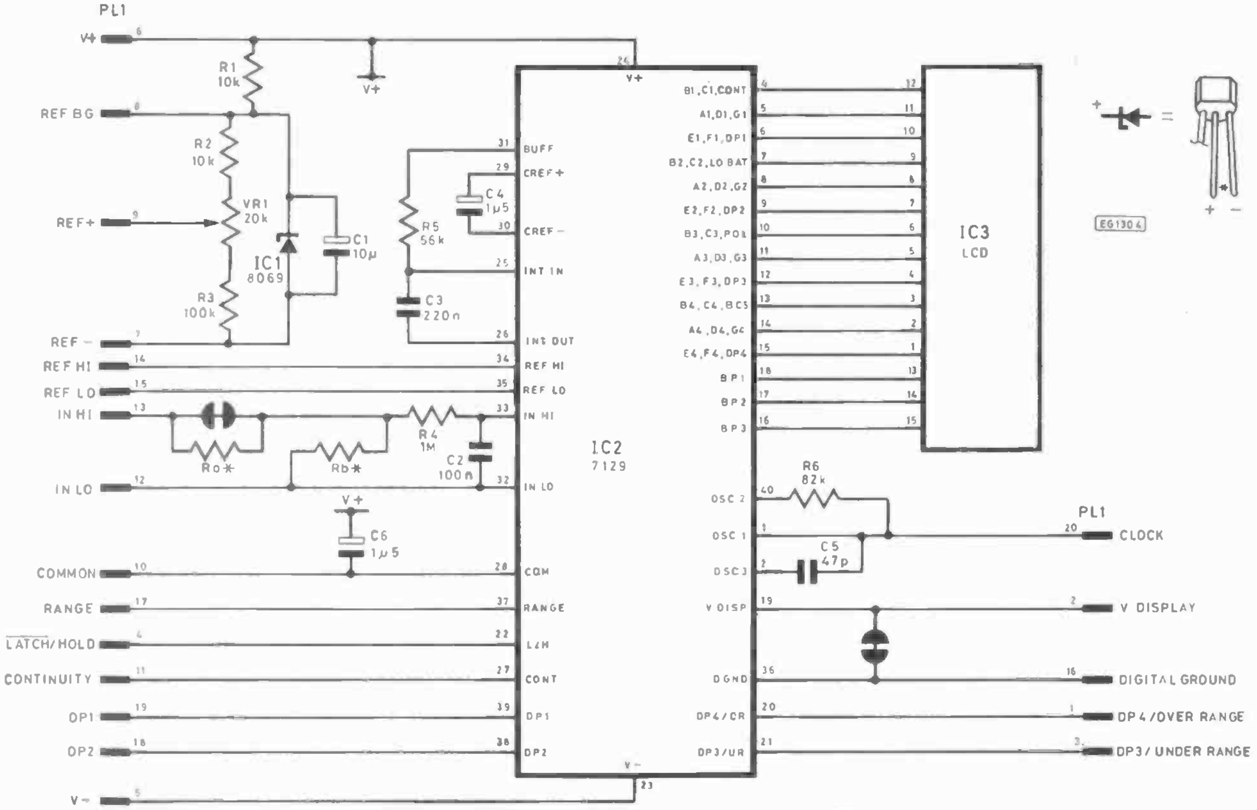
To make a complete conversion, the ICL7129 repeats this cycle twice—once using the unknown input voltage and once with zero input. The difference of these results then gives a final result free of any zero errors, so the offset voltages of amplifiers and comparators on the chip don't matter. Because the internal resolution is ten times the displayed resolution, auto zeroing is good to one tenth of a displayed increment. A further refinement is that, by increasing the integrate period by a factor of ten, the chip can switch from 2 volts full scale to 200mV full scale (corresponding to 10 microvolts resolution) with no other circuit changes. A digital range input controls this facility.

Another novel feature of the ICL7129 is its direct drive to a three way multiplexed LCD. Multiplexing is necessary to keep a reasonable pin count. Because of the unusual drive waveforms, it is difficult to use external drivers for extra annunciators and decimal points. The ICL7129 therefore provides on chip decimal point drivers for four decimal points and two annunciators. The continuity annunciator indicates when the input voltage falls below approximately 0·6 volts and is useful for quick continuity checking, while the low battery annunciator warns that the battery voltage has fallen to approximately 7·2 volts. Continuity can be user disabled. Finally, an annunciator drive waveform is provided which is guaranteed to turn on any annunciator connected to it regardless of its backplane. This will most commonly be used for range or function flags.

The analogue part of the chip also features fully differential input and reference, allowing easy implementation of

SPECIFICATION

Input Impedance	>100M
Full Scale Reading	199·99mV
Accuracy	0·01% of reading ±1 digit.
Power Supply	6-14 V dc
Power Supply Current	2mA max.
Sample Rate	1·6 reading per sec.
Over Range Warning	M.S.B.=1 other digits blank
Temperature Range	0–35°C
Temperature Stability	50ppm/°C typical
Digit Height	10mm
Low Battery Warning	6·3 to 7·7 volts
Continuity Detector threshold	100 to 400mV
Overall Dimensions	72 x 36 x 27mm
Panel Cut Out	68 x 33mm



EG1309 **Fig. 1. Circuit of Panel Meter. The pin-out of IC1 is shown top right**

LINK (EASILY CUT FOR ALTERNATIVE DESIGN OPTIONS)

* OPTIONAL INPUT SCALING COMPONENTS

ratiometric resistance measurement and simplicity of use with bridge connected sensors or transducers. Input noise voltage is only 7 microvolts peak to peak, giving steady displays even at 10 microvolts resolution, while input bias current is 10 picoamps maximum at 25°C. On the digital side, control inputs include range change and run/hold control. Digital output signals indicate continuity, over-range, and under-range (i.e. less than 5% of full scale), allowing easy integration into autoranging DVMs.

Because of its combination of facilities, the ICL7129 is therefore equally at home as a stand alone DVM chip or as the heart of a sophisticated, auto ranging multimeter.

CIRCUIT

The ICL7129 has the unique feature of a range input. This is a digital input which if left unconnected, or held to DGND, will give a 200mV full scale meter. By taking the input high (to V+) the time for which the capacitor is charged will be reduced by a factor of 10 and thus give a 2V full scale meter.

Referring to Fig. 1, C3 is the integrator capacitor and R5 the integrator resistor. It should be noted that C3 is polypropylene as it must have a very low dielectric loss in order not to give the meter poor linearity. C4 is used to hold the reference voltage during the de-integrate phase of the converter cycle.

IC1 is a bandgap voltage reference which has a low temperature coefficient. The voltage is divided by R2-3 to form the required 1V reference voltage. The equation for a reading is given as:

200mV f.s.d. $\quad \text{Reading} = 10^5 \; V_{in}/V_{ref}$

2V f.s.d. $\quad \text{Reading} = 10^4 \; V_{in}/V_{ref}$

COMPONENTS

Resistors

R1	10k	5%
R2	10k	1%
R3	100k	1%
R4	1M	5%
R5	56k	5%
R6	82k	5%

All $\frac{1}{8}$W metal film

Potentiometers

VR1	20k	multiturn

Capacitors

C1	10µ	elect 16V
C2	100n	polycarbonate 63V
C3	220n	polypropylene 160V
C4	1·5µ	tantalum 35V
C5	47p	polystyrene
C6	1·5µ	tantalum 35V

Integrated Circuits

IC1	ICL 8069 DCA
IC2	ICL 7129 CPL
IC3	Lucid L.U.I 1179/121F (4½ digit triplex)

Miscellaneous

PCB—Display edge connector (2 off), plug—(2 off) socket—(2 off), bezel, bezel mounting clips—(2 off), bezel mounting screws—(6 off)

A kit of parts is available from **Lascar Electronics Ltd., Module House, Whiteparish, Salisbury, Wilts, SP5 2SJ.** (Tel. 07948 567) at a price of £29.95 including p&p and VAT.

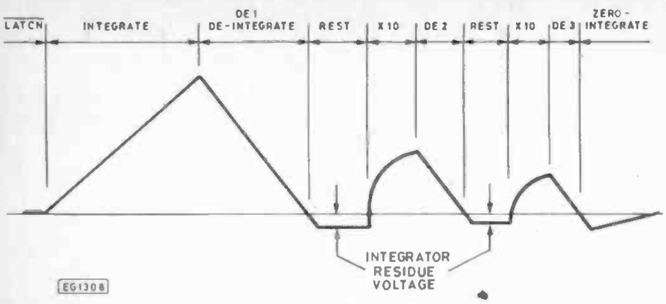


Fig. 2. Integrator waveform for negative input voltage showing successive integration phases and residue voltages

Ra and Rb are optional extra resistors which can form a potential divider if greater than 2V f.s.d.s are required.

Rb should be added on its own if the instrument is required to measure current.

Required F.S.D.	Range input	Ra	Rb
2V	HI	—	—
20V	HI	9M1*	1M
200V	HI	10M*	100k
2kV	HI	10M*	10k
200μA	LO (o/c)	—	1k
2mA	LO (o/c)	—	100R
20mA	LO (o/c)	—	10R
200mA	LO (o/c)	—	1R

***Ensure PCB link across Ra is cut**

R4 and C2 form an input smoothing filter and R6 and C5 form the oscillator time constant. The oscillator runs at about 100kHz.

ANALOGUE INPUTS

IN HI, IN LO, REF HI and REF LO (pins 13, 12, 14, 15) are true differential inputs. That is to say that they respond to the voltage across them and not their voltage with respect to the power supply. There is a limit to this however, known as the common mode range. Any input can be no greater than (V+) −0·5V and no less than (V−) +1·5V. It is recommended, however, that for best performance the inputs are kept well within the common mode range. The ideal situation is to connect both IN LO and REF LO to COM (pin 10). Common is actively held at approximately 3·2V below V+. The COM pin can sink up to 2mA but can only source 20μA.

By far the biggest problem encountered by users is failing to appreciate the limitation imposed by the common mode range. A typical example is a user connecting IN LO to V−. Doing that will give very odd results!

DIGITAL SECTION

Digital ground (DGND) is held at between 4·5 and 6 volts below V+. This is the supply voltage for the digital section including the display drivers. If CMOS logic is used to provide or decode DPM60 digital signals, then it can be powered from V+ and DGND up to a maximum of 1mA. For greater power it will need to be buffered.

DISPLAY FORMAT

The ICL7129 is designed to drive a triplexed liquid crystal display. This type of display has three backplanes and is driven in a multiplexed format. The actual display is shown in Fig. 3. Notice that the polarity sign, decimal points, low battery and continuity annunciators are directly driven by the i.c. The individual segments and annunciators are addressed in a manner similar to row-column addressing. Each backplane (row) is connected to one-third of the total number of segments. BP1 has all F, A and B segments of the four least significant digits. BP2 has all the C, E and G segments. BP3 has all D segments, decimal points and annunciators. The segment lines (columns) are connected in groups of three, bringing all segments of the display out on just 12 lines.

MODULE FEATURES

The ICL7129 has a large number of features which make it very useful in such applications as auto-ranging digital multimeters. Note that 'Hi' means V+(6) and 'Lo' means DGND(16). Four of the pins are input/outputs featuring 'weak' outputs. Referring to Fig. 4, the output is connected to the input internally via a resistor. Thus to use it as an input, the 'output' is easily and safely overridden. In order to obtain the output data, the pin must be connected to a high impedance input.

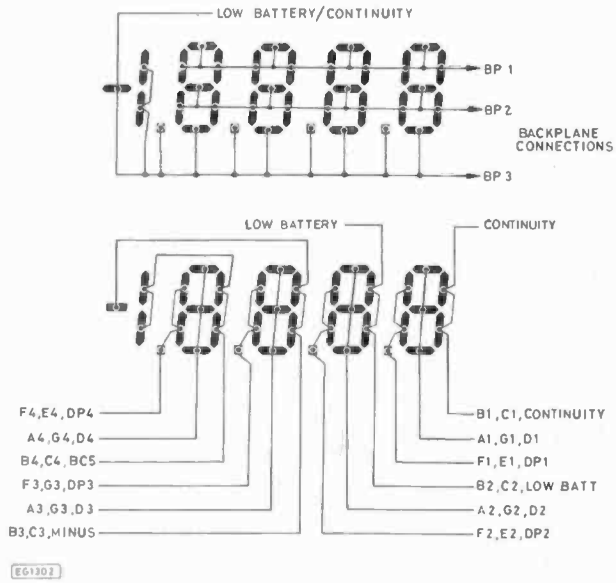


Fig. 3. Triplexed liquid crystal display layout for ICL7129

CONTINUITY (11)
If the converter input voltage drops below a nominal 230mV, then the continuity annunciator will be shown and the output will be high. This feature is very useful because it is much faster than the converter and can give an instant continuity signal in meters requiring this feature. The output can be used to trigger an audible continuity alarm, To disable the continuity indicator, pin 11 should be held Lo.

$\overline{\text{LATCH}}$/HOLD (4)
Input: When floating, the converter operates in the free-run (normal) mode. When pulled Hi, the last displayed reading is held. When held Lo, the result of the counter contents are shown incrementing during the de-integrate phase of the cycle.
Output: A negative pulse occurs when the data in the display latches is updated. It can be used as a convertor status signal.

DP4/OVER RANGE (1)
Input: When pulled Hi the left-hand decimal point will be shown. If DP4 is not to be used, connect it Lo.
Output: The output will go Hi if the result exceeds ±19999. This can be used to initiate an autoranging facility.
Note: If DP4 is to be shown and the O/R signal is to be sensed at the same time, then Pin (1) should be used as an input under normal conditions except during $\overline{\text{latch}}$/hold output when the O/R flag should be sensed.

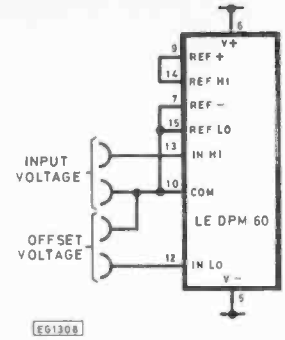


Fig. 11. If a zero display is required when the applied input is not zero volts the offset voltage should be connected between IN LO and COM, while the input voltage is connected between COM and IN HI

edge connector for extra anchorage. The fitting of the edge connector is shown in Fig. 8. The lower edge of the display is identified by the fact that it has metallised glass connectors. The upper edge has no connection.

Carefully place the LCD on the board over IC2. Ensure that it is level and in contact with IC2 but not pressed hard against it then solder in place.

The board is now complete but before applying power, ensure that all solder connections have been made and that all component leads are cropped close to the board.

To calibrate wire up the two sockets to give the module connections shown in Fig. 9. Apply a known voltage to the input (e.g. 100mV) and adjust R3 to give a reading of 10000.

BAZAAR

MON 02 for UK101 computer wanted. Good price, as new. Hans-Petter Naas, 2450 Rena, Norway.

KAY 6 string guitar built-in effects. Include fuzz, echo, tremolo etc. £150 unwanted present. Neil Taylor, 4 Bereckeley Close, Hyde, Cheshire. Tel: 368 2168.

UK101 8K, Cegmon, cased, 300/600 Baud, lots of software and information £90 o.n.o. D. Callender, 17 Badger Way, Banbury, Oxon OX16 9UD. Tel: Banbury 53475.

DYNAMCO manual etc. needed for 'scope units 7103 (sweep), 7130 (display), 7118 (input). Borrow or buy. K. J. Preston, 10 Stream Farm Close, Lower Bourne, Farnham, Surrey GU10 3PD. Tel: Farnham 725764.

WANTED Mullard f.m. tuner module LP 1186 in good working condition. Mr. L.J. Channing, 8 Brymore Close, Bridgwater, Somerset TA6 7PL.

TANNEX bare board brand new with circuit diagram £15.00. P. Martin, 17 High St., Wyke Regis, Weymouth DT4 9NZ. Tel: 03057 71917.

OVER fifty electronic mags. including many PE and EE good condition £5.00. Buyer collects. Paul Williams, 31 Gainsborough Rd, Warrington, Cheshire WA4 6DA. Phone: 0925/36018.

MARCONI TF1389 nanosecond pulse generator, repetition: 35-350pps and external drive, variable output voltage, amplitude, offers. Nick Powell, 66 Lock St., Abercynon, Mountain Ash, Mid Glam.

SOLDERING iron Weller t.c.p. 24V 45W with bench stand £11. Unused present, needs transformer. Oxford (0865) 779855. Tel: Oxford (0865) 779855.

BELLS 24V 6inch ideal for burglar or fire alarms brand new only 10 available £3 each. Mr. D. Harries, 12 Penk Rise, Tettenhall Wood, Wolverhampton, Staffs. Tel: (0902) 780958.

KSR teletype with paper tape punch and reader working order with manual £65 o.n.o. Dave Davis, 13 Maple Rd, Surbiton, Surrey KT6 4AA. Tel: 01-399 5487.

WANTED manual and circuit diagram for Heath-Kit Laboratory Oscilloscope Model 10 12 U to copy. Good price paid. W.H. Davis, Gate House, Little Barford, St. Neots, Cambs. PE19 4YB. Tel: (0480) 72480.

COMMODORE PR100 Programmable £12. Casio FX31 £8. Holdway, No. 20 Studland Close, Millbrook, Southampton, Hants.

ELECTRONICS nut. Clearing out bedroom. All new, bargain packs value approx. £80 only £10, p.o., cheque. Mr. Driver, 27 Haverhill Rd, Steeple Bumpstead, Haverhill, Suffolk CB9 7DN.

ZX81, leads, manual, 16K, printer, I/O port and software all hardly used £100 o.n.o. Paul Harris, Yew Tree Farm, Pencroesoped, Llanover, Nr Abergavenny, Gwent NP7 9EW. Tel: Nantyderry 880213.

DP3/UNDER RANGE (3)
Input: When pulled Hi the next most left decimal point will be shown. If DP3 is not to be used, connect it Lo.
Output: The output will go Hi if the result is less than ±1000.
Note: If DP3 is to be shown and the U/R signal is to be sensed at the same time, then Pin (3) should be gated with latch/hold as described above.
DP2(18), DP1(19)
These pins have an internal 3μA pull down and need not be connected if the decimal points are not to be shown. To show the point, connect Hi.
RANGE (17)
This pin has an internal 3μA pull down and need not be connected for a 200mV full scale. For 2V full scale connect Hi.
LOW BATTERY (NO PIN)
If the power supply voltage between V+ and V– is less than 7·3V (nominal) then the low battery annunciator will be shown. The feature cannot be overridden.

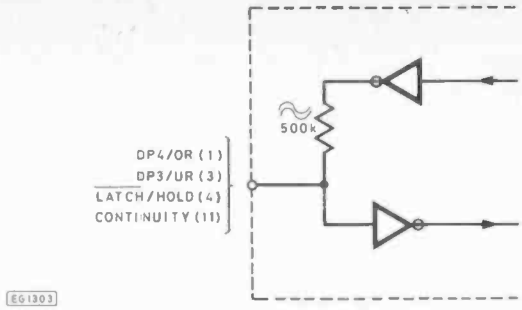


Fig. 4. 'Weak' output

CONSTRUCTION

The p.c.b. supplied is of the double-sided plated through hole type and if a mistake is made in soldering the components in (especially the ICL7129 or the LCD), it can be very difficult to rectify the fault. Avoid using excessive solder and hold the iron on the component for no longer than is necessary. The ICL7129 is a MOS device and although its inputs are protected, antistatic precautions should be taken. The order in which the components are soldered onto the board is important, so do follow the instructions.

All components except C3, VR1 and the plug are inserted on the top of the board. The top is the side marked DPM60/2/B. Because the LCD has to straddle the components on the board, they should be mounted as close as possible to it. Although the board is solder-masked, ensure no solder bridges are allowed to occur.

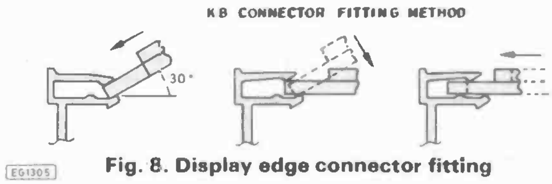


Fig. 8. Display edge connector fitting

1. Assemble all the resistors (except VR1) onto the board and solder in place.
2. Bend and cut the leads of C3 to size, ensuring that when fitted underneath the board, the leads will not protrude more than 0·5mm above the top. Solder C3 in and the other capacitors. Ensure that C1, 4 and 6 are fitted with the correct polarity and that C2, 4 and 6 are fitted flat to the board (see Fig. 7).
3. Fit IC1 ensuring that the correct lead is removed (see Fig. 1). Fit close to the board ensuring correct polarity and solder.
4. Next fit IC2. Ensure that all the leads are correctly spaced and it is correctly orientated before soldering close to the board.
5. Now fit VR1 from underneath the board and solder in place from top of the board.
6. Repeat 5 for the two-part plug, PL1.
7. If you intend to use the DPM60 inside the case then only fit the lower edge connector to the display. For general purpose panel meter applications fit the upper

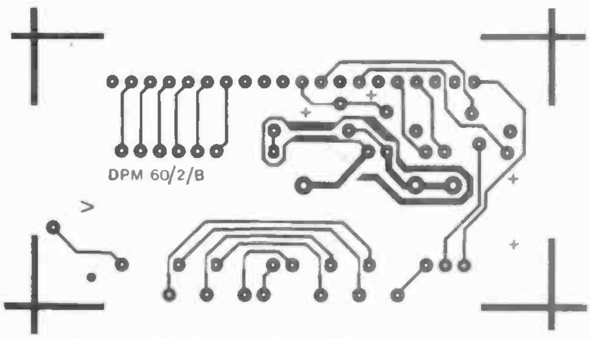


Fig. 5. Topside etching detail

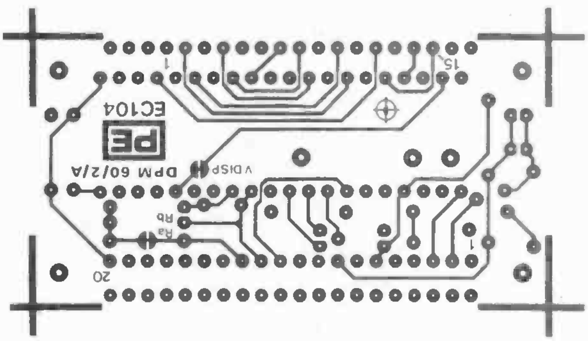


Fig. 6. Underside detail

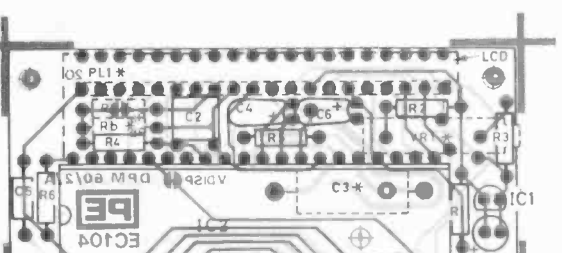


Fig. 7. Track and component layout

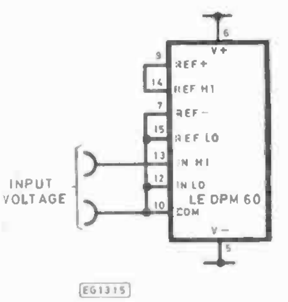


Fig. 9. Module connections for measuring a floating voltage source with 200mV full scale

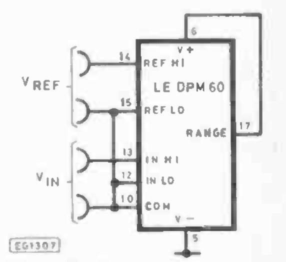


Fig. 10. Basic arrangement for measuring the ratio of two voltages. The display equals 10^4 V_{in}/V_{ref}. Maximum input voltage is ±2V with a 9V supply

SEMICONDUCTOR CIRCUITS

TOM GASKELL B.A.(Hons)

OVERVOLTAGE PROTECTOR (MC 3423)

MOST semiconductor circuitry is very sensitive to excessively high supply voltages. A supply voltage below the rated minimum can cause incorrect functioning of the circuit, but voltages above the rated maximum, whether continuous or transient in nature, will often result in both malfunction and permanent damage. Such an 'overvoltage' condition is usually caused by either a short circuit between one supply rail and another of higher voltage, or by the failure of a voltage regulator, which could then pass high level unregulated voltages directly to the rest of the circuitry. The problem is made especially serious when the main circuit components are particularly expensive. This can cause difficulties for many designers, who as a result may be unwilling to use a power supply of their own design with complex or costly circuitry.

The MC 3423 is an 8 pin i.c. which can give a considerable measure of protection against overvoltage conditions. It monitors the voltage of the power supply continuously, and as soon as the voltage rises above a predetermined level it trips, turning on an external thyristor and causing the supply to current limit, shut down, or blow a fuse, as appropriate. This arrangement of shorting out the power supply is often called crowbar protection. Naturally, it assumes that the supply itself is capable of withstanding such a short circuit.

The pinout and specifications of the device are shown in Fig. 1, and the basic protection circuit is shown in Fig. 2. Note that D1, C1, and R4 are only needed if the positive supply is greater than 36V; they ensure that the positive supply to the i.c. is kept well below its maximum, while still allowing voltages of up to 45V to be used for the main supply. Normally, D1, C1 and R4 are omitted, and pin 1 connects directly to the positive supply. If these components are being used, R4 should be arranged to allow 25mA to flow through it:

$$R4\,(\text{in kilohms}) = \frac{(\text{positive supply voltage})}{25} - 10$$

Pins 2 and 3 are the sense pins, with the potential divider formed by R1 and R2 determining the proportion of the power supply voltage fed to them. This sense voltage is compared with a fixed internal voltage reference of nominally 2·6V. The result of the comparison is used to determine whether or not to fire the thyristor. Hence, the voltage at which the MC 3423 trips is given by:

$$\text{Trip voltage} = 2{\cdot}6\left(\frac{R1 + R2}{R2}\right)$$

For best results, R2 should be kept below 10k. Note that both pin 2 and pin 3 must have reached 2·6V before the thyristor is turned on.

DRIVING THE THYRISTOR

Pin 8 of the i.c. is the output for driving the external thyristor. R3 should be provided to limit the drive current from the i.c.; Fig. 4 shows the minimum value to use, and normally it is wise to stick with the smallest value permissible to ensure fastest turn on of the thyristor. (For supplies in excess of 36V, make R3 a short circuit.) With a low value of R3 the response time of the circuit will be very fast indeed: 0·5μs for the i.c., plus approximately 1μs for the thyristor, and a little for the rise time of the i.c. output current. The total is between 1·5 and 2μs.

The thyristor itself should be chosen with reference to the power supply voltage and current capabilities. Bear in mind not just the regulated supply, but the unregulated supply from which it is derived, since this will be presented to the circuit if the regulator goes short circuit. An unregulated d.c. supply may be capable of supplying a short circuit current of many amps for a few seconds, whereas the regulator may pass only 500mA or 1A typically. The usual arrangement is to provide a suitable fuse prior to the regulator i.c. or circuitry, to reduce the current carrying requirements of the thyristor. The continuous current rating of the thyristor should in any case be

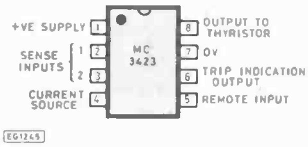


Fig. 1. Overvoltage protector integrated circuit pin-out with its specification below

Characteristic	Notes	Minimum	Typically	Maximum	Units
Supply voltage	All specs measured at +5V supply	4·5		36	V
Monitored voltage	Supply to pin 1 ⩽36V			45	V
Temperature range		0		70	°C
Quiescent current			5		mA
Sense input voltage	Both sense input 1 and 2			6·8	V
Remote input voltage				7·0	V
Output current	Pin 8 (to thyristor)			300	mA
Output voltage	Pin 8		3		V
Internal reference voltage	V_{ref}		2·6		V
Temp. variation of V_{ref}			0·08		%/°C
Current from pin 4	Constant current source		220		μA
Trip indication current			10		mA
Remote input current			100		μA
Time delay	Minimum time, from overvoltage, to driving of thyristor		0·5		μs
Output current rise time			0·4		A/μs

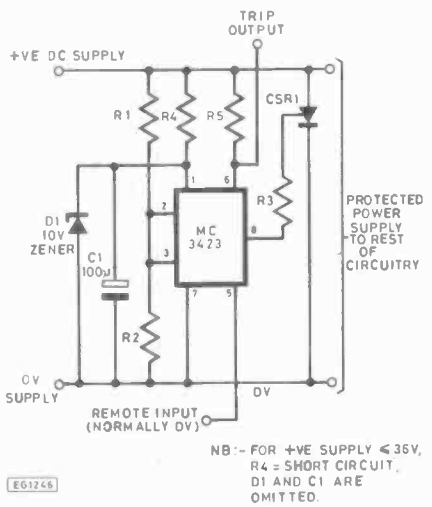


Fig. 2. Basic overvoltage protection circuit

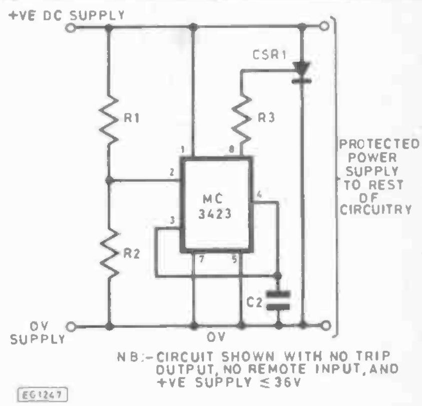


Fig. 3. Circuit to give delay before tripping

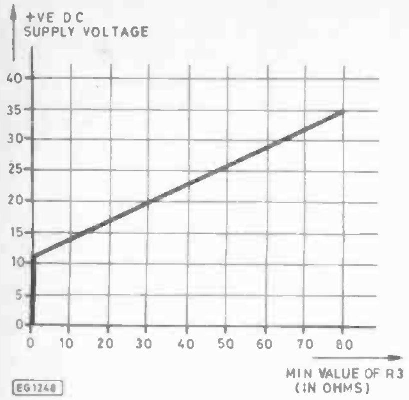


Fig. 4. Graph of minimum value of R3 versus positive supply voltage

considerably higher than the fuse rating and the maximum regulated current. Too low a current capability can result in the thyristor breaking down, overheating, or sometimes even causing false tripping of the overvoltage protection i.c. Adequate heatsinking, of course, should be provided. The whole circuit is reset by turning off the supply for a few seconds, then turning it back on again.

OTHER FACILITIES

Pin 6 provides a trip indication output. This is an open collector output from a transistor, so it needs a load resistor (R5 in Fig. 2) taken up to a positive supply rail to give an output voltage swing. The transistor turns on inside the i.c. (i.e. pin 6 is switched to 0V) when the i.c. detects an overvoltage condition, and turns off again when the thyristor shorts out the supply rail. Hence, under most circumstances, this output is only a pulse of approximately 1µs which will need suitable extra circuitry to indicate the condition or act on it. (Note that it is pointless feeding it into circuitry which is powered from the same protected supply rail). Pin 5 is a remote input which can be used to activate the i.c. and shut down the power supply. Normally this should be held at 0V, but if raised to above 2V or thereabouts it causes the i.c. to trip, even if there is no actual overvoltage condition present.

Pin 4 is a constant current source which can be used in conjunction with an external capacitor (C2) to provide a time delay facility; see Fig. 3 and Fig. 5. In some applications, short duration spikes or noise on the power supply could cause the protection system to operate, yet may not pose any threat of damage to the particular circuitry used in the rest of the system. A suitable time delay can be provided to ensure that the overvoltage condition must last for a fixed period before being acted upon. The constant current source charges up C2 when pin 2 detects an overvoltage condition. If the voltage on C2 reaches 2·6V, the thyristor is turned on, but if the overvoltage condition is removed before the C2 voltage reaches 2·6V, C2 is discharged (at 10 times the charging rate) and the system carries on as normal.

APPLICATIONS CIRCUIT

Fig. 6 shows the circuit diagram of a 5V protected regulator, designed to take an unregulated d.c. supply, and provide a 5V output with overvoltage protection, with a current capability of up to 1A depending on the heatsink provided and the unregulated supply used. The basic regulator circuit is formed by IC2, with C3 and C4 providing decoupling (essential to prevent oscillations) and D2 providing a measure of protection against temporary shorts to negative supply rails. R4 and D3 (which can be any type of l.e.d.) merely give an indication that the supply is operational. R1 and R2 set the trip voltage at approximately 5·8V. (It is wise to leave a few hundred millivolts at least above the nominal regulator voltage to allow for device and component tolerances, noise, etc). R3 is set to 47 ohms, not a short circuit as one may have chosen from Fig. 4, because if IC2 were to go short circuit a much higher voltage could be fed to IC1. With R3 equal to 47 ohms, this unregulated supply can safely be up to 25V d.c. (For other supplies, scale this accordingly).

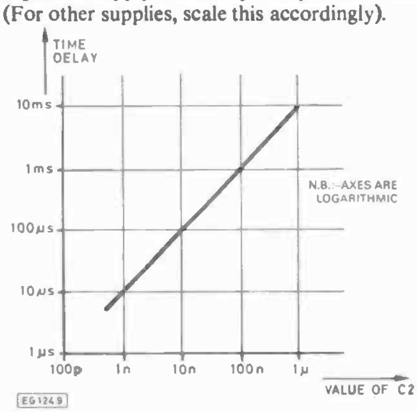


Fig. 5. Graph of value of C2 versus time delay (see Fig. 3)

The thyristor chosen is a 5A type, which in conjunction with a 1A regulator i.c. and a 1A fast blow fuse gives more than enough protection capability. Large, finned heatsinks should be provided, the largest being for IC2 since that might have to pass short circuit currents for quite long periods with high power dissipation, and silicon grease should be used between the semiconductor device and the heatsink surface. Beware of letting the heatsinks or their fixing screws short against anything; IC2's heatsink is connected to 0V via IC2 itself, but TR1's connects to its anode (the positive supply rail) so take care. It may be necessary to open up the Veroboard holes a little with a fine drill to take the large leads of TR1; take care not to cut away all the copper track, and make a good solder joint to these leads.

The unregulated supply used should be chosen to suit IC2, i.e. a minimum voltage under load of 8·5V d.c., at 1A or more, but not too large a voltage or IC2 will dissipate too much power, and the amount of regulated supply current available will be small. (The voltage should, in any case, be kept under 25V off load). The final circuit can be tested by shorting IC2's input to its output, which should shut down the supply and blow the fuse, or by connecting a 9V battery across the 5V supply, which will shut down the supply but probably not blow the fuse. (Connect the battery only momentarily, or via a ½A fuse itself). Try not to let the circuit stay shut down for too long as IC2 will get rather hot. Naturally, all voltages given in this circuit can be scaled to suit different supply voltages as required.

The MC 3423 can be obtained from **Watford Electronics.**

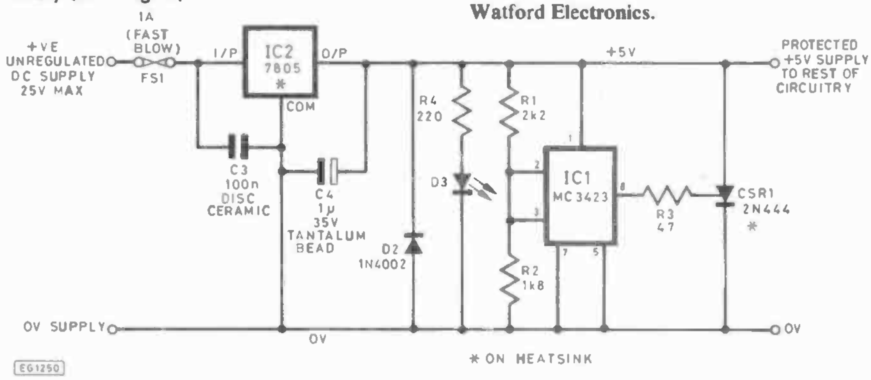


Fig. 6. Circuit of 5 volt protected regulator (D1 and C1 of Fig. 2 are omitted)

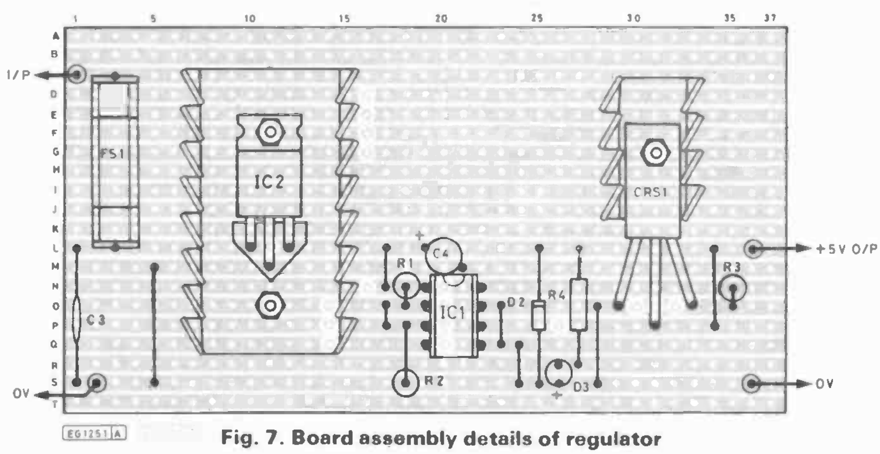
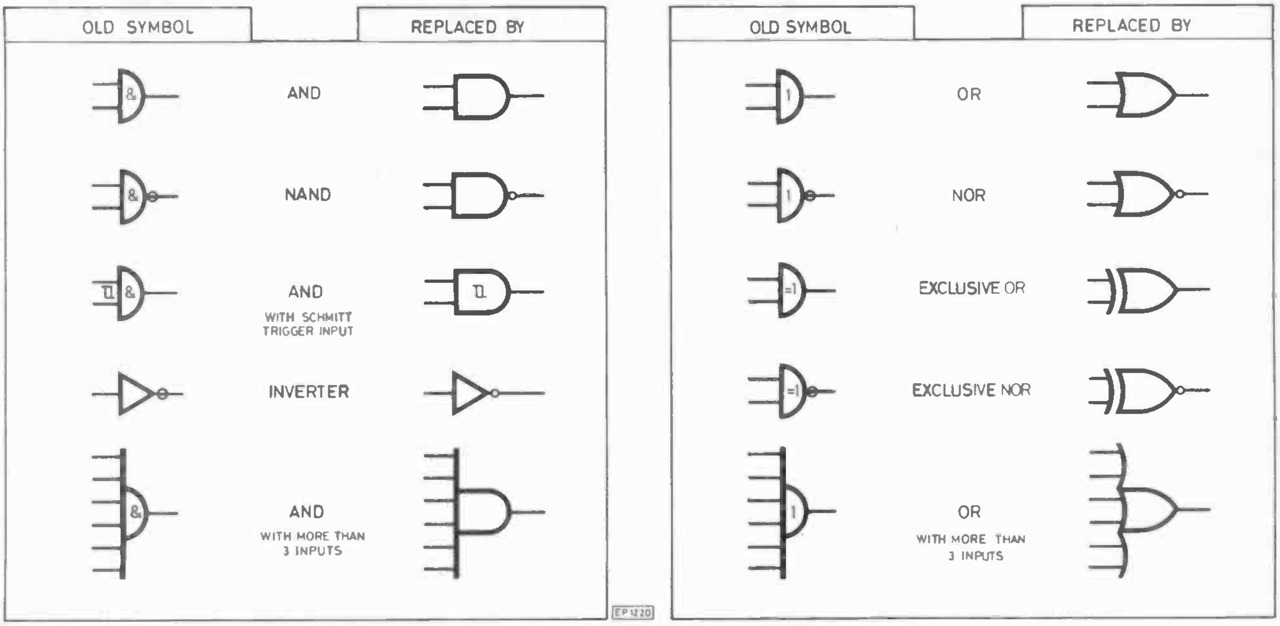


Fig. 7. Board assembly details of regulator

NEW LOGIC SYMBOLS



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PE BAZAAR OCTOBER '83

INTRODUCTION TO DIGITAL ELECTRONICS

MICHAEL TOOLEY BA DAVID WHITFIELD MA MSc CEng MIEE

O & A Level Part One

TWENTY-FIVE YEARS ago the use of digital electronics was almost solely confined to computers. At that time only about one thousand machines were completed in the whole year. Since that time, however, the growth of digital electronics has been both continuous and spectacular. Today, one manufacturer alone can produce more hand calculators in one hour than the total number of computers then produced worldwide in a whole year. To underline the rate of advance which has occurred, some of these new calculators now have more computational ability than any of those 1958 computers.

This series aims to provide a practical introduction to the subject of digital electronics. The material that we shall be covering is suitable for students in education, electronics hobbyists, and newcorners with an interest in digital electronics. All that we assume is that the reader has some elementary knowledge of basic electricity (a familiarity with voltage, current and resistance), and an understanding of simple wiring. No mathematical knowledge is required other than the ability to count up to two! Indeed, the most important requirements are a curiosity about the way in which things work, and an interest in building real circuits to solve practical problems.

The series will appear in eight monthly parts, and is supported by practical work on a Logic Tutor to simplify the construction and investigation of digital circuits. Each part of the series will build on the preceeding parts, and the pages will be laid out in a constant format to allow them to be collected into a complete reference. Regular data sheets will be used to summarise useful practical information separately to avoid interrupting the flow of material. The basic approach that we will adopt is to introduce each logic element in terms of a small number of basic 'building blocks'. It should be possible to explain each new circuit in terms of these basic elements.

The most important point to make, however, is that this series is all about 'real' digital electronics. The idea is to use logic in practice, and to this end the examples given will involve using real integrated circuits to bridge the gap between theory and practice. It is otherwise all too easy to overlook the differences between 'perfect' paper devices, and the ones that can actually be bought in the shops. This problem usually only shows itself as a circuit which 'should' work, but doesn't.

ELECTRICAL SIGNALS AND INFORMATION

One effect of the continuous advance of semiconductor technology is that electronics are being used in an ever increasing variety of everyday applications. The complex functions of these electronic circuits can, however, easily obscure some of their basic characteristics. As a result, it is not always obvious at first sight that everything which is done in an electrical system involves either manipulating information or doing work, or sometimes a mixture of both. The 'information' in an electronic circuit is in the form of an electrical signal, while the 'work' done is often some type of mechanical movement. A radio receiver, for example, manipulates information in the broadcast programme which starts as a modulated radio carrier, and ends up as an audio signal; the work done is in making the loudspeaker cone vibrate to transfer the final sound to the listener.

The aim of this series is to investigate a branch of electronics which is devoted to manipulating electrical signals which are being used to represent information. We will start, therefore, by looking at the ways in which electrical signals can be used to represent information in practical circuits and systems.

ANALOGUE SIGNALS

We usually think of an electrical signal as a voltage which varies in level as time passes, but it can just as easily be a varying current. When this voltage is plotted against time on a graph, the result is known as the waveform of the signal during the time shown by the graph. A waveform which is often encountered in electronics is the sinewave, shown in Fig. 1.1. Examples of signals which have a sinewave shape include the mains electricity, and the output signal from a microphone being used to record a tuning fork.

A sinewave has a simple and regular waveform which has two peaks at different voltage levels, and which repeats every cycle. The signal changes smoothly from one peak of voltage to the other peak, and then back again. Other signals, such as those shown in Fig. 1.2, are not as smooth as a sinewave, but they are still of a regular nature. Returning to the tuning fork for a moment, we can see that if we watch the microphone output for a longer time after it is struck, the shape of the signal remains the same but the peaks gradually die away as the sound gets quieter. This is an example of the way in which one waveform may be added to another. There is, however, no reason why the waveform of a signal needs to be regular at all, and Fig. 1.3 shows what the microphone signal might look like if used to record a singing voice, rather than a tuning fork.

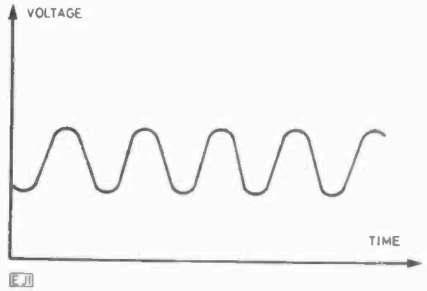

Fig. 1.1. Waveform for a sinewave signal

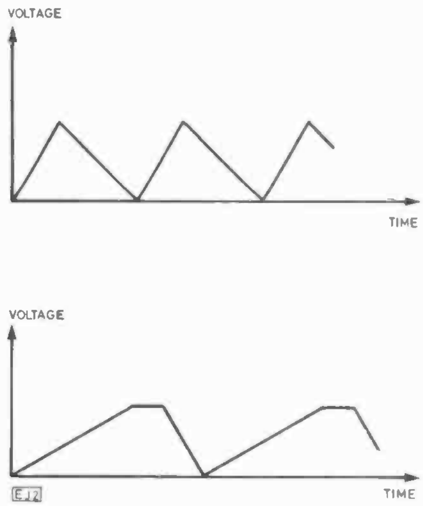

Fig. 1.2. Regular waveforms which are not smooth

Signals with waveforms of the type described above fall into a general category known as analogue signals. The voltage level of an analogue signal typically varies smoothly between two extreme limits, though not necessarily always reaching these limits. The variations will not always be regular, however, nor will the changes always be smooth. Circuits which use these types of signals are called analogue circuits, and are widely used in radio, television and audio, as well as in many types of measuring equipment.

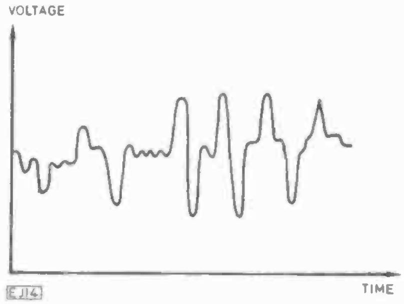

Fig. 1.3. Waveform for a singing voice

DIGITAL SIGNALS

Digital signals are very different in nature to the analogue signals described above. A digital signal does not change its level smoothly, nor does it vary freely over a range of levels. When the voltage level of a digital signal is not rapidly changing, it remains steady at one of only two possible levels, called states. Any changes between these two states occur very rapidly (typically requiring only a small fraction of a microsecond), and are so fast that for practical purposes they occupy an almost negligible time. The two possible states for digital signals are commonly referred to variously as 'low'/'high', 'off'/'on', 'false'/'true' or, most often, simply as '0'/'1'. Conventionally, the two (binary) states in a digital system are defined so that the low/off/false/0 state refers to the lower voltage level, while the high/on/true/1 state refers to the higher voltage level. In this series we will adopt 0 and 1 to refer to the binary logic states since this is the most common and useful definition. The majority of practical digital applications are designed so that 0 is usually represented by a level near zero volts, and 1 by a level slightly below the supply voltage.

A transfer characteristic for a circuit shows graphically how the output responds to an input signal. The characteristic for a typical digital circuit is shown in Fig. 1.4. The output remains at the 0 level until the input exceeds a certain (threshold) value, at which point the output rapidly changes state from 0 to 1.

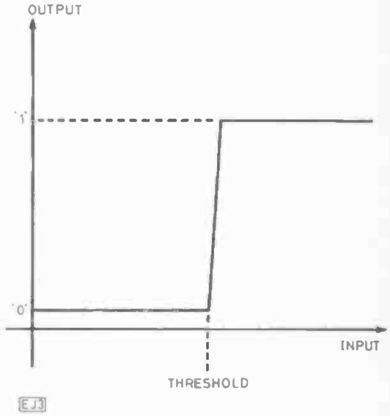

Fig. 1.4. Digital transfer characteristic

ADVANTAGES OF DIGITAL SYSTEMS

One of the attractions of digital systems is that they offer a number of significant advantages over their analogue counterparts. In an analogue system, changes in component values (due to ageing and temperature effects) can have a marked effect on circuit performance, and considerable care must be taken to combat such changes. Applications requiring high precision are particularly troublesome in this respect. Digital systems, however, use switching techniques and are much less susceptible to individual component changes, and they are thus not as prone to the effects of ageing and drift.

Noise and interfering signals can be a significant problem in some analogue circuits, particularly those handling small signals. Digital circuits, on the other hand, can be almost impervious to the effects of noise or interference. This is because, if it is to have any effect, the unwanted signal must have an amplitude which is comparable to the switching threshold of the circuit.

THE PE LOGIC TUTOR

The PE Logic Tutor is introduced on page 26 and a full description of the system, together with constructional details is given there.

The purpose of the PE Logic Tutor is

to allow us to investigate the behaviour of a wide range of practical logic circuits. We will be reviewing the range of facilities provided by the Logic Tutor a little later. For the moment, however, we will direct our attention towards some practical ways of indicating and generating the logic levels to be found in practical digital circuits.

INDICATING LOGIC STATES

We have seen that digital circuits transfer information by using signals which represent the binary states of 0 and 1. The designers of such circuits, while free to choose the actual voltages used to represent these two states, usually choose to keep to the convention of representing 0 by the lower voltage, and 1 by the higher voltage. The majority of today's digital circuits in fact use the same voltage levels for 0 and 1 as those used in the PE Logic Tutor. These levels are such that any voltage below 1 volt is a logic 0, and any voltage above 2·5 volts is a logic 1.

When we investigate how a digital circuit works, it is useful to be able to look at the logic state (0 or 1) at any point. We could use a conventional voltmeter for this purpose, but it becomes rather tedious each time to have to measure the voltage, and then decide whether this represents 0 or 1. A much easier, and quite widely used, alternative is to use some sort of indicator which shows the logic state at a glance. Light emitting diodes (l.e.d.s) are ideally suited to this purpose, and are used extensively in the PE Logic Tutor. The normal convention adopted is that when an l.e.d. is on, this indicates that a logic 1 is present, otherwise the state is a logic 0. The PE Logic Tutor follows this convention for displaying logic states.

Indicators D1 to D4 are each available to show the logic state at any point in a digital circuit. They are used by simply linking a wire between the point under investigation and the appropriate indicator's connector; D1, D2, D3, or D4. A simple demonstration of this technique can be given by using the power supply rails as sources of logic signals. According to our definition above, +5 volts should indicate as a 1, and 0 volts as a 0 when connected to the input of D1 in turn. Therefore when +5 volts (logic 1) is connected, the l.e.d. should be illuminated, whereas when 0 volts (logic 0) is connected, D1 should be extinguished. Repeating this demonstration using the signals from the sockets labelled 'logic 0' and 'logic 1' (adjacent to i.c. socket A) should produce similar results.

GENERATING LOGIC LEVELS

When investigating the behaviour of a digital circuit, it is useful to be able to produce a known logic level (0 or 1) to apply to the circuit in question. This allows us to see how the circuit responds to different combinations of inputs. As we have seen, the PE Logic Tutor provides us with indicators to show logic states at any point in the circuit. In addition, therefore, four logic level generators, S1 to S4, are provided to complement the indicators. These generators are operated by push-button switches, and allow us to produce logic 0's and 1's as required. Built in to each generator is an l.e.d. to indicate the instantaneous logic state of its output. Operating these switches in turn will show that two of them (S1 and S2) produce a 1 for only as long as the switch is pressed, whereas the other two (S3 and S4), change the output state each time the switch is pressed. These two different types of logic generator will be useful in differing applications, as will be seen in due course.

FIXED LOGIC LEVEL

Sometimes, instead of a variable level, a circuit requires a fixed logic level at one of its inputs. This may possibly be routed via a switch or other external electromechanical device, before being input to a logic circuit. To cater for such requirements, the Logic Tutor provides fixed logic 0 and logic 1 sources. These have no indicator l.e.d.s associated with them since they are each capable of driving over twenty logic inputs. As before, however, indicators D1 to D4 may be used to verify their correct operation in case of any doubt. Wherever possible, it is preferable to use the logic 1 source rather than the +5 volt supply rail since this will minimise the effects of accidentally shorting the supply to the 0 volt rail. Even though the power supply is protected, a short circuit could still upset the logic states established in a circuit.

I.C. LOGIC FAMILIES

As we have mentioned, computers were the majority users of digital circuits during the 1950's. Since then, however, digital techniques have been applied to the solution of an ever wider range of problems. One of the major reasons for this expansion has undoubtedly been the rapid advances in semiconductor manufacturing technology during the same period. Indeed, we are now seeing the introduction of some advanced circuits which manipulate analogue signals by first converting them into equivalent digital signals, processing them using digital techniques, and then converting back to an analogue signal at the output. This, however, is running ahead of the present series, in which we aim to provide an introduction to the underlying principles of digital logic circuits.

The computers of the 1950's used assemblies of discrete semiconductor devices (transistors and diodes) and passive components. Often the basic circuits were repeated many times over in a single unit, and as a result, the development of the integrated circuit (i.c.) in the late 1950's led quickly to the introduction of digital i.c.s. Initially, these i.c.s were simply subcircuits (known as 'gates'), comprising a few transistors, diodes and resistors in a single semiconductor 'chip'; capacitors were (and still are) rarely included due to the difficulty of fabrication. As the technique developed, a number of 'standard' gates came into common, use, and these were subsequently interconnected in a single chip to produce more complex digital circuits. This increase in complexity has continued to the present day, to the point where a modern microprocessor i.c. may have the equivalent of over 20,000 basic gates in a single chip.

STANDARD LOGIC FAMILIES

As part of the development of digital i.c.s, a number of standard ranges have been introduced. The importance of the concept of standard logic families cannot be over-stated. The basic gate in each range gives the name to the complete family of devices, and determines the operational characteristics of all devices in the family. In this way, the designer is freed from the problem of checking that the logic levels between gates are compatible; the logic levels, power supply requirements, and general rules are common to all i.c.s in a logic family. This then allows the designer to concentrate on the design of the function of his circuit, and greatly simplifies his overall task once the basic 'rules' for that family are understood.

Over the years a number of different

logic i.c. families have been available, but many have now virtually dropped out of use. The main families to have emerged are as follow:—

(a) DTL = Diode-Transistor Logic
(b) TRL = Transistor-Resistor Logic
(c) RTL = Resistor-Transistor Logic
(d) DCTL = Direct-Coupled-Transistor Logic
(e) RCTL = Resistor-Capacitor-Transistor Logic
(f) TTL = Transistor-Transistor Logic
(g) TSL = Tri-State Logic (a type of TTL)
(h) ECL = Emitter-Coupled Logic
(i) CMOS = Complementary MOS logic
(j) PMOS = P-channel MOS logic
(k) NMOS = N-channel MOS logic

Each logic family listed above has its own special characteristics which may make it more appropriate for particular applications, e.g. ECL is very fast, but requires considerable power. In current practice, however, the families which are most commonly used are TTL, TSL and CMOS; ECL is also frequently used where the highest speed is required. Without doubt, however, it is the TTL family in its various forms which is the logic family in widest use, and we have therefore restricted practical discussions in the majority of this series (parts one to seven) to TTL, with part eight providing coverage of CMOS.

At this point we should, however, stress that the theory of digital logic is the same for all logic families. The differences between the various families are confined to the practical aspects of building circuits, e.g. the power supplies required, the logic levels, etc. A clear understanding of the theory of logic circuits, therefore, can rapidly be applied to any logic family by simple reference to the electrical specifications and the operating 'rules'.

THE 7400 TTL SERIES

TTL is a form of logic which has gained a very high degree of acceptance. The internal circuit for a basic TTL gate is shown in Fig. 1.5: note the distinctive multi-emitter transistor associated with th: input stage of the gate. We do not actually need to understand the details of this circuit in order to be able to use it, but it is an indication of the size of circuit which would be involved if i.c.s were not available. The commonest TTL family is known as the '7400 Series'. Each i.c. in the 7400 series has a type number of 4 or 5 digits, always starting with '74', e.g. 7404, 74123. Different manufacturers add various letters before and after the basic number, e.g. SN7400N, but i.c.s of the same number will always have the same function, whoever the manufacturer. The range of TTL i.c.s which is available is considerable, with many manufacturers offering hundreds of different types.

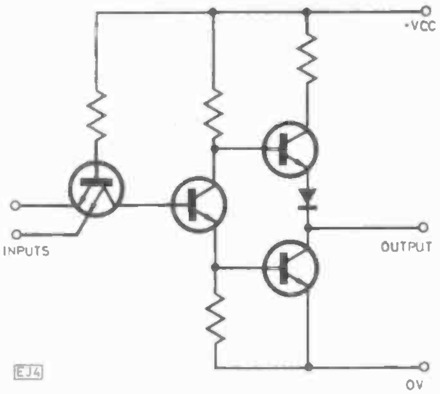

Fig. 1.5. Internal circuit for a basic TTL gate

The basic transfer characteristic for TTL is shown in Fig. 1.6. As we can see, there is a range of input voltage which will produce an indeterminate output level. This means that the output for an input in this range cannot be predicted in terms of logic level. Although possibly surprising, this is quite common in digital logic circuits, and does not destroy the theory. A logic 0 is defined in TTL as a level of less than 0·8 volts, while a logic 1 is a level greater than 2·4 volts. The indeterminate outputs therefore correspond to illegal input levels! We shall return to consider the other characteristics of TTL at a later stage, but for the moment the only other information

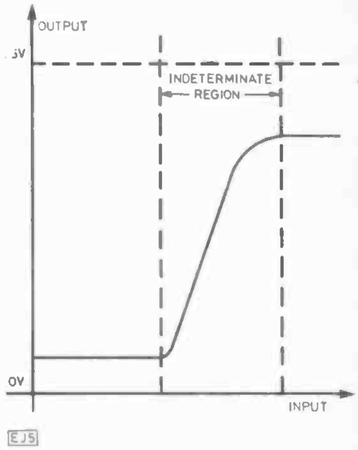

Fig. 1.6 Transfer characteristic for TTL

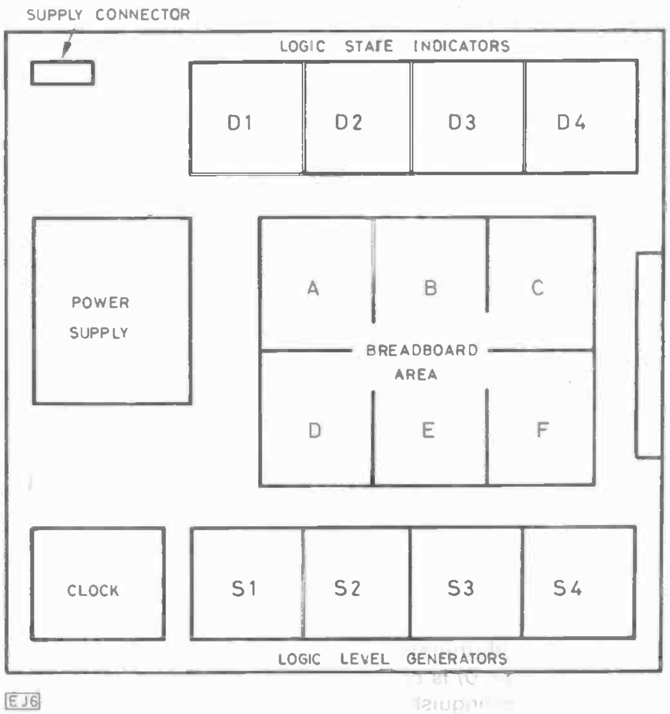

Fig. 1.7. Main features of the PE Logic Tutor

we require is that the supply voltage for TTL is +5 volts.

The basic characteristics of the TTL 7400 Series are summarised in the data sheets which accompany this series. Further details are available from manufacturers' data books.

PE LOGIC TUTOR SUMMARY

The aim of the PE Logic Tutor is to allow the user to construct and investigate the behaviour of a wide range of i.c. logic circuits. The main elements of the Logic Tutor, are summarised in Fig. 1.7. The items of significant interest are as follows:—

(a) A regulated and protected power supply which provides supply rails at +5 volts and 0 volts
(b) A breadboarding area which can accommodate up to six 14-pin or 16-pin dual-in-line i.c.s
(c) Four logic state indicators incorporating l.e.d.s
(d) Four switch-controlled logic level generators; two of these have a momentary action, while the other two have a latching action
(e) A low frequency square wave signal generator which provides a logic-compatible clock at approximately 1Hz

In order to cater for developing and investigating the behaviour of more complex circuits than can be built in the existing breadboarding area, a 10-way expansion connector is also provided. This allows the connection of external circuitry and, with the aid of a suplementary circuit board, also provides a way of increasing the breadboarding area.

The power supply to drive the board may be either an a.c. or d.c. source of between 8 and 12 volts, with a typical supply current of around 150 to 200mA. This type of supply is usually readily available in most laboratories and workshops. Just as suitable, however, is a simple a.c. mains 9V adaptor of the type used with many calculators and cassette recorders.

The use of the Logic Tutor provides a means of reinforcing the subjects covered in this series. The object is to supply examples every month which allow practical investigations to be undertaken, in order to provide the essential 'hands-on' experience. The examples have been carefully designed to complement the subjects discussed, and to develop a familiarity with the use of digital logic techniques. Even when the series has been followed through, the Logic Tutor will still be useful as a development tool in its own right.

THE BUFFER

We have already mentioned the fact that there is an almost bewildering array of digital 'building blocks' available to today's logic designer. The simplest of all active logic elements is without doubt the logic buffer. This has only one input and one output, and the logical state of its output is a direct copy of the logic state at its input. Hence an output of 0 is produced whenever the input is 0, and a 1 is produced for an input of 1. Since no apparent logical operation has been performed by the buffer, it may at first sight seem to be a rather strange element to want to include in any logic circuit. There are, however, a number of situations in which a buffer can be quite invaluable.

The first point to note is that the description given above refers only to the voltage levels at the input and output of the buffer. The current flowing at the output of a buffer, however, can be much greater than the current at its input, even though the logic levels (in terms of the input and output voltages) remain essentially the same. Hence a buffer is said to exhibit 'current gain', which is a consequence of its internal circuitry. In this way, buffers can be used to interface a logic system to circuitry which demands so much current that the logic levels could not be maintained within their limits if other types of logic elements were used instead. Similarly, it is often possible to connect more logic elements to the output of a buffer than is possible with other types; the buffer preserves the logic state of the signal, but increases the current 'drive' which is available.

Finally, buffers may be used to regularise and standardise the input signals, in terms of logic levels, that are presented to, or taken from, a logic circuit.

When drawing logic circuits, the symbol used to represent a buffer is shown in Fig. 1.8. In logic diagrams it is normal to show the input on the left hand side, and the output on the right. Thus, in most logic circuits, the 'progress' of a logic signal is usually

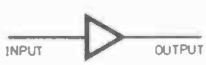

Fig 1.8. Logic symbol for a buffer

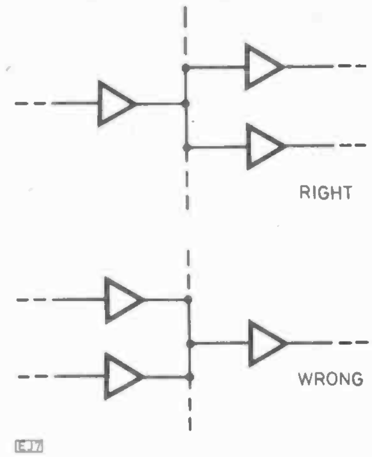

Fig. 1.9. Connecting buffers together

from left to right across the page. At this juncture, it is worth illustrating these points by introducing the first of the rules which must be observed when connecting logic elements together. A single output may be connected to a number of different inputs, but each may normally only be taken from one output (i.e. you may not connect serveral outputs together and expect the circuit to behave properly!). We shall return to discuss this point in greater detail later on, but for the moment this important rule is summarised in Fig. 1.9.

THE INVERTER

An inverter, or inverting buffer as it is sometimes known, is a logic element which is like a buffer in that it has only one input and one output. Inverters are used to generate the logical opposite, or complement, of a logic signal. In order to understand this definition, however, we must first explain that the complement (or inverse) of 1 is 0, and the complement of 0 is 1. Hence, when the input of an inverter is 0, its output will be 1; similarly, when the input is 1, the output will be 0.

The action of an inverter can be illustrated by looking at the simple relay circuit shown in Fig. 1.10. When the

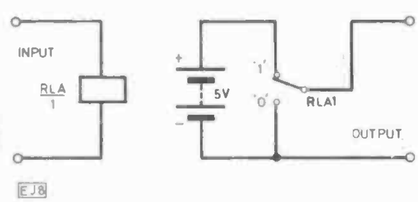

Fig. 1.10. Relay analogy for inverter operation

logical input is at a 0 level, no current flows in the relay coil and the contacts remain in the state shown, producing an output level of 1. When the logical input is a 1, current flows in the relay coil, the contacts change over, and a 0 is produced at the output. The relay thus inverts the logical signal so that an input of 0 becomes an output of 1. and vice versa. The relay in this example is in effect acting as an electromechanical inverter.

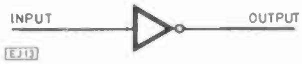

Fig. 1.11a. Symbol for an inverter

The symbol for an inverter is shown in Fig. 1.11a. Note that this is almost the same symbol as we used earlier for the buffer; the small circle on the output, however, shows that the signal has been complemented. In effect, the circle indicates that the output of the logic element to which it is attached is inverted. Thus the symbol for the inverter is made up of that for a buffer, with the addition of a circle to show that the buffer output is inverted. Hence the inverter is sometimes referred to as an inverting buffer.

Inverters can, if required, be made to function as buffers, and because of this flexibility they are often used in preference to simple buffers. Connecting two inverters in series will produce an output from the second which is at the same logic level as the input to the first. The first inverter complements the input (e.g. changes 1 to 0), while the second complements it back again (e.g. 0 back to 1). The overall effect, illustrated in Fig. 1.11, is

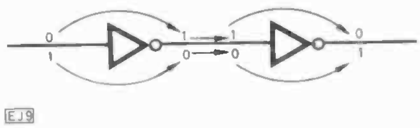

Fig. 1.11b. Action of two series connected inverters

that of a buffer. We shall return to this point again later, but for now we shall proceed with a practical investigation of the behaviour of the inverter. As this is the 'first use' of the PE Logic Tutor, the example will be covered in somewhat greater detail than will be given in subsequent practical exercises.

7404 INVERTER CIRCUITS

The 7404 consists of six individual inverters in a single 14-pin dual-in-line package. The pin connections and internal logic arrangement for the i.c. are shown in Fig. 1.12. When identifying

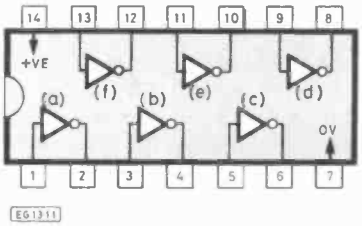

Fig. 1.12. Pin connections and internal logic for the 7404

the pins, view the i.c. from above (i.e. with the pins pointing downwards). The notch on the package is then between pins 1 and 14, and with the notch on the left, the pins are numbered anti-clockwise starting with 1 in the bottom left corner. In a few cases there will be no notch on the i.c. package, but instead there will be a round indentation on the top of the package next to pin 1. The power supply connections for 0 volts and +5 volts are at pins 7 and 14, respectively. It is worth pointing out that the six inverters in a 7404 are all electrically identical, although they are usually labelled (a) to (f) for convenience of identification in circuit diagrams.

A 7404 should be carefully inserted into the dual-in-line socket marked 'A' on the Logic Tutor. It may be necessary to pre-form the i.c. leads so that both rows of pins will fit into the socket, or an i.c. insertion tool may be used instead. Care should, in any event, be taken to ensure that the chip is orientated with pin 1 in position A1; this will then mean that pin 14 will be in position A16; the notch should be between A1 and A16. As a final check before proceeding, it is worth verifying that all of the i.c. pins are correctly inserted in the socket, and that none have been bent under during the installation.

The first test circuit to be set up is shown schematically in Fig. 1.13, and uses the (a) inverter. The diagram here includes the connections to the power supply, as well as the logic interconnections. In normal practice, however, these power supply links are omitted from circuit diagrams since it is assumed that every i.c. will be connected to the +5 volt and 0 volt rails at the appropriate pins. The resulting diagram otherwise becomes very confusing. It is recommended that the circuit is wired up with the power supply to the Logic Tutor switched off. Link the positive supply to pin 14 of the i.c. by connecting a wire from any +5V point to A16. Similarly the 0V rail is connected to i.c. pin 7 by a wire between any 0V pint and A7. The input to the inverter (at i.c. pin 1) is connected to the logic level generator by a wire between S1 and A1. The output from the inverter (at i.c. pin 2) is connected to the logic state indicator using a link between A2 and D1. To re-cap, there should be a total of four links on the board, connected as follows:—

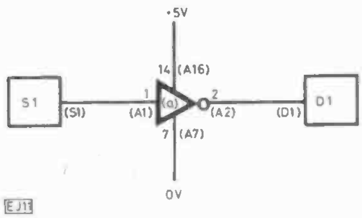

Fig. 1.13. Single inverter test circuit

S1 to A1	(input to inverter)
A2 to D1	(output from inverter)
A7 to 0V	(ground)
A16 to +5V	(positive supply)

When the power supply to the Logic Tutor is connected, the output of S1 will be a 0 (shown by the associated l.e.d.), and the output of the inverter (shown by D1) should represent a 1. Pressing S1 will cause it to generate an output of 1, and the output of the inverter should now change to a 0, i.e. D1 should now be extinguised. Releasing S1 should cause the output of the inverter to resume its original state, i.e. 0.

Readers may wish to verify that the same behaviour is obtained from the other inverters in the 7404; the necessary pin connections may be taken from Fig. 1.12.

Keeping the circuit already set up, we can now extend it to demonstarte the result of cascading two inverters to produce the buffer action mentioned earlier. The two inverter circuit shown

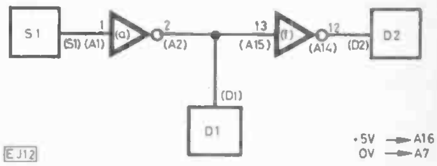

Fig. 1.14. Double inverter test circuit

in Fig. 1.14 uses the (a) and (f) inverters from our 7404, though any pair may be used. This circuit is set up on the Logic Tutor using the following links:—

S1 to A1 | As for previous circuit
A2 to D1
A7 to 0V
A16 to +5V

A2 to A15 (connect O/P of (a) to I/P of (f))
A14 to D2 (O/P of (f) to D2)

When this circuit has been set up, D1 should normally be on and D2 off. Pressing S1 should cause this to swap over so that D1 is off and D2 is on; D2 should always be in the same state as the l.e.d. associated with S1.

The final circuit is left as an exercise for the readers, and uses all six inverters in the 7404. The idea is to prove that replacing EACH inverter in the circuit above with THREE inverters in series (i.e. output of first to input of second, and output of second to input of third), and using the input of the first and the output of the third, will give a circuit which behaves in the same way as the one last investigated. Thus if we have connected up the inverters in the sequence a-b-c-d-e-f, then connecting S1 to A1, D1 to A6/A11, and D2 to A14 will produce an equivalent circuit from a logical point of view. In effect, the whole i.c. has been set up to behave as a single buffer made up of six inverters!

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4023	0.13
4024	0.32
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4027	0.20
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4041	0.36
4042	0.34
4043	0.36
4044	0.36
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4051	0.38
4052	0.44
4053	0.44
4054	0.85
4055	0.85
4060	0.39
4063	0.85
4066	0.24
4068	0.14
4069	0.14
4070	0.13
4071	0.13
4072	0.13
4073	0.14
4075	0.13
4076	0.43
4077	0.13
4078	0.15
4081	0.13
4082	0.13
4085	0.50
4086	0.44
4093	0.20
4502	0.46
4507	0.32
4508	0.96
4510	0.40
4511	0.41
4512	0.40
4514	0.96
4515	0.96
4516	0.40
4518	0.40
4519	0.27
4520	0.40
4521	0.90
4522	0.52
4526	0.52
4527	0.52
4528	0.41
4532	0.72
4541	0.50
4543	0.50
4553	1.57
4555	0.35
4556	0.35
4585	0.75

74LS SERIES

00	0.11
01	0.11
02	0.11
03	0.12
04	0.12
05	0.12
08	0.12
09	0.12
10	0.12
11	0.12
12	0.12
13	0.12
14	0.25
15	0.12
20	0.12
21	0.12
22	0.12
26	0.12
27	0.12
28	0.12
30	0.12
32	0.12
33	0.12
37	0.12
40	0.12
42	0.28
47	0.35
48	0.45
49	0.12
51	0.12
54	0.12
55	0.12
73	0.18
74	0.16
75	0.18
76A	0.17
78A	0.18
83A	0.36
85	0.42
86	0.16
90	0.22
91	0.60
92	0.32
93	0.22
95B	0.40
109A	0.27
112A	0.20
113A	0.20
114A	0.22
122	0.28
123	0.34
125A	0.24
126A	0.25
132	0.34
136	0.25
138	0.25
139	0.27
145	0.57
148	0.70
151	0.40
153	0.40
155	0.30
156	0.35
157	0.25
168	0.30
160A	0.32
161A	0.35
162A	0.35
163A	0.35
164	0.40
165A	0.50
166A	0.60
173A	0.55
174	0.40
175	0.38
181	0.90
190	0.35
191	0.35
192	0.35
193	0.35
194A	0.35
195A	0.35
196	0.45
197	0.45
221	0.46
240	0.55
241	0.55
242	0.55
243	0.55
244	0.55
245	0.70
248	0.55
249	0.55
251	0.30
253	0.35
257A	0.30
258A	0.35
259	0.55
261	1.00
266	0.20
273	0.54
279	0.30
283	0.40
290	0.39
293	0.39
365	0.27
366	0.27
367	0.27
368	0.27
373	0.62
374	0.62
375	0.35
377	0.60
378	0.60
379	0.90
386	0.35
390	0.45
393	0.45

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20 PIN	1.46
26 PIN	1.76
34 PIN	2.06
40 PIN	2.32
50 PIN	2.35
60 PIN	3.20

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20 PIN	2.48
26 PIN	3.24
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40 PIN	4.90
50 PIN	5.48
60 PIN	6.38

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Space Watch...

A COMPANION FOR UKIRT

The soil of Mauna Kea, on Hawaii, has been disturbed again. The work was begun at an official ceremony on the 14,000 ft high mountain early in June. A budget of 1.5 million pounds per annum is to be shared between the Science and Engineering Research Council (SERC) and the Nederlandse Organisatie voor Zuiver-Wetenschappeijk Ondersek (ZWO). The capital cost of the project will be £7M, in the ratio of 80% from the United Kingdom and 20% from Holland. The telescope should be completed by 1986. It will be remotely controlled like UKIRT but cover a different part of the spectrum.

The view on the Universe is to some extent dependent on the atmosphere. There are as it were various windows through which the astronomer may examine the surrounding scene. Thus at certain frequencies there must be a window which is transparent to those frequencies. Also the clouds of gas and dust that lie between the stars and the Earth are the source of most of the radiation which is under study in this area. The frequency is between a few millimetres and a third of a millimetre.

There were a number of reasons why this area was relatively poorly developed by astronomers. The three main ones were—the lack of receivers which were sensitive enough, the signals being absorbed by water-vapour before reaching the telescopes and the problem of making large instruments with sufficiently accurate reflecting surfaces.

Detectors using elements as small as one micron square and cooled to a few degrees above absolute zero have been developed now to satisfy the first difficulty. The second problem has also been overcome to a large extent now that the University of Hawaii has an observatory at such high altitude. The new telescope will be 15 metres in diameter and will overcome the third problem. To be capable of efficient operation the reflecting telescope used must have a surface accuracy of a small fraction of the wavelength of the radiation to be received. The surface of the 15 metre bowl must not deviate from paraboloid by more than 50 microns, including the effects of gravitation when the bowl is tilted or as the temperature changes. To protect it from the weather and from Solar Radiation it will have a co-rotating enclosure which will turn with the telescope. This will have a window covered with a special membrane which is transparent to the wavelengths required but which will reflect much of the sunlight which falls upon it. This also helps to control the temperature gradients that will be encountered in the environment.

The paraboloid surface of the telescope will be made up of 276 panels mounted on a steel frame designed for the minimal and also predictable distortion under gravity as the elevation angle is changed. The panels are of lightweight construction consisting of an aluminium honeycomb covered with thin skins of aluminium sheet. Each is supported on three mounts which can be adjusted remotely. The measurement of this surface is very difficult and a sophisticated machine which incorporates a laser interferometer is being developed to deal with this problem. The mount of the telescope is of the Alt-Azimuth type with motor drives and friction contact with the tracks.

The optical design is that of the folded Cassegrain type with a 75cm diameter secondary mirror to focus the radiation on to one of a number of receivers via a third mirror mounted behind the primary. By mounting a number of receivers simultaneously, each set at a particular frequency or range of frequencies, it will be possible to optimise the use of the telescope and observe at the highest frequencies when the transparency of the atmosphere permits.

Although the telescope has been sited at the highest major observatory in the world, thus providing outstanding conditions for submillimetre wavelength observations, the conditions do vary both seasonally and on a much shorter time-scale. Substantial testing of the site has been carried out and the atmospheric conditions are being continuously monitored to assist in the planning of future programmes.

THE ECLIPSE FROM JAVA

As is usual at the time of an eclipse the most suitable observation point is the subject of an invasion of scientists both professional and amateur to catch the very fleeting moments of this event. This time the site was at Surubaya, East Java. It is a remarkable thing that observing such occurrences in various parts of the world reveals details of the diversity of mankind in its daily life and worship. In Surabaya the populace remained indoors so that they could pray to be free of blindness from the visitation of a power to black out the Sun.

There is quite an amount of lore in Java connected with the eclipse. Though there are some eighteen eclipses each year they occur mainly in inaccessible places or at sea. It is therefore not possible to do much more than just watch the eclipse itself. On this occasion it was possible to measure the shadow of the eclipse. A very accurate measure of this was the task of a team from New Scientist and University College, London. The standard semi-diameter of the sun is 959·63 arc-seconds.

Normally to check this figure it is necessary to ensure that there is a facility for doing this. Observers were stationed at suitable positions and the measurements averaged. From this the team were able to say that for 1983 the diameter of the Sun was smaller than the standard figure. Their measurements gave a figure for the polar radius as 0·34 arc-seconds less than the standard figure.

SATELLITE TDRSS-A

It took 39 steps to put this satellite into correct orbit. From this experience a ten years functioning period of thruster operation was accomplished. Thus necessity provided a bonus while doing an essential task. This satellite was the first of four in the planned Tracking and Data Relaying Satellite System. Stabilisation was obtained for a very elongated elliptical orbit after the upper stage failed following deployment by the Shuttle. For a time it was thought that it would have to be abandoned. But the ground controllers decided on rescue. They were eventually faced with the onerous task of getting it into the correct orbit. This task was completed after several weeks of painstaking effort. They used the attitude thrusters to slowly put the satellite into orbit. The thrusters finally succeeded at the 39th burn which itself took 5 min. 48 sec.

During this positioning some 817 lb of Hydrazine was sacrificed to the repositioning. For its original task it is now left with only 500 lb of fuel. However it has been worked out that to do its normal task the thrusters would need only 200 lb. This would leave enough for emergencies. It was fortunate as it turned out that a cancelled experiment allowed an excess of Hydrazine to accrue. It is expected that TDRSS will be ready for testing on the 8th shuttle mission and for operational purposes on the 9th mission.

The special bonus of this emergency operation was the fact that the thrusters had some 817 lb of fuel through them during the period of orbit correction. These thrusters are about the size of a thimble and have had what is the equivalent to ten years of working life during the sixty days of this emergency use.

EUROPEAN SPACE AGENCY

EXOSAT, the X-ray Observatory Satellite, has already sent detailed information on the location, spectral and temporal characteristics of cosmic X-ray emission sources. The satellite was launched from the Vandenburg site in May last.

On-board experiments include two imaging telescopes to collect information on cosmic X-ray sources in the 0·04–2 k-electron volts range. X-rays in this part of the electromagnetic spectrum have a wavelength 1,000 times shorter than the eyes are able to see. Imaging telescopes for low energy sources such as remnants from supernova stars are also included. A colour catalogue of extra galactic X-ray sources and studies of the time variations associated with X-ray sources which vary between milliseconds and days will be made. It would in fact take a complete *Spacewatch* to cover the tasks which are set. This is really an extension of the work of new discoveries made by the Cos-B satellite of the European Space Agency.

Frank W. Hyde

LOGIC ANALYSER

Part Three

D. MANDELZWEIG MSc Eng

LAST MONTH, construction of the basic unit was described. This month the circuit description and construction details of both the display options are given. At least one option must be fitted to the basic unit; however, fitting both options vastly increases the versatility of the instrument.

SCOPE OPTION

This option allows stored data to be displayed as timing diagrams on an ordinary dual trace oscilloscope. The oscilloscope must have X—Y capability. The option displays eight traces, one trace per data line, and each trace displays 16, 32 or 64 bits, depending on the EXPAND function. The circuit has been designed for oscilloscope displays with a minimum of 1cm square graticule markings. Smaller sized displays may impair readability of the displayed data.

THEORY

Eight traces are displayed on the oscilloscope in the following manner. A repetitive ramp waveform is applied to the X input of the oscilloscope, causing the beam to move across the display. Eight d.c. levels, equally spaced and in decreasing value, are in turn applied to the d.c.-coupled Y input of the oscilloscope, each for the duration of a single sweep. If the sweep repetition rate is fast enough, then the eye will see eight traces on the screen. When an analogue (or digital) signal is superimposed on the d.c. level, then eight traces of data can be seen. Remember though, that each trace follows sequentially the one preceding it and therefore eight real-time data signals cannot be displayed in parallel. Since the analyser is displaying stored data, this is of no concern to us. What happens is that a multiplexer applies a d.c. shifted signal with the DØ bus one superimposed on it to the oscilloscope. The RAM is clocked for 16, 32 or 64 clock cycles, during which the trace is moving across the screen. This causes the DØ contents of 16, 32 or 64 memory locations to be displayed as a waveform of ones and zeros. At the end of the trace, D1 is connected through, and the memory is again cycled through the *same* locations. Thus the data bits of D1 are displayed directly under the corresponding bits of DØ. All eight data lines are therefore displayed and then the whole sequence repeats itself. In this manner a display of 16, 32 or 64 bytes of 8-bit data is built up. A timing diagram is shown in Fig. 3.1.

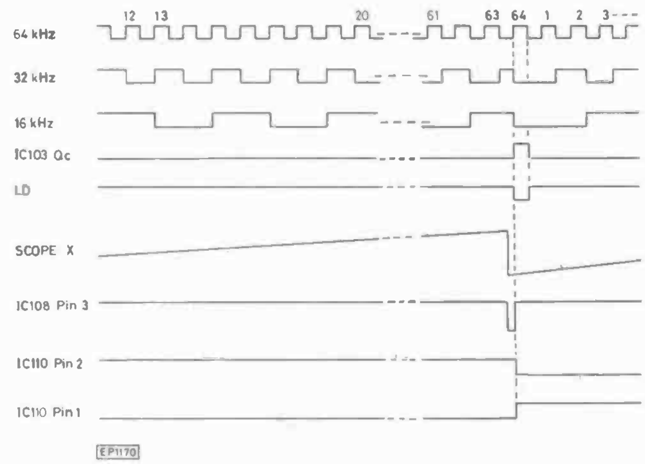


Fig. 3.1. Oscilloscope option timing diagram

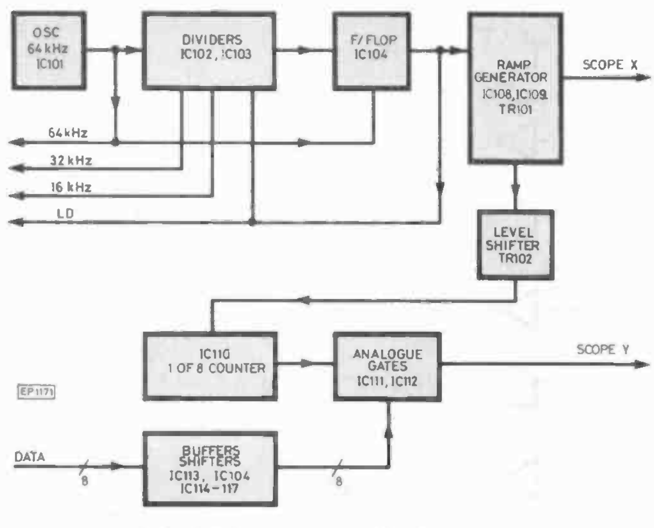


Fig. 3.2. Scope option block diagram

CIRCUIT DESCRIPTION

Refer to the block diagram and circuit diagram, Figs. 3.2 and 3.3 respectively. IC101 is configured as an oscillator running at 64kHz. The output is fed to IC102, IC105b and S20c via buffers IC105a & d. IC102 and IC103 are binary counters, used as dividers. The frequency at QA of IC102 is 32kHz and QB is 16kHz. These outputs are also taken to S20 and depending on the switch position, one is applied to the RAM counter circuitry on the main p.c.b. Output QC of IC103 is 1/64th of the input frequency, i.e. 1kHz. When QC goes high, IC104d goes low, albeit for a very short time, as the 64kHz clock resets the flip flop via IC105b. This short duration negative going pulse reloads the counters so that they count from zero again, triggers IC108 and provides the LD pulse used on the main p.c.b. for reloading the RAM base address (refer to part 1) and for the HEX display option (see below). Because these pulses are 1ms apart and are derived

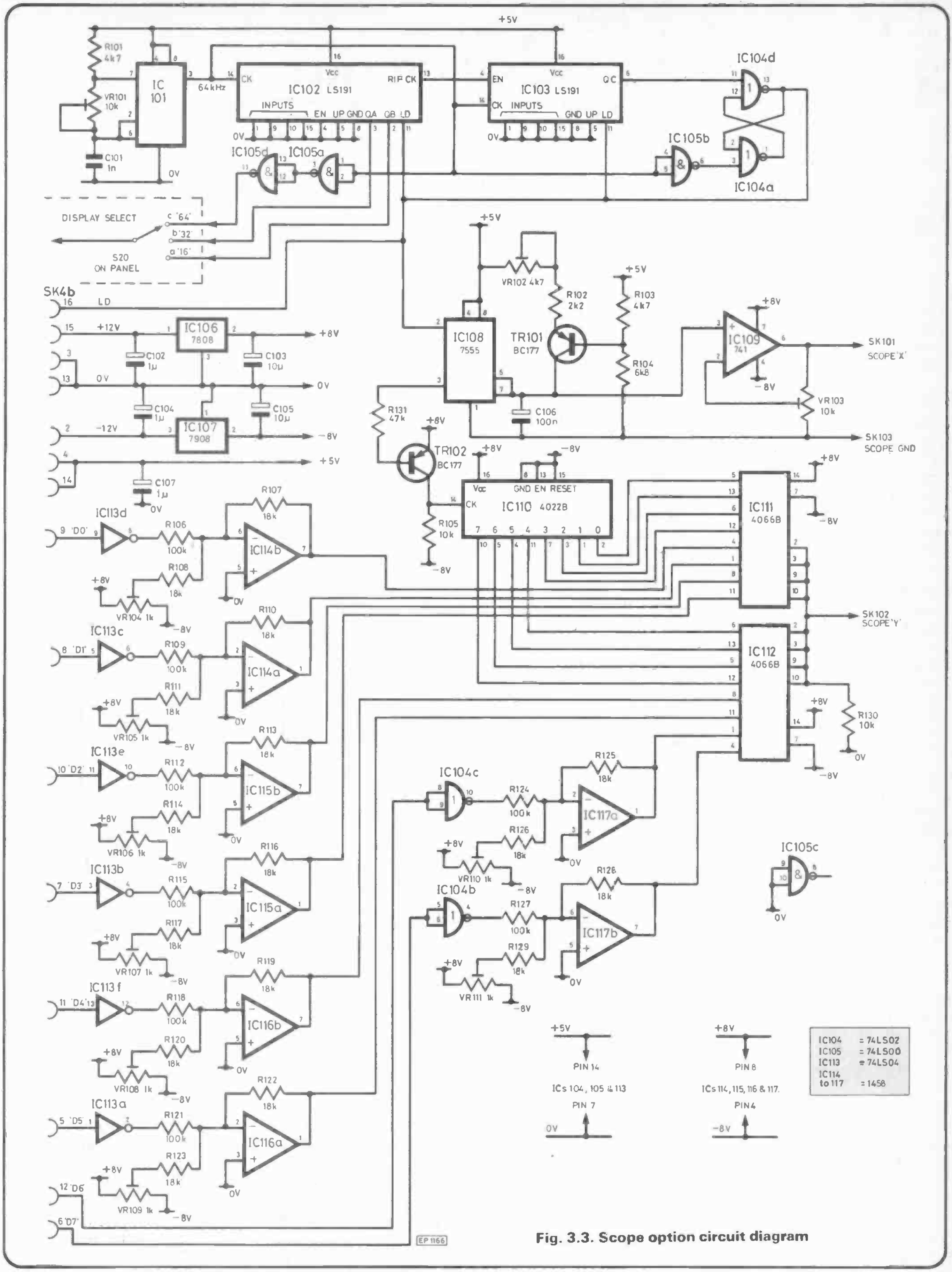


Fig. 3.3. Scope option circuit diagram

from the 64kHz clock, the RAM address counters increment 64, 32 or 16 times between the pulses, corresponding to the expand function allowing 64, 32 or 16 bytes to be displayed. IC108 is configured as a monostable, with its timing capacitor being charged via a constant current generator formed by TR101, VR102 and R102–R104. When IC108 is triggered, a ramp waveform is generated at the junction of TR101 and C106. The timing components have been chosen (and can be adjusted with VR102) such that the period of the ramp is just less than 1ms. The ramp is buffered and amplified by IC109, the output of which drives the X channel of the oscilloscope. VR103 is used to adjust the ramp amplitude and thus the width of the sweep on the display. With the ramp period slightly under 1ms and the ramp start tied to the 64kHz clock, the ramp is just long enough for the 64, 32 or 16 clock pulses to be completed before the next LD pulse is generated. TR102 level-shifts the square wave output of IC108 (period 1ms) to a level compatible with the dual supply rails used on the CMOS i.c.'s. IC110 is a 1-of-8 counter, each output goes sequentially high with every clock pulse. The outputs of IC110 control the analogue gates in IC's 111 and 112 with the result that every 1ms (equivalent to the ramp length, or a set of 64, 32 or 16 clock pulses) the outputs of IC's 114 to 117 are gated sequentially for 1ms to R130. R130 is in turn connected to the Y input of the oscilloscope. In other words, the 8 outputs are switched in turn for 1ms to the Y oscilloscope input. The data bus is buffered by IC113 and IC104b & c and applied to the op-amp IC's 114-117. The associated resistors (for example R106 and R107) are chosen such that the gain of the op-amp is 0·18. Multiplied by 5V, the output is 0·9V and with the oscilloscope Y input set to 1V/div, the waveform sits nicely within the graticule squares. Summed with the input signals are d.c. levels, adjusted by VR104-VR111. The gain of the d.c. level is 1 and therefore the signals fed to IC111 and IC112 consist of 0·9V amplitude waveforms superimposed on d.c. levels which can be adjusted from approximately −7V to +7V. These presets enable the traces to be correctly spaced on the oscilloscope screen.

CONSTRUCTION

Construction procedures follow closely those of the main p.c.b.—Soldercon sockets, followed by components and then the through-hole connections. Refer to Fig. 3.6. Fit the i.c.'s in place, then check for solder splashes and correct component orientation. Use Veropins for the connections to S20 and SK101, SK102 and SK103. If you intend fitting the HEX display option at this stage, complete it first, as it is fitted below the oscilloscope option. (If the HEX option is only to be fitted at a later stage, it will be no problem to lift the oscilloscope option board and place the new option board in between. It is therefore not essential to fit both options now.) The display option board(s) are mounted on stand-offs, between SK6 and SK8 on the main p.c.b. Wire the board to the front panel (i.e. S20 and SK101-103).

SETTING UP

With a frequency counter or an oscilloscope connected to pin 3 of IC101, adjust VR101 for an output of approximately 64kHz. Then connect up the oscilloscope with X input set to 0·5V/div. and the Y input to 1V/div. Apply a clock to the analyser, let the data inputs float high, ARM the analyser and store the high inputs. Adjust VR104-VR111 so that the traces are in order from the top of the screen downwards and that the traces are just under their respective upper graticule lines (i.e. indicating a high). Note that the presets are *not* in order on the p.c.b. (the author wasted an hour trying to figure out why the scope data did not agree with the HEX data, and all because the traces were adjusted in the wrong order!). Adjust VR103 so that the length of the traces just fit in the graticule area. Connect up (on protoboard or vero-board) the test circuit in Fig. 3.7 and store the data.

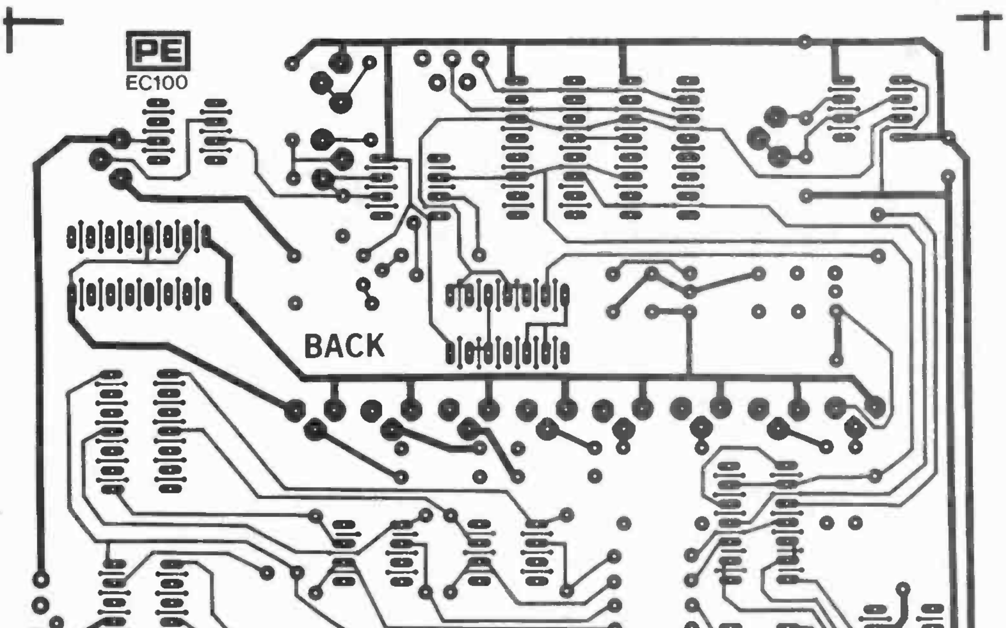


Fig. 3.4. Scope option p.c.b. track (track-side)

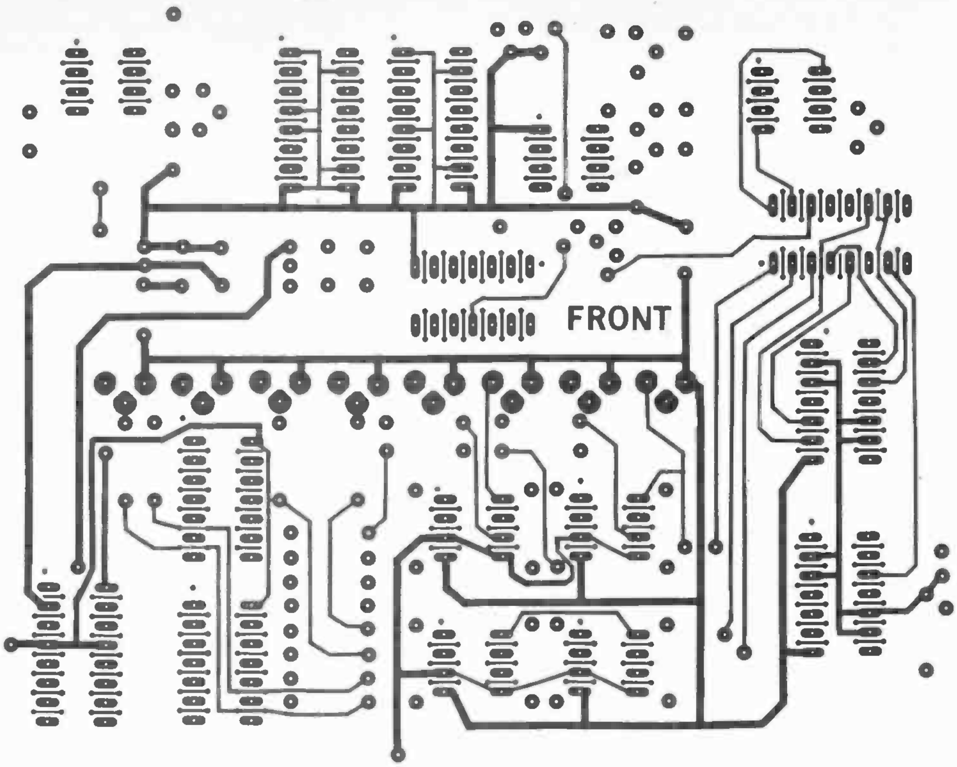


Fig. 3.5. Scope option p.c.b. track (component-side)

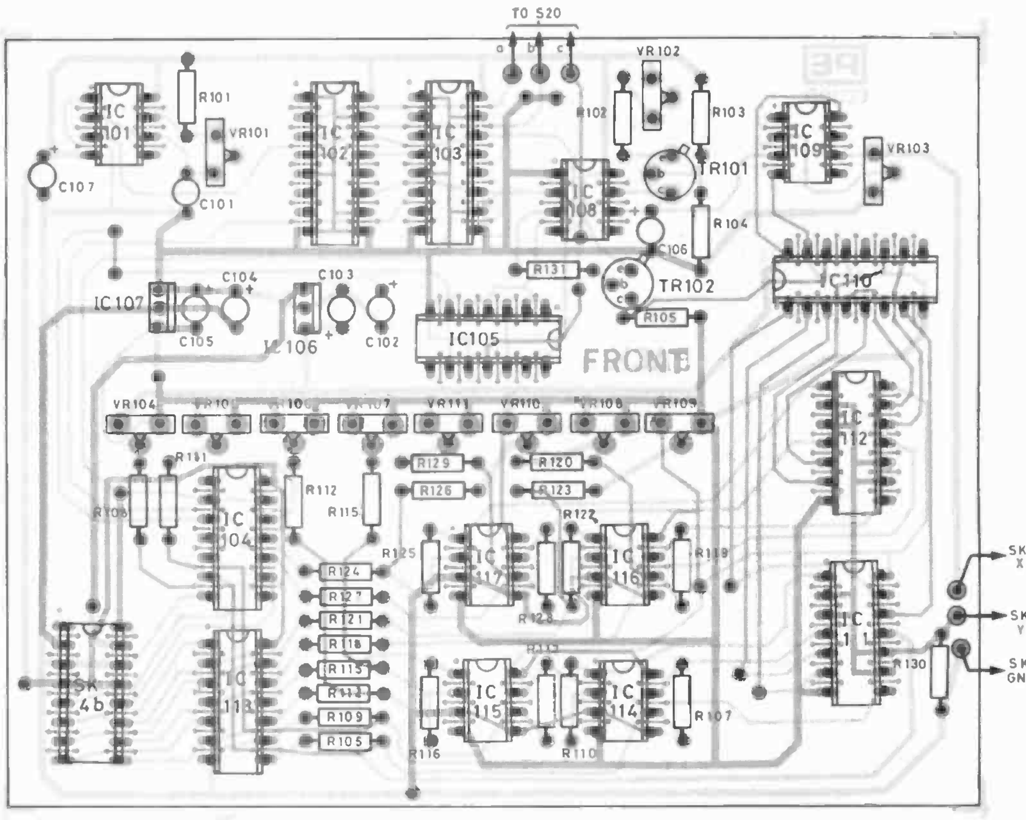


Fig. 3.6. Scope option component layout (actual size)

With the EXPAND switch set to 16, adjust VR102 so that the top trace (DØ) has 16 cycles on the screen. It may be necessary to readjust VR103 while the adjustment of VR102 is being done. Changing the position of the EXPAND switch will cause more bytes to be displayed. Final testing of the unit will be described at the end of the article, as the procedure is common to both display options.

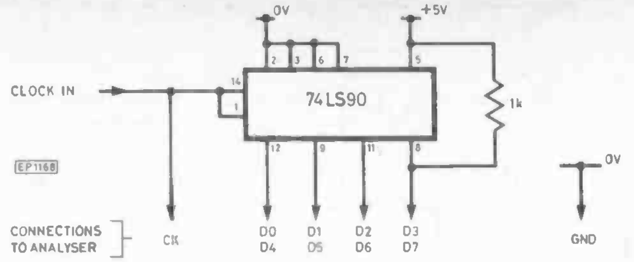


Fig. 3.7. Analyser test circuit

COMPONENTS . . .

SCOPE DISPLAY OPTION

Resistors

R101,R103	4k7 (2 off)
R102	2k2
R104	6k8
R105,R130	10k (2 off)
R106,R109,R112,R115, R118,R121,R124,R127	100k (8 off)
R107,R108,R110,R111, R113,R114,R116,R117, R119,R120,R122,R123, R125,R126,R128,R129	18k (16 off)
R131	47k
All resistors ¼W 5%	

Potentiometers

VR101,VR103	10k vert min. preset (2 off)
VR102	4k7 ,, ,, ,,
VR104–111	1k ,, ,, ,, (8 off)

Capacitors

C101	1n
C102,C104,C107	1µ/35V tant. (3 off)
C103,C105	10µ/35V tant. (2 off)
C106	100n/16V tant.

Transistors

TR101,TR102	BC177 (2 off)

Integrated Circuits

IC101,IC108	7555 (2 off)
IC102,IC103	74LS191 (2 off)
IC104	74LS02
IC105	74LS00
IC106	7808CT
IC107	7908CT
IC109	741
IC110	4022B
IC111,IC112	4066B (2 off)
IC113	74LS04
IC114-117	1458 dual 741 (4 off) (1558 may be used)

HEX DISPLAY OPTION

This option displays the HEX value of the data byte corresponding to the base memory address selected on the ADDRESS display, on two 7-segment displays. The HEX characters are displayed as shown in Fig. 3.8. The 7-segment displays should have already been fitted to the front panel p.c.b.

HOW IT WORKS

Fig. 3.9 shows the circuit. Incoming data is latched in IC201 by the LD input from the oscilloscope option via IC205C. If the oscilloscope option is not fitted, then as explained in Part 1, the latch is always disabled (i.e. unlatched). The output of the latch is connected to IC202 which is a quad 2-line-to-1-line multiplexer. The output lines A, B, C or D are either connected to DØ–D3 or D4–D7, depending on the S input. This input is derived from IC205d and IC207, which is configured as a 100Hz oscillator. The oscillator allows the multiplexing of the data to the displays, minimising the HEX decoding circuitry and the connections between the option board and the front panel p.c.b. Multiplexing is achieved by TR201 and TR202 switching on alternately and hence enabling each display in turn. The selected 4 bits are decoded into 7-segment format by IC203. This i.c. decodes the values 0–9. IC204c and IC205b detect when the value is greater than 9 and when this is the case, enables IC203's lamp test facility and enables IC206. IC203 was chosen because it displays a complete "6", compared to the more common 7447 which has the tail missing. It is therefore easy to differentiate between a "6" and a "b" corresponding to the HEX "B". To explain how the display works, we will consider an example, say a "1". To display a "1", outputs b and c of IC203 will be high (off), allowing current to flow via R208 and R207 through the b and c segments to the common cathode. All other outputs will be low (on), shorting out the segments, so they do not light. When the lamp test facility is enabled, all outputs are off, allowing all segments to light. However, IC206 decodes the 3 bit binary input to 1-of-6 lines and the selected line, buffered by IC208, blanks the not-required segments via the diode matrix, leaving the corresponding HEX character lit.

CONSTRUCTION

Once again, construction follows the previous procedures. Refer to Fig. 3.12 for the component overlay. The board is fitted to the main p.c.b. with stand-off pillars and is connected to the front panel p.c.b. via a 14 way ribbon cable, with headers connected such that the pin numbers correspond 1 to 1. There is no setting up required and testing is done as described below.

FINAL TESTING

Set up a word on the word recogniser switches and select WORD trigger, POST trigger and SYNCH clock. Select CQ1 and CQ2 to "dont care" and CQ3 to Ø. Connect up the test circuit in Fig. 3.7, leaving the qualifiers open. ARM the unit and switch the CQ3 switch to "dont care". The analyser will

Fig. 3.8. Hex character display

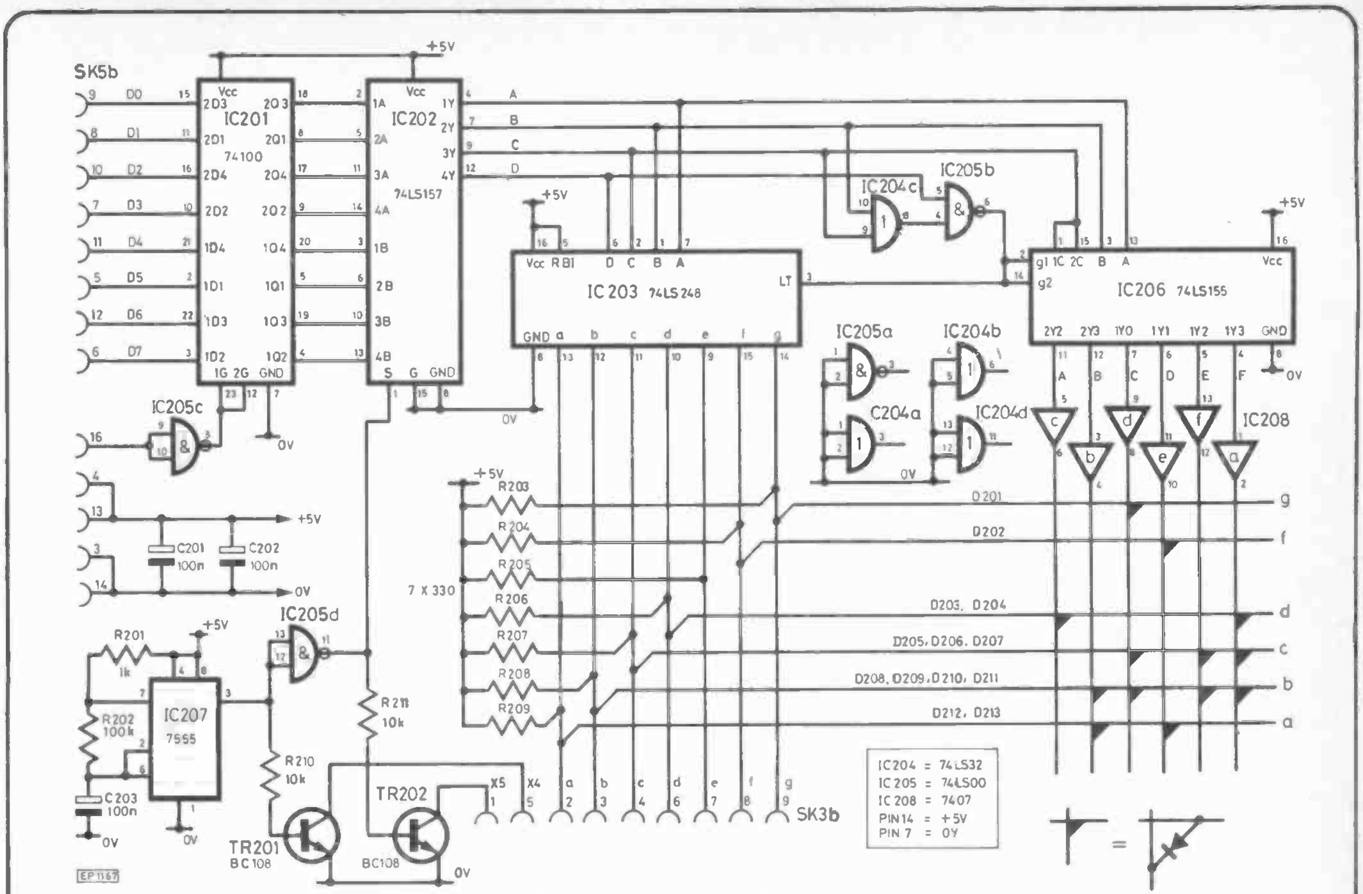


Fig. 3.9. Hex option circuit diagram

COMPONENTS . . .

HEX DISPLAY OPTION

Resistors

R201	1k
R202	100k
R203–209	330 (7 off)
R210,R211	10k (2 off)

Capacitors

C201–203	100n/16V tant. (3 off)

Transistors & Diodes

D201–213	1N4148 (13 off)
TR201,TR202	BC108 (2 off)

Integrated Circuits

IC201	74100
IC202	74LS157
IC203	74LS248
IC204	74LS32
IC205	74LS00
IC206	74LS155
IC207	7555
IC208	7407

Miscellaneous

Soldercon i.c. socket strips
SK3b can be a 14-pin i.c. socket

capture the counter's output. Now check that the HEX display corresponds to the chosen trigger word (on the switches) and that the left hand byte displayed on the oscilloscope also corresponds. (If only one of the options is fitted, then obviously it is only necessary to check that option.) Repeat the procedure with PRE and CENTRE triggering. Activating the UP/DOWN switch should cause the HEX display to increment or decrement between 00 and 99. (The 7490 is a decimal counter, therefore no HEX characters will be displayed.) The waveforms on the scope display should also move to the left or right. Switch off the analyser and switch on again. The memory will contain random data. Scan up the memory and check that the HEX characters are correctly displayed. Finally, check that MANUAL and EXT trigger (by applying an external signal, positive and negative edge selected) work and that the clock qualifiers work. If the option(s) and the unit work satisfactorily, the power supply wiring can be neatly finished off. The fuse is mounted on the back panel and remember to twist the mains wire going to the ON/OFF switch to reduce noise radiation. The analyser is now ready.

NEXT MONTH: Z-Mod and Internal Clock Options.

NOTE . . .
Fig. 1.6, the Main p.c.b. circuit schematic (August issue) should be corrected to show a link between pins 3 and 4 of IC32 and pin 5 of IC30.

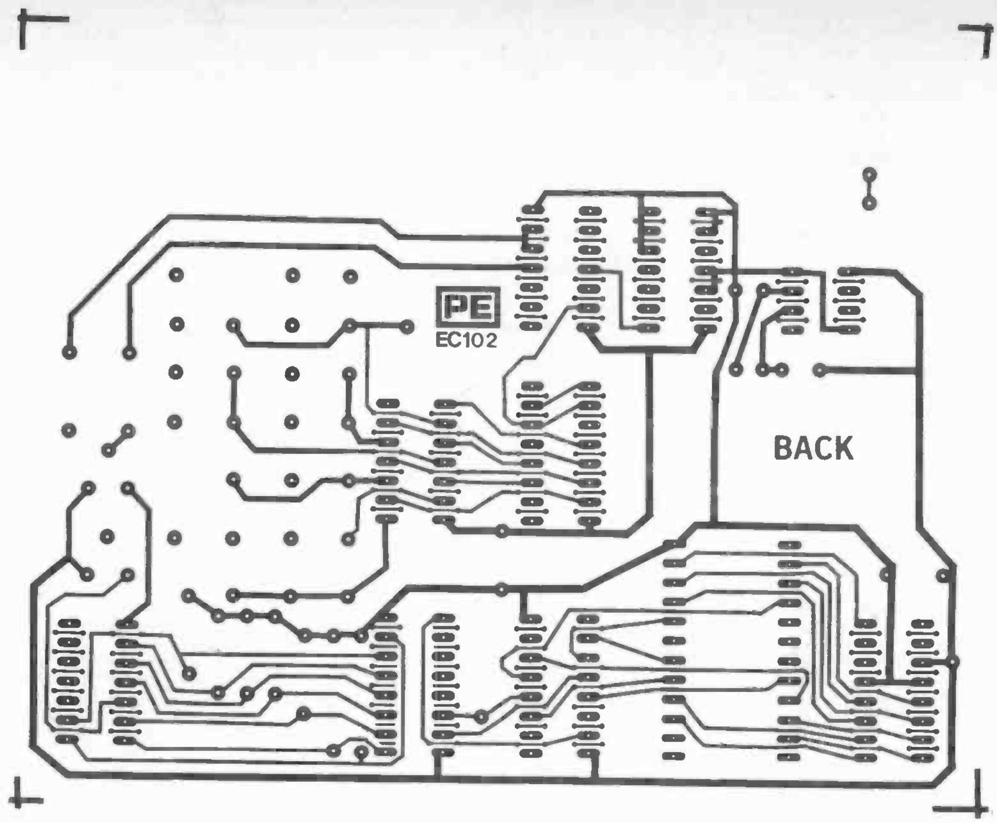


Fig. 3.10. Hex option p.c.b. track (track-side)

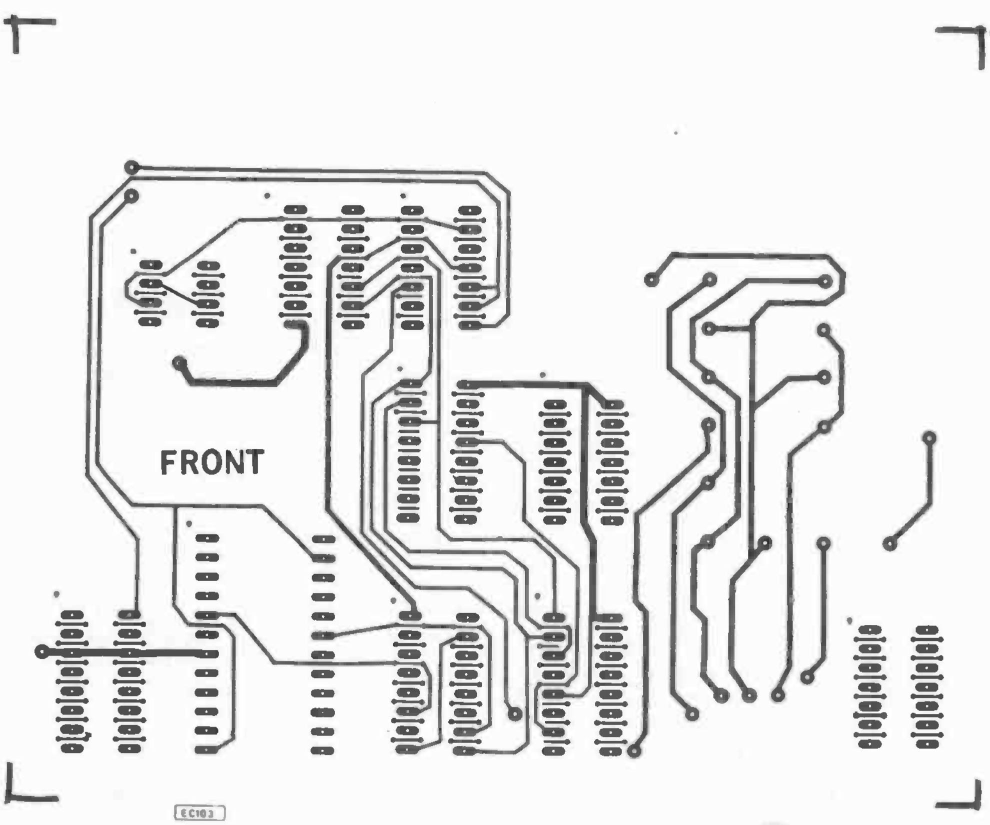


Fig. 3.11. Hex option p.c.b. track (component-side)

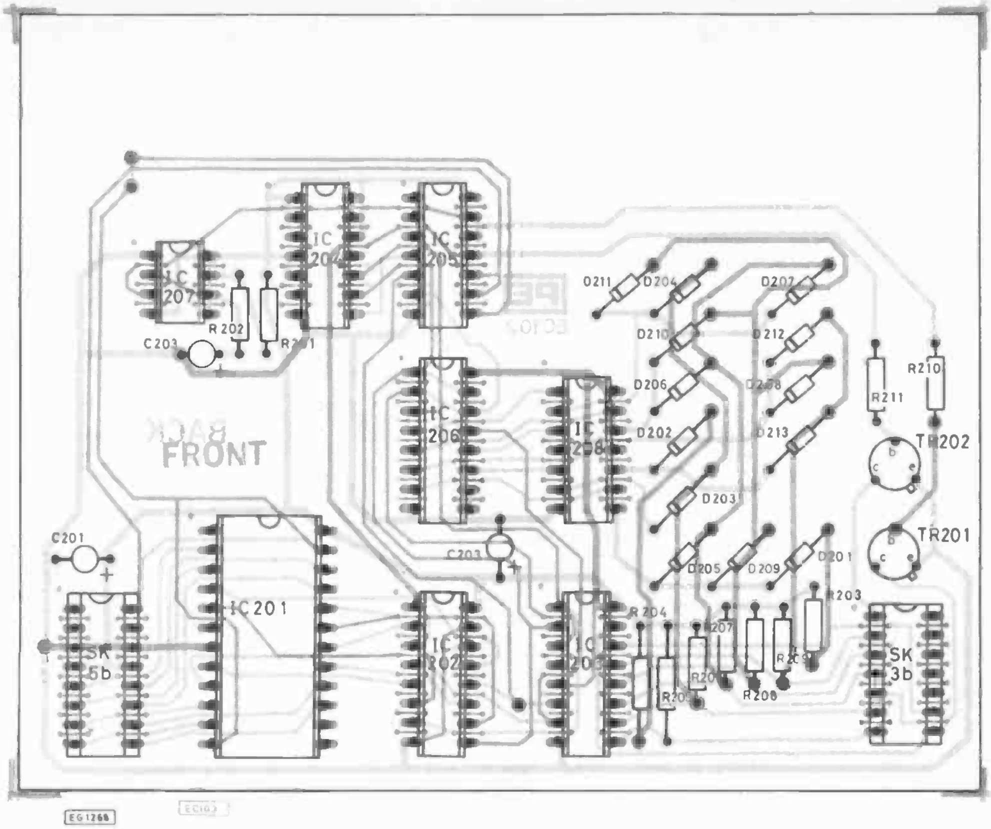


Fig. 3.12. Hex option component layout (actual size)

ELECTRONIC HOBBIES FAIR

Alexandra Palace, London – October 27-30, 1983

We are sorry to announce the cancellation of this year's Electronic Hobbies Fair, planned for 27th–30th October.

In spite of a significant success last year, the continuing recession is hitting the electronics hobby industry pretty hard. This has meant that many companies feel that this year they cannot sensibly allocate the resources of time, money and manpower involved in participation in exhibitions.

We feel that any exhibition sponsored by PE must offer the visitor a full range of components, equipment, projects and demonstrations from a wide selection of companies across the industry. As we cannot be absolutely sure of doing just this, we have decided, with regret, that we must disappoint our readers now rather than in October. Practical Electronics would like to thank those companies who had undertaken to support the Electronic Hobbies Fair this year. With our apologies for the disruption of their plans we combine our hopes for a future event in a more buoyant business climate.

ELECTRONICS in PHOTOGRAPHY

Clifford Stokes
AIIP ARPS FRSA

SINCE the invention of a means of permanently recording an image made by "painting with light", photography still requires the same techniques as it did 150 years ago. There has always been a light tight box or camera and there has always been a pinhole or optical lens to form an image.

At first the image was copied by hand, a small portable camera being a popular means of sketching tourist views for the non-artistic traveller. When light sensitive emulsions were discovered, photography as we know it was made possible. Over the years the sensitivity of film emulsion has been improved, the optical performance of lenses and the method of varying and controlling the amount of light reaching the film, with some form of aperture and shutter arrangement, has been the subject of continual invention.

The actual method of exposing the film for a particular length of time has always been mechanical, clockwork gear trains or pneumatic systems, subject to variation and failure and requiring expensive and precision maintenance. When electronic control of these functions was introduced, it was without doubt one of the most important fundamental developments in the techniques of practical photography.

ELECTRONIC CONTROL

The huge "snap-shot" market was the first to benefit from electronic control, not only in the camera at the taking stage (which shall be dealt with later) but in the developing and printing of vast quantities of amateur colour negative films in 35mm, 126, 110 and Disc formats.

Meticulous attention to processing standards at the laboratory is required, to ensure acceptable quality prints at economical prices. To try to achieve adequate control by manual means is impossible due to time/cost considerations in a mass market.

The films are developed in automatic sequence where time, temperature and replenishment of used chemicals is strictly monitored. After development, the films, either in individual, short lengths or joined together on a continuous spool, are printed on to roll paper which is processed and cut into single prints.

The laboratory printers used for this work can be either:

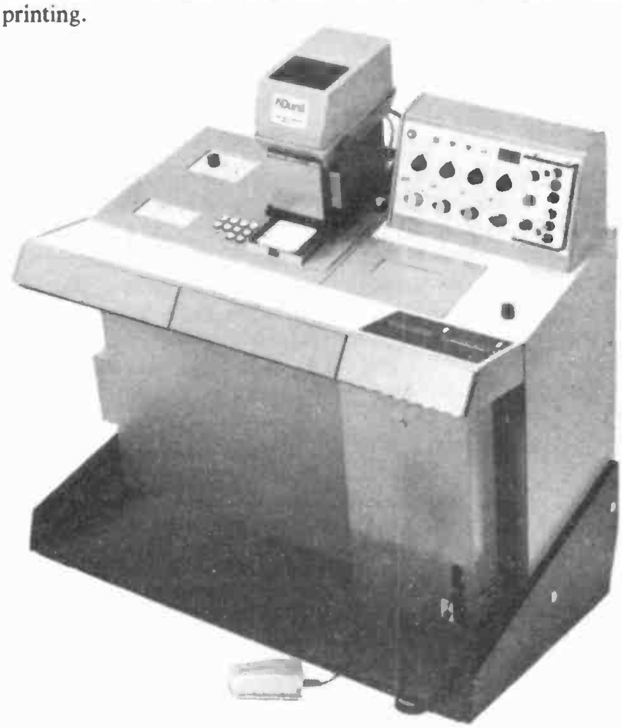
A. Fully automatic,
B. Partly automatic, where the operator can override or modify the function.
C. Manual.

Amateur developing and printing is always automatically printed. A typical standard subject, based on the holiday view or group picture on a particular type of mass sale film, like Kodacolor II with C41 process, is programmed into the printer, which adjusts the function to compensate for any variables in the subject lighting and exposure.

OPERATING THEORY

The operating theory, established by Kodak in 1946, depends on the premise that most colour photographs can be integrated or scrambled to a standard grey. If a full colour image is projected onto a screen through a diffuser, the mixture of coloured light will produce the same effect on the screen irrespective of the content of the picture, assuming that the picture is a typical standard subject. If the picture is untypical, i.e. a white seagull against a blue sky, or a white cat on a red rug, the printer must have manual correction or sophisticated programme memory systems to estimate the required compensation.

Laboratory printers for the more exacting market of professional photographers are usually automatic with manual operator override. The film is handled in short strips, say three $2\frac{1}{4}''$ square negatives; these are numbered and test printed, checked and printed again with any required correction. These printers are capable of handling roll paper in a range of widths and format, the size being selected and set up prior to batch printing.



High-speed laboratory printer

The working principle of all printers for colour negative and reversal film material, is based on the theory that white light is composed of Blue, Green and Red light in equal amounts.

PRINTING

All colour film and paper has three layers of emulsion sensitive to Blue, Green and Red light respectively and can record any colour in the original subject by mixing different proportions of any two.

A colour printer, therefore, must have the facility to adjust the colour of light used to project the image onto the paper.

There are two basic printing methods,

Additive Printing where three consecutive exposures are made first through a Blue filter
then through a Green filter
then through a Red filter,
different times of exposure through each will give in total an infinitely adjustable colour result.

Subtractive Printing (or white light) where one exposure is made through a pack of filters of complementary colours.
Yellow filters to absorb Blue light
Magenta filters to absorb Green light
Cyan filters to absorb Red light
varying the densities of any two of these filter colours will again give an infinitely adjustable result.

All printers and enlargers for colour, either negative or reversal, operate on variants of the two basic systems.

As distinct from laboratory printers operating in a mass quantity market, enlargers are used for the independent printing of negative and slide originals onto sheets of paper in a wide range of sizes and surface finishes. Individual treatment, shading, masking and local correction and optical distortion control, to correct for camera angle errors, can be done during the printing process.

PRINT ANALYSIS

The correct combination of exposure times through the BGR filters in the case of additive enlargers and the exposure and filter densities in the case of subtractive, can be arrived at by a series of test prints, which can be wasteful of time and materials. To overcome these problems analysers are used, programmed to a standard subject. To illustrate the operation of an analyser we will look at the Durst CM300, a sophisticated home darkroom electronic analyser and timer. When used in conjunction with a colour head enlarger fitted with "dial in" dichroic filters the printing filter settings and exposure are quickly established, to a set programme.

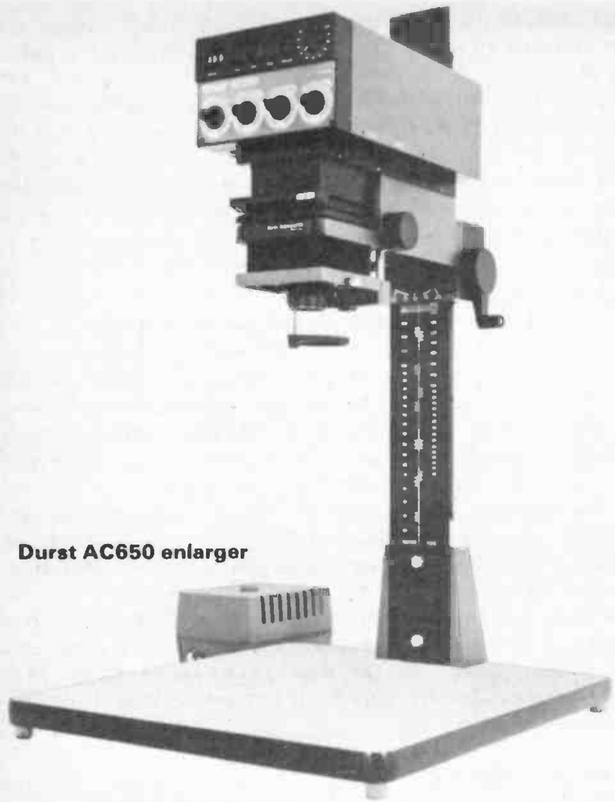
To calibrate the unit, a negative is selected having a good distribution of colour, a market place or fairground shot is usually ideal, the negative should be of normal density and correctly processed.

The negative is test printed until a satisfactory result is obtained.

The analyser is then programmed. With the enlarger set exactly as for the test print, filters, lens aperture and magnification, the analyser probe is placed on the baseboard under the lens. The slide on the probe is moved until the l.e.d. on the cyan channel lights and the calibration knob is adjusted until the two l.e.d.s come on together. The process is then repeated for magenta and yellow.

Any other negative of a similar type can be focused to a particular size, the probe placed on the baseboard and the filters adjusted in turn to light the two l.e.d.s together on each channel.

The Durst CM300 analyser measures the colour and density of colour negatives and directly controls the exposure procedure of the enlarger



Durst AC650 enlarger

For a portrait negative a print can be made by test and the analyser can be programmed by placing the probe (without the diffuser) on part of the face projected on the baseboard and calibrated as before. This will be for a typical skin tone and will yield an identical colour and tone in future prints irrespective of the background colour. The unit can be used for exposure determination for slides and black and white printing and as a basic exposure timer.

All analysers and computers for colour printing, work on the same principle irrespective of the manufacturers' operating sequence and attempt to provide guidance on optimum printing conditions for any negative, but the successful interpretation and use still depends to a large extent on the skill of the operator. To cater for different combinations of film and paper batch, some analysers have switchable memory banks or plug in modules for any number of calibration programmes,

STAGE TIMING

The accuracy and repeatability of electronic control has enabled a number of darkroom aids to be designed, one of which is the Nocon timer, an interesting electronic timer with programmable memory.

When making a test strip for exposure determination either in black and white or colour, it is necessary to make a series of time stages, maybe 2,4,6,8,10,12, seconds or a doubling up range like 2,4,8,16,32, seconds. A laborious technique subject to errors of repetition. The final print as a result of information obtained from the test, may require a different exposure in certain areas and it is usual to make a careful note of these times and aim to work to them for the finished print. With the Nocon timer, the basic exposure, say 10 seconds, can be entered on the display panel, five keys can select 0–59 minutes, 0–59 seconds and 0–·9 seconds. A panel of 20 keys each with its own l.e.d., can be selected to give under or over the basic 10 seconds in terms of aperture f stops and $\frac{1}{4}f$ stops to give a range of up to 21 evenly spaced exposures. The correct exposures for different areas of the print can be entered into the memory and can be repeated any number of times, exactly the same.

LEVEL PEGGING

The relative merits of additive versus subtractive colour printing systems have been expounded for a number of years without any real evidence of either's superiority. Most enlarger manufacturers use the subtractive system for manual enlargers, where the colour of the light projecting the negative, or positive image, is adjusted by means of a complementary filter pack, of gelatine or resin filters, or dial in fade free dichroic filters, using one exposure.

The Philips Tri-one colour enlarger uses a system which is a single exposure, as in the subtractive method, but a single exposure from three separate bulbs, one with a blue filter, one with green and one with red. The colour of the resulting mixture of light is varied by adjusting the intensity of each bulb, infinite control is thus obtained. The Durst AC650 is intended to give the advanced amateur and professional photographer an enlarger with the characteristics of a laboratory printer, with the ability to constantly vary the size of print and selectively compose the final result. A tungsten halogen bulb provides the illumination for 35mm and 6 × 6cm negatives and slides. Exposure is made by three consecutive exposures, each one timed automatically.

All the necessary colour and density measurements are carried out automatically once the photocells have recorded the correct amount of light for each colour.

However, the unit carries four control knobs for calibration to the standard negative and for personal manual override.

All automatic printing systems are subject to failure due to the inconsistency of the negative. Where there is a variation in density either through a negative process fault or wide change in the magnification, a reciprocity fault can occur. Each batch of paper has its own characteristics and the three layers of emulsion can be different in their response to over and under exposure, ideally, the photocell and filter response would match the sensitivity of the three emulsion layers, but in practice a shift occurs in both colour and density because of variations in the three characteristic curves. Special provision must be made in automatic printers to allow for this error and the adjustment is known as the slope control.

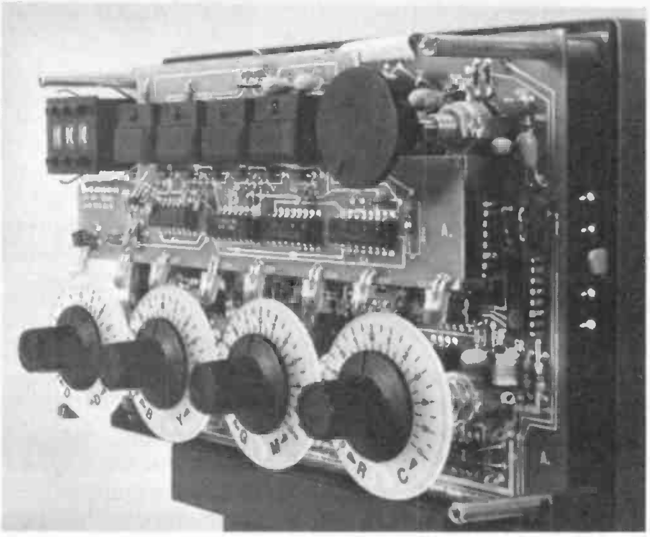
SLOPE CONTROL

For the mass market printer the slope control must be automatic without operator intervention. If it is found that the shift is toward green from an over exposed negative and toward its complementary, magenta, with an under exposed negative, a proportional reduction in the green exposure is required for under exposed negatives and an increase in the green exposure for over exposed negatives. In each channel adjustable response is provided, in series with the integrating condenser the photocell will read a "thinner than normal" negative and proportionately vary the green exposure.

An analyser used with an enlarger is subject to user override and the operator will make an allowance for thin or very heavy negatives and for larger or smaller degrees of magnification after normal analysis.

EQUIPMENT OPTIONS

Laboratory printers are now available in a wide range of specifications in both additive and subtractive variants. Mainly to cater for the professional photographer, there are package printers which analyse and simultaneously, through a cluster of lenses, produce a set of prints of different sizes, perhaps 1 @ 8× 6, 2 @ 5 × 4, 4 @ 3 × 2, all exactly matched for colour. Also in the laboratories catering for the professional photographer, particularly in wedding and portrait work where a consistently high



With the cover removed the extensive use of electronic control in the AC650 can be seen

standard of printing is required at reasonable prices, methods to avoid the reprint of unsatisfactory prints are in demand.

Video systems enable the operator to view the negative reversed in values to a correct colour image on the screen, the image is compared to a correct standard alongside, the colour balance is automatically assessed and fine tuned manually. The printing values are entered and produce a readout on punched tape or magnetic retrieval systems, this data with the negative is passed to the printer and high quality "one off" prints are produced. This method with moderate quantity production is not suitable for the mass market.

In general the printing of slides usually involves the making of an "interneg", so that the prints can then be made on automatic printers with other negatives. Slides can be printed on enlargers, with selective control and composition and many laboratories offer this service, which is well within the scope also of the home darkroom. In the home the colour can be balanced visually and the exposure established by a meter or the exposure channel of an analyser.

Successful photography depends to a large extent on accurate standardisation. Exposure of the film in the camera is critical if a high quality negative or transparency is to be produced. A professional photographer should have the skill to measure and judge the infinite variety of the effects of light and get his exposures correct; an amateur, who may only use his camera on holidays and occasionally at special events, will not have the experience and get very uneven results so it is in this area where automatic camera exposure control is very beneficial.

A simple meter system measuring the whole of the image area can produce very good results and more sophisticated camera exposure controls, measuring the centre of the image, an area around the centre and the outside edges and calculating the overall average. As the main subject is probably around the centre of the frame the method can hardly be faulted.

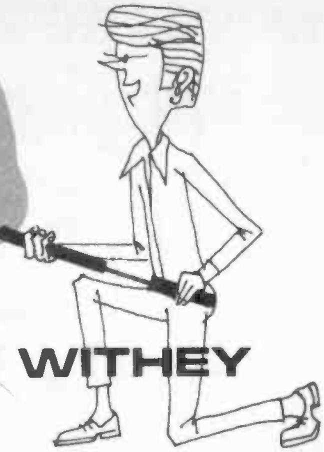
Standardisation in processing the film and printing the resulting negative is absolutely vital. Electronic control of process temperature and time and control of chemical replenishment, together with the programmed analysis of printers and enlargers, has revolutionised the practice of photography as it has been known since its invention, replacing years of experience and trial and error, with accurate, predictable and repeatable results, leaving the photographer free to concentrate on the picture composition.

LOOKING AHEAD

The future of silver based photography is now challenged by electronic image recording. Video has largely replaced home cine and an increasing amount of professional work and will undoubtedly produce an alternative means of recording family events, holidays and the snap shot.

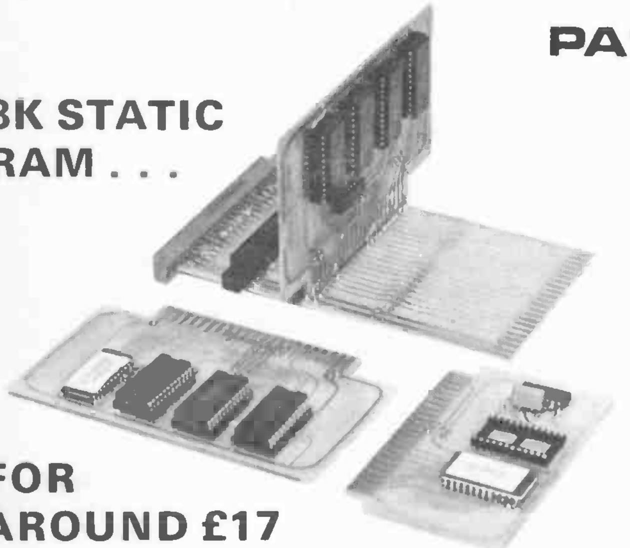
The attraction of taking pictures, either still or cine, and then seeing the results on the domestic television must be obvious. There is still, however, the problem of producing a high quality print from a video image comparable to that obtained from the traditional silver base film. ★

EXPANDING THE VIC 20



PART ONE **SAM WITHEY**

8K STATIC RAM . . .



FOR AROUND £17

FALLING prices of the Commodore VIC 20 home computer have outpaced the prices of expansion packs, which, perhaps due to the high price of 2K RAMs, remain beyond the pocket of many home programmers. However, for the hobbyist constructor, an 8K static RAM card can be made for around £17, a considerable saving over the normal price of approximately £45.

Included in this series of articles is an 8K RAM pack, which uses 4x6116 2K CMOS static RAM, an 8K ROM board, which can accommodate a single 2716 EPROM, a single 2532 EPROM, 2x2532 EPROMS, or one 2532 and one 2716 EPROM. A simple modification to the 8K RAM board enables it to be converted into a 3K RAM card with provision for 4K of RAM. Finally, there is a mother board capable of holding 3 cards vertically plus a horizontal socket for further extension. An independent power supply can be added to the mother board at any time.

All boards are constructed on double sided fibreglass laminate and are designed so that a minimum of lines on the top (component) side of the board make through plating unnecessary.

An EPROM programmer and other interfaces designed specially for the VIC 20 are being prepared in this series. (We expect these to include a stepper motor controller for robotics, DAC/ADC board, and an l.e.d./switches simulator I/O control port for designers.)

ADAPTABILITY TO OTHER SYSTEMS

Since decoding is carried out on the individual cards, the only problem in direct interfacing with other systems is the arrangement of Data, Address, R/W, Enable and power lines on the edge connector, and the physical spacing of the segments. This can be easily overcome, by preparing a suitable connector on a ribbon cable harness.

THE 8K RAM BOARD

The 8K RAM board (Fig. 1.1) has provision for 4x24 pin devices laid side by side to facilitate paralleling of Data and Address lines. All of this is carried out on the under side of the board. Address lines A0 to A10 are taken directly to the edge connectors, whilst A11 and A12 are taken from the upper surface of the board using through-the-board link pins. Similarly, the +5V rail is distributed to all devices after transfer from the upper surface via a link pin. The ground rail appears on both sides of the board, interconnected by the −ve leads of decoupling capacitors C1 and C2.

Data lines D0 to D7 are taken directly to the edge connectors on the upper surface of the board from the adjacent 2K RAM IC4. The R/W is taken from pin 21 (WE) of IC1 to edge connector 17 and Pin 20 (OE) of IC1 is taken to ground. As stated earlier, these lines are paralleled on the under side of the board.

Pin 18 (CE) of IC1 to IC4 are decoded by one half of IC5, a 74LS139, I of 4 decoder. Data Select A and B from this device are taken to A11 and A12 respectively on the lower side of the board with link pins. Pin 13 (EN) of this device is taken to RAM blocks 1, 2 or 3, selected by a suitably placed blob of solder on the pads provided.

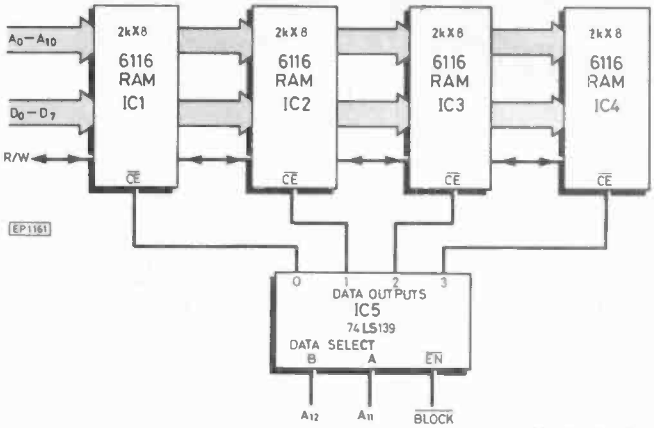
C1 and C2 are 330nF tantalum bead capacitors used for decoupling. The values are not critical, physical size being the more important. 10nF ceramic discs would probably provide sufficient noise suppression.

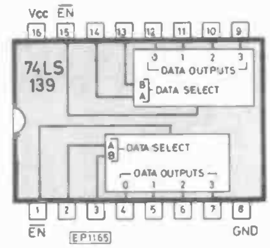
The 6116 CMOS RAM has the advantage of a very low operating current, avoiding the need for an additional power supply. Also, if 100k pull down resistors are soldered between the address lines and ground, the quiescent current is as low as 2µA, enabling a 2·4V back-up battery pack (2x1·2V nicads or 2x1·5V penlight) to be installed between the +5V rail and ground, to maintain programs during switch-off time.

CONSTRUCTION

4x6116, 150ns CMOS 2K Static RAMs are used for I.C.s 1 to 4 and it is therefore advisable to use sockets. Unless the constructor is a real novice IC5, being TTL, can be safely soldered directly on the board, Pins 8 to 15 on the upper surface and Pins 8 and 16 on the under side. See Fig. 1.4.

The socket of IC4 should be mounted first, because it has pins to be soldered on both edges. Do not insert the sockets fully, but leave sufficient clearance to enable a fine soldering tip to touch the pins from the upper surface of the board. Having done this, tack the socket in position by soldering the corner pins on the lower side of the board. After soldering





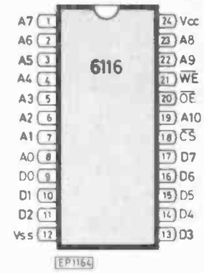
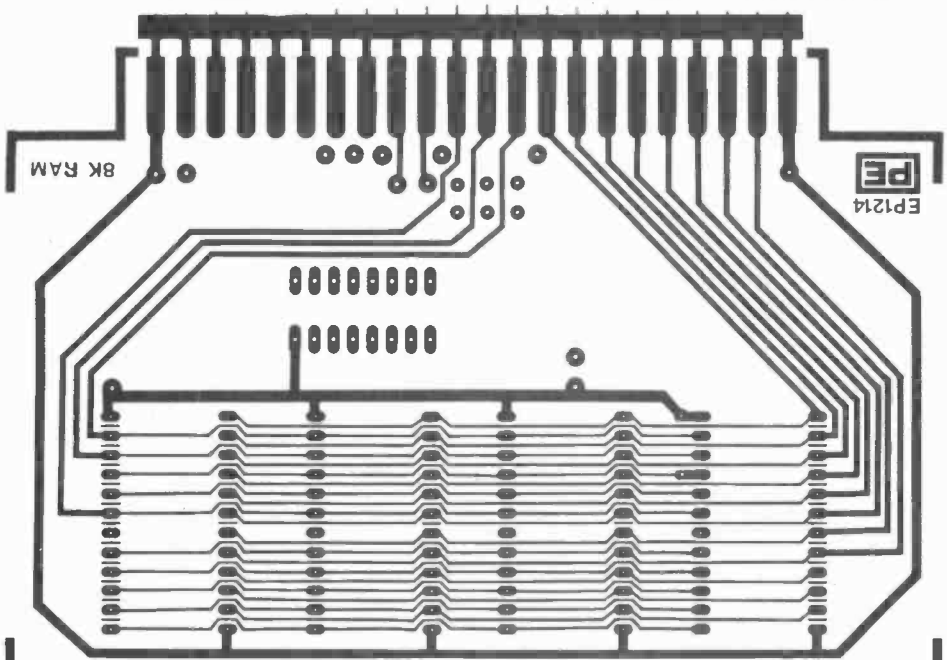


Fig. 1.1. 8K RAM card

Fig. 1.2 (below). RAM board track layout (track-side)



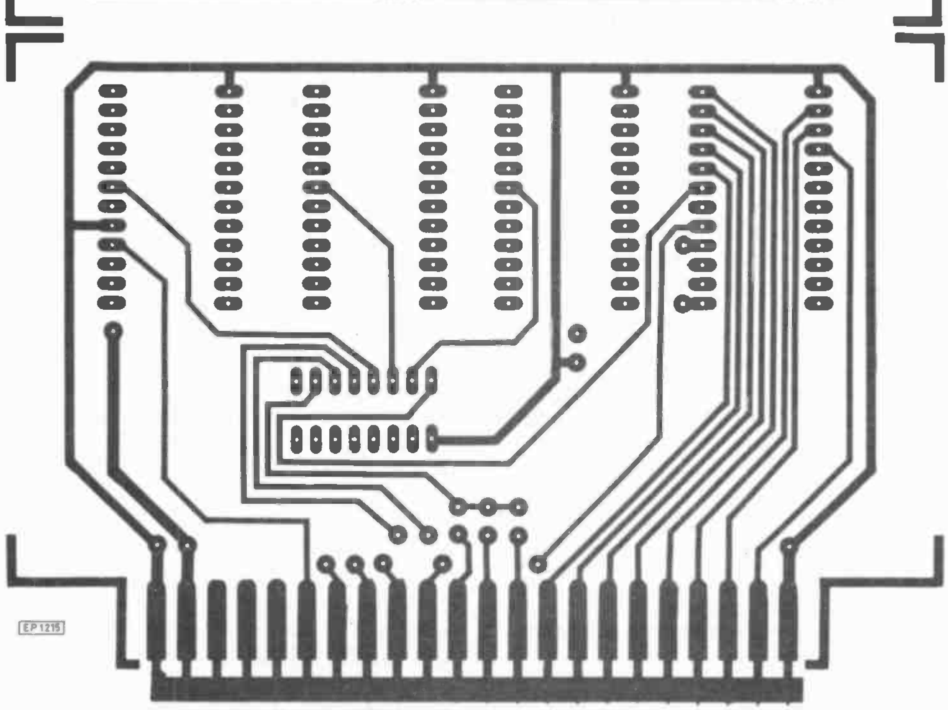


Fig. 1.3. RAM board track layout (component-side)

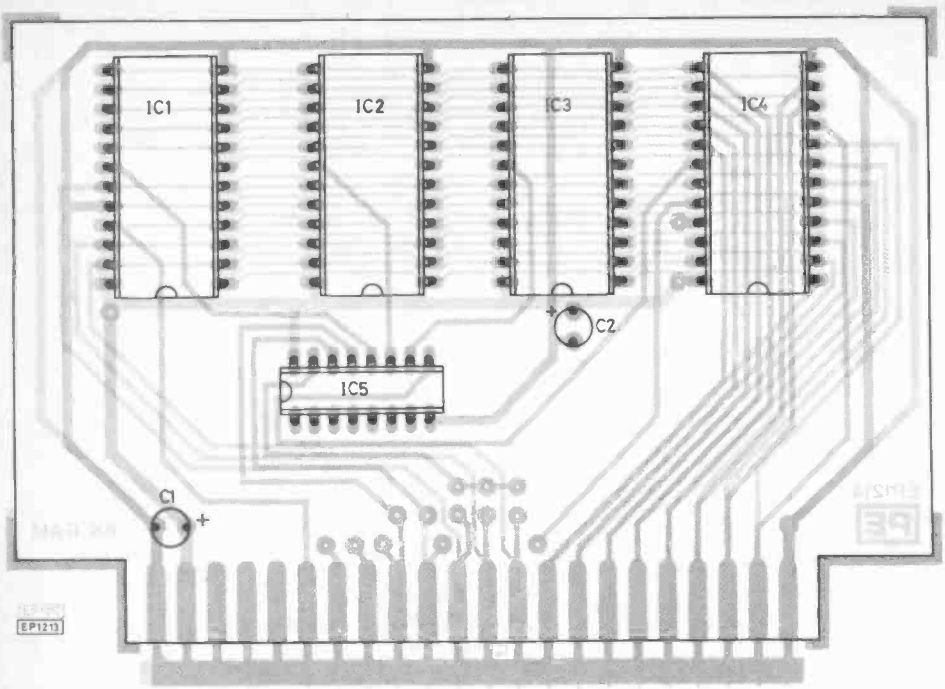


Fig. 1.4. RAM board component layout (actual size). It is suggested that soldercon pins (or RS socket strips) be used as i.c. holders, to simplify component-side soldering. Not all constructors will share the author's skill at soldering near the "underbelly" of plastic i.c. sockets—Ed.

NOTE: *Whilst using the "Super-Expander" alone, VIC 20 BASIC ignores it when extra RAM blocks are added. It may, however, be used for m/c routines.*

COMPONENTS . . .

8K RAM BOARD

Capacitors

C1, C2	330n tant. bead (2 off)

Integrated Circuits

IC1–4	6116 CMOS 2K Static RAM (4 off)
IC5	74LS139 1-of-4 decoder

Miscellaneous

Integrated circuit sockets
Printed circuit board*

Pins 9 to 18 (inclusive) on the upper surface of the board check that there are no bad joints before proceeding to IC3. This is best done by inserting an old 24 pin device in the socket and checking continuity with a multimeter.

Next insert IC3 socket where only Pins 12 and 18 have to be soldered on the upper surface. IC2 socket is the same. IC1 socket has to be soldered on Pins 12, 18, 20 and 21. As these are all clear of the previously mounted sockets this presents no difficulty. If the pins on the underside of the board were not soldered previously, solder them now.

The CMOS RAMs should be handled with care and it is worthwhile inserting an old 24 pin device into the sockets, not only for continuity checking, but also to "break-in" the socket and avoid risking bending the pins of the RAMs.

C1 and C2, together with the through-the-board links, are soldered in place before inserting the RAMs.

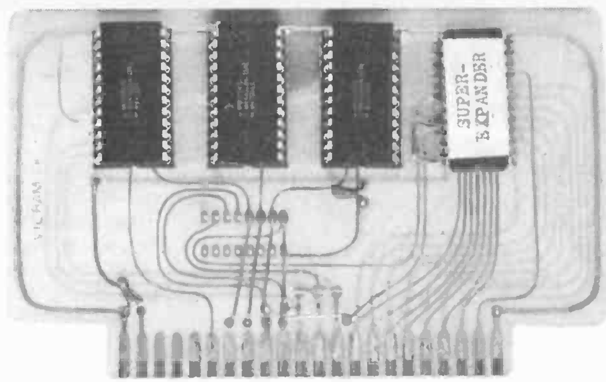
It is time well spent to check all solder joints before using the board on the computer. In particular, check that there is no short between +5V and ground.

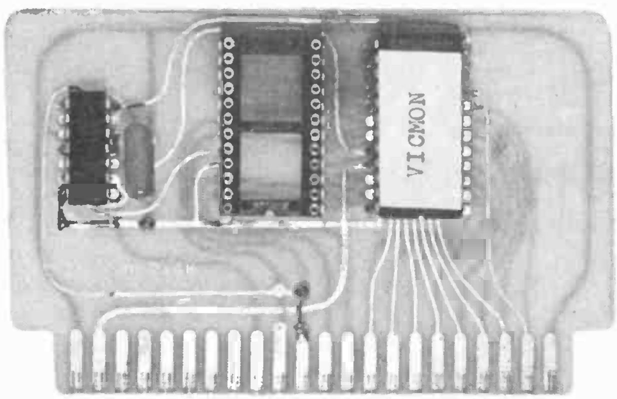
CONVERTING THE 8K RAM BOARD TO 3K RAM PLUS 4K ROM (SUPER-EXPANDER)

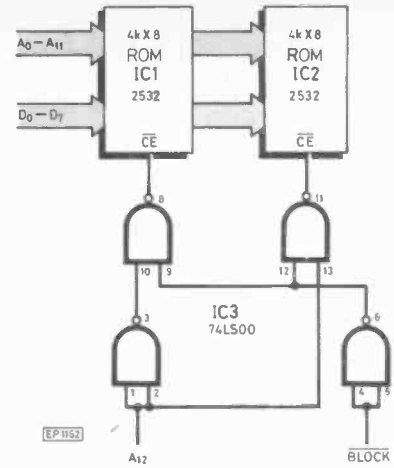
Having designed an 8K RAM board it became obvious that at some time it would be desirable to fill in the 3K memory gap at location 0400Hex. Because of its pin compatibility with the 6118 first consideration was given to the use of the 4118A static RAM. At first it was decided to modify the 8K RAM board by eliminating one socket and the decoder. Then the possibility of using the 4th socket as a 4K ROM socket was considered. Since all Data and Address lines are shared and the 4118A and 2532 are also compatible a further look was taken at the 8K RAM board to realise that very few modifications were necessary in order to use the same board for both purposes.

The only pin connections which differ are 18, 19, 20 and 21. For the 3x4118 RAMs Pin 21 (WE) remain in parallel and connected to edge connector 17, whilst the track was cut under the board at IC4 and a small link made between Pin 21 and Pin 24 on the upper surface to tie Vpp to +5V. Pin 20 (OE) on the 3x4118A RAMs remain in parallel and tied to ground, Pin 20 on IC4 once more being isolated by cutting the track under the board. Pin 20 of the 2532 is the CE and a short insulated lead is taken from this pin to Block select 3 or 5. As there is no internal connection at Pin 19 of the 4118A it was decided to leave the existing line connected in parallel as A10 is required by the 2532. Pins 18 (CE) of the 4118A RAMs are taken individually to RAM 1, 2, and 3 at edge connectors 16, 15 and 14. Use is made of the pads of the decoder i.c. to keep leads short and neat. Pin 18 of IC4, 2532 ROM is also taken from the pad of the decoder i.c. and the link pad formerly used as a through-the-board link to A11 on the lower side of the board.

For the hobbyist who produces his own printed circuit boards this eliminates a considerable amount of work required in producing a new set of double sided board masks. It is suggested that provision should be made for this modification when preparing the 8K RAM board mask, i.e. provide pads over edge connectors 13 to 16 and a provisional line from Pin 20 of IC4 terminating in a pad by the side of Data 7.







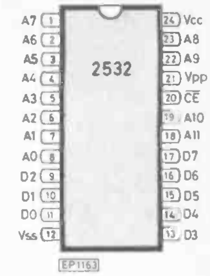


Fig. 1.5. ROM board

8K ROM BOARD

The ROM board (Figs. 1.5 and 1.8) is arranged in a similar manner to the 8K RAM board, having 2 x 24 pin devices laid side by side. All pins are paralleled on the under side with the exception of Pins 24 (+5V) and Pins 21 (A11), which are tied to +5V on the upper side and Pins 20 (OE), which are decoded by IC3, a 74LS00 Quad 2 Input NAND Gate. As with the RAM board, all Data and Address lines are taken directly to the edge connectors, A12 being taken to Pins 1, 2, and 13 of IC3.

The ground rail is on the lower side of the board, but is taken from Pin 12 of IC1 on the upper side of the board to supply ground for IC3. The +5V rail is on the upper side of the board. C1, a 100nF ceramic disc, supplies sufficient noise suppression and is connected to the +5V rail via a through the board link pin.

If sockets are to be used, it is advisable to insert and solder Socket 1 first, leaving sufficient clearance for a fine soldering iron tip as with the RAM board. An insulated wire link selects ROM Block 3 or 5.

ROM is normally located in memory at A000Hex for ROM Block 5, or 6000Hex for RAM/ROM Block 3. If the latter arrangement is chosen, IC1 is located at 6000Hex and IC2 at 7000Hex. Referring again to the schematic diagram it will be seen that when A12 is low OE of ROM 1 is low and therefore active. OE of ROM 2 would be high and would not be selected. Inversely, when A12 is high, OE of ROM 2 is low and would be active, whilst OE of ROM 1 would be high and not selected. Blocks are always active low. Unlike the RAM used by BASIC, the ROM memory locations do not have to be one continuous program, but can be 2 or more separate functional routines that can be called from BASIC or machine code. Whilst a 2532 would normally occupy each socket, there is nothing to prevent a 2716 being used to provide programs from 6000Hex to 67FFHex or 7000Hex to 77FFHex.

COMPONENTS . . .

8K ROM BOARD

Capacitors

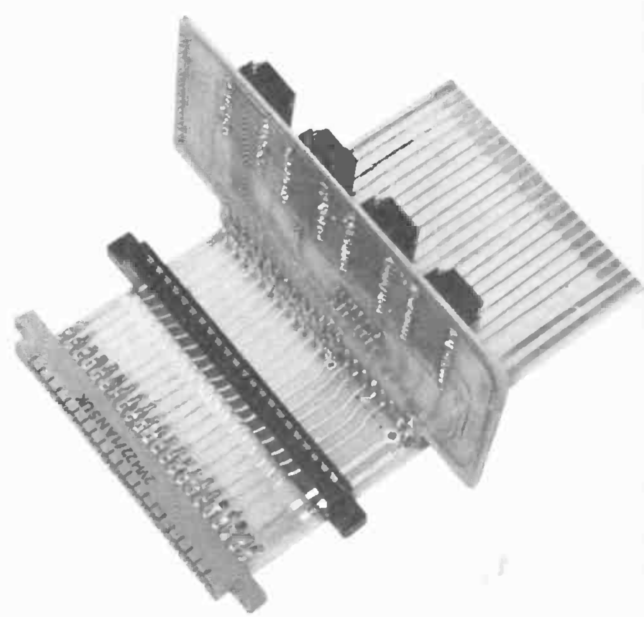
C1	100n disc cer.

Integrated Circuits

IC1, IC2	2532 4K x 8 ROM (2 off)
IC3	74LS00

Miscellaneous

Integrated circuit sockets
Printed circuit board*



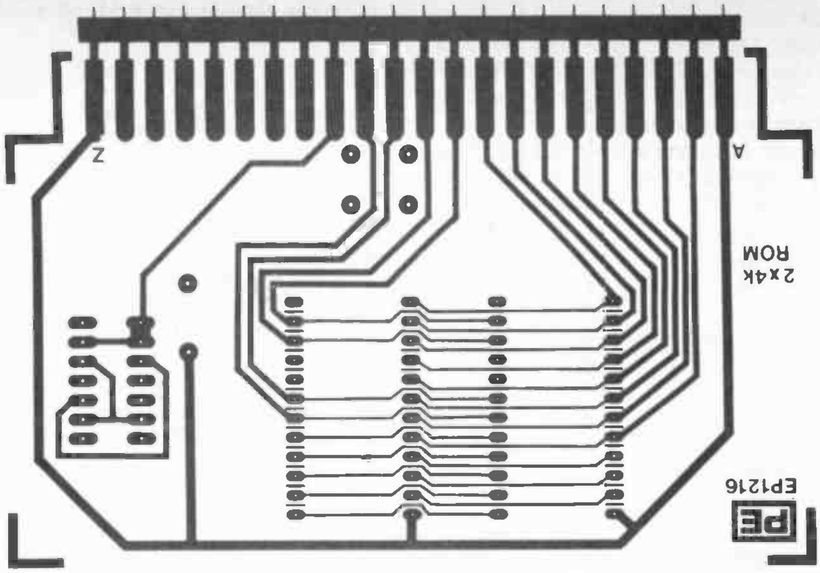


Fig. 1.6. ROM board p.c.b. (track-side)

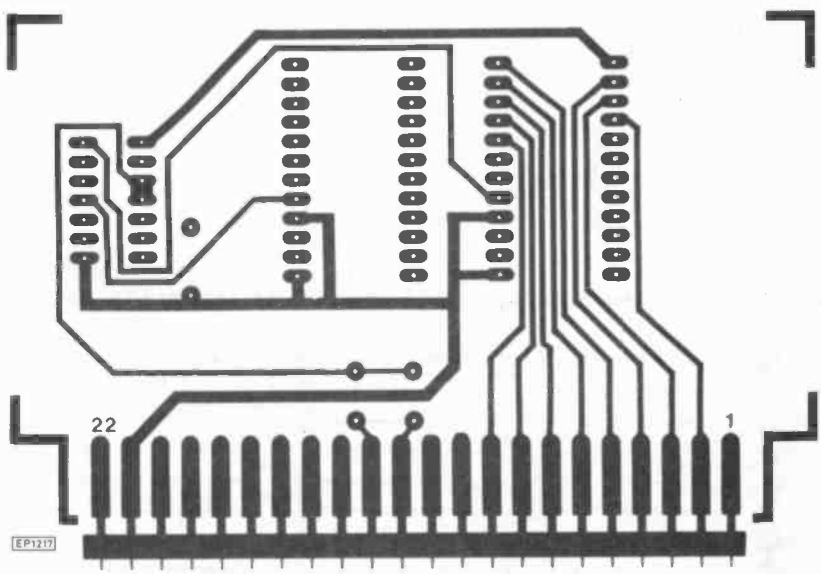


Fig. 1.7. ROM board p.c.b. (component-side)

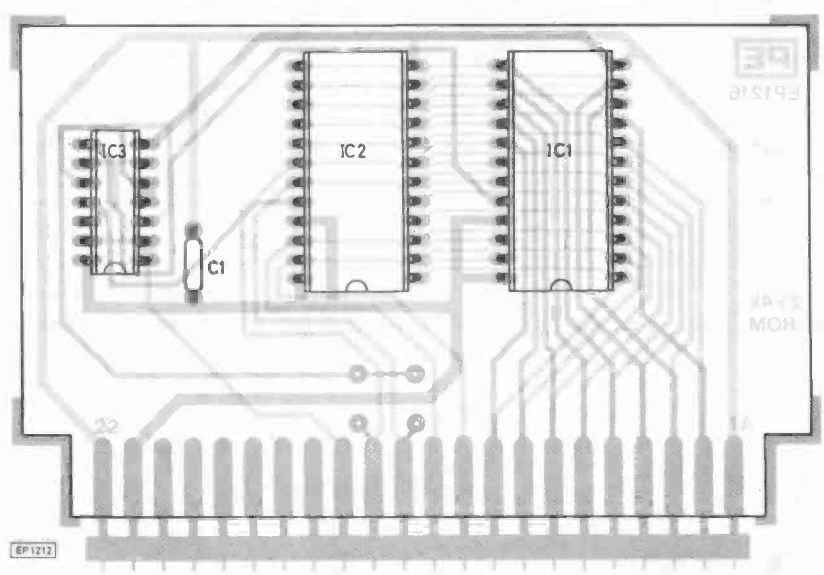


Fig. 1.8. ROM board component layout (actual size)

THE MOTHER BOARD

The Mother Board (Fig. 1.11) described here holds 3 boards vertically and a socket is provided for further horizontal expansion. Unused lines have been omitted, but it will be necessary to drill holes if sockets are to be used.

On the prototype, the first positions were used for RAM Blocks 1 and 2, memory locations 2000Hex and 4000Hex. The third position was taken by a 2 x 4K ROM Board, covering memory location 6000Hex at RAM/ROM Block 3. The lower 4K of the latter was used for the VICROM Machine Code Monitor, leaving the section 7000Hex to 77FFHex free for user Machine Code programs.

Since these boards were intended for regular use they were soldered directly to the Mother Board, with wires, saving the cost of sockets and leaving the rear horizontal socket for such applications as games cartridges.

Construction presented no difficulties, but it should be observed that boards or sockets should be mounted starting from the rear position first. This is because the mounting pads for the top lines are towards the front and should not be obstructed. Additional pads are provided on the lower surface for extra support for these pins. Sockets should, of course, be mounted slightly proud of the board to permit application of solder on the top pads.

The sockets required are 0·156 inch, or 4mm spacing and are 2 x 22.

COMPONENTS . . .

MOTHER BOARD

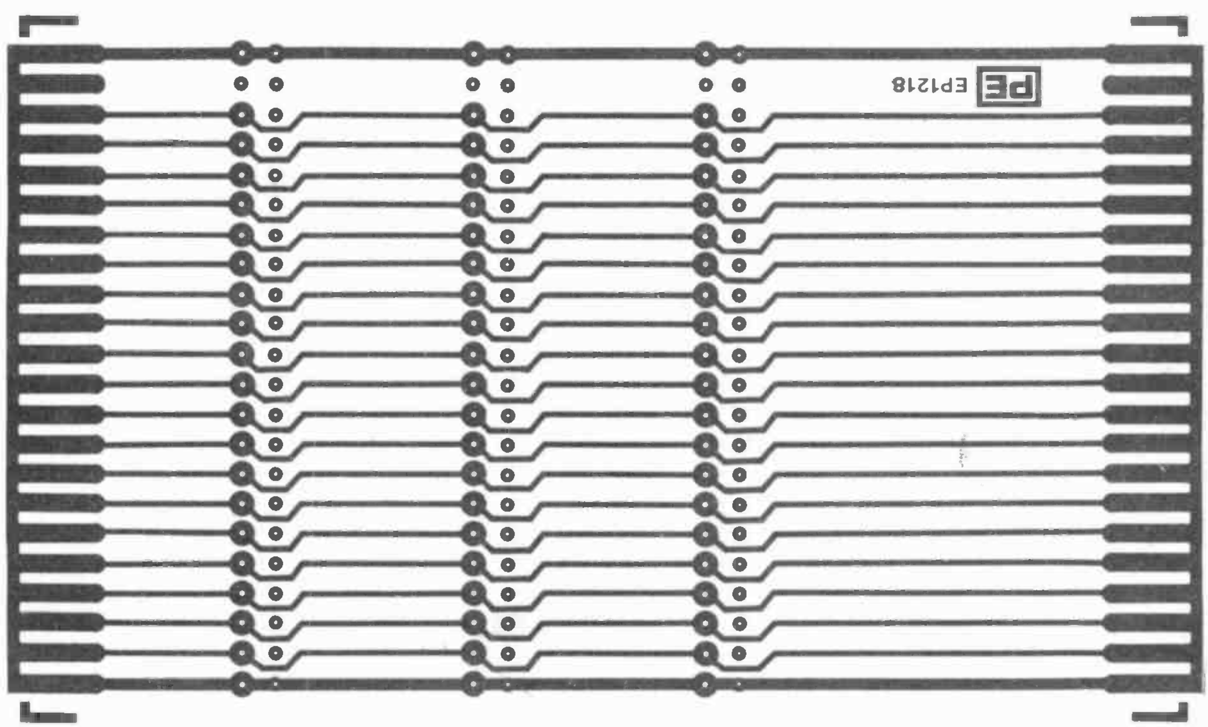
Miscellaneous

Edge connectors: 0·156in. (4mm) 2 x 22 contact
Printed circuit board

Constructors' Note

Edge connectors to suit (and most components) are available from **Watford Electronics.**
* If p.c.b.s are found to be unavailable from PE's usual suppliers, they may be obtained from Meridan Ltd., ✆ 0639 898277.

Fig. 1.9. Mother Board p.c.b. (track-side)



EXPANDING THE VIC 20

X

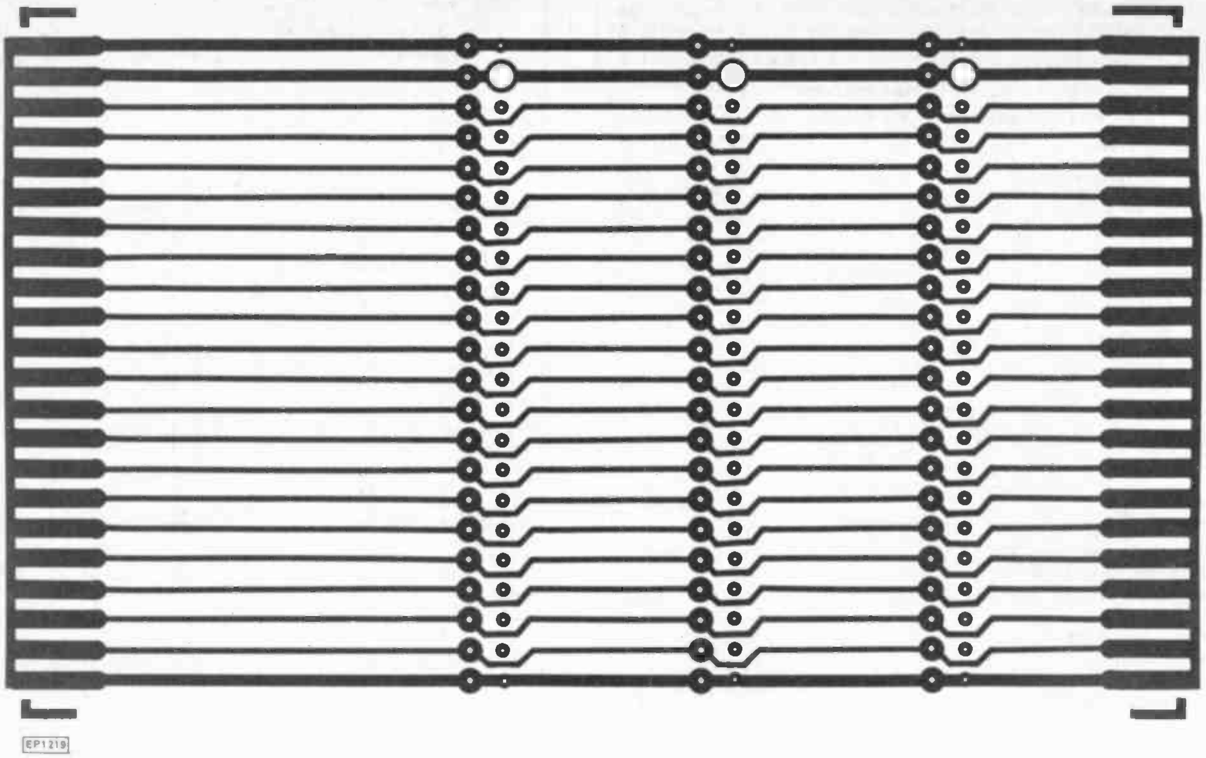


Fig. 1.10. Mother Board p.c.b. (component-side)

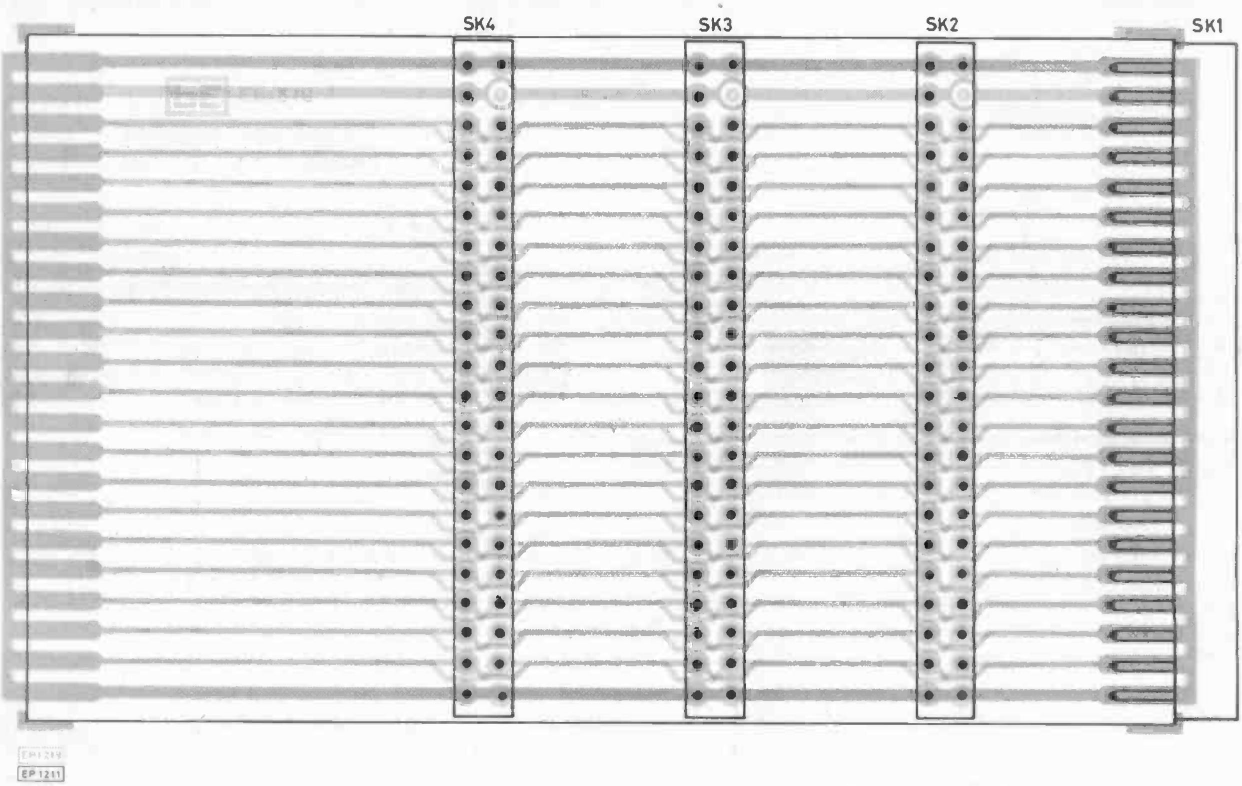


Fig. 1.11. Mother Board component layout (actual size)

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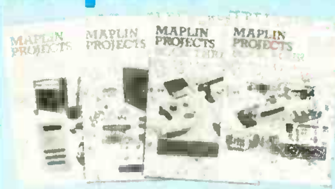

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