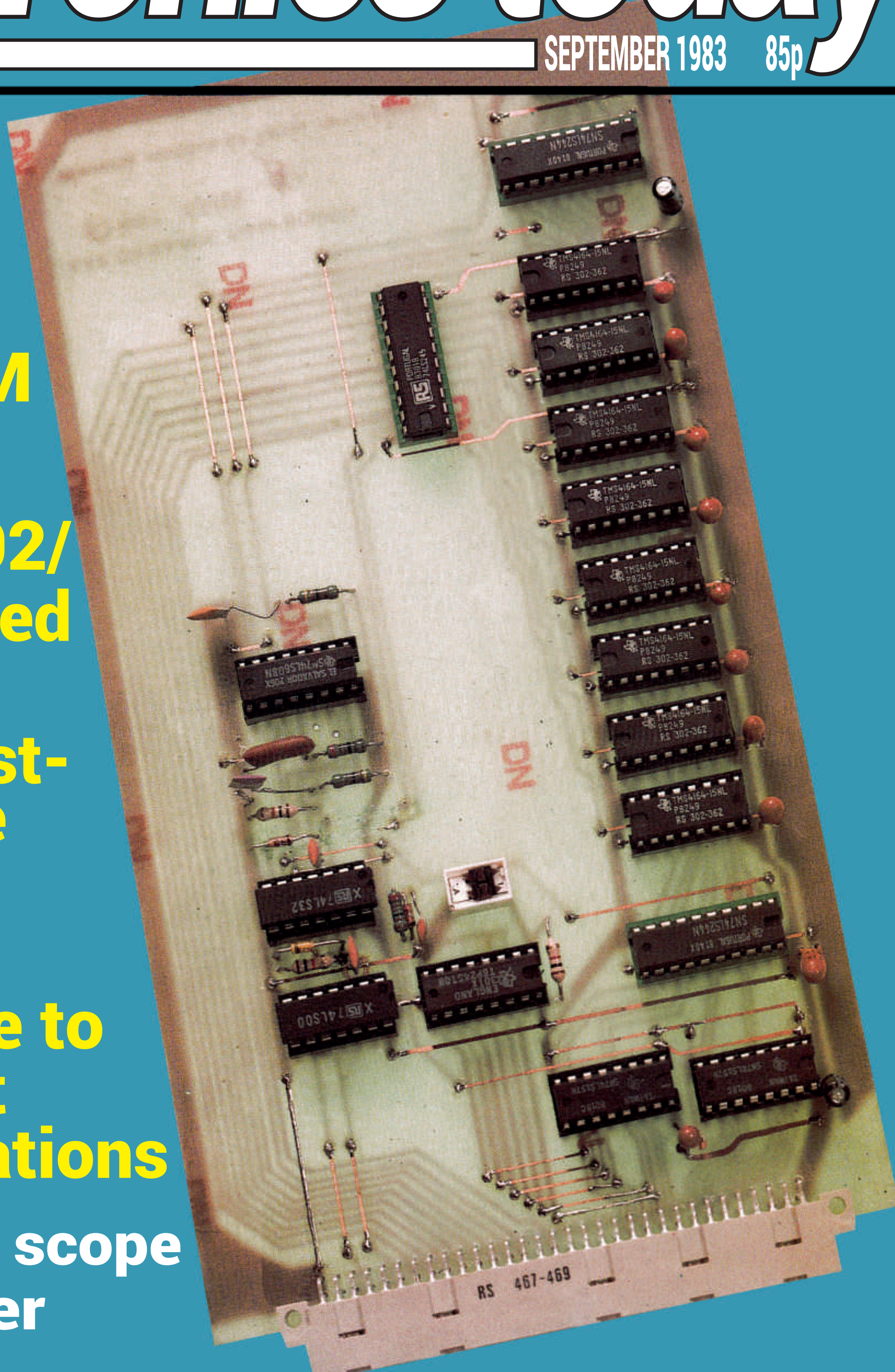
electronics today

INTERNATIONAL SEPTEMBER 1983 85p



REFRESH YOUR MEMORY!

64 K DRAM project

- suits 6502/6800 based micros
- highly cost-effective design
- readily adaptable to different configurations

Logical scope trigger

PLUS Audio Design-a major new series from Linsley Hood

Videotone Minimax IIs on test

Automatic NiCad charger/regenerator

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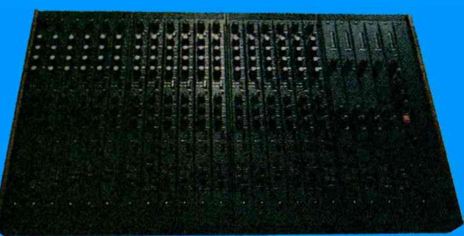
BIG NEWS ABOUT OUR LATEST ADVANCES IN ROBOTICS SEE INSIDE BACK COVER

DJ90 Stereo Mixer — this is a really versatile new mixer that enables the constructor DJ to produce a professional performance every time. There are two stereo inputs for magnetic cartridges, a stereo auxiliary input and mike input. Other 'plus' features are auto-panning for fast or slow slider controls, multi-mixing, ducking, interrupt, input modulation, in short everything . . . the whole works — AND — under £100 complete! Complete kit **£97.50** + VAT

TRANSCENDENT 2000 — Although only a 3 octave keyboard the '2000' features the same design ingenuity, careful engineering and quality components of its larger brethren. The kit is well within the scope of the first time builder — buy it, build it — play it! You will know you have made the right choice.
Complete kit **£165.00** + VAT



SALES COUNTER Collect your order from the factory. Open 9-12/1-4.30 Mon-Thurs. Easy parking, no waiting

Digital Delay Line — With its ability to give delay times from 1.6 mSecs to up to 1.6 secs. Many powerful effects including phasing, flangine, A.D.T., chorus, echo &

vibrato are obtained. The basic kit is extended in 400 mS steps up to 1.6 secs. Simply by adding more parts to the PCB. Compare with units costing over £1,000!
Complete kit (400 mS delay)
£130 + VAT
Parts for extra 400 mS delay
£9.50 + VAT

This versatile modular mixer, featured as a constructional article in Practical Electronics can be built up to a maximum of 24 inputs, 4 outputs and an auxiliary channel. Each input channel has Mic and Line inputs, variable gain, bass and treble controls and a parametric middle frequency equalizer. There are send and return jacks, auxiliary, pan and fader controls and output and group switching. The output channels have PPM displays and record and studio outputs. The auxiliary channel also has a PPM display and there is a headphone monitor jack and a built-in talk-back microphone. The mixer modules plug into base units each of which takes up to 6 channels. To eliminate hum, the power supply is in a separate cabinet.

KIT PRICES

Input channel	**£19.90**	Base unit and wooden front	**£27.50**
Output channel	**£18.50**	Pair of mahogany end cheeks	**£12.50**
Auxiliary channel	**£22.50**	Power Supply and cabinet	**£19.50**
Blank Panel	**£3.00**		

All prices are VAT exclusive

Free Soldering Practise Kit on request with your first kit — useful tips, well illustrated.

TRANSCENDENT POLYSYNTH — A four octave polyphonic synthesiser with outstanding design characteristics and versatility and performance to match.
Complete kit **£275.00** plus VAT (single voice)
Extra voice (up to three more) **£42.00** plus VAT

MPA 200 — is a low price, high power 100W amplifier, its smart styling, professional appearance and performance, make it one of our most popular designs. With adaptable inputs the mixer accepts a variety of sources yet straightforward construction makes it ideal for the first time builder. Complete kit **£49.90** + VAT

Chromatheque 5000 — a 5 channel lighting system powerful enough for professional discos yet controllable for home-effects. Sound to light, strobe to music level, random or sequential effects — each channel can handle up to 500W yet minimal wiring is needed with our unique single board design. Complete kit **£49.50** + VAT

ETI VOCODER — 14 channels, each with independent level control, for maximum versatility and intelligibility; Two input amplifiers — for speech/excitation — each with level control and tone control The Vocoder is a powerful yet flexible machine that is interesting to build and thanks to our easy to follow construction manual, is within the capability of most enthusiasts. Complete kit **£175.00** + VAT

SP2 200 twice the power with two of the reliable, durable and economic amps from the MPA 200, fed by separate power supplies from a common toroidal transformer. Superb finish and quality components throughout — up to (even over) the standard of high prices factory-built units! Complete kit **£64.90** + VAT

Component packs for most kits are available See our great free catalogue, full details of all our range

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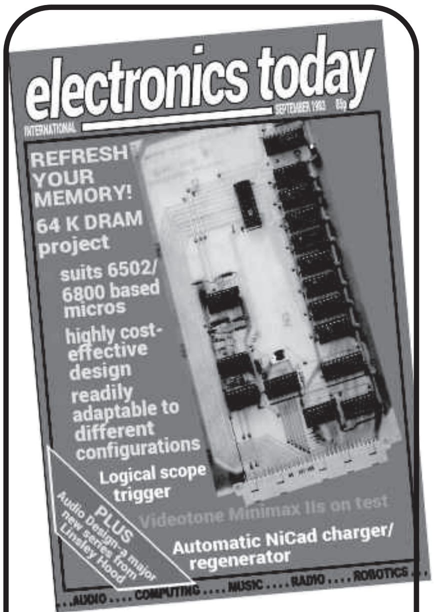

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ELECTROLYTIC CAPACITORS: (Values in uF) 500v; 10uf52; 47 78p: 63V: 0.47, 1.0, 1.5,2.2,3.3.4.7 Sp 10 10p, 15.22 12p; 33 12p: 68 20p; 100 19p; 220 26p; 1000 70p: 2200 19p; SOY: 68 20p; 100 17p:220 24p: 40Y; 22 9p: 33 12p; 330.470 32p; 1000 48p: 2200 90p: 25Y: 1.5.4.7.10,22,47 ep; 10011p: 15012p: 2201Sp: 330 22p; 470 25p; 680. 1000 34p, 1500 42p; 2200 50p; 3300 76p; 4700 92p; 16V;47,68,100 9p; 125 12p; 330 16; 470 20p: 680 34p'. 000 27p: .1_SD9_1p: 00 2Sp 4:00 72p

TAG-END CAPACITORS: 83Y: 2200 120p; 3300 145p; 4700 2'5p; 50Y: 2200 95p; 3300 155p; 40Y: 4700 160p; 25Y: 2200 70p; 3300 8Sp; 4700 10,000 250p; 15,000 270p; 18Y: 22;000 200p.

LYE.STER CAPACITORS: Axlal Lead Type
1000V: 1nF 17p; 10nF 30p; 15n 40p, 22n 36p; 33n 42p; 47n, 1D0n42p.1.5u a p ; 2.2uf

POLYESTER RADIAL LEAD CAPACITORS: 250V
10n, 15n.22n,27n8p; 33n,47n,68n, 100n8p; 150n.220 10p; 330n, 470n 15p; 680n Hip; 1u5 40p; 2u2 48D.

FEEDTHROUGH CAPACITORS
1OOOpF/450V 10p

TANTALUM BEAD CAPACITORS
35V: 0.uF, 0.22, 0.33 15p 0.47, 0.88, 1.0, 1.5 18p; 2.2, 3.318p; 4.7, 6.8 22p 10 28p; 18V: 2.. 3.3 1lp; 4.7, 6.8, 10 1lp; 15,38p; 22 45p; 33, 47 50p; 100 95p; 10V: 15, 22, 21p; 33,47 50p; 100 eop; ev : 1oo 55p.

POTENTIOMETERS: Carbon Track
Rotary 0.25W Log & LIN Values.
470 n , 1K & (Linear only)
5K-2M Single Gang oP°iwltch ••••• 1DOp
5K-2M Double Gang Log & Lin 110p

SIEMENS pdb
Type Miniature paly Cap1c1tor1

280V
1nF, 1n5, 2n2, 3n3. 4n7, 8n8, 10n, 15n 7p
18n, 22n. 27n, 33n.39n,47n
39n, 58n 12p
82n, 100n 11p

100Y
100n, 120n 10p
150n, 160n 12p
220n. 270n
330n, 390n 20p
470r,.. 560n 28p
680n 30p 1uF
34p 2u2 50p

MYLAR FILM CAPACITORS
100V: 1nF,"2, 4, 4nF, 10 8pj 15nF, 22n, 30n, 40n, 47n 7p; 56n, 100n, 200n 9p; 50V: 470nF 12p.

SLIDER POTENTIOMETERS
0.25W log and linear values 80mm
S K - 500K single gang 80p
Graduated Bezels for above ,s p

CERAMIC CAPACITORS SOY:
Range: 0.5pF to 10nF- 4p
15nF, 22nF 33nF; 47nF Sp
100nF/20V 7p 200nF/6V 8p

PRESET POTENTIOMETERS
0.1 W Miniature Horizontal or Vertical
1oon·10 4M7 Sp
0.25W Larger 100R 10 3M3 Hort 12p
0.25WLarger200R to4M7 Vertical 12p
" cermet muUiturn preaet
100 π to sooi.. 80p

POLYSTYRENE CAPACITORS,
10pF to 1nF8p; 1.5nF to 12nF 10p.

SILVER MICA (Values in pF)
2, 3.3, 4.7, 6.8, 10, 12, 15, 18, 22, 27, 33, 39, 47, 50, 58, 68, 75, 82, 85, 100, 120, 150. 180pf 15p each
200, 220, 250, 270, 300, 330, 380, 390, 470, 580, 800, 820pl 21p each
1000, 1200, 1800, 2200pf 30p NCh
3300, 4700, 5600pf 80p ach

MINIATURE TRIMMERS Capacltora
2to6pf, 2 to 10 22p
2-25pF 5-65pF 30p
10-88pF 35p

RESISTORS Carbon Film, miniature, Hi·St1b, Slt.

	RANGE	Val	1·99	100+
0.25W	202 - 10M	E24	3p	1p
0.5W	202 - 4M7	E12	3p	1p
1W	202 - 10M	E12	6p	4p
2% Metal Film	51o-1M	E24	6p	4p
1% Metal Film	51o-1M	E24	Sp	4p

100+ price applies to Re1iators of each type not mixed

RESISTORS NETWORK S.I.L
7 Commoned: (8 pins) 1000, 6800. 1K 2k2, 4K7; 10K, 47K, 100K 18p
8 Commoned: (9 pins) 1son. 1800. 2700. 3300, 1K, 21<2, 4K7, 6KB, 10K, 22K, 47K. 100K

DIODES
AA119 8
AA129 10
AAY30 8
BA100 10
BY100 10
8Y126 12
8Y127 10
CR033 118
OA9 10
OA47
OA70
OA79 10
OA81 10
OA85 10
OA90 12
OA91 15
OA9:5
OA200
OA202 5
1N914 4
1N916 5
I N4001/2 5
1N4003
1N4004/5
1N4006/7 7
1N4148 4
1N5401 12
1N5404
1N5406 1
1N5408
15'4
15921
6A/100V
6A/400V
6A/800V

VARICAPS
BB105B 40
BB106 40

TRIACS
3A200V 54
3A400V 56
8A100V 64
8A400V 69
8A800V 115
12A100V 78
12A400V 82
12A800V 136
16A100V 103
16A400V 108
16A800V 220
25V500V 220
25A800V 296
T2800 125

SCR THYRISTORS
5A/40V 32
5A400V 40
5A600V 48
8A300V 80
8A600V
12A100V
12A400V
BT106 185
BT116 150
C106D 180
TIC44 38
TIC45 24
TIC47 21
2N5062 32
2N5064
2N4444 130

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1A/50V 18
1A/100V 20
1A/400V 25
2A/50V 30
2A/100V 36
2A/400V 42
2A/600V 53
6A/100V 83
6A/400V 86
10A/200V 215
10A/600V 205
25A/200V 240
25A/600V 338
BY164 58

75 SERIES
75107
75108
75110 00
75114 139
75115 139
75121 121
75122 111
75154 131
75158
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75162 145
75182
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75184 11
75188/9 70
75322 140
75324
75325 21S
75361 131
75363 131
75365 210
75450 70
75451 41
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Range: 3V3 to 33V 1.3W 15p each

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27128-250n1
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418' 115
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4818-100ns 100
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6522A
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81LS9B 175
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SAA5050 175
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TMS4418 355
TMS4500 £12
TMS4532

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W01691 £14
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280ACPU 4M 310
280 CTC 285
Z80A CTC 310
280 DART 650
280A DART
Z80 OMA
Z80AOMA
280 PIO 250
280A PIO 315
280 510·1 150
Z80A SIO
ZS0ASI0·2

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702
709C 8 pin
710
741 8 pin 00
747C 14Pin
748C 8 pin
110 110
MOCCJ 171
AOCD808 1000
AY-1-1320 220
AY-I-5050
AY-3-1350
AY-3-8910
Booklet for
AY-3-8Cl10 150
AY-3-8912 410
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AY-5-1350
AY-5-8100 575
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CA3012 175
CA3014 275
CA3018
CA3019
CA3020 210
CA3023 210
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CA3180 15
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CA3162 540
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74393 103
74426 85
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74C245 125
74C373 210
74C374 210
74C922 210
74C923 590
74C925 625

74HC
HC00 30
HC02 30
HC08 30
HC10 30
HC20 30
HC24 55
HC32 40
HC42 50
HC51
HC74
HC86 50
HC107 40
HC109 50
HC139 65
HC153 60
HC160 80
HC161 80
HC164 80
HC165 es
HC173 90
HC174 90
HC175 100
HC240 120
HC249 110

HC2d1 100
HC24.? 100
HC244 100
HC245 110
HC25'cl to
HC373 110
HC3.'d 05
HC393 110
HC640 165
185

74LS
LS00 22
LS01 22
LS02 22
LSOJ 22
LS04 22
LS05 22
LS0a 25
LS09 22
LS10 22
LS11 22
LS12 22
LS1J 30
LS14 50
LS15
LS19 22
LS20 22
LS21 22
LS2 22
LS24 50
LS2e 22
LS27 22
LS28 24
LS30 22
LS32 22
LS33 23
LS37 25
LS38 22
LS40 25
LS42 50
L5'7 75
L5'9
LS51 22
LS52 25
LS54 22
LS55 22
LS63 25
LS73 28
LS74 28
LS75 38
LS76 3'
LS78 35
LS83 50
LS85 70
LS86 30
LS90 40
LS91 ea
LS92 50
LS93 45
LS95
LS96 to
LS107 40
LS109 45
LS112 40
LS113 38
LS114 38
LS122 40
LS123 50
LS124 120
LS125 37
LS126 37
LS132 42
LS133
LS136 28
LS138 48
LS139 45
LS145 10
LS147 130
LS148 115
LS154 120
LS155
LS156 47
LS157 48
LS158
LS160 30
LS161 50
LS162 50
LS163 80
LS164
LS165
LS16d
LS166
LS168 138
LS169 to
S170 120

LS173 80
LS174 80
LS175 80
LS181 180
LS183 185
LS190 7S
LS191 05
LS192 75
LS193 70
LS194 70
LS195 80
LS196 7S
LS197 75.
LS221 85
LS240 co
LS241 co
LS242 co
LS243
LS244 70
LS245 88
LS247 75
LS248 100
LS249 100
LS:'1
LS251 70
LS253 to
LS257 55
LS258 ll
LS259 to
LS260 70
LS261 100
LS266 25
LS273 80
LS275 380
LS279
LS280 180
LS283 70
LS290 ao
LS292 750
LS293
LS294
LS295 130
LS297 850
LS298 100
LS299 220
LS320 210
LS323 300
LS324 140
LS325 150
LS326 280
LS327 280
LS347 120
LS348 140
LS352 115
LS353 125
LS355 200
LS356 200
LS363 140
LS364 150
LS365
LS366 42
LS367 42
LS368 42
LS373 80
LS374 80
LS375
LS377 100
LS378 85
LS379 127
LS380 310
LS381 310
LS382 457
LS384 310
LS385 50
LS386 80
LS390 45
LS393 100
LS395 115
LS398 180
LS399 115
LS445 125
LS447 75
LS465 130
LS490 1'5
LS540 100
LS541 15
LS624 120
LS629 150
LS640 140
LS641
LS645
LS668 87
LS669 80
LS670 150
LS673 800
LS674 800
LS676 275
LS684 300
LS687 140
LS688 275

74S
S00 45
S02 40
S03 40
S04 40
S05 40
S08 40
S09 40
S10 40
S1t 50
S15 80
S20 40
S22 80
S30 50
S32 50
S37 50
S38 70,
S'0 40
S51 40•
S64 40
S65 40
S74 70
S86 215
S68 100
9113 120
S114 120
9124 300
S132 80
5133 80
S134 80
S13 110
5138 170
5139 170
5140 75
S151 140
S153 140
S157 200
S158 180
5162 300
5183 300
S174 250
5175 300
5188 200
5189 220
S194 280
S197 300
5201 250
S225 500
S226 350
S240 375
S241 375
S244 475
S251 225
S257 220
S258 225
S260 70
S262 £10
S287 200
S288 180
S289 200
S301 350
S365 250
S373 375
S374 375
S412 380
5'70 320
5'7t 400
5'72 400
5'74 400
5'75 420
S571 300
S573 450

TRANSISTORS
AC12B/7 30
AC141/2 35
AC176 25
AC187 25
AC188 25
ACY19/21 75
ACY22/41 75
A0142 120
A0149 71
A0181
A0162
AF11:5/6 IO
AF166 ao
AF124/28 IU
AF139 40
AF178 75
AF186 70
AF239 80
SC107 12
BC107B 12
BC108 12
BC108B
BC108C 12
BC109 12
BC109B 14
BC109C 14
8C114/5 20
8C117/6 25
8C119 35
BC137/9 40
BC140 21
8C142/3
BC147 12
BC1478 15
BC148 12
BC1488
BC149 12
BC149C 15
8C182L 10
BC183L 10
BC184 10
BC184l 10
8C186/7 28
BC212 10
8C212L 12
BC213 10
BC213L 12
BC214 10
BC214L 12
BC237/8 10
BC256B 35
BC3078 15
BC308 12
BC318 co
BC327/8 12

BC337/8 12
BC441/61 M
BC461 22
SC518/7 30
BC547/8 12
BC549C 15
BC656/7 15
BC5589 15
SCY38/40 II
BCY41/42 30
SCY415 80
SCY:58/59 H
SCY70/71 11
8CY72 11
BCY78 30
80114 180
80121
80124 115
80131/32 5S
80133 80
90135 45
90138/37 SI
'B0138/39 35
90140 40
80144/45111
B0158
80184 38
80205/B 110
80245
80378 70
80434 70
80:517 75
80845 to
80695A 150
80896A 180
8F115
BF154/8 30
BF167
8F173
BF177
BF178
BF179 40
BF184/5 38
BF194/5 12
8Ft98/9 ,a
8F200
BF224A 40
BF2248 40
BF245 38
BF248
BF256A 45
BF2568 50
8F257/H 32
BF259 30
8F275

BF336/7 35
BF394 40
BF451 40
BF494/5 40
BF594/5 30
BFRJQ/40 30
8FR41/79 25
BFRS0/81 25
8FR15 105
BFX29 28
BFX81 ,5
BFX84 35
BFXSIS/8 35
BFYS0/51 30
BFY52 30
8FYS3
BFY55/:5oe H
8FY84 40
BFY61 120
BFYIO ao
BRY39 80
BSX20 28
BSX25/29 32
BSY26
BBY95
BU10:5 180
BU205 180
BU208 200
eu2oe 170
euveec 22s
M08001 250
MJ29:515 to
MJE170 180
MJE180 150
MJE340
MJE370 100
MJE371 100
MJE520 50
MJE521 to
MJE29:55 H
MJE30:5ei 70
MPF102 40
MPF103 30
MPF104 30
MPF105 30
MPF108 40
MPSAOS 23
MPS-'08 30
MPSA12 21
MPSA55 30
MPSA:56 30

MPSA70 40
MPSU02
MPSU05 80
MPSU06
MPSU52
MPSU55 80
MPSU56
OC26 170
OC28 220
OC35 80
OCJB/41 75
OC42/75 75
OC71/72 80
OC61/62 50
OCB3/84 70
OC170/71 75
OC200 75
TIP29A 32
TIP29C
TIP30A
TIP30C 37
TIP31A
TIP318 31
TIP31C 45
TIP32A 43
TIP32C
TIP33A 70
TIP33C 75
TIP34A
TIP34C 108
TIP35A 120
TIP35C 130
TtP36A 130
T1P36C 140
TIP41A 50
TIP418 52
TIP42A 58
TIP42B
TIP120 70
TIP121/2 73
TIP141/2 120
TIP147 120
TIP295 70
TIP3055 70
TI544/:5 45
TI588A 80
TI590/91 30
UC734
VK1010
VN10KM
VN46AF to

VN66AF 110
VN8SAF 220
VN89AF 120
ZT:.'107 12
ZTX10&f9 14
ZTX212 28
ZTXJOO 13
ZTX302
ZTX303 25
ZTX304 17
ZTX326 30
ZTX451 23
ZTX500
ZTX501/2 15
ZTX503 1a
ZTX504 20
ZTX531 125
ZTX550 20
2N697 23
2N69El 40
2N699
2N70SA 25
2N708 25
2N918 40
2N1131/2 40
2N1302 45
2N1307 70
2N16718180
2N2160 295
2N221'A
2N2220A 28
2N2221A 20
2N2222A 20
2N2368 20
2N2369A 18
2N2483/4 27
2N2848 IO
2N2 4/5 21
2N2 8/7 21
2N2907A 28
2N292SG 10
2N3053 20
2N3054 55
2N3055 50
2N3252 48
2N3441/2 80
2N361-'/5100.
2N3663 20
2N3702/3 10
2N3704/5 10
2N3706/7 10

2N3708/9 10
2N3713 140
2N3771 171
2NJ772
2N3773 210
2N38HI 35
?N3820 60
2N3822/3
2N3886 125
2N3003/4 11
2N3905/6 15
2N3906 17
2N4037 80
2N40:58 15
2N4081/2 15
2N4264 30
2N4286 25
2N4289 25
2N4314 78
2N4400 25
2N4427 25
2N4871 75
2N5135/6 3()
2N5138 20
2N:5172 20
2N:5179 45
2N5180 40
2N5190/1 75
2N5194 80
2N5305/8 30
2N5457/8 30
2N5459 30
2N5485 38
2N5777
2N5879 180
2N6027 32
2SA.671 280
2SA715 75
25C49:5 es
2SC498 85
2SC1oe1 250
2SC1098
2SC1162 45
2SC1173 12:5
25C1308100
2SC1307150
2SC1449
2SCt678140
2SC1679180
2SC1923 50
2SC1945 225

2SC1883
2SC1957 10
2SC1169180
2SC2028 15
2SC2029 200
2SC2078 170
2SC2091 15
2SC2J14
2SC216B 105
2SC2335 200
2SC2547 40
2SC2612 200
290234 74
2SK45 80
2SK288 225
2SJ83 225
2SJ80 225
3N128 115
3N140 115
40315 to
40316
40324 100
40326/7 70
403'7 to
403'8 120
40360 80
40381/2 70
40407/8 70
00.11 285
00.12 to
40407A 130
40<488 55
40594 108
40803 110
40873 75
40871/2 to

ACCESS & VISA orders
Just phone your orders through we do the rest.
IPI: 0923 5023'

AF Choke1 Miniature PCB type
/1uH. 2u2. 4u7. 10u. 22u. 33u. 47u, 100u. 220u. 330u. 470u 35p
1mH. 1m5, 2Tl2. 4m7. 10mH 40P
122mH. 33mM. 43mH. 47mH OOp
,100mH. 220mH 70p

SWITCHES

TOGGLE 2A. 250V
SPST 35p DPDP 48p

SUB-MIN TOGGLE

SPST on/off	58p
SPDT c/over	64p
SPDT centre off	85p
SPDT biased both ways	105p
DPDT 6 tags	80p
DPDT centre off	88p
DPDT biased both ways	145p
DPDT 3 positions on/on/on	185p
4-pole 2 way	220p

SLIDE 250V:

DPDT 1A	14p
DPDT 1 Ac/off	15p
DPDT ½A	13p

PUSH BUTTON 6A

with 10mm Button

SPDT latching	150p
DPDT latching	200p
DPDT moment	200p

Mini Non Locking

Push to Make	15p
Push to Break	25p

DIGITAST Switch
Assorted Colours
75p each

DIP SWITCHES

(SPST) 4 way 65p; 6 way 80p; 8 way 65p; 10 way 125p (SPDT) 4 way 190p

ROTARY SWITCHES

(Adjustable Stop type)
1 pole/2 to 12 way; 2 pole/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way **55p**

ROTARY: Mains DP 250V 4 Amp on/off **68p**

ROTARY: (Make-a-switch)
Make a multiway switch Shafting assembly has adjustable stop Accommodates up to 6 waters (max 6 pole/12 way + DP switch) Mechanism only **90p**

WAFERS: (make before break) to fit the above switch mechanism 1 pole/12 way; 2 pole/6 way 3 pole/4 way 4 pole/3 way 6o/2 Way **65p**
Mains DP 4A Switch to f1 **45p**
Spacers 4p. Screen 8p.

ROCKER SWITCHES

ROCKER 5A/250V SPST	28p
ROCKER 10A/250V SPDT	38p
ROCKER 10A/250V DPDT c/off	95p
ROCKER 10A/250V DPST with neon	65p

THUMBWHEEL Mini front mounting switches

Decade Switch Module	320p
BCD Switch Module	350p
Mounting Cheeks (per pair)	95p

VERO

VERO BOARDS 0.1"

2½ × 1	30p
2½ × 3¼	96p
2½ × 5	110p
3¾ × 3¾	110p
3¾ × 5	125p
3¾ × 17	420p
4¾ × 17	550p
VO Board	185p
DIP Board	395p
Vero Strip	95p

VERO PINS per 100

Single Ended	55p
Double ended	60p
Wire Wrap S/E	155p
Wire Wrap D/E	255p

VERO TOOLS

Spot face cutters	150p
Pin insertion tool	185p

VERO WIRING

PEN — Spool	380p
Spare Spool	75p
Combs	8p
Pen + Spool + Combs	580p

PHOTO DECs

Veroblock	480p
S Dec	350p
Eurobreadboard	500p
Bimboard	575p
Superstrip S52	1350p

COPPER CLAD BOARDS

Fibre glass	Single-sided	Double-sided
6" × 6"	100p	125p
6" × 12"	175p	225p

DALO ETCH RESIST PEN
Plus spare tip **100p**

FERRIC CHLORIDE
1 lb bag Anhydrous
125 + 50p p&p

EDGE CONNECTORS

	1"	156"
2 × 6 way		75p
2 × 12 way		160p
2 × 15 way		165p
2 × 18 way	175p	160p
2 × 22 way	200	170p
2 × 23 way	150p	
2 × 25 way	250p	245p
2 × 28 way	180p	
2 × 30 way	280p	
2 × 36 way	300p	
2 × 40 way	320p	
2 × 43 way	400p	
2 × 75 way	600p	

DIL SOCKETS

Pin	Low Prof	Wire Wrap	Turned Pin
8	8p	20p	18p
14	10p	23p	28p
16	10p	40p	28p
18	16p	40p	33p
20	20p	58p	37p
22	22p	60p	39p
24	25p	68p	42p
28	28p	78p	52p
40	30p	89p	72p

IDC CONNECTORS

	PCB Plugs Pins Strt	Plugs latch Pins Angle	Female Header Plug	Female Card Edge Conct
10 way	65p	65p	65p	100p
16 way	75p	75p	80p	
20 way	90p	90p	95p	165p
26 way	105p	110p	115p	230p
34 way	115p	130p	135p	320p
40 way	140p	145p	150p	335p
50 way	165p	170p	175p	350p
60 way	195p	210p	225p	495p

EURO CONNECTORS

Gold Flashed Contacts	Female Strt Pins	Socket Angle Pins	Male Strt Pins	Plug Angle Pins
DIN41617 31 way	125p	—	—	175p
DIN41612 2 x 32 A + B	200p	—	175p	—
DIN41612 2 x 32 A + C	225p	—	165p	210p
DIN41612 3 x 32 A + B + C	280p	290p	295p	300p

DIL PLUG (Header)

	Solder	IDC
14 pin	40p	95p
16 pin	45p	100p
24 pin	85p	135p
28 pin	150p	200p
40 pin	200p	255p

RIBBON CABLE
price per foot

	Grey	Color
10 way	15p	28p
16 way	25p	40p
20 way	30p	50p
24 way	40p	65p
28 way	55p	80p
34 way	60p	85p
40 way	70p	90p
50 way	100p	135p
64 way	120p	180p

ZIF TEXTOOL DIL SOCKETS

24 pin	550p
28 pin	695p
40 pin	800p

PANEL METERS

FSD
80 x 46 x 35mm
0–50µA
0–100µA
0–500µA
0–1mA
0–5mA
0–10mA
0–50mA
0–100mA
0–500mA
0–1A
0–2A
0–25V
0–50V
0–300V AC
845p

RELAYS

Miniature, enclosed, PCB mount

SINGLE POLE Changeover
RL-91 205R Coil; 12V DC (10V5 to 19.5V). 10A at 30VDC or 250VAC **195p**

DOUBLE POLE Changeover. 8A 30V DC or 250V AC
RL-113 53R Coil 6V DC (5V4 to 9V8) **190p**
RL8-111 205R Coil. 12V DC (10V7 to 19V5) **195p**
RL8-114 740R Coil. 24V DC (22V to 37V) **200p**

ASTEC UHF MODULATORS

Standard 6MHz	375p
Wideband 8MHz	550p

BUZZERS

miniature, solid-state 6V, 9V & 12V	70p
PIEZO TRANSDUCERS FB2720	70p

LOUDSPEAKERS

Miniature, 0.3W- 8 Ohm

2in, 2½in 2¾in, 3in	80p
2½in 40Ω, 64Ω or 80Ω	80p
6" x 4" 8Ω	200p
7" x 5" 8Ω	225p
8" x 5" 8Ω	250p

ULTRASONIC TRANSDUCERS

40 Khz **475p** (pr).

GAS/SMOKE DETECTORS

TGS812 or TGS 813
650p
Holders for above 40p

JUMPER LEADS (Ribbon Cable Assembly)

Length	14 pin	16 pin	24 pin	40 pin
Single ended DIP (Header Plug) Jumper 24 inches	145p	165p	240p	380p

Female IDC Header Jumper Leads 36 inches long

	20pin	26 pin	34 pin	40 pin
Single ended	160p	200p	260p	300p
Double ended	290p	370p	460p	525p

ANTEX SOLDERING IRON

C-15W	600p	CS17W	820p
G-18W	620p	XS25W	650p
Spare tips assorted size			100p
Spare elements			245p
Iron stand with sponge			195p

SIL SOCKET
0.1" pitch
20 way
65p

CRYSTALS

32.768KHz	100
100KHz	400
200KHz	370
455KH	370
1MHz	265
1.008M	275
1.28MHz	450
1.6MHz	200
1.8MHz	345
1.8432M	210
2.0MHz	225
2.4576M	200
3.12MHz	240
3.278M	150
3.5794M	95
3.8864M	300
4.0MHz	140
4.032MHz	290
4.19430M	150
4.43619M	100
4.608MHz	200
4.80MHz	200
5.0MHz	150
5.185MHz	300
5.24288M	390
6.0MHz	125
6.144MHz	140
6.5536MHz	225
7.0MHz	150
7.168MHz	175
7.88MHz	200
8.0MHz	140
8.089333M	395
8.86723M	175
9.00MHz	200
10.0MHz	170
10.24MHz	200
10.5MHz	250
10.7MHz	150
12.0MHz	150
12.528M	300
14.31814M	170
15.0MHz	155
16.0MHz	200
18.0MHz	150
18.432M	150
19.968MHz	150
20.0MHz	150
24.0MHz	150
24.930MHz	325
26.69M	150
27.648M	170
27.145M	180
38.6667M	240
48.0MHz	240
100.0MHz	295

BT TELEPHONE CONNECTOR

LJU 1/4A	Mini Line Master	435p
LJU 1/6A	Mini Line Slave	295p
LJU 2/4A	Line Master	370p
LJU 2/6A	Line Slave	250p
LJU 3/4A	Flush Master	370p
LJU 3/6A	Flush Slave	240p
LJU 10/3A	Dual Splitter	475p
4 WAY BT Plug		65p

'D' CONNECTORS

	9 way	15 way	25 way	37 way
Male				
Solder lugs	55p	80p	120p	150p
Angle pins	110p	175p	225p	300p
PCB pins	100p	100p	160p	250p
Female				
Solder lugs	90p	125p	180p	275p
Angle pins	150p	200p	260p	390p
PCB pins	100p	125p	195p	355p
Covers	75p	70p	70p	65p

IDC 25 way 'D' Plug 385p Socket 450p

25 way 'D' CONNECTOR (RS232)

Jumper Lead Cable Assembly

18 long Single end. Male	475p
18 long. Single end. Female	510p
36 long. Double Ended. M/M	995p
36 long. Double Ended. F/F	£10
36 long. Double Ended. M/F	995p

AMPHENOL CONNECTORS

	IDC	SOLDER
24 way IEEE plug	465p	460p
24 way IEEE skt	485p	480p
36 way Centronics plug	375p	390p
36 way Centronics skt	480p	450p

VIDEO MONITORS

VIDEO MONITORS

- 1431 – MICROVITEC Medium resolution 14" colour TTL Input £176
- 1451 – MICROVITEC High resolution 14" RGB, suitable for 80 column £225
- KAGA Vision II High resolution RGB colour monitor £210
- KAGA Vision III+ Ultra High resolution RGB colour monitor, TEX mode switch allows monochrome tex display £630
- KAGA KX1201G Hires Green Monitor £90
- KAGA KX1202G Ultra Hi-res Green Monitor £105
- KAGA KX1203A Ultra Hi-res Amber Monitor £105
- ZENITH 12" Hi-res monitor. Ideal for word processing as its Green or Amber screen is very restful to read
- ZVM1220 Amber Hi-res £76
- ZVM1230 Green Hi-res £72

All monitors supplied with connecting leads to the BBC MICRO

- Carriage on monitors £7 (Securicor)

TRANSFORMERS

3-0-3V, 6-0-6V, 9-0-9V, 12-0-12V, 15-0-15V @ 100mA **130p**
PCB mounting Miniature, Split bobbin
3VA: 2x6V/0.25A; 2x9V/0.15A, 2x12V/0.12A; 2x15V/0.2A **235p**
6VA: 2x6V/05A, 2x9V/0.3A; 2x12V/0.25A; 2x15V/0.2A **280p**
Standard Split Bobbin type
6VA: 2x6V/0.5A; 2x9V/0.4A 2x12V/0.3A; 2x15V/0.25A **250p**
12VA: 2x4.5V/1A3, 2x5V.1A, 2x9V/06A; 2x12V/0.5A; 2x15V-0.4A; 2x20V/0.3A **345p** (35p p&p)
24VA: 2x6V/1.5A; 2x9V/1.2A, 2x12V/1A, 2x15V/08A; 2x20V/0.6A **385p** (60p p&p)
50VA: 2x6V/4A; 2x9V/2.5A; 2x12V/2A 2x15V/1.5A; 2x20V/1.2A; 2x25V/1A; 2x30V/0.8A **520p** (60p p&p)
50VA: Outputs +5V/5A, +12V, +25V, -5V, -12V at 1A **620p** (60pp&p)
100VA: 2x12V/4A, 2x15V/3A, 2x20V/2.5A; 2x25V/2A, 2x30V/1.5A, 2x50V/1A **955p** (75p)
p&P charge to be added over and above our normal postal charge

VOLTAGE REGULATORS

1A TO220 Plastic Casing

	+ ve		− ve	
5V	7805	45p	7905	50p
12V	7812	45p	7912	50p
15V	7815	45p	7912	50p
18V	7818	45p	7915	50p
24V	7824	45p	7918	50p
			7924	50p

100mA TO92 Plastic package

5V	78LO5	30p	79LO5	45p
6V	78LO6	30p		
8V	78LO8	30p		
12V	78L12	30p	79L12	45p
15V	76L15	50p	79L15	45p

ICL7660	245p	TAA550	50p
RC4194	375p	TDA1412	150p
RC4195	160p	TL497A	165p
LM309K	135p	78H05 + 5V/5V	550p
		78H12+12V/5A	
LM317K	250p		
LM317KP	450p	78HG+5V10+25V/5V 5A	550p
LM323K	450p		
LM337	175p	79HG 5V to-24V/5A	765p
LM723 Var	30p		
78S40	225p		

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100 pins	35p
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3 × 2 × 1	85p
4 × 2½ × 2	100p
4 × 2½ × 2½	103p
4 × 4 × 2	105p
4 × 4 × 2½	120p
5 × 4 × 1½	99p
5 × 4 × 2½	120p
5 × 2¾ × 1½	90p
5 × 2¾ × 2½	130p
6 × 4 × 2	120p
6 × 4 × 3	150p
7 × 5 × 3	180p
8 × 6 × 3	210p
10 × 4 × 3	240p
10 × 7 × 3	275p
12 × 5 × 3	280p
12 × 8 × 3	295p

CMOS

4000	20	4078	25	4557	280
4001	20	4061	20	4558	120
4002	20	4082	20	4559	340
4006	70	4085	80	4560	110
4007	25	4086	80	4581	104
4008	60	4089	120	4582	350
4009	40	4093	25	4566	160
4010	40	4094	70	4568	280
4011	20	4095	70	4569	175
4012	20	4096	100	4572	45
4013	25	4097	250	4580	255
4014	50	4098	70	4581	125
4015	40	4099	110	4582	90
4016	25	4160	96	4583	100
4017	40	4161	96	4584	40
4018	55	4182	96	4585	65
4019	40	4183	96	4597	330
4020	40	4174	96	4599	155
4021	55	4175	105	40085	90
4022	90	4194	105	40097	45
4023	20	4408	850	40098	42
4024	35	4409	880	40100	215
4025	20	4410	725	40101	130
4026	90	4411	780	40102	100
4027	30	4412	805	40103	412
4028	40	4415	590	40104	120
4029	45	4419	280	40105	220
4030	20	4422	770	40106	40
4031	125	4435	850	40107	50
4032	65	4440	900	40108	325
4033	130	4450	390	40109	100
4034	146	4451	360	40110	236
4035	70	4490	450	40114	240
4036	280	4500	395	40161	150
4037	115	4501	40	40163	75
4038	75	4502	50	40173	100
4039	270	4503	45	40174	75
4040	45	4504	100	40174	80
4041	55	4505	250	40181	220
4042	45	4506	100	40182	80
4043	45	4507	45	40192	75
4044	50	4508	130	40193	90
4045	110	4510	55	40194	70
4046	80	4511	55	40195	75
4047	50	4512	55	40244	150
4048	50	4513	150	40245	150
4049	25	4514	85	40257	196
4050	25	4515	115	40373	220
4051	50	4516	50	40374	220
4052	40	4517	275	45106	586
4053	60	4518	50		
4054	70	4519	35		
4055	70	4520	50		
4056	70	4521	110		
4057	1000	4522	125		
4059	400	4526	70		
4060	70	4527	80		
4061	500	4528	45		
4062	986	4529	80		
4063	80	4530	90		
4066	25	4531	120		
4067	230	4532	65		
4068	20	4534	365		
4069	20	4536	280		
4070	22	4538	80		
4071	20	4539	60		
4072	20	4541	65		
4073	20	4543	65		
4075	25	4548	40		
4076	80	4549	390		
4077	25	4553	210		
		4554	180		
		4555	50		
		4556	50		

OPTO

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REFLECTIVE Optical Switch 225
SLOTTED Optical Switch similar to RS Components 295

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Green/yellow	115p
0.2 Tri colour Red/Green/Yellow	65
Hi-BrightnessRed	56
Flashing red 0.2 red	55
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Rectangle Stackable LEDs Red, Green or Yellow	18
Triangular LEDs Red	16
Green or yellow	22
LD271 Infra Red	48
SFH205 Detector	118
TIL32 Infra Red	52
TIL78 Detector	55
TIL38	50
TIL100	75

BARGRAPH ARRAY
Ten Segments
MV57164 Red 225
MV54164 Grn 230

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ILD74	145
ILQ74	275
TIL111/2/4	70
ILCT6 Darlington	135
TIL117	125
TIL127	120
4N33 Photo Darlington	136

7 Segment Displays

TIL312 .3" CA	120
TIL313 .3" CC	120
TIL321 .5" CA	140
TIL322 .5" CC	140
TIL729/730	140
DL704 .3" CC	125
DL707 .3" CA	125
FND357 Red	120
FND500	130
.3" Green CA	150
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.3" ± 1 Red CA	150
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(All Drives are supplied cased with Power Supply and Utilities Disc

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Top Quality 5¼" Disc
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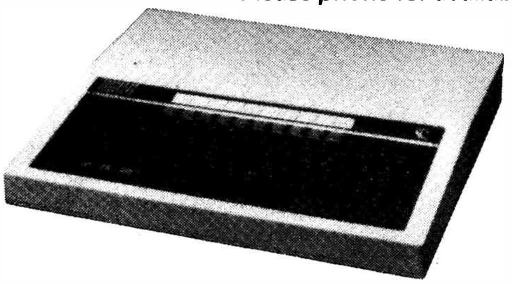

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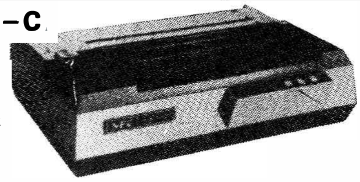

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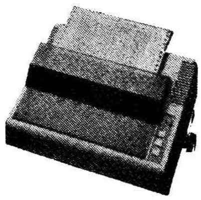

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This Z80 micro controlled clock/calender receives coded time data from NPL Rugby. The clock never needs to be reset. The clock never needs to be reset. The facilities include 8 independent alarms and for each alarm there is a choice of melody or alternatively these can be used for electrical switching. A separate timer allows recording of up to 240 lap times without interrupting the count. Expansion facilities provided.
See July/August ETI for details. Complete Kit
£120 + £2.00 p&p

MICROTIMER
6502 Based Programmeable clock timer with
* 224 switching times/week cycle
* 24 hour 7 day timer
* 4 independent switch outputs directly interfacing to thyristor/triacs
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* Output to drive day of week switch and status LEDS.

Full details on request. Price for kit £57.00

I.D. CONNECTORS
(Speedblock Type)

No of ways	Header Plug	Receptacle	Edge Conn
10	90p	90p	200p
20	145p	125p	240p
26	175p	150p	300p
34	200p	160p	380p
40	220p	190p	550p
50	235p	200p	600p

CONNECTOR SYSTEMS

JUMP LEADS
4in Ribbon Cable with headers

	14 pin	16 pin	24 pin	40 pin
1 end	145p	165p	240p	380p
2 ends	210p	230p	345p	540p

24in Ribbon Cable with sockets

	20 pin	26 pin	34 pin	40 pin
1 end	160p	210p	270p	300p
2 ends	280p	385p	490p	540p

24in Ribbon Cable with D. Conn
25 way Male 500p Female 550p

AMPHENOL CONNECTORS

36 way Solder Type Plug (centronix type)	550p
36 way Solder Socket (centronix type)	550p
36 way IDC Plug (centronix type)	500p
24 way Solder Plug (IEEE type)	500p
24 way Solder Socket	500p
24 way IDC Plug	485p

RIBBON CABLE (Grey)

10 way	60p
14 way	80p
16 way	90p
20 way	105p
26 way	140p
34 way	220p
40 way	265p
50 way	330p
64 way	370p

D-CONNECTORS

	9 way	15 way	25 way	37 way
MALE				
Solder	90p	130p	160p	250p
Angled	180p	230p	265p	425p
FEMALE				
Solder	110p	160p	210p	350p
Angled	175p	240p	310p	500p
Hood	95p	95p	95p	125p

RS232 CONNS (25 way D)

24" Single end Male	£6.50
24" Single end Female	£6.00
24" Female-Female	£11.00
24" Male-Male	£10.00
24" Male-Female	£11.50

DIL HEADERS

	older type	IDC type
14 pin	40p	100p
16 pin	50p	110p
24 pin	100p	180p
40 pin	200p	225p

EURO CONNECTORS
(Indirect Edge Conn)

DIN STD	Plug	Skt
41617 21 way	170p	170p
41617 31 way	180p	180p
1612 2 x 32 way	280p	320p
Angled 2x32 way	325p	375p
1612 3x32 way	275p	380p
Angled 3x32 way	-	400p
x32 way zidc a + c	-	625p

(for 2x32 way specify a + b or a + c)

EDGE CONNECTORS

	0.1in	0.156in
2x16 way	—	140p
2x22 way	200p	170p
2x23 way	210p	—
2x25 way	225p	220p
1x43 way	280p	—
2x43 way	395p	—
2x50 way		
1x77 way	700p	—
S100 Conn	—	600p

DISC DRIVES FOR THE FORTH COMPUTER
51/4" Teac FD55 Slim Line Mechanisms
FD55 40 track SDD 250kbytes unformatted — bare £135 Cased £155
2 x FD55A 40 track SSDD 500kbytes unformatted — cased + PSU £350
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2 x FD55E 80 track SSDD 1 Mbyte unformatted — Cased + PSU £475
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Single drive cable £8 Dual Drive Cable £12
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PLEASE SEND SAE FOR PRICE LIST

SOFTY II INTELLIGENT PROGRAMMER
The complete microprocessor development system forEngineers and Hobbyists. You can develop programs debug, verify and commit to EPROMS or used in host computers by using softy as a romulator. Powerful editing facilities permit bytes, blocks of bytes changed, deleted orinserted and memory contents can be observed on ordinary TV. Accepts most +5v Eproms. Softy II complete PSU, TV lead and Romulator lead £169.

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(fully built and documented)
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7417	40p
7420	30p
7421	50p
7422	36p
7423	36p
7425	30p
7426	40p
7427	40p
7428	43p
7430	30p
7432	36p
7433	30p
7437	30p
7438	40p
7439	40p
7440	40p
7441	80p
7442A	70p
7443A	100p
7444	110p
7445	100p
7446A	100p
7447A	100p
7448	120p
7450	36p
7451	35p
7453	35p
7454	36p
7460	55p
7470	50p
7472	55p
7473	55p
7474	50p
7475	50p
7476	45p
7480	65p
7481	180p
7483A	105p
7484A	125p
7485	110p
7488	42p
7489	210p
7490A	55p
7491	70p
7492A	70p
7493A	55p
7494	110p
7495A	80p
7496	80p
7497	210p
74100	180p
74107	50p
74109	75p
74110	75p
74111	55p
74116	170p
74118	110p
74119	170p
74120	100p
74121	55p
74122	70p
74123	80p
74125	65p
74126	55p
74128	65p
74132	75p
74136	70p
74141	80p
74142	250p
74143	270p
74144	270p
74145	110p
74147	170p
74148	140p
74150	175p
74151A	70p
74153	60p
74154	140p
74155	80p
74156	100p
74157	80p
74159	175p
74160	110p
74161	80p
74162	110p
74163	110p
74164	120p
74165	110p
74166	140p
74167	400p
74170	200p
74172	420p
74173	140p
74174	110p
74175	105p
74176	100p
74178	150p
74179	150p
74180	100p
74181	340p
74182	140p
74184	180p
74185A	180p
74190	130p
74191	130p
74192	110p
74193	115p
74194	110p
74195	80p
74196	130p
74197	110p
74198	220p
74199	220p
74221	110p
74251	100p
74259	150p
74265	380p
74273	200p
74276	140p
74278	170p
74279	80p
74283	105p
74285	320p
74290	80p
74293	80p
74298	180p
74351	200p
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74LS11	24p
74LS12	24p
74LS13	34p
74LS14	50p
74LS15	24p
74LS20	24p
74LS21	24p
74LS22	24p
74LS24	50p
74LS26	24p
74LS27	24p
74LS28	24p
74LS30	24p
74LS32	24p
74LS33	24p
74LS37	24p
74LS38	24p
74LS40	24p
74LS42	50p
74LS43	150p
74LS47	80p
74LS48	80p
74LS49	100p
74LS51	24p
74LS54	24p
74LS55	24p
74LS73A	30p
74LS74A	30p
74LS75	45p
74LS76A	36p
74LS83A	70p
74LS85	75p
74LS86	35p
74LS90	48p
74LS91	80p
74LS92	55p
74LS93	54p
74LS95B	75p
74LS96	80p
74LS107	40p
74LS109	40p
74LS112	45p
74LS113	45p
74LS114	45p
74LS122	70p
74LS123	80p
74LS124/629	140p
74LS125	80p
74LS126	60p
74LS132	65p
74LS133	60p
74LS136	45p
74LS138	55p
74LS139	55p
74LS145	95p
74LS147	175p
74LS148	140p
74LS151	65p
74LS152	200p
74LS153	65p
74LS154	150p
74LS155	65p
74LS156	65p
74LS157	50p
74LS158	60p
74LS160A	75p
74LS161A	75p
74LS162A	75p
74LS163A	75p
74LS164	75p
74LS165A	110p
74LS166A	150p
74LS168	130p
74LS169	100p
74LS170	140p
74LS173A	100p
74LS174	75p
74LS175	75p
74LS181	200p
74LS183	180p
74LS190	75p
74LS191	75p
74LS192	80p
74LS193	80p
74LS194A	75p
74LS195A	75p
74LS196	80p
74LS197	80p
74LS221	80p
74LS240	80p
74LS241	80p
74LS242	80p
74LS243	80p
74LS244	80p
74LS245	110p
74LS247	110p
74LS248	110p
74LS249	110p
74LS251	75p
74LS253	75p
74LS256	80p
74LS257A	70p
74LS258A	70p
74LS259	120p
74LS260	75p
74LS261	120p
74LS266	80p
74LS273	125p
74LS279	70p
74LS280	180p
74LS283	80p
74LS290	80p
74LS292	900p
74LS293	80p
74LS295	140p
74LS297	£9
74LS298	100p
74LS299	220p
74LS321	370p
74LS323	300p
74LS324	320p
74LS348	200p
74LS352	120p
74LS353	120p
74LS356	210p
74LS363	180p
74LS364	180p
74LS365	80p
74LS366	50p
74LS367	50p
74LS368A	50p
74LS373	90p
74LS374	90p
74LS375	75p
74LS377	130p
74LS378	65p
74LS379	130p
74LS381	450p
74LS385	325p
74LS390	100p
74LS393	100p
74LS395A	100p
74LS399	140p
74LS445	180p
74LS465	120p
74LS467	120p
74LS490	150p
74LS540	100p
74LS541	100p
74LS608	700p
74LS610	1900p
74LS612	1900p
74LS624	350p
74LS626	225p
74LS628	225p
74LS629	125p
74LS640	200p
74LS640-1	300p
74LS641	150p
74LS642	70p
74LS642-1	300p
74LS643	280p
74LS643-1	300p
74LS644	350p
74LS645	200p
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74S22	50p
74S30	50p
74S32	80p
74S37	50p
74S38	80p
74S40	80p
74S51	45p
74S64	45p
74S74	70p
74S85	300p
74S86	100p
74S112	150p
74S113	120p
74S114	120p
74S124	300p
74S132	100p
74S133	80p
74S138	180p
74S138	180p
74S139	180p
74S140	100p
74S151	150p
74S153	150p
74S157	200p
74S158	200p
74S163	300p
74S169	550p
74S174	300p
74S175	320p
74S188	180p
74S189	180p
74S194	300p
74S195	300p
74S196	350p
74S200	450p
74S201	300p
74S225	520p
74S240	400p
74S241	400p
74S244	500p
74S251	250p
74S257	250p
74S258	250p
74S280	200p
74S261	300p
74S283	270p
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74S289	225p
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4012	25p
4013	36p
4014	60p
4015	70p
4016	36p
4017	55p
4018	60p
4019	60p
4020	80p
4021	70p
4022	70p
4023	30p
4024	48p
4025	24p
4026	120p
4027	40p
4028	60p
4029	75p
4030	35p
4031	125p
4032	100p
4033	125p
4034	250p
4035	70p
4036	70p
4037	110p
4038	100p
4039	250p
4040	60p
4041	55p
4042	60p
4043	60p
4044	60p
4045	100p
4046	60p
4047	60p
4048	55p
4049	36p
4050	36p
4051	55p
4052	80p
4053	60p
4504	60p
4055	60p
4056	85p
4059	400p
4060	7
4063	65p
4066	40p
4067	230p
4068	25p
4069	24p
4070	24p
4071	24p
4072	24p
4073	24p
4075	24p
4076	65p
4077	28p
4078	25p
4081	25p
4082	25p
4085	50p
4086	75p
4089	120p
4093	35p
4094	80p
4095	80p
4096	80p
4097	270p
4098	75p
4099	80p
4501	30p
4502	55p
4503	36p
4504	65p
4505	360p
4506	80p
4507/4030	35p
4508	120p
4510	55p
4511	55p
4512	55p
4513	150p
4514	110p
4515	110p
4516	55p
4517	220p
4518	40p
4519	32p
4520	60p
4521	115p
4522	80p
4526	70p
4527	80p
4528	65p
4529	100p
4531	75p
4532	65p
4534	380p
4536	250p
4538	75p
4539	75p
4541	80p
4543	70p
4551	100p
4553	240p
4555	36p
4556	36p
4557	240p
4560	140p
4566	140p
4568	240p
4569	170p
4572	45p
4583	60p
4584	48p
4585	60p
4724	150p
14411	750p
14412	750p
14418	300p
14419	260p
14490	420p
14495	450p
14500	650p
14599	200p
22100	350p
22101	700p
22102	700p
40014/4584	
40106	48p
40085	120p
40097	36p
40098	48p
40100	150p
40101	125p
40102	150p
40103	200p
40104	120p
40105	150p
40106	48p
40107	50p
40108	320p
40109	200p
40110	225p
40114	225p
40147	280p
40163	100p
40173/4067	120p
40174	100p
40175	100p
40192	100p
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40245	150p
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40373	180p
40374	180p
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CA3046	70p
CA3059	300p
CA3060	300p
CA3080E	70p
CA3086	70p
CA3089E	210p
CA3090AQ	375p
CA3130E	
CA3130T	130p
CA3140E	45p
CA3140T	100p
CA3160E	80p
CA3161E	100p
CA3162E	450p
CA3189E	375p
CA3240E	120p
CA3280G	375p
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DAC0800	300p
DAC0808	300p
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LF347	130p
LF351	60p
LF353	90p
LF355	90p
LF356N	110p
LF357	100p
LM10C	300p
LM301A	30p
LM307	45p
LM308CN	70p
LM310	300p
LM311	80p
LM318	180p
LM319	180p
LM324	45p
LM334Z	115p
LM335Z	130p
LM336	180p
LM339	45p
LM348	60p
LM358P	50p
LM377	300p
LM380N-8	180p
LM380	180p
LM381AN	175p
LM382	130p
LM383	325
LM384	220p
LM386N-1	100p
LM387	270p
LM389	180p
LM391	180p
LM392N	110p
LM393	380p
LM394CH	400p
LM709	50p
LM710	50p
LM711	100p
LM723	50p
LM725CN	400p
LM733	50p
LM741	18p
LM747	70p
LM748	30p
LM1011	400p
LM1014	100p
LM1801	300p
LM1830	300p
LM1871	300p
LM1872	300p
LM1886	300p
LM1889	300p
LM2917	300p
LM3302	80p
LM3900	60p
LM3909	100p
LM3911	100p
LM3914	300p
LM3915	300p
LM3916	300p
LM13600	180p
M51513L	300p
M51516L	500p
MB3712	300p
MC1310P	150p
MC1413	75p
MC1458	45p
MC1495L	300p
MC1496	70p
MC3340P	120p
MC3401	70p
MC3403	80p
MF10CN	400p
MK50240	300p
MK50398	750p
ML920	300p
ML922	300p
MM6221A	300p
NE531	130p
NE544	100p
NE555	50p
NE556	50p
NE564	400p
NE565	120p
NE566	150p
NE567	125p
NE570	400p
NE571	300p
NE592	100p
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TA7130	140p
TA7204	150p
TA7205	80p
TA7222	150p
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TDA1022	600p
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TDA1170S	300p
TDA2002	300p
TDA2003	300p
TDA2004	300p
TDA2006	300p
TDA2020	300p
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TDA7000	300p
TEA1002	900p
TL061CP	40p
TL062	90p
TL064	90p
TL071	40p
TL072	70p
TL074	110p
TL081	30p
TL082	60p
TL083	75p
TL084	100p
TL094	180p
TL170	50p
UA759	300p
UA2240	150p
UAA170	170p
UCN4801A	300p
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ULN2803	180p
ULN2804	180p
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UPC1156H	300p
UPC1185H	300p
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XR2207	375p
XR2211	375p
XR2216	675p
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ZN414	80p
ZN419P	175p
ZN423E	130p
ZN424E	130p
ZN425E8	300p
ZN426E	300p
ZN427E	600p
ZN428E	400p
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ZNA234E	950p

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5V		7805	45p	7905	50p
6V		7806	50p	7906	80p
8V		7808	50p	7908	50p
12V		7812	45p	7912	50p
15V		7815	50p	7915	50p
18V		7818	50p	7918	50p
24V		7824	50p	7924	50p
5V	100mA	78L05	30p	79L05	45p
8V	100mA	78L08	30p		
12V	100mA	78L12	30p	79L12	50p
15V	100mA	78L15	30p	79L15	50p

OTHER REGULATORS

Fixed Regulators		
LM309K	1A 5V	140p
LM323K	3A 5V	250p
78H05KC	5A 5V	575p
78H12	5A 12V	750p
Variable Regulators		
LM305AH		250p
LM317T	TO-220	150p
LM317K	TO3	240p
LM337T	3A+VAR	225p
LM350T	5A+VAR	400p
LM396K	10A+VAR	£15
LM723N		50p
78HGKC	5A+VAR	650
79HGKC	5A+VAR	675p
78GUIC	1A+VAR	225p
79GUIC	1A+VAR	250p
Switching Regulators		
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SG3524		300p
TL494		300p
TL497		300p
78S40		250p

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2650A	1050p
6502	400p
6502A	450p
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6800	250p
6802	300p
6809	650p
6809E	£8
68B09	£10
68B09E	£12
68000-LB	£36
8035	350p
8039	420p
80C39	700p
8080A	420p
8085A	300p
80C85A	900p
8086	£22
8088	1750p
8741	£12
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68B21	300p
6829	£12.50
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6850	160p
68B50	300p
6852	300p
6854	600p
68B54	300p
6875	600p
8154	300p
8155	600p
8156	300p
8205	600p
8212	300p
8216	160p
8224	300p
8226	600p
8228	600p
8243	300p
8250	600p
8251A	300p
8253C-5	300p
8255AC-5	320p
8256	£18
8257C-5	400p
8259C-5	400p
8275	£29
8279	£11
8282	300p
8284	600p
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TMS9901	300p
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TMS9901	600p
TMS9902	600p
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Z80ADMA	750p
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Z80BCTC	600p
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2532-30	300p
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2732	600p
2732A-2	600p
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27C64-25	£10
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CRT5037	£12
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EF9365	£25
EF9366	£25
EF9367	£36
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MC6847	600p
SFF96364	£8
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TMS9928	£10
TMS9929	£10

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AD561J	£20

AD7581	£18
ADC0808	1150p
AM25S10	300p
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AM26LS32	120p
D7002	£9
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DM8131	300p
DP8304	300p
DS3691	300p
DS8830	140p
DS8831	180p
DS8832	150p
DS8833	600p
DS8835	300p
DS8836	150p
DS8838	600p
MC1488	60p
MC1489	60p
MC3446	300p
MC3459	600p
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MC3466	300p
MC3487	300p
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MC4044	600p
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ULN2004A	75p
ULN2068	300p
ULN2802	180p
ULN2803	180p
ULN2804	180p
75107	90p
75108	90p
75109	120p
75110	90p
75112	180p
75113	120p
75114	140p
75115	140p
75121	140p
75122	140p
75150P	120p
75154	180p
75159	300p
75160	600p
75161	300p
75162	600p
75172	300p
75182	90p
75188	90p
75189	60p
75365	150p
75450	60p
75451	90p
75452	60p
75453	75p
75454	70p
75480	150p
75491	65p
75492	65p
8T26	120p
8T28	180p
8T95	120p
8T96	120p
8T97	180p
8T98	180p
81LS95	140p
81LS96	140p
81LS97	140p
81LS98	140p
88LS120	300p
9602	300p
9636A	160p
9637AP	160p
9638	190p
ZN425E8	350p
ZN426E8	350p
ZN427E	600p
ZN428E8	450p
ZN429E	210p
ZN447E	900p

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2101	400p
2102	250p
2107B	500p
2111A-35	400p
2114-3L	250p
2147	400p
4116-15	200p
4416-15	300p
4532-20	250p
4816AP-3	300p
5101	370p
5514	450p
5516	550p
6116P-3	350p
6116LP-3	400p
6264-15	700p
6264LP-15	340p
6810	260p
74S189	225p
74S201	350p
74S289	225p
93415	600p
93L422	950p
93425	600p

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16SA030	200p
74S188	180p
74S287	225p
74S288	180p
74S387	225p
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82S123	150p

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FD1791	£20
FD1793	£20
FD1797	£22
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WD2797	£27
WD1691	£15
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32.768 KHz	100p
100 KHz	400p
1.00MHz	270p
Freq in MHz	
1.8432	225p
2.00	255p
2.45760	200p
2.5	250p
2.662	250p
3.12MHz	175p
10.00MHz	175p
3.276	150p
3.5795	100p
4.00	140p
4.194	150p
4.43	100p
4.608	250p
4.9152	200p
5.000	150p
6.00	140p
17.734	200p
7.00	150p
7.168	175p
8.00	150p
8.867	175p
10.50	250p
10.70	150p
11.00	300p
12.00	150p
14.00	175p
14.318	160p
14.756	250p
15.00	200p
16.00	200p
18.00	170p
18.432	150p
19.969	150p
20.00	175p
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18 pin	16p	40 pin	30p
20 pin	18p		

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18 pin	50p	40 pin	130p
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		MAN6610	200p
		NSB5881	570p
		TIL311	650p
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MAN74/DL704	100p		
MAN71/DL707	100p	MAN8910	120p
MAN3640	175p		
TIL32	75p	TIL78	75p
TIL31A	120p	TIL81	120p
TIL100	90p	SFH305	100p

DRIVER

9368	350p

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74C926	650p
74C928	650p
ZN1040	670p

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MCT26	100p	TIL112	70p
MCS2400	190p	TIL113	70p
MOC3020	150p	TIL116	70p
ILQ74	220p	16N137	360p
		6N139	175p

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TIL220 Red	15p
TIL212 Green	18p
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TL082	0.46
TL084	1.58
TL091	0.40
TL092	0.58
TL094	1.34
TL487	0.62
TL489	0.62
TL494	1.63
TL496	0.60
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748	0.27

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7905	0.45
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4008	0.32
4009	0.24
4010	0.24
4011	0.10
4012	0.16
4013	0.20
4014	0.40
4015	0.36
4016	0.20
4017	0.32
4018	0.36
4019	0.36
4020	0.36
4021	0.40
4022	0.40
4023	0.13
4024	0.32
4025	0.13
4026	0.74
4027	0.20
4028	0.32
4031	0.94
4033	1.80
4034	0.94
4035	0.38
4040	0.36
4041	0.36
4042	0.34
4043	0.36
4044	0.36
4045	1.35
4046	0.42
4047	0.70
4048	0.38
4049	0.23
4050	0.23
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

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03	0.12	112A	0.20	242	0.55
04	0.12	113A	0.20	243	0.55
05	0.12	114A	0.22	244	0.55
08	0.12	122	0.28	245	0.70
09	0.12	123	0.34	248	0.55
10	0.12	125A	0.24	249	0.55
11	0.12	126A	0.25	251	0.30
12	0.12	132	0.34	253	0.35
13	0.12	136	0.25	257A	0.30
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32	0.12	168	0.30	365	0.27
33	0.12	160A	0.32	366	0.27
37	0.12	161A	0.35	367	0.27
40	0.12	162A	0.35	368	0.27
42	0.28	163A	0.35	373	0.62
47	0.35	164	0.40	374	0.62
48	0.45	165A	0.50	375	0.35
49	0.12	166A	0.60	377	0.60
51	0.12	173A	0.55	378	0.60
54	0.12	174	0.40	379	0.90
55	0.12	175	0.38	386	0.35
73	0.18	181	0.90	390	0.45
74	0.16	190	0.35	393	0.45
75	0.18	191	0.35		
76A	0.17	192	0.35		
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83A	0.36	194A	0.35		
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Typewriter Interface

We've come across what must be one of the more crazy situations in electronics - namely that you can't buy a daisy wheel printer for less than around £400, but you can buy a typewriter with a daisy wheel printing mechanism and a keyboard for just over £200! Needless to say, it didn't take one of our contributors long to get out his soldering iron and find out exactly how you can interface the typewriter in question to a micro - well, not a micro, but just about any micro! And the make of the typewriter, well, we're not foolish enough to tell you that until next month.

Another New Series

Following on from our attempt to de-mystify audio, we're about to embark upon an even more arcane area, the mention of which will usually bring a look of despair to even the most hardened engineer's face - machine code programming. This series will be so simple that even the Editor - a confirmed microphobe - will be able to understand it.

...And While We're Talking About Series ...

John Linsley Hood will be continuing his look at audio design with a discussion of ICs for audio applications and a look at some gremlins - noise and distortion being two of the best known of this breed.

IC Update

Almost without us thinking about it, this seems to have sprung into being an established series in the magazine; well, it seems to be one of the most useful roles we can play - that of disseminating information on new devices. To try and counterbalance all these micro-based projects (and to keep our Editor happy), we'll be looking at some up-to-date linear devices.

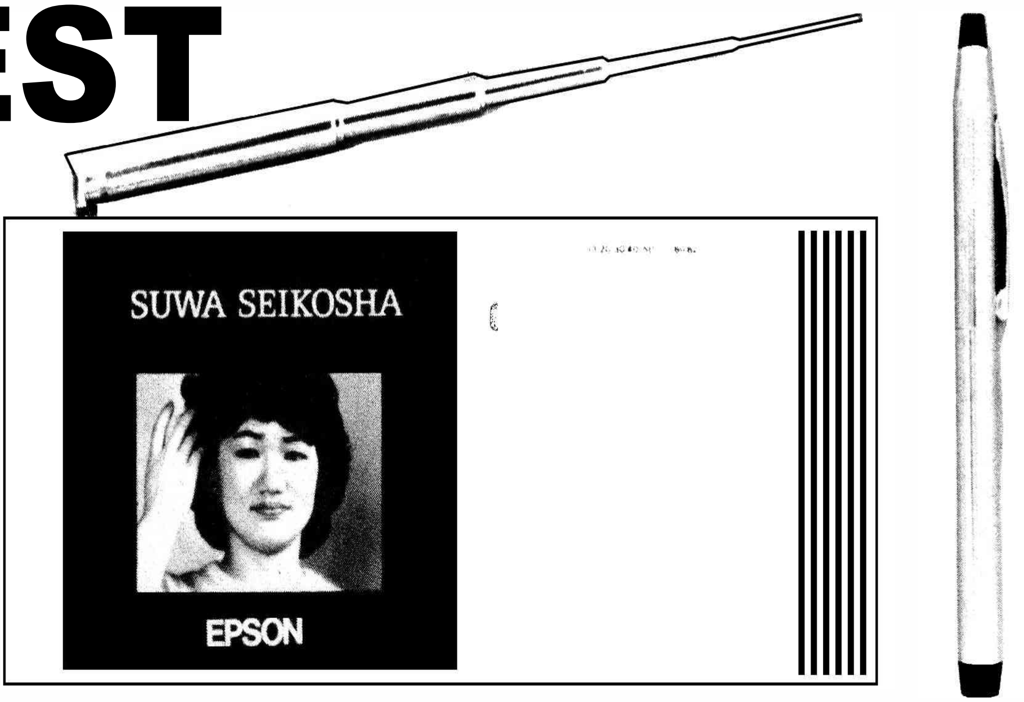
ZX Backup Supply

This must be. one of the simplest projects we've published in a long while - and such a simple idea that it's surprising no one else has thought of it. What it does is to keep your ZX going if there should be a temporary supply interruption, or a blown fuse - or if grandfather should trip over the power connector!

ALL THIS AND MORE IN THE OCTOBER ISSUE OF ETI, ON SALE SEPTEMBER 2ND. PLACE YOUR ORDER NOW, OR RISK MISSING OUT!

Articles described here are in an advanced state of preparation. However, circumstances may dictate changes to the final contents.

DIGEST



Worlds Smallest Colour TV

The first-ever LCD pocket colour television in the world has been developed in Japan by the Epson Corporation and Suwa Seikosha Company Ltd, the parent company of Epson (UK) Limited.

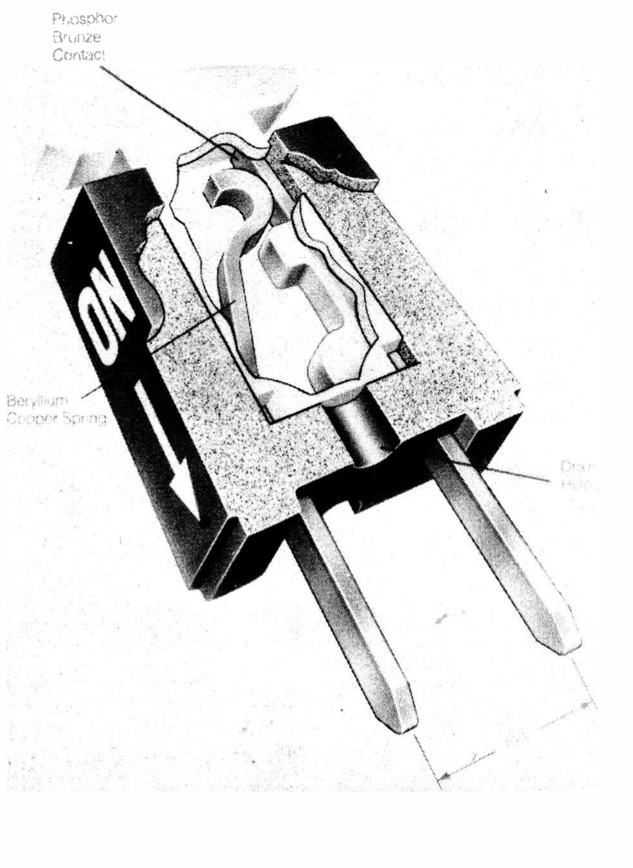
Measuring 16cm x 8cm x 2.8cm, the pocket TV utilizes new picture display devices invented by Seiko in its development of a TV watch. This flat display - which provides the key to the ultra-miniaturization represents a breakthrough in picture tube advancement and will play an important role in the progression towards a picture style colour TV, the technological goal of research organisations all over the world.

Amongst the pocket TV's advantages Epsom claim no colour aberration at corners, or distortion of pictures, and good visibility in dark or light situations.

There are no plans to market the TV in the UK. Epson (UK) Limited, Dorland House, 388 High Road, Wembley, Middlesex.

Is It Clicket?

A new micro-miniature switch is available through Cambion Electronic Products, and it's called the Clicket. As you can see from the photograph, it's pretty small, with a 0.1" leading space, and it has a push-on, push-off action. Cambion Eletronic Products Division, Cambion Works, Castleton, nr Sheffield S30 2WR.



Silicon On Insulator Success

Mitsubishi Electric Corporation has succeeded in manufacturing on an experimental basis a silicon-on-insulator (SOI) structure complementary metal oxide semiconductor (CMOS) device with the worlds shortest delay time of 280 picoseconds, using a laser beam recrystallization technique. This delay time is only a quarter of that of a conventional SOI device and even shorter than that of a device using a single-crystal silicon wafer.

Mitsubishi Electrics success in trial manufacture of the new SOI CMOS marks a major step toward the realization of three-dimensional integration - integration greater than the conventional very large scale integration (VLSI). To make a 3-D integrated circuit, it is necessary to cover integrated circuits on every tier of the multiple layers with oxide or nitride film for complete electrical insulation, and to place a single crystal of silicon on top of this film for the next ICs.

Transistors and other devices are integrated on the surface of single crystal silicon in conventional ICs. In the case of the SOI structure IC, single-crystal silicon is formed on an insulator substrate; such as silicon oxide. When an SOI structure is employed, there is no malfunctioning from short circuits or in-terference, even if the distance between devices is made shorter
for higher integration.

In conventional methods of making an SOI structure, polycrystalline silicon is melted by a laser beam or an electron beam for recrystallization into a single crystal. But the single crystal thus formed is small and the direction of its growth is not fixed, causing electrical leakage and shortening of circuits.

Mitsubishi Electric solved these problems by developing a revolutionary recrystallization method, under which the scanning speed, the intensity and the direction of the laser beam are adjusted to control the direction and size of crystal.

Mitsubishi Electric expect their SOI technology to have a wide variety of applications:- as the key technology for 3-D integrated circuits of the future; for high speed and highly reliable CMOS LSI's without latch-up; and for thin film transistors for driving liquid crystal displays.

The work was performed under the management of the R & D Association for Future Electron Devices as part of the R & D project of Basic Technology for Future Industries, sponsored by the Agency of Industrial Science and Technology, MITI, Japan.

Lead Free Solder

Jimi Heat of Watford announce the introduction of a new British made all-purpose solder to replace their widely acclaimed, imported, all-metal solder launched around 12 months ago.

Supa Solda is lead free, non corrosive and capable of handing all metals including aluminium. It can be shaped, polished and even chromed.

Its relatively low melting point and capillary action is claimed to make it suitable for even the most delicate applications that formerly required expensive silver-based solders.

The suggested retail price of a 'bubble pack' of Supa Solda is £1.65 and it is available from Halfords and other selected retail outlets.

Z800 Details

Zilog have revealed details of their new Z800 family of 8/16 bit microprocessors. The new CPU's will run on all existing Z80 software at object code level and will provide up to five times greater performance operating at clock rates of 10 to 25 MHz.
The Z800 also saves board space and reduces system design costs by including DMA functions, counter/ timers, serial I/O and refresh logic on the chip. Using these on-chip peripherals a small system can be designed with only the Z800 CPU, external memory and a clock crystal. An on-chip memory management unit (MMU) and cache/local memory are also included to increase the power and flexibility of the Z800.The MMU extends the Z800 CPU's logical addressing space up to 16 megabytes compared to the the Z80s maximum of 64 kilobytes. This is achieved by dividing the logical address space into pages which are mapped into larger physical memory. The MMU also provides all the features necessary to implement a virtual memory system transparent to the applications program.
The 256 byte cache memory on the Z800 chip provides the CPU with high speed access to instructions and data that would otherwise reside in slower external memory. Since this feature coupled with programmable bus timing allows the CPU clock speed to differ from the memory clock speed, fast processors (up to 25 MHz) need not be accompanied by equally fast memory devices as was necessary with earlier designs.
The Z800 CPU instruction set includes all those in the Z80 set plus a number of new enhancements. New instructions allow the Z800 to perform 8 and 16-bit hardware and multiply and divide, 16-bit arithmetic, 16-bit load, system call (for controlled operating system access by the user) and test and set (for multi-processing support). A group of extended processing instructions similar to those used in the Z8000 and Z80,000 allows the Z800 CPUs to be used with any co-processor compatible with Zilog's extended processing architecture, including the Z8070 floating point processor.
Several new addressing modes have also been added to the Z80 CPU's original set: index with a 16-bit displacement, base index, and stack pointer relative. A program counter relative mode exists for the Z80 chip but in the Z800 chip it is enhanced to allow 16-bit displacement. Furthermore, the Z80 CPU register set has been improved by allowing byte access to both the IX and IY registers (providing four additional 8-bit registers) and the use of two stack pointers instead of one.

Four versions of the Z800 will be available, known as the Z8108, Z8116, Z8208, Z8216. The Z8108 and Z8208 are intended for the smaller systems and employ the same 8-bit non-multiplexed bus as the Z80, allowing them to be used with either the existing Z80 peripherals or the Z8500 family. The Z8116 and Z8216 are 16-bit multiplexed Z-Bus devices and can, therefore be used with the same peripheral chips used by Zilog's 16-bit Z8000 CPUs, the Z8002, Z8001, Z8003 and Z8004.
Although all four Z800 CPUs have the peripheral support circuits integrated within the chip, only the Z8208 and Z8216 include the necessary address lines to permit access to the UART and the DMA functions. The versions of the Z800 (Z8216 and Z8208) with all the peripheral features are supplied in 64-pin packages and support extra signal such as bus buffer control, multiple interrupts and global bus Req/Ack. The Z8108 and Z8116 which do not allow access to the DMA and UART functions are supplied in 40-pin packages. The 64-pin package used for the Z800 has pin spacings of 70 mil, therefore the package is approximately the same size as the standard DIL 48-pin package, currently used by the Z8001 and the Z8010 MMU.
The Z800 CPU is aimed at traditional 8-bit applications including personal computers, workstations, I/O processors, network controllers, etc, that now require 16-bit performance to meet market demands. Zilog (UK) Limited, Zilog House, Moorbridge Road, Maidenhead, Berks, SL6 8PL.

New, Large EPROMS

Now available in the UK from Bytech Ltd are the latest Intel range of UV-Erasable Proms. Both D2764 (8K x 8) and D27128 (16K x 8) devices are being stocked, in industry standard approved JEDEC 28-pin packages. Both devices are available in a choice of 200, 250, 350 and 450ns access times.
The 2764 is a 5V only, 65,536-bit UV erasable and electronically programmable EPROM fabricated in HMOS technology. Access time is compatible to high performance microprocessors such as Intel's 8MHz 8086-2. In these systems the 2764 allows the microprocessor to operate without the addition of WAIT states devices is that the Output Enable (OE) is separate from the Chip Enable (CE). The (OE) control eliminates bus contention in multiple bus microprocessor systems. The standby mode reduces the power dissipation without increasing access time. The active current is 100mA, whilst the standby mode is achieved by applying a TTL-high signal to the CE input. Bytech Ltd, Sutton's Industrial Park, London Road, Earlye, Reading RG6 1AZ

Monolithic Microphone

Honeywell has developed a process for building zinc oxide acoustical microphones and microelectronics on single silicon substrates. The "mike-on-a-chip" offers high performance, sensitivity and reliability at a fraction of the cost and size of current available ceramic acoustic microphones.
The chip-sized microphone is made possible by a new Honeywell technique. The company recently developed a reproduceable process for depositing high-quality zinc oxide thin films, substances similar in electronic response to piezoelectric ceramics but compatible with standard integrated circuit processing. Honeywell used existing semiconductor processes and equipment to fabricate the zinc oxide thin-film sensors and electronic conditioning circuitry on silicon.
The advantages of Honeywell's integrated acoustical microphones over ceramic devices are many. The integrated microphones operate at frequencies down to 0.1 hertz, whereas ceramics lose sensitivity at about 20 hertz. The integrated sensors also offer greater reliability because they are solid state, there are no parts to glue or solder, as with ceramic devices. The Honeywell sensors are also smaller and lighter than their ceramic counterparts. In addition, the sensing element is a passive device and the electronics draw less than 40 milliwatts, which means it can remain working in the field for months before requiring battery recharge or replacement.
Zinc oxide, like piezoelectric ceramic, produces an electrical charge when strained. However, zinc oxide is also pyroelectric, it produces a voltage change in response to thermal change, and this effect must be minimised in low-frequency applications of this device. Honeywell eliminated the thermally-induced voltage fluctuations through a unique design of concentric electrodes, that cancel all pyroelectric-induced electrical signals.
The "mike-on-a-chip" is very sensitive. It can detect one microbar of pressure (one bar equals one atmosphere or 14.69 pounds of pressure per square inch) and will exhibit signal-tonoise ratios of 5:1 at one microbar. Honeywell's "mike-on-a-chip" could have various applications, including hearing aids. Honeywell has applied for a patent on its integrated acoustical microphone technology.
Honeywell Control Systems Ltd, Honeywell House, Charles Square, Bracknell, Berkshire RG12 1FB.

Industry's Fastest RAM

The industry's fastest RAM has been introduced by Motorola. It's the new bipolar 64-bit ECL RAM (MC10H145) with an address time of 3ns (typ) and 6ns (max). The MC10H145 is organised as a 16 x 4 memory array and is a member of the MECL 10KH family. These very high speeds were achieved through new circuit designs as well as advanced processing techniques. Because the device is a member of the 10KH family, its gate structure was changed from 10K configuration to include both constant current source gates and a voltage regulator. Thee additions, as well as new configurations of logic, reduce gate delays thus producing these high speeds. Since the device is in the MECL 10KH family it is processed with Motorola's new oxide isolated process called MOSAIC (Motorola Oxide Self-Aligned Implanted Circuit - but it took them quite a while to think that one up:; which achieves smaller device geometries, improved bandwidth and reduced parasitic capacitances. The European Literature Centre, Motorola Semiconductors, 88 Tanners Drive, Blakelands, Milton Keynes.

New Micro With ROM

The NEC uPD7809G contains the largest on-chip ROM capacity of 8K among current commercially available products, as well as 256 bytes of RAM. In addition to the powerful instruction set with 16-bit arithmetic/logic instructions, the device contains versatile functional blocks such as 8-comaparator input lines, watchdog timer, programmable wait, hold function, 16-bit event/timer counter, two 8-bit programmable timers and serial interface (UART). The new unique 8-bit comparator input lines can be used, for example, for direct interface with the keyboard and the watchdog timer will prevent the program from running out of control in a noisy environment.
The 7809 (seem to have seen that number before!) features a high speed instruction cycle time of 1uS, which under 12MHz, allow much faster 16-bit multiply/divide operations. It is estimated at 1.5 to 5 times faster than conventional micros.
In addition to on-chip memories of 8K for ROM and 256 for RAM, external memory expansion up to 56K bytes is also provided for, with battery back-up operation applicable to some on-chip RAM under stand-by mode.
NEC Electronics (UK) Limited, 116 Stevenson Street, New Stevenson, Motherwell ML1 4LT, Scotland.

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K2583	Heating Controller	81.45
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31 Way E. C. Plug	2.00
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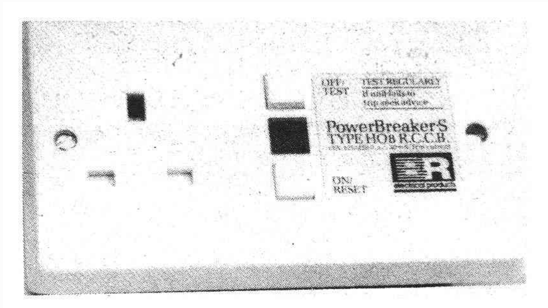
Electronic Memo Pad

A unique totally British designed electronic memo pad which can carry out the functions of a calendar, diary, address book, note pad and a expense account log has been launched into the UK by Domicrest Ltd. The unit measures 136mm (W) x 90mm (H) x 9mm (D) about the same size as a cigarette case, and will therefore fit in the pocket or the handbag. Called the Biztek Pad it will be percolating through. the shops with a retail price of £69.95,



Vital Safety Device

New from B & R Electrical Products is the Power Breaker-S, which is a residual current circuit breaker mounted in the same body as a double 13A socket. Like the HI ELCB (Dec 1982), the device works by detecting any difference of more than 30mA between the two supply lines from the mains, and cutting off the supply before this can result supply before this can result in electrocution. Why every electronics hobbyist doesn't protect his or her equipment supply with one of these (or a similar) device, we'll never know let it suffice to say that we very strongly recommend doing so. B & R Electrical Products Ltd., Temple Fields, Harlow, Essex CM20 2BC.

ZX Music Board

There are now two ready-made cased versions of the ZX81 Music Board (ETI April and May this year), one for the ZX81 which costs £24.95 inclusive, and one for the Spectrum, which costs £26.95. A demonstration cassette is available for £1.25, from Petron Electronics, 1 Courtlands Road, Newton Abbot, South Devon TQ12 2JA.

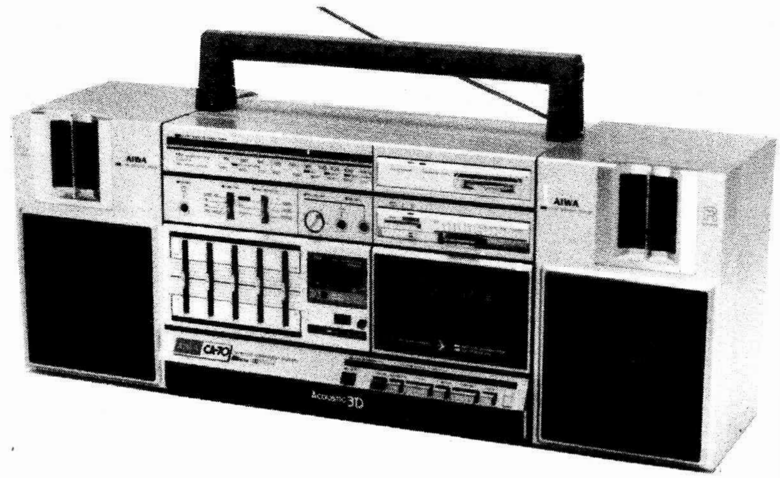
Another Video "Standard"

RCA Corporation and Hitachi Ltd have announced jointly that they plan to introduce the Capacitance Electronic Disc (CED) system in the United Kingdom this autumn in time for the Christmas selling season. RCA will make the video disc albums and Hitachi will supply the players for the UK launch.

Players are expected to be priced at under £300, and discs will be between £12.95 and £21.95, with many titles under £20.

New Portables(??)

The portables market is getting just silly, as these two pictures show. Top is the latest offering in this field from Aiwa - it's styled so that all the various 'components' (the tuner, the cassette deck, etc) look like separate units all just glued together. Actually, you can detach the speakers, but when they're attached to the unit, a special port is opened between them and the main case, which brings a passive radiator into play and boosts the bass response. Total output power is 28 Watts per channel (peak), and the thing has a built-in five-band graphic equaliser (readers wanting a proper graphic equaliser should turn to page 41, where they'll find part two of our own, 28-channel equaliser). Price is a cool £199.95. (It's the CA-70, from Ai-ee-wah UK Ltd, 163 Dukes Road, Western Avenue, London W5 OSY).



The other of these monsters has, as you can see, a B & W TV as well as the usual tape and radio facilities. But won't you bump into people if you walk along holding the TV in front of you? And how strong do your arms have to be the weight isn't stated in the press release? This beast costs £149.95 and is made by Heron Electronics, Heron House, 19 Marylebone Road, London NW1 5JL (confusingly, it's called the Ingersoll XK 500).

There must be a whole generation of youth growing up with one arm longer than the. other due to carrying these things around when will manufacturers think of fitting wheels to them?

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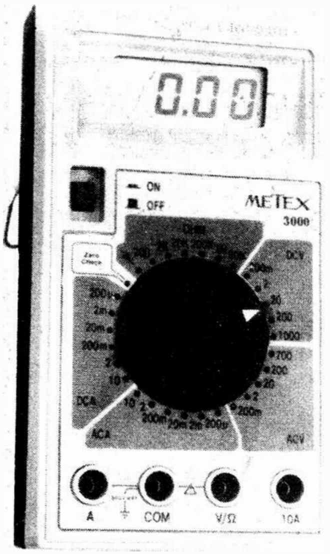


Cheap DMM

Possibly the best value for money hand-held DMM in the UK is available from the House of Instruments and hi! distributors.

Metex type 3000 is a 31/2 digit LCD hand held DMM with a basic DC accuracy of 0.5%. It comes fully guaranteed for 12 months complete with test leads, battery, spare fuse, operating manual and free carrying case at £29.50 including post and packing (but exclusive of VAT).

There are 30 individual ranges of 1000V, 10 amps, 20M ohms, and diode test and zero check functions. Zeroing, over-range, polarity and low battery indication are all catered for automatically. Normal overload protection is provided as well as high voltage surge to approximately 3KV. House of Instruments, Clifton Chambers, 62 High Street, Saffron Walden, Essex, CB10 1EE.

New Line for TV

A slow-scan TV system currently undergoing field tests in prototype, will bring slow-scan television within reach of the average amateur pocket. Designed and built by Davtrend Limited, it will be introduced in late summer with the launch of the Model SST-1000 Slow-Scan Receiver, which will be offered at the highly competitive price of less than £200.

The receiver will have facilities for accommodating a transmitter PCB that will upgrade the equipment for two-way communications. This PCB will be introduced at a later date to coincide with the launch of the full transceiver system, designated as the SST-2000 Slow-Scan Transceiver.

System specifications will be standard: that is, 128 by 128 discrete picture elements each encoded into 16 grey shades to produce one picture every 8.5 seconds. Davtrend Limited, Sanderson Centre, Lees Lane, Gosport, Hampshire PO12 3UL.

Video Recorder Head Testers

Two Video-Head Testers have been added to the Leader range of test equipment marketed by Thandar Electronics designated LHC-909V (VHS) and LHC-909B (Beta) the tester will measure the amount of wear in video heads. The unit costs £45.00 plus VAT, and for further details contact Thandar Electronics Limited, London Road, St Ives, Huntingdon, Cambs, PE17 4HJ.

New Cards Make Apples Grow

New from Hawk Electronic Test Equipment is a GP1B interface card which allows the Apple to become an IEEE 488 controller for test measurement and control. The board will run up to 14 separate controllable devices with a transmission path of up to 20 meters. The on-board software interfaces directly with basic and Applesoft strings, making the Apple into a powerful and east to use IEEE 488 GP1B controller. The price of the card is £189.00 inclusive.

Also form Hawk is a 32-channel I/O card for the Apple, which enables external control and data feedback for the Apple, with four 8-bit bi-directional I/O parts, four 16-bit timers, two serial to parallel, parallel to serial, parallel to serial register and handshake capability. The price of £49.50 also includes documentation and example program. Hawk Electronic Test Equipment, Bircholt Road, Parkwood Industrial Estate, Maidstone, Kent ME15 9XT.

From Owl Micro-Communications comes a new multi-function communications interface card that turns the Apple microcomputer into a highly versatile communications device, with applications ranging from electronic mail to IBM terminal emulation.

The new Owl Multicom card is available for the Apple II plus, Apple IIe and Apple III computers and provides all the standard communications interfaces - a V24 (RS232) serial interface for synchronous and asynchronous communications, a parallel printer interface and clock/timing functions - from a single slot in the Apple Card-frame. Owl Micro-Communications, The Maltings, Station Road, Sawbridgeworth, Herts CM21 9LY.

Versatile LCD Display

A 175 x 50mm LCD display panel, featuring a fully programmable 240 x 64 dot matrix, has been introduced by Impectron Ltd. The panel, manufactured , by Sharp of Japan, is designated the Model LM-24002G and incorporates LCD display panel, CMOS-LSI driver circuits and interconnection facilities.

The new unit is capable of displaying graphs, diagrams or animated pictures as well as letters, figures or symbols. Viewing angle is a minimum of 40°, whilst contrast ratio is typically 3.00 and response speed better than 300 milliseconds. The back of of the display contains ten CMOS control and driver chips, which ensure complete applications flexibility. Impectron Ltd, Foundry lane, Horsham, West Sussex RH13 5PX.

Fibre Optic Photodiode

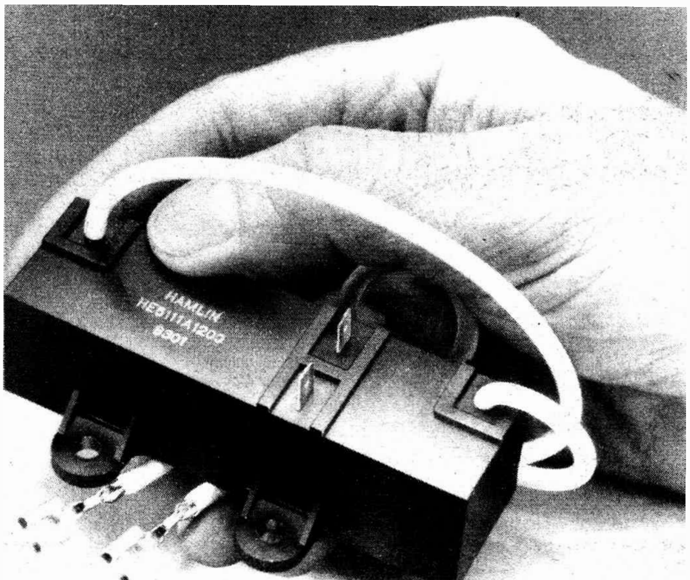
Norban Electro-Optics Limited, sole distributors of RCA fibre optic components in the United Kingdom, have launched a new trans-impedance pre-amplfier photo diode module for "second-window" fibre optic applications.

The RCA C30986E utilise the new Indium Gallium Arsenide PIN photo diode which has excellent responsivity between 900nm and 1700nm and it is ideal for use at the low attenuation wavelength of 1300nm increasingly used in fibre optic systems.

The trans-impedance preamplifier employs a low-noise gallium arsenide FET front end and a cascode feedback circuit. An emitter follower stage been added for improved output coupling efficiency. Additional device features include a system bandwidth of typically 250 MHz end and a signal to noise ratio of typically 22 db for a bit error rate of 10-9. Norban Electro-Optics Ltd., Norban House, Boulton Road, Reading, Berks RG2 0LI.

High Voltage Reed Relay

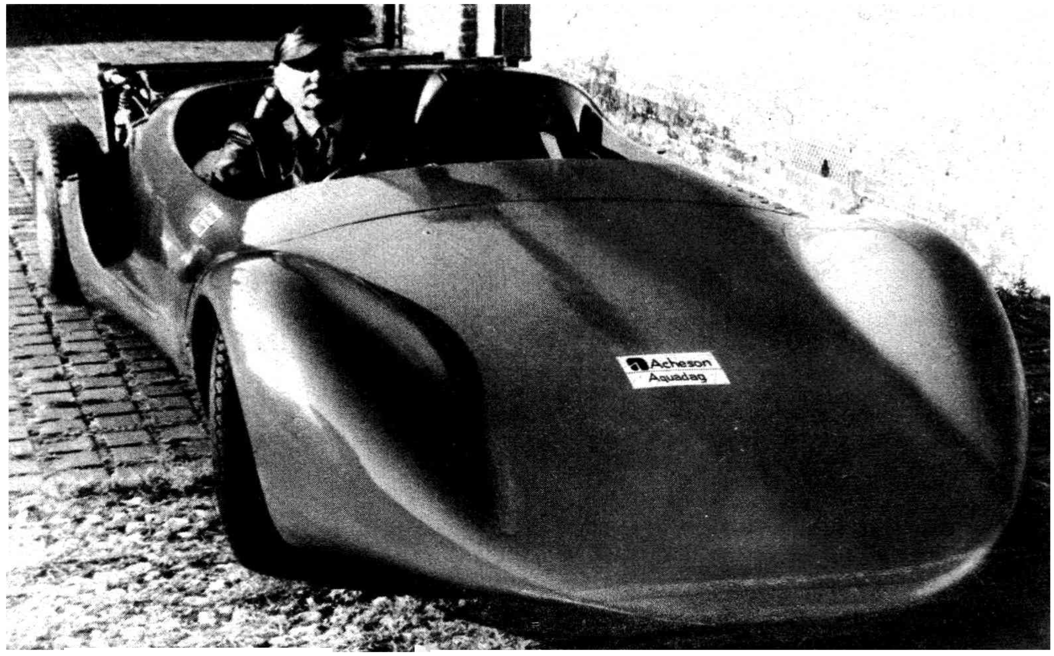
A new high-voltage reed relay developed by Hamlin Electronics uses a vacuum reed switch with tungsten contacts to give an excellent isolation interface, with hold-off voltages ranging from 5kV up to 20kV DC. The new HE5100 Series is available with a selection of switching voltages from 3.5kV DC to 17.5kV DC. Minimum insulation resistance is 101°0, and maximum initial con-tact resistance is 0.10; coil voltages are of 5, 12, 24 and 48V DC.Hamlin Electronics Europe Limited, Diss, Norfolk, IP22 3AY.



64K Mask ROM

Mitsubishi Electric have been busy lately! Their semiconductor division is now mass producing its newly developed 64K mask ROM chip at the monthly rate of 100,000 units. Operating on a single 5V power source featuring low power consump-tion - maximum 80mA - it is capable of fast reading with a maximum access time of 250 nanoseconds. This new M5M2364P 64K ROM is totally compatible with the 64K EPROM, so EPROM chips used in experimental models may be replaced by the mask ROM chip without any modifications. It is ideally suited for use in personal computers, word processors, various peripheral equipment and video games.

In line with the increasing memory capacities of EPROM chips, such as 128K and 256K, Mitsubishi Electric plans to develop mask ROMs compatible with them, expanding its share of the mark ROM market. Mitsubishi Electric (UK) Ltd., Centre Point, 103 New Oxford Street, London WC1A 1 EB.



So far as we know, this has got absolutely nothing to do with electronics, but we thought that it might interest you anyway. It's a steam car that Acheson Colloids are sponsoring in an attempt on the land speed record for steam cars (set in 1906 at 129 mph). In case you are wondering what's happened to our caption photo, none of us here seem to have quite the same warped sense of humour as Peter Green who used to do them!

Shorts

● Mini discs are here! Advanced Memory Services Ltd., Woodside Technology Centre, Green Lane, Appleton, Warrington are now selling 3" Hitachi disc drives for the BBC micro, at £225 for the single version, and £399 for the double.

● Jingoistic jig: apparently British standards have been adopted for 98% of view data and Teletext TV sets throughout the world. But does it make us any money? It must have been done before, it seems such an obvious idea — GenRad Limited, Norreys Drive, Maidenhead, Berkshire have produced a noise dosimeter that can be worn in a shirt pocket.

● Jump on your micro! Crofton Electronics, 35 Grosvenor Road, Twickenham, Middlesex TW1 4AD have introduced a metal case for the BBC, at a price of £39.50 inclusive. They intend to introduce another version, with integral floppy disk housing.

● Take your floppy for a walk with a new Winchester/floppy disk exerciser from Monitest Ltd, Highdiffe House, 411-413 Lym-ington Road, Highcliffe, Christchurch, Dorset BH23 5EN. It's called the AVA 103D, and is intended as a piece of test equipment.

● A new leaflet, Power Darl-ingtons For Semiconductor Ignition (we think they mean for car engines) is available from Telefunken Electronic GmbH, Postfach 1109, D-7100, Heilbron, W. Germany.

● Now we really are getting into leaflet territory: PSP Electronics, Unit 2, 2 Bilton Road, Perivale, Greenford, Middlesex UB6 7DX have issued a leaflet on the range of connectors that they sell.

● Greenpar Connectors, PO Box 15, Harlow, Essex CM20 2ER have issued a leaflet on their coaxial cables.

● Could someone please tell us why around half the leaflets we're told about are for connectors? This one is from Thorn EMI Electrical Components Ltd., Great Cambridge Road, Enfield, Middlesex EN1 1UL, and it details electrical connectors to BS 9522 N0001.

● Cotswold Electronics Ltd., Unit T1 Kingsville Road, Kingsditch Trading Estate, Cheltenham GL51 9NX have issued a leaflet on their budget range of off-the-shelf transformers.

● A new range of Suzuki electronic products is now available in the UK through Craftmaster (UK) Ltd, Tower House, Lea Valley Trading Estate, London N18 3HR. The range includes some rather neat jack connectors and cables, microphones, pianos and a personal stereo amplifier/speaker.

● Sony UK have launched their own mag for CD users, which will be distributed free to owners of Sony players.

● There's something in the air — and it could be coming from the UoSAT satellite. A newsletter on this facility for amateurs is available from UoSAT Group, Dept of Electronic and Electrical Engineering, University of Surrey, Guildford, Surrey GU2 5XH (large SAE required).

● Camel Products have introduced a 4K ROM/RAM unit, along similar lines as the unit reported in Digest, January ("High-Rise RAM"); however, this makes it only half the capacity of the ETI PseudoROM! Camel Products were too modest to attach their address to their press release, but it is One Milton Road, Cambridge CB4 1YU.

● More jingoism: Gould Micro Power Products Division, 11 Ash Road, Wrexham Industrial Estate, Wrexham LL13 9UF have been awarded a contract from NASA worth more than $100,000 to provide zinc-air power packs for the Space Shuttle.

● Prentice-Hall International, 66 Wood End Lane, Hemel Hemptead, Hertfordshire HP2 4RG have released a booklet on the personal computing and micro books that they publish.

● It had to come! Zemco (UK) Ltd, 66 Earlsdon Street, Coventry CV5 6EL, have introduced a handlebar mounted computer for cyclists — so that you can keep a check on your speed, average speed, etc — all for £19.95 inclusive. Incidentally, your dear Editor saw one of these in use during the recent London to Brighton 'Fun Run', but it didn't seem to help its owner go any faster.

● Jackson Brothers have been busy producing new capacitors, including a nigh voltage air dielectric variable type (the TX5), a new precision trimmer (the MT5) and a differential sensor capacitor that can be used to measure angular displacements. Jackson Brothers (London) Ltd., Kingsway, Waddon, Croydon CR9 4DG.

● New catalogues! Electrovalue, 28 St Judes Road, Englefield Green, Surrey TW20 0HB will send you theirs for free, but Bi-Pak, The Maltings, 63A High Street, Ware, Herts SG12 9AD will take 75p plus 25p p&p off you for theirs.

● Axiom Electronics tell us that they now hold 'in-depth' stocks of the MC68008, a reduced data bus version of the 68000. Axiom Electronics Limited, Turnpike Road, Cressex Estate, High Wycombe, Bucks HP12 3NR.

● The latest edition of the IBA Technical Review has landed on our doorstep, and it contains a survey of recent developments in Teletext. ETI readers may obtain copies by sending a large SAE to IBA Information Service, Crawley Court, Winchester, Hants S021 2QA.

● A new company has been formed to exploit the microprocessor and micro computing innovations at Bath University. Called Sirius Microtech Ltd., the company is at Ashchurch Industrial Estate, Tewkesbury, Gloucestershire, and it would surprise us at ETI if this were not one of many such companies to be formed.

● Rifa have introduced a longlife electrolytic capacitor specifically for use in switched mode PSUs, with low ESR and ESL. The PEH 179 series is available through RIFA AB, Market Chambers, Shelton Square, Coventry.

● AB Engineering Co have issued a catalogue of their range of tool kits for professional engineers. AB Enginering Co, Timber Lane, Woburn, Milton Keynes MK17 9PL.

AUDIO DESIGN

The object of this series is to de-mystify audio design, and show that even a comparative beginner can design circuits that work, and work well. But don't let the apparent simplicity of the approach fool you - there will be something here for all, including the most experienced of our readers.
In this first part, John Linsley Hood looks at transistors, both bipolar and field effect, and how to do simple yet very useful calculations on them.

There is a great deal of satisfaction to be gained in building something to one's own design, and finding that it works as well as one had hoped, particularly if this is the sort of thing which one can do, on one's own, without the need for a lot of technical facilities or expensive components.

This is an advantage which we share with some of the manual crafts like pottery or carpentry, but with the additional benefit that if we are not pleased with what we have done, we can take it to pieces and re-use the parts. Moreover, the scope of electronics is exceedingly wide, and this adds enormously to the interest which it will give to the experimenter.

However, there is a truism in engineering that a good design will not necessarily cost more than a poor one, in materials and labour, indeed it may sometimes cost even less, but will give much more satisfaction in use, and may have a longer trouble-free service life. Therefore, it pays in electronics, as in other forms of engineering, to know ones materials and their strengths and weaknesses. In this part, I propose to have a look at the *active* components (bipolar transistors and FETs) which we are likely to wish to use, and to discuss the characteristics of the passive components (resistors, capacitors and inductors) only as and when we come across them in the circuit design, and when we need to be particularly concerned with their qualities in order to obtain the best results.

Transistors Or ICs?

Most of the things which we need to do in audio circuit design can now be done just as well by the use of integrated circuits as they can be done by any assembly of transistors and separate components. Moreover, it is nearly always a lot cheaper to use an IC, if a suitable one is available, and it will also occupy a lot less space.

Unfortunately (I say this sincerely, since I am as lazy as the next person, and I like my design work to be done for me) there are still a few fields in which discrete component circuitry will perform rather better than the equivalent ICs, or in which suitable ICs are just not available. These are high voltage systems, with supply voltages in excess of some 45 volts, high power systems, very low noise circuitry (though ICs are beginning to make inroads here), and very high fidelity systems, particularly where these also involve low signal levels.

There are, indeed, some very good ICs of recent origin which are aimed specifically at the hi-fi field, and one would be foolish to ignore their existence, so I will talk about some of these later. However, discrete component (resistor/transistor) circuitry is still the mainstay of audio electronics, so I will start with this.

Bipolar Junction Transistors

These, the 'transistors' of common use, are now almost exclusively silicon planar devices, made from a slice of mono-crystalline, very high purity silicon, 500 to 750 microns thick, and 75 to 100 millimetres in diameter. During manufacture this slice is photographically masked in an intricate and repetitive series of patterns across its face, and controlled quantities of specific impurities are selectively diffused in a vacuum oven through the succeeding mask patterns, into the slice. This gives a construction of the type shown in cross section in Fig. 1, when the large slice is cut down into a thousand or more individual segments or 'dies'.

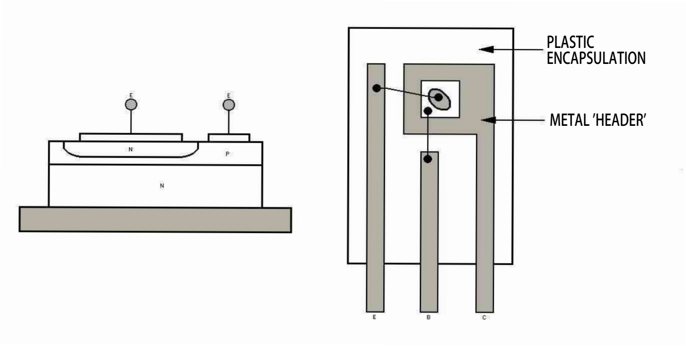


Fig. 1 (a) Cross section of a die; (b) a complete small-signal transistor.

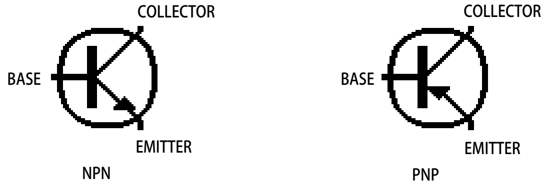


Fig. 2 Transistor circuit symbols - these should be all too familiar to you!

When connections are attached to the impurity regions and the whole lot is encapsulated in a pea-sized piece of plastic, or, more expensively, mounted in a small hermetically-sealed metal container, this becomes the 'transistor' which is shown in the conventional circuit drawing of Fig. 2.

The enormous commercial success of the silicon transistor

transistor, which has now almost completely superseded the earlier germanium type, stems from the fact that this method of construction makes them very cheap to produce. I don't think that I am letting too many secrets out of the bag if I say that a large scale commercial user would probably be reluctant to pay more than 1 to 2p each for these devices in any large quantity, and even at this price it is possible for the manufacturer to make a living.

Discrete junction transistors of this silicon planar type are, conveniently, available in NPN (positive supply line)and PNP (negative supply line) types, and they can be used for an enormous range of applications. However, the one which comes most readily to mind is that of a voltage amplifying stage of the type shown in. fig. 3(a) or (b). Of these, the circuit shown in 3(b) is much more predictable in its characteristics, and would therefore be preferred by the experienced circuit designer if a single transistor amplifying stage would be adequate for his purposes.

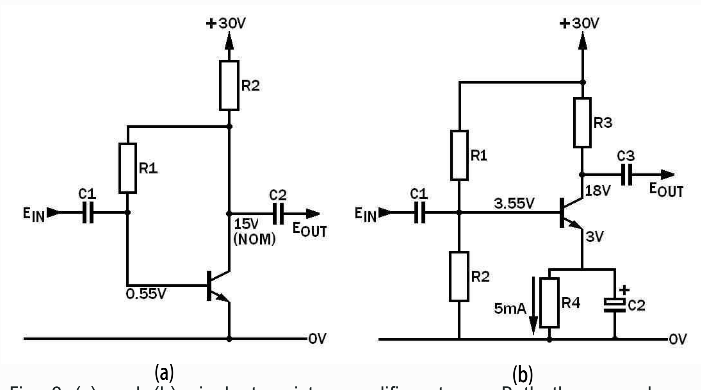


Fig. 3 (a) and (b) single transistor amplifier stages. Both these employ feedback in the setting of the operating point, but not in the signal path (assuming that the source output impedance is much lower than the value of R1 in (a).

That last comment is, however, an important one, in that the performance which can be gained from the use of a group of transistors, acting in combination, is so much. better than that of a single device that there is seldom any good reason for not using a more complex construction.

A typical two transistor amplifying stage, using complementary (NPN and PNP) devices is shown in Fig. 4.This employs some negative feedback (much more on this topic later on) to improve its linearity and bandwidth, and control its AC stage gain. With the circuit values shown, this has a gain of 100, a bandwidth of 10-500kHz, an output voltage swing of 28V p-p, and,a distortion of less than 0.01 %, as compared with a gain of about 40, a bandwidth of only about halt this, and a distortion of some 5% for the single transistor circuit.

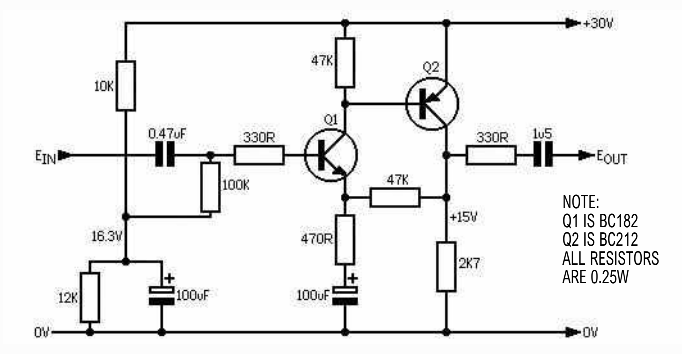


Fig. 4 A two stage transistor amplifier with a gain of 100.

This type of circuit can be elaborated still further as shown in Fig. 5, which will amplify DC as well. However, I am running ahead a little too fast. If we are to make use of circuits of this type, we must first be able to decide upon

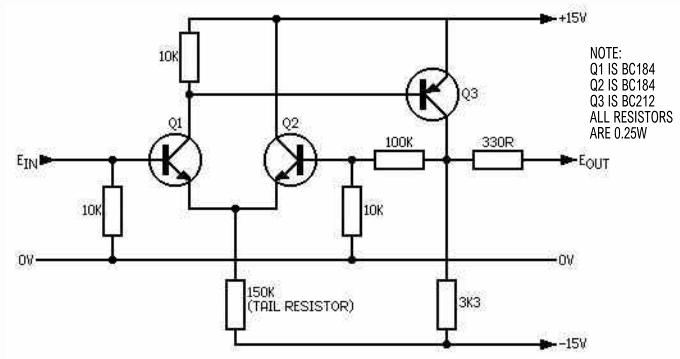


Fig. 5 DC amplifier (with a gain of 10) using an input iong-tailed pair, Q1 and Q2.

our component values and types, with the intended use in mind. So let us do this for the circuit of Fig. 3(b), and while we are at it examine why 3(b) is a better circuit than 3(a). All we need at this stage is a knowledge of Ohms Law, a little familiarity with transistor characteristics, and a pocket calculator!

A typical small-signal plastic encapsulated transistor will have a maximum permitted dissipation of around 300 milliwatts, a current gain of 100 to 500, which will depend a little on collector current and a maximum operating voltage in the range 20-80 volts, with 30 volts being a typical value. In addition, to make the transistor work, there will need to be a forward bias voltage between the base and emitter of some 0.55 volts at room temperature (0.2 volts for a germanium device).

So, let us choose a 30 volt supply line for Fig 3(b), and decide to have about 15 volts across the transistor itself. A collector current of 5 mA will give a dissipation of 75 milliwatts (P_{watts} = VI or = I^2R), which is comfortably within its permitted range. This sort of collector current will also give a reasonable small signal performance. If we choose an emitter potential of 3 V, the required base voltage will be 3.55 volts, and the collector voltage will be 18 V, giving a voltage drop of 12 V across R_3.

From the ohms law relationships V = IR, which can be rearranged as R = V/I or I = V/R, where V is in volts, I is in amps, and R is in ohms, we can work out that R3 should be 12/0.005 or 2k4 ohms. For 3 volts dropped across R4, this resistance, which carries virtually the same current, will need to be 1/4 of this, or 600 ohms. If we assume a minimum current gain for the transistor of 100, then the base current will be 50 uA. To make sure that this doesn't influence the voltage drop in the potential divider chain R1/R2 too much, let us make the current through this 0.5 mA, which gives values for these resistors, calculated as above, of 53k/7k1, to provide a base voltage of 3.55 V.

Rounding these values off to the nearest 'preferred' values will give R1 = 56k, R2 = 6k8, R3 = 2k7 and R4 = 680 ohms. This will not affect the desired operating potentials too much. At this sort of collector current, the input impedance of the transistor itself will be about 5k, giving an input impedance to the whole amplifier circuit of some 2k7. (R_{in} = 1/(1/R1 + 1/R2 + 1/R_{tx})). A calculator with a reciprocal (1/x) function make this kind of calculation very easy.

This leaves us only with the task of deciding what values to use for C1, C2 and C3, which will be determined by the lowest frequency we want to amplify. The impedance of a capacitor is given by the formula $Z_C = 1/(2\pi fC)$, where f is the frequency, in Hz, and C is the value of the capacitor, in Farads. C1 and C3 should both have impedances which are a bit smaller at this frequency than the input impedance (2k7) and the output load impedance (Z_L) presented to the circuit — say 10k. Z_{C2} should be less than R3/M, where M is the hoped-for value of stage gain — say × 100. Doing these calculations gives C1 = 6 u, C2 = 600 u and C3 = 1.5 u, for a lowest operating frequency of 10 Hz.

The upper operating frequency will be determined mainly by the output stray capacitances of the circuit and its associated wiring, but could be a few hundred pF. The −3dB point (at which the output is down to 70% of its original value) is that frequency at which Z_{CS} is equal to R3 in parallel with ZL. The userful formula here is $f_t = 1/2\pi R3CS$. If CS = 300p, ft will be 250 kHz.

Using the calculated resistor values shown above, we could swap transistors in the circuit of Fig. 3(b) with very little change in the DC operating conditions. How about Fig. 3(a)? In this case, the base current is determined by the collector-base voltage and the value of R1. If, as before, we make V_{ce} = 15V, and decide on a collector current of 5mA, then R2 will be 3k. If we assume a current gain of 100, then R1 = 14.45/0.00005 = 289k. However, suppose that the transistor current gain turned out to be 500, instead of 100, then the collector current would increase and the collector voltage would fall to about 5.5 V to preserve the status quo. The circuit would still work, but one wouldn't be able to get nearly as much output voltage swing before it began to clip. So, although simpler, and a bit cheaper in components, the circuit of Fig. 3(a) would be much more influenced by transistor characteristics than that of 3(b).

Going through the same sort of calculations as above gives the component values shown for the two transistor circuits Figs. 4 and 5. A further advantage of the two transistor circuits not mentioned earlier is that the use of the internal negative feedback loop substantially increases the input impedance of the circuit, above the rather inconveniently low values given by the circuits of Fig. 3, which is typically a few kilohms.

The other frequently used transistor circuit configurations are the **common collector** (collector at zero AC potential) also referred to as **emitter follower,** and the **common base,** which is used mainly in RF circuits or low impedance, very low noise circuit configurations.

These are shown in Figs. 6 and 7. Once again the emitter follower unity gain circuit can be improved by the use of more than one transistor, giving in a two-transistor form the very valuable **compound emitter follower** arrangement of Fig. 8. This has a very high input impedance, determined mainly by the input resistor network, and a very low output impedance, so that it can drive low impedance loads with very little loss of signal. Moreover, as a circuit, it has a very low distortion indeed, and, with suitable transistors and operating values, also very low circuit noise, making it usable in a whole variety of low signal level arrangements. All in all, the two transistor compound emitter follower is one of the most useful of the unity-gain circuit building blocks, which can be made, with complementary transistor types, to work from either a positive or a negative supply rail.

A word of warning is necessary at this point. All feedback circuits (and this includes those in Figs. 4,5,6 and 8) can oscillate if enough phase shift occurs within the input/output feedback loop. The emitter followers of Figs. 6 and 8 are very prone to this with suitable (though often unintended) combinations of lead inductance and stray circuit capacitance on input or output. To prevent this, it is useful to put a small value of resistance — a few hundred ohms will often suffice, or a bit more if the circuit conditions will tolerate this — in the input and output leads. This will not normally have any adverse effect on performance.

Combinations of transistors can be used to make oscillators and other waveform generators, but the numbers of circuits used for this are legion, and there is inadequate space to disucss these here, though they do have a part to play in audio testing.

Field Effect Transistors

These come in two basic types, junction FETs — usually referred to as just FETs — and insulated gate FETs, normally known as MOSFETS, because of their construction (metal-oxide-silicon). Both types are made by much the same general manufacturing processes as bipolar transistors. However, they tend to be quite a bit more expensive, partly because they do use rather a larger area of the slice, but mainly because they are not made as discrete transistors in such large quanitities (though very large numbers are made in CMOS and NMOS ICs) and therefore don't benefit from the same economies of scale.

Both of these devices have a much higher input impedance than bipolar devices — usually measured in millions of megohms — but do not give as high a stage gain as junction transistors when used in equivalent circuits. Junction FETs are not much bothered by static electrical charges, though some care is needed in handling MOSFETs.However, having said that, the only instance I have ever come across of them failing in handling was when a colleage of mine soldered them into an earthed circuit with a soldering iron whose case was not earthed and floated somewhere around 120 VAC!

The junction FET, whose circuit drawing is shown in Fig. 9(a), is now almost exclusively used in small signal circuitry — though Sony did produce some high power ones, a few years ago — with maximum working voltages in the range up to 50 VDC, and dissipations of a few hundred milliwatts. It is, however, a very linear device with a very high dynamic impedance. MOSFETs are very fast devices, capable of operating up to the 500MHz range, and, until comparatively recently, have been used almost exclusively as RF amplifiers. In the past few years, though, high power MOSFETs have come into service in audio output

Fig. 6 A basic emitter follower.

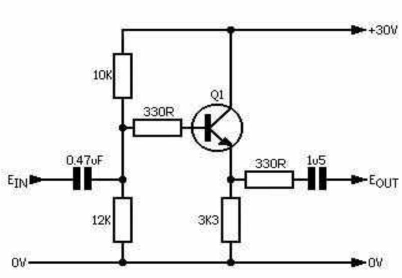


Fig. 7 Common base circuit, shown as an RF amplifier.

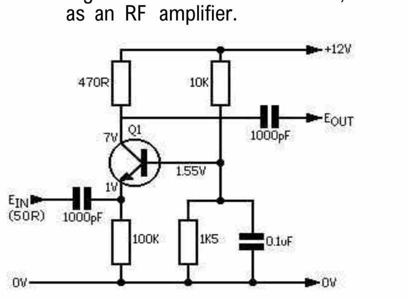
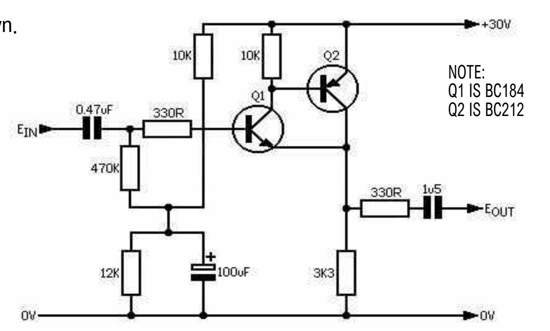
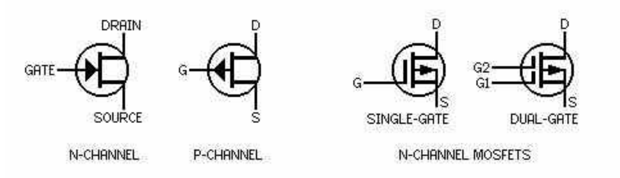


Fig. 8 Compound emitter follower, with gain very close to unity and 300k input impedance.





(a) (b)

Fig. 9 FET circuit symbols: (a) junction FETS and (b) N-channel MOSFETs (P-channel would have the small arrow on the source pointing in the opposite direction).

stages, where their fast response and good linearity has conferred useful advantages. On the debit side, they do need more careful treatment in circuit design (mainly because their very high speed makes wiring inductances and circuit capacitances important where they are not even noticed in normal power transistor output stages) if troubles are to be avoided, which is why there are still relatively few power MOSFET audio amps in general use.

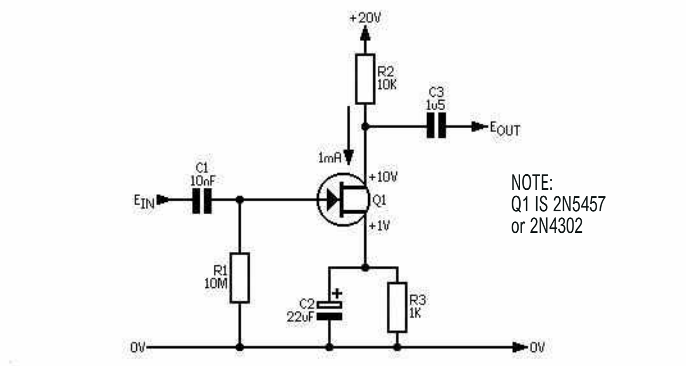
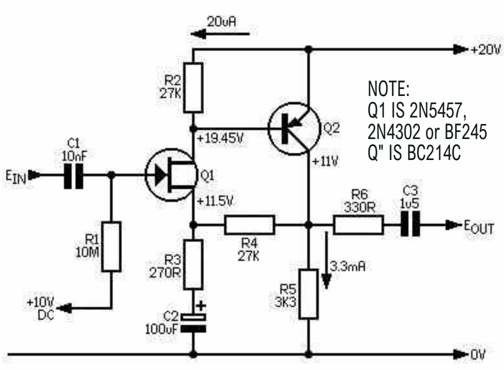


Fig. 10 Single stage FET amplifier.

The design of FET amplifier stages follows similar general principles to those indicated earlier in respect of bipolar circuit designs, but with a few significant differences, which we ·can consider in relation to the single. FET amplifier circuit of Fig. 10, and the rather better two stage circuit shown in Fig. 11. To begin with, the normal junction FET is what is referred to as a 'depletion mode device, which is to say that it normally passes current, which is reduced by the application of a bias voltage {negative in respect to an N-channel device, and positive in respect of a P-channel one) to the gate electrode. This means that an input biasing network of the kind shown in Fig. 3 is unnecessary, and the correct operating conditions can be established by a resistor in the source lead, in an identical manner to that of cathode bias in the case of a thermionic valve.

The second practical difference is that, unfortunately, the characteristics of FETs are nowhere near as precisely



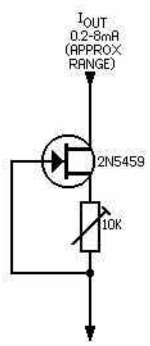


Fig. 11 (Left) Two stage FET amplifier with overall negative feedback gain will be 100 and input impedance will be 10 Megohms.
Fig. 12 (right) Use of a junction FET as an adjustable constant current source.

controlled as in the case of the normal bipolar junction transistor, which will always begin to turn on at a forward bias between 0.5 and 0.6 V on its base. By contrast, the specification quoted by Motorola for their 2N5457 N-channel small signal junction FET, which is quite a popular and representative type of device, merely claims a current, at zero bias, somewhere in the range 1 to 5 mA, a slope (g_m) which lies between 1 and 5 mA/volt, and a cut-off negative gate voltage between -0.5 and -6 volts. Happi-ly these are extreme limit values quoted so that the users won't throw too many of their FETs back at them as being 'outside spec'. Nevertheless, although a typical 2N5457 might have a cut-off voltage of -2 to -3 V and a zero bias drain current *of* 2 mA.

In the case of the circuit shown in Fig. 10, the very low input leakage current means that we could make R, 10 M, which lets us use a relatively small and cheap input capacitor, while still having a good LF response. For a drain current of 1 mA, a source bias resistor of 1K will give an effective negative gate bias voltage of 1 V, and a 10K drain resistor will give (at 20V positive supply and 1mA drain current) a drain voltage of +10V. Unfortunately, this doesn't give a very good stage gain. The simple formula for stage gain, where one knows the device gm, is Gain = $g_m R_L$. is still 10K, then the gain is 10 for a slope of 1mA/volt.

To retain the FET advantage of a very high input impedance, while still having a useful stage gain, coupled with the ability to use the stage with normal load impedances, we need to use a two stage circuit such as that shown in Fig. 11. In this, by using a very high current gain (C grade) transistor for Q2, and remembering that the input impedance of a transistor amplifier stage depends at LF on its base current, which becomes less as the current gain B increases, we can operate the FET at a low drain current, and a fairly high resistor for R2. By making R2 and R4 of the same value, the voltage drop across both, due to the drain current {0.55_/27k -20 uA) will be 0.55 V, and the output DC voltage, at Q2 collector will be about + 11 V, with the FET having, say, -1.5 V effective gate bias. As in the circuit shown in Fig. 4, the gain is controlled by negative feedback to a value of 100; and the circuit will have a good output swing, very low distortion, and a wide bandwidth. This circuit is also quite tolerate of FET characteristics, in that variations in cut-off voltage will only make smallish changes in the DC output level.

To summarise, apart from their very much higher input impedance, and their low intrinsic distortion characteristics, FETs tend to offer rather better noise levels in high impedance circuitry than bipolar devices, but for very low impedance circuits, as would be used, for example, in a moving coil head amp, even the best of the FETs are less good than suitably chosen bipolar types. At low impedances MOSFETs tend to be rather noisy. One very useful facility of the junction FET is its capability of being used as a 'two terminal' constant current source, as shown in Fig. 10. The ability of the source current flowing through the adjustable source resistor to bias the device to a drain current level which is almost completely independent of drain voltage, within its possi-ble working limits, makes an almost ideal arrangement for giving a constant, though adjustable, current source which is usable right up to the maximum gate-source voltage of the FET. This could be used to provide an almost perfect 'fail' for the long-tailed pair circuit (Q1 and Q2 in Fig. 5).

In the next part of this series, I propose to have a look, at ICs, and some of the circuit configurations which can be used with these in the audio field, before going on to look in rather greater detail at some of the problems such as noise and distortion and other unwanted effects.

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NICAD CHARGER/ REGENERATOR

Many a Ni-Cad charger has graced these pages in the past; the Ni-Caddy is a bit different, in that it will regenerate the battery automatically for you. Design and development by Mike Punnett.

Nickel-cadmium cells are becoming increasingly popular as replacements for conventional dry batteries in a wide range of equipment. Properly used, they can give an enormous cost saving over the life of the equipment, but if misused, tend to fail early.

Since Ni-cads have a tendency to self-discharge over a few months, they have to be charged regularly. Furthermore, to avoid the inconvenience of a flat battery, they are often "topped up" with charge even when far from discharged. This leads to an effect known as whiskering, where fine deposits of cadmium build up, which can partially short-circuit the cell, as well as reducing the active electrode size. This leads to a loss of capacity; a 500mAh cell may be reduced to 300mAh after a year of light service and frequent charges.

It has been found that "cycling" Ni-cads can return them to an almost-new condition. This process involves discharging the battery hard (at the 1 hour rate, e.g. 500mA for a 500mAh battery), until it reaches the minimum safe voltage - Ni-cads can be easily damaged by over-discharging. A full charge at the 10 hour rate follows. This rather rough treatment disintegrates the whiskers of cadmium, and the full charge redeposits the metal on the electrodes. However, cycling Ni-cads "by hand" is a risky business, since they can easily be damaged.

The ETI Ni-Caddy was designed to cycle Ni-cads correctly and easily. It uses a minimum of components, and has two "programs": **cycle** and **charge.**

Operating the unit is very straightforward: the Ni-Cad is connected to it, and the appropriate button for the required program

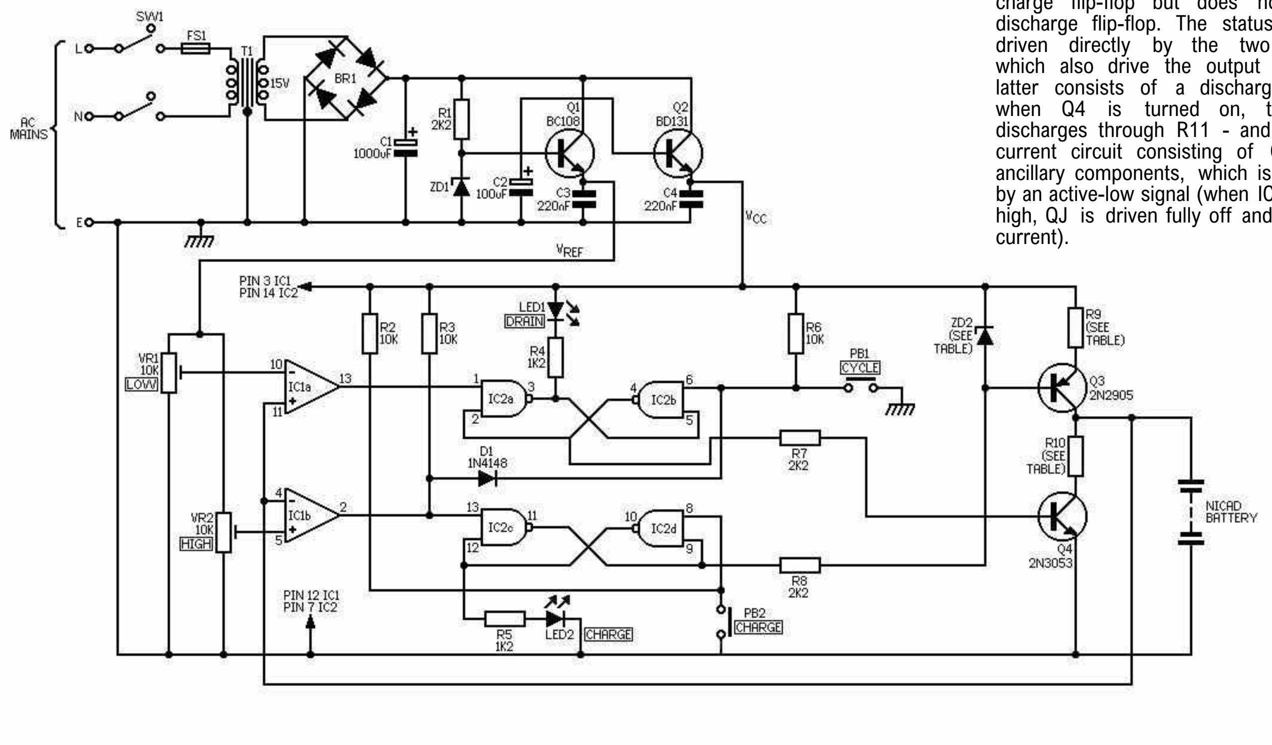
HOW IT WORKS

The power supply section is quite straightforward, using a very simple voltage regulator. V_{CC} is not critical, but the reference voltage, V_{ref}, must be stable, even though the precise voltage is not important. With a separate regulating transistor (Q1) the circuit shown is quite adequate. The two reference levels (the points at which discharge and charge respectively terminate) are derived by RV1 and RV2.

IC1 is a dual comparator which has a number of advantages over similar units, including single-rail operation, the ability to accept inputs at near-ground potential, very low offset, and open-collector outputs. In the circuit, the output of IC1a goes low to indicate that the battery has reached minimum voltage, and that of IC1 b goes low when maximum voltage is reached.

IC2 is wired as two flip-flops, one for discharging (IC2a,b) and one for charging (IC2c,d). Pressing "Cycle" sets the discharge flip-flop and clears the charge flip-flop (via 02). When the battery reaches minimum voltage, or "Charge" is pressed, the discharge flip-flop is cleared and the charge flip-flop is set. The battery reaching full charge clears the charge flip-flop but does not set the discharge flip-flop. The status LEDs are driven directly by the two flip-flops, which also drive the output stage. The latter consists of a discharge circuit - when Q4 is turned on, the battery discharges through R11 - and a constant current circuit consisting of QJ and its ancillary components, which is turned on by an active-low signal (when IC2 pin 11 is high, QJ is driven fully off and passes no current).

Fig. 1 Circuit diagram.



pressed. Cycle mode discharges the battery to its minimum safe voltage, and then switches to charge mode, in which the unit functions as a constant-current charger, automatically turning off when the battery reaches full charge. If the Ni-Cad is already below its minimum safe voltage when connected up, the unit will automatically enter charge mode, overriding the switches, which are re-enabled when the battery rises above minimum safe voltage.

Construction

Construction of the unit is quite straightforward, either on the PCB or Veroboard. Sockets are recommended for the ICs, particularly IC2 which is a CMOS device. Do not forget the three wire links on the PCB.

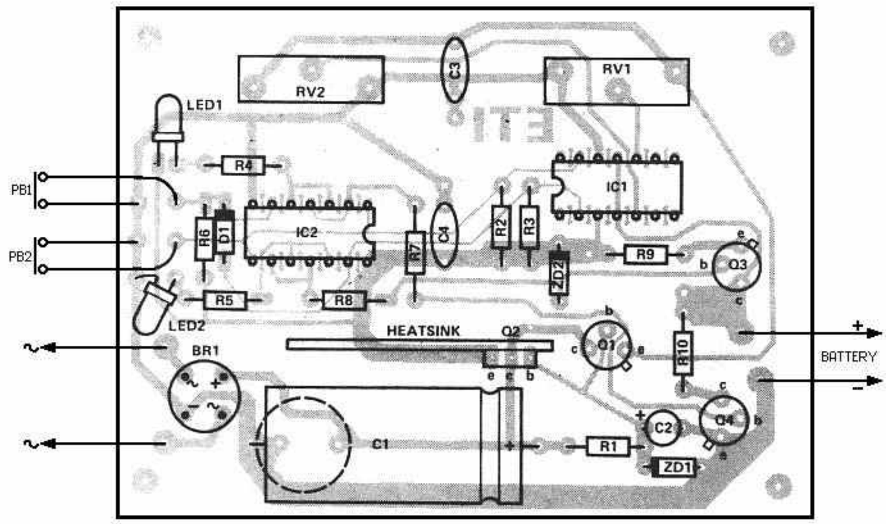
Table 1 gives component values for AA size (500mAh) cells (see later for details of use with other battery sizes). The circuit will work with batteries of up to eight cells. Remember that R11 will get hot, since the battery is discharged through this. For power ratings over 4W, this component should be mounted off the board, preferably outside the box, to aid heat dissipation. Some of the transistors are fitted with heat sinks; Q1 has an aluminium heatsink (see overlay), Q3 and Q4 have pusj fit TO5 heat sinks.

Testing and Calibration

Check the voltages across C3 and C4. Both should be in the range 1·6.5 - 17.4 V. If not, the power supply section should be investigated. The precise values do not matter, since the calibration will allow for some variability.

If the power supply is working properly, the unit can be calibrated. RV1 is set to the minimum safe voltage for the battery; this is 1.1 V per cell (4.4V for a four cell battery).

An accurate, high resistance voltmeter connected to pin 8 of IC1 will enable the voltage to be checked. RV2 (full charge voltage) must be set rather more accurately, since the step in voltage which a Ni-Cad exhibits as it reaches full charge is quite small. The best method is to set the voltage too high at first; about 1.7 V per cell on IC1 pin 11 is adequate. The operation of the unit is then checked with a



battery which is known to be in full working order; at this stage the circuit should perform as described above, except that it will not turn off after charging. The charging current can be checked; it should be 0.1 of the cell capacity (e.g. about 50mA for 500mAh (AA) batteries). The test battery is then left on charge for a long period - 20 hours, if flat. This guarantees that it stabilises at full charge voltage. Since the charging is constant-current, there is no risk of damaging the battery by charging for too long. At this point, VR2 can be slowly turned down until the circuit just switches off, and the setting re-checked. The unit is now completed.

Modifications

The circuit was originally designed for AA size (500mAh) Ni-Cads, since these are the most widely used, but it can easily be adapted for other sizes by changing R9 and R10. These are calculated from the quoted values simply by reducing the resistance and increasing the wattage in proportion to the capacity; so for a 1 Ah six-cell battery, R9 would be 50R 1W and R10, 6R 15W. (The values do not have to be absolutely exact, of course). For cells over 1 Ah capacity, it is best to upgrade Q3 and Q4; since the circuit will be on for long periods it is advisable to rate components generously, especially heat sinks. Replacing Q3/Q4 with BD132/BD131 respectively, mounted off the PCB on a suitable heat sink, will enable the unit to cope with cells up to about 4 Ah. As a rough guide, allow 1 Watt dissipation per Ah cell capacity when choosing heat sinks.

Remember that the heat sink on Q1 may need upgrading also. Allow a dissipation of 1.2 W per Ah cell capacity.

PARTS LIST

RESISTORS (all 1/4W 5% unless stated	
R1,7,8	2k2
R2,3,6	10k
R4,5	1k2
R9,10	See text
VR1,2	10k multi-turn preset pot
CAPACITORS	
C1	1000u 40V PCB mounting electrolytic
C2	100u 25V PCB mounting electrolytic
C3,4	220n polyester
SEMICONDUCTORS	
IC1	LM339
IC2	4011B
Q1	BC108
Q2	BD131
Q3	2N2905 (but see text)
Q4	2N3053 (but see text)
D1	18V 400mW Zener
D2	1N4148 or similar
D3	400mW Zener (see Table 1)
LED1,2	Any 0.125" LED
BR1	WO2 or similar bridge rectifier
MISCELLANEOUS	
PB1,2	Min push-to-make switches
SW1	Two-pole mains switch
FS1	1A mains fuse and holder
T1	Mains transformer, 15V 1A secondary (but see text)

Two 14-pin DIL sockets, case to suit, battery connectors, heatsinks as required (see text).

No of cells	D3 voltage	R9 ohms/watts	R10 ohms/watt
2	10	210/1	4.7/2
4	8.2	160/0.5	10/4
6	5.1	100/0.5	13/7
8	3.6	68/0.25	18/10

BUYLINES

Nothing to cause any problems here. PCB through PCB service page, case a la carte (to choice), semiconductors all readily available -when was the last time we published such a trouble-free project?

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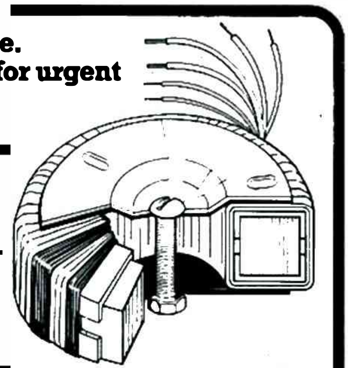

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15 VA	0x010	6+6	1.25	
62 x 34mm	0x011	9+9	0.83	
0.35Kg	0x012	12+12	0.63	**£5.12**
Regulation	0x013	15+15	0.50	+ p & p £0.78
19%	0x014	18+18	0 42	+ VAT £0.89
	0x015	22+22	034	TOTAL £6.79
	0x016	25+25	0.30	
	0x017	30+30	0.25	

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TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
30 VA	1x010	6+6	2.50	
70 x 30mm	1x011	9+9	1.66	**£5.49**
0.45Kg	1x012	12+12	1.25	+ p & p £1.10
Regulation	1x013	15+15	1.00	+ VAT £0.99
18%	1x014	18+18	0.83	TOTAL £7.58
	1x015	22+22	0.68	
	1x016	25+25	0.60	
	1x017	30+30	0.50	
50 VA	2x010	6+6	4.16	
80 x 35mm	2x011	9+9	2.77	
0.9Kg	2x012	12+12	2.08	
Regulation	2x013	15+15	1.66	**£6.13**
13%	2x014	18+18	1.38	+ p & p £1.35
	2x015	22+22	1.13	+ VAT £1.12
	2x016	25+25	1.00	TOTAL £8.60
	2x017	30+30	0.83	
	2x028	110	0.45	
	2x029	220	0.22	
	2x030	240	0.20	
80 VA	3x010	6+6	6.64	
90 x 30mm	3x011	9+9	4.44	
1Kg	3x012	12+12	3.33	**£6.66**
Regulation	3x013	15+15	2.66	+ p & p £1.72
12%	3x014	18+18	2.22	+ VAT £1.26
	3x015	22+22	1.81	TOTAL £9.64
	3x016	25+25	1.60	
	3x017	30+30	1.33	
	3x028	110	0.72	
	3x029	220	0.36	
	3x030	240	0.33	

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
120 VA	4x010	6+6	10.00	
90 x 40mm	4x011	9+9	6.66	
1.2Kg	4x012	12+12	5.00	
Regulation	4x013	15+15	4.00	**£7.42**
11%	4x014	18+18	3.33	+ p & p £1.72
	4x015	22+22	2.72	+ VAT £1.37
	4x016	25+25	2.40	TOTAL £10.51
	4x017	30+30	2.00	
	4x018	35+35	1.71	
	4x028	110	1.09	
	4x029	220	0.54	
	4x030	240	0.50	
160 VA	5x011	9+9	8.89	
110 x 40mm	5x012	12+12	6.66	
1.8Kg	5x013	15+15	5.33	
Regulation	5x014	18+18	4.44	**£8.43**
8%	5x015	22+22	3.63	+ p & p £1.72
	5x016	25+25	3.20	+ VAT £1.52
	5x017	30+30	2.66	TOTAL £11.67
	5x018	35+35	2.28	
	5x026	40+40	2.00	
	5x028	110	1.45	
	5x029	220	0.72	
	5x030	240	0.66	
225 VA	6x012	12+12	9.38	
110 x 45mm	6x013	15+15	7.50	
2.2Kg	6x014	18+18	6.25	
Regulation	6x015	22+22	5.11	**£9.81**
7%	6x016	25+25	4.50	+ p & p £2.05
	6x017	30+30	3.75	+ VAT £1.78
	6x018	35+35	3.21	TOTAL £13.64
	6x026	40+40	2.81	
	6x025	45+45	2.50	
	6x033	50+50	2.25	
	6x028	110	2.04	
	6x029	220	1.02	
	6x030	240	0.93	

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
300 VA	7x013	15+15	10.00	
110 x 50mm	7x014	18+18	8.33	
2.6Kg	7x015	22+22	6.82	
Regulation	7x016	25+25	6.00	**£10.88**
6%	7x017	30+30	5.00	+ p & p £2.05
	7x018	35+35	4.28	+ VAT £1.94
	7x026	40+40	3.75	TOTAL £14.87
	7x025	45+45	3.33	
	7x033	50+50	3.00	
	7x028	110	2.72	
	7x029	220	1 36	
	7x030	240	1.25	
500 VA	8x016	25+25	10.00	
140 x 60mm	8x017	30+30	8.33	
4Kg	8x018	35+35	7.14	**£14.38**
Regulation	8x026	40+40	6.25	+ p & p £2.40
4%	8x025	45+45	5.55	+ VAT £2.52
	8x033	50+50	5.00	TOTAL £19.30
	8x042	55+55	4.54	
	8x028	110	4.54	
	8x029	220	2.27	
	8x030	240	2.08	
625 VA	9x017	30+30	10.41	
140 x 75mm	9x018	35+35	8.92	
5Kg	9x026	40+40	7.81	**£17.12**
Regulation	9x025	45+45	6.94	+ p & p £2.55
4%	9x033	50+50	6.25	+ VAT £2.95
	9x042	55+55	5.68	TOTAL £22.62
	9x028	110	5.68	
	9x029	220	2.84	
	9x030	240	2.60	

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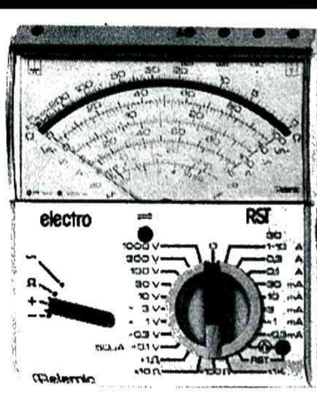

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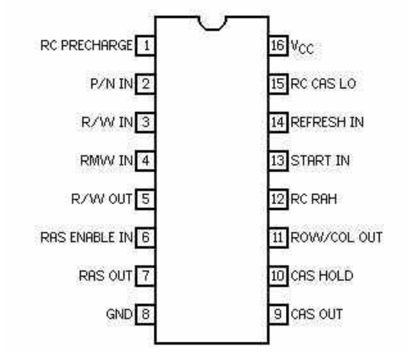
IC UPDATE

Here are some more new ICs this month - ones that we do know you can buy!

74LS608 Memory Cycle Controller

- Provides correct timing for memory cycles
  - read cycle
  - write cycle
  - read-modify;write. cycle
  - "RAS"-only refresh cycle
- Page or normal modes
- Stand alone controller for CPU-to-memory interface
- Also designed to be part of a three-chip set consisting of LS600 through LS603, LS604 through LS607, and LS608
- RAS output is 3-state to share bus with LS600
- Critical times are user RC-programmable to optimise system performance



TOP VIEW

Fig. 1 Pin out of the 74LS608.

The LS608 memory cycle controller is designed to interface between a microprocessor and dynamic RAM memories. It contains six RS latches, five D-type flip-flops, and more than 50 miscellaneous gates on a single chip. The LS608 combines maximum flexibility and ease of programming via RC nodes to allow optimum memory cycle performance.

After the user has selected and attached RC networks to pins 1, 12 and 15, the LS608 will deliver proper RAS, CAS, and READ/WRITE output signals to execute one memory cycle as the start input is switched from low to high. The actual cycle executed will depend upon steady state input conditions of the LS608 as indicated in the table below.

INPUT CONDITIONS

MEMORY CYCLE	MODE	P/N IN	R/W IN	RMW IN	RAS ENABLE IN	CAS HOLD IN	START IN	REFRESH IN
READ		H	H	H	L	H	†	L
WRITE	PAGE	H	L	H	L	H	†	L
READ-MODIFY-WRITE		H	H	L	L	H	†	L
READ		L	H	H	L	H	†	L
WRITE	NORMAL	L	L	H	L	H	†	L
READ—MODIFY—WRITE		L	H	L	L	H	†	L
REFRESH	REFRESH				L	H	†	H
EXTERNAL REFRESH					H	H		L

H - High; L - Low; • - Irrelvant; † - low-to-high transition

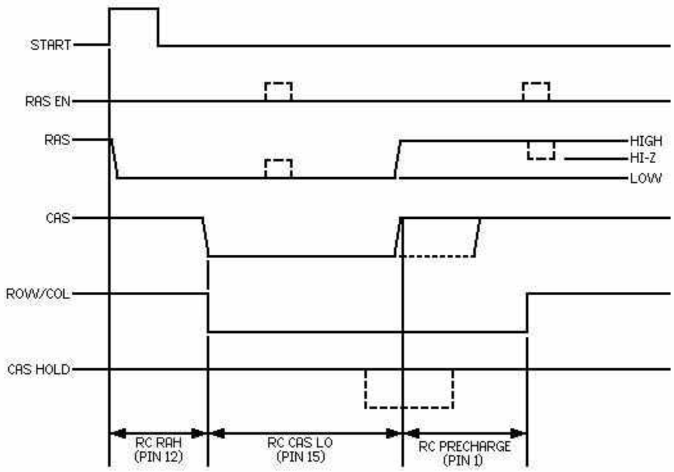
Absolute Maximum Ratings

Supply voltage, V_{cc}	7 V
Input voltage	7 V
Off state output voltage	5.5 V
Operating free-air temperature range	0°C to 70°C

Pin Function Table

PIN	PIN NAME	FUNCTIONAL DESCRIPTION
1	RC PRECHARGE	User-programmable timing mode for precharge/$\overline{CAS}$ high and $\overline{RAS}$ high).
2	P/$\overline{N}$ IN	When low, allows a normal read or write cycle. When high allows page mode read or write cycle. Holds $\overline{RAS}$ continuously low while CAS and column addresses are sequenced.
3	R/W IN	When high, initiates a read cycle (holds R/$\overline{W}$ OUT high) and, when low, initiates a write cycle (holds R/$\overline{W}$ OUT low) if pin 4 is high and pin 14 is low.
4	$\overline{RMW}$ IN	When low, enables read-modify-write cycle. R/$\overline{W}$ IN must be high at the start of the RMW cycle.
5	R/$\overline{W}$ OUT	When high, indicates a read cycle is in progress. When low, indicates a write cycle is in progress. Normally ties to a W memory input in a system.
6	RAS ENABLE IN	When low, enables RAS output. When high, $\overline{RAS}$ is in the high-impedance or third state.
7	$\overline{RAS}$ OUT	3-state row-address-strobe output controlled by RAS ENABLE IN. In the three-chip controller set, the $\overline{RAS}$ output of the 'LS608 ties to the $\overline{RAS}$ output of the refresh controller (LS600 through LS603).
8	GND	Device and substrate ground.
9	$\overline{CAS}$ OUT	Column-address-strobe output.
10	$\overline{CAS}$ $\overline{HOLD}$ IN	When low, allows $\overline{CAS}$ to latch in low state. When high, latch is removed. Can be used to improve data retrieval during read cycle.
11	ROW/$\overline{COL}$ (or MEMBSY) OUT	Drives memory address multiplexer select input, and indicates BUSY condition to processor.
12	RC RAH	User-programmable timing mode* for row address hold time (high level at ROW/$\overline{COL}$ OUT).
13	START IN	When changed from low to high, initiates a memory cycle.
14	REFRESH IN	When high, enables $\overline{RAS}$-only refresh cycle.
15	RC $\overline{CAS}$ LO	User-programmable timing mode* for column address strobe low time.
16	V_{cc}	5-volt power supply terminal.

* All timing modes require a resistor to V_{cc} and a capacitor to ground Programmed time is approximately 0.29 RC.



NOTE: TAKING RAS EN HIGH TAKES RAS TO HIGH IMPEDANCE STATE AS INDICATED

Fig. 2 Normal read mode.

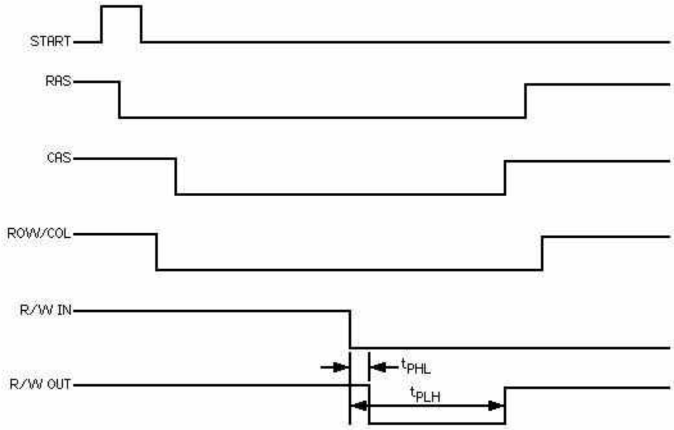


Fig. 4 Normal read-modify-write mode.

Note that the read-modify-write cycle requires that R/W should go low at a suitable time after CAS (depending on the memory used). This cycle can be aborted (no write) by taking RMW high to terminate it, as shown in Fig. 5.

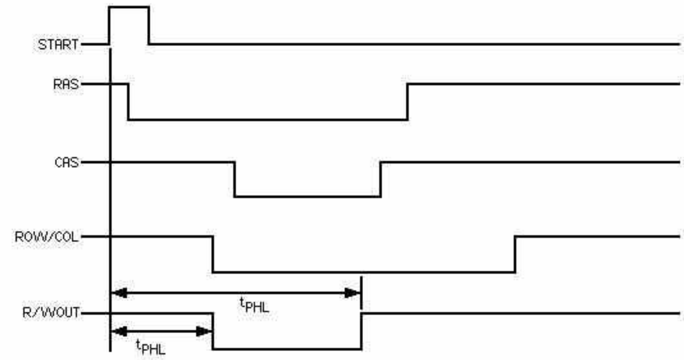


Fig. 3 Normal write mode.

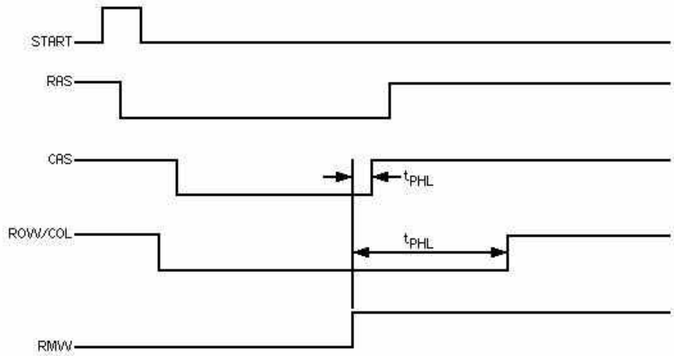


Fig. 5 Normal read-modify-write with abort after read.

Switching Characteristics (see waveforms for more detail) V_{cc} - 5V, T_A = 25^{0}c, C_L = 45 pf to GND

PARAMETER	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS	MODE	TYP	UNIT
t_{PHL}	START ↑	RAS	R_L = 667 R to V_{cc}	NORMAL READ	12	ns
t_{PLH} [1]	START ↑	RAS			425	ns
t_{PHL}[2]	START ↑	CAS			140	ns
t_{PLH} [1]	START ↑	CAS			405	ns
t_{PHL}[2]	START ↑	R/W		NORMAL WRITE	115	ns
t_{PLH}[1]	START ↑	R/W			440	ns
[illegible]	CAS HOLD↑	CAS		NORMAL READ	10	ns
t_{PHL}[2]	START ↑	ROW/COL	R_L = 2 kO to V_{cc}		125	ns
[illegible][3]	START ↑	ROW/COL			670	ns
t_{PHL}	R/W↓	R/W	R4L = 667 R to V_{cc}	NORMAL RMW	14	ns
t_{PLH}[4]	R/W↑	R/W			355	ns
t_{PLH}	RMW↑	CAS			40	ns
t_{PLH}[S]	RMW↑	ROW/COL			320	ns
t_{PZH}	RAS EN↑	RAS	R_L = 667 R to GND	NORMAL READ	15	ns
t_{PZL}	RAS EN↓	RAS	R_L = 667 R to V_{cc}		17	ns
t_{PHZ}	RAS EN↑	RAS	R_L = 667 R to GND		10	ns
t_{PLZ}	RAS EN↑	RAS	R_L = 667 R to V_{cc}		17	ns

NOTE: Measurement point for all t_{PHZ} output pulses is 2.9 V. Measurement point for all t_{PLZ} output pulses is 0.8 V. All other measurement points are 1.3 V.

[1] Depends on RC network at pin 12 (2k0, 180 pF used for testing) and the RC network at pin 15 (Sk0, 180 pF).

[2] Depends on RC network at pin 12 (2k0, 180 pF).

[3] Depends on RC network an pin 12 (2k, 180 pF), pin 15 (Sk0 180 pF7, and pin 1 (Sk0, 180 pF).

[4] Depends on RC network at pin 1S (Sk0, 180 pF).

[S] Depends on RC network at pin 1 (Sk0, 180 pF7.

Recommend Operating Conditions		MIN	NOM	MAX	UNIT
Supply Voltage, V_{CC}		4.75	5	5.25	V
High-level output current, I_{OH}	ROW/$\overline{COL}$			−0.4	
	$\overline{RAS}$			−2.6	mA
	All others			−1.2	
Low-level output current, I_{OL}	ROW/$\overline{COL}$			8	
	All others			24	
Set up time, t_{sp}	R/W, RMW, P/N, or REFRESH to START	20			nS
	CAS HOLD to CAS	20			
Hold time, t_p		0			nS
External timing resistor, R_{ext}	RC, RAH	0.1		2	kΩ
	RC CAS LO, RC PRECHARGE	1		6	
Operating free-air temperature, T_A		0		70	°C

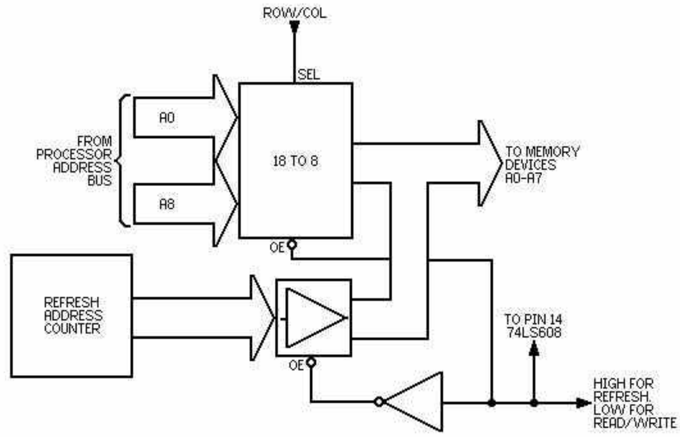


Fig. 6 Typical circuit for use with 64K by 1 DRAMs; for refresh, pin 14 is taken high, pin 13 is pulsed high, and refresh address is placed on the memory devices address pins.

LF13331/2/3, LF13201/2 Quad Analogue Switches

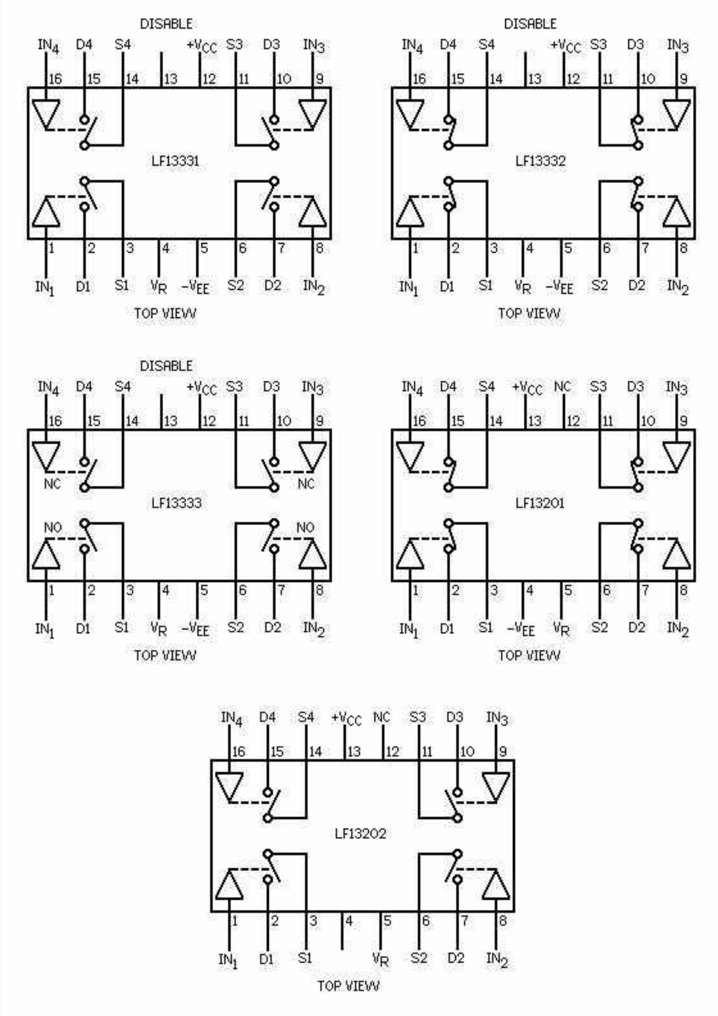


Fig. 7 Pin outs: LF1331 is four normally open switches with disable; LF13333 is two normally closed and two normally open with disable; LF13201/2 are as LF13331/2 but without disable.

These devices are a monolithic combination of bipolar and JFET technology producing the industry's first one chip quad JFET switch. A unique circuit technique is emoloved to maintain a constant resistance over the analog voltage range of ± 10V. The input is designed to operate from minimum TTL levels, and switch operation also ensures a break-before-make action.

These devices operate from ± 15V supplies and swing a ± 10V analog signal. The JFET switches are designed for applications where a DC to medium frequency analog signal needs to be controlled.

General Information

"ON" resistance are essentially independent of analog voltage or analog current. The leakage currents are typically less than 1nA at 25^{0}C and less than 100nA at 125°C in both the "OFF" and "ON" switch states and introduce negligible errors in most applications. Each switch is controlled by minimum TTL logic levels at its input and is designed to turn "OFF" faster than it will turn "ON". This prevents two analogue sources from being transiently connected together during switching.

Because these analogue switches are JFET rather than CMOS, they do not require special handling.

Logic Input

The logic input (IN}, of each switch, is referenced to two forward diode drops (1.4V at 25° C} from the reference supply (YR} which makes it compatible with DTL, RTL, and TTL logic families. For normal operation, the logic "O" voltage can range from 0.8V to -4.0V with respect to V_R and the logic "1" voltage can range from 2.0V to 6.0V with respect to V_R, provided V_{in} is not greater than (V_{cc} - 2.5V). If the input voltage is greater than Vcc - 2.5V, the input current will increase. If the input voltage exceeds 6.0V or -4.0V with respect to V_R, a resistor in series with the inputs should be used to limit the input current to less than 100 μA.

Analog Voltage

Each switch has a constant "ON" resistance (R_{on}) for analog voltages from (V_{ee} + 5V) to (V_{CC} - 5V). For analog voltages greater than (V_{CC} − 5V), the switch will remain ON independent of the logic input voltage. For analog voltages less than (V_{EE} + 5V), the ON resistance of the switch will increase. Although the switch will not operate normally when the analog voltage is out of the previously mentioned range, the source voltage can go to either (V_{EE} + 36V) or (V_{CC} + 6V), whichever is more positive, and can go as negative as V_{EE} without destruction. The drain (D) voltage can also go to either (V_{EE} + 36V) or (V_{CC} + 6V), whichever is more positive, and can go as negative as (V_{CC} − 36V) without destruction.

Analog Current

With the source (S) positive with respect to the drain (D), the R_{ON} is constant for low analog currents, but will increase at higher currents (>5 mA) when the FET enters the saturation region. However, if the drain is positive with respect to the source and a small analog current loss at high analog currents is tolerable, a low R_{ON} can be maintained for analog currents greater than 5 mA at 25°C.

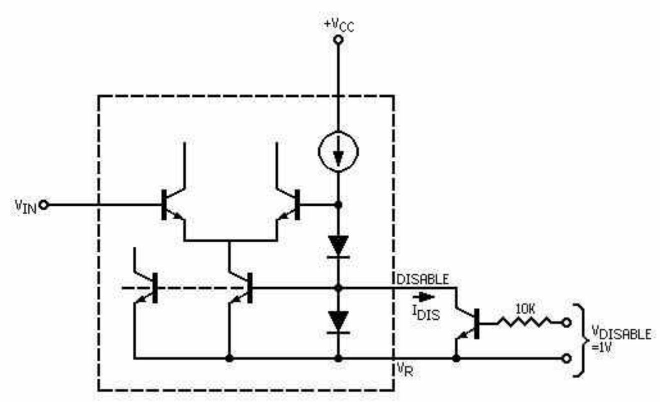


Fig. 8 Use of the disable node.

Power Supplies

The voltage between the positive supply (V_{CC}) and either the negative supply (V_{EE}) or the reference supply (V_R) can be as much as 36V. To accommodate variations in input logic reference voltages, V_R can range from V_{EE} to (V_{CC} − 4.5V). Care should be taken to ensure that the power supply leads for the device never become reversed in polarity or that the device is never inadvertently installed backwards in a test socket. If one of these conditions occurs, the supplies would zener an internal diode to an unlimited current, and result in a destroyed device.

Disable Node

This node can be used, as shown in Fig. 8, to turn all the switches in the unit off independent of logic inputs. Normally, the node floats freely at an internal diode drop (≈0.7V) above V_R. When the external transistor in Fig. 8 is saturated, the node is pulled very close to V_R and the unit is disabled. Typically, the current from the node will be less than 1 mA.

Absolute Maximum Ratings

Positive Supply − Negative Supply (V_{CC} − V_{EE})	36V
Reference Voltage	$V_{EE} \leq V_R \leq V_{CC}$
Logic Input Voltage	$V_R - 4.0V \leq V_{IN} \leq V_R + 6.0V$
Analog Voltage	$V_{EE} \leq V_A \leq V_{CC} + 6V$; $V_A V_{EE} + 36V$
Analog Current	$\|I_A\| < 20$ mA
Power Dissipation (Note 1)	
Moulded DIP (N Suffix)	500 mW
Cavity DIP (D Suffix)	900 mW
Operating Temperature Range	0°C to +70°C

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
"ON" Resistance	V_A = 0, I_O = 1 mA	T_A = 25°C		150	250	Ω
				200	350	Ω
"ON" Resistance Matching		T_A = 25°C		10	50	Ω
Analog Range			±10	±11		V
Logical "1" Input Voltage			2.0			V
Logical "0" Input Voltage					0.8	V
Delay Time "ON"	V_S = ±10V	T_A = 25°C		500		ns
Delay Time "OFF"	V_S = ±10V	T_A = 25°C		90		ns
Break-Before-Make Time	V_S = ±10V	T_A = 25°C		80		ns
Source Capacitance	Switch "OFF," V_S = ±10V	T_A = 25°C		4.0		pF
Drain Capacitance	Switch "OFF," V_D = ±10V	T_A = 25°C		3.0		pF
Active Source and Drain Capacitance	Switch "ON," V_S = V_D = 0V	T_A = 25°C		5.0		pF
"OFF" Isolation	(Note 3)	T_A = 25°C		−50		dB
Crosstalk	(Note 3)	T_A = 25°C		−65		dB
Analog Slew Rate	(Note 4)	T_A = 25°C		50		V/µs
Disable Current	(Note 5)	T_A = 25°C		0.6	1.5	mA
				0.9	2.3	mA
Negative Supply Current	All Switches "OFF," V_S = ±10V	T_A = 25°C		4.3	7.0	mA
						mA
Reference Supply Current	All Switches "OFF," V_S = ±10V	T_A = 25°C		2.7	5.0	mA
						mA
Positive Supply Current	All Switches "OFF," V_S = ±10V	T_A = 25°C		7.0	9.0	mA
						mA

Note 1: For operating at high temperature the molded DIP products must be rated based on a +100^{0}C maximum junction temperature and a thermal resistance of + 150^{0}C maximum junction temperature and are rated at + 100^{0}C/W.

Note 2: Unless otherwise specified, V_{CC} = +15V, V_{EE} = -15V, V_R = 0V, and limits apply; -25^{0}C T_A +85^{0}C for the LF13331, 2, 3 and the LF13201,2.

Note 3: These parameters are limited by the pin capacitance of the package.

Note 4: This is the analog signal slew rate above which the signal is distorted as a result of finite internal slew rates.

Note 5: All switches in the device are turned "OFF" by saturating a transistor at the disable diode as shown in Fig. 8. The delay times will be approximately equal to the t_{on} or t_{off} plus the delay introduced by the external transistor.

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Name ....

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....

....

UNIVERSAL EPROM PROGRAMMER

To use our Universal EPROM programmer, you've got to have the software to drive it. Mike Bedford fills us in on what's needed.

The logical choice of programming language for a software package which is required to perform critical timing .and which contains large frequently repeated loops, is assembler. On the other hand, the obvious choice of language for a package which is intended to run on a variety of different personal computers is BASIC. The software presented here is a compromise between the two: a BASIC program which performs the 1/0 but which calls an assembler subroutine for the time critical or time consuming tasks.

The assembler routine starts at address 1C00, but this may need to be relocated in order to fit in with the memory map of some systems. If this routine is relocated, the variable MC on line 290 of the BASIC program will have to be changed to the decimal start address of the routine. Another portion of the BASIC program which may require tailoring to a particular system is line 310. The variable PA on this line contains the start address of the EPROM programmer hardware as selected by the links on the board. This address should also be updated in the assembler subroutine on line 23 which equates IC9PIA to the start address.

Microtan 65 BASIC uses the statement I = USR(X) to call a machine code subroutine, having first POKE'd the low order byte of the M/C address to 34 and having POKE'd the high order byte to 35. This is done on lines 4040-4060, 5030-5050, 6040-6060 and 7040-7060 of the BASIC program and may require modification on other machines.

Finally, the programming timing loop in the assembler routine assumes a processor clock frequency of the 750KHz as used on the Microtan. The value loaded into register Y on line 143 of the routine will have to be modified accordingly for other clock speeds (use hexadecimal 27 for 1 MHz).

As far as entering the program is concerned, the main BASIC program is rather long and it would be advisable to enter it in relatively small portions, saving it after the addition of each new section. This suggestion is made for two reasons: firstly it is difficult to concentrate for sufficiently long to enter the whole program at once without making errors; and, secondly it would be extremely frustrating if the computer were to crash for some reason after having typed in over 200 lines of code!

The assembler listing is rather long, and will only be of interest to readers wishing to modify the software. For this reason we haven't reproduced it here, but a copy may be obtained by sending a large stamped addressed envelope (or international reply coupon) to the ETI office -please mark the outer envelope "PROGRAMMER LISTING". Most users will find it easiest to enter the hex code directly.

Once the program and subroutine have been entered and recorded on cassette, it will be worthwhile investing some time carefully checking through the program. It is quite possible that a mistake may cause more than the appearance of the all too familiar SYNTAX ERROR on the screen: an error in the software could easily turn an EPROM programmer into an EPROM destroyer!

Sample Run

On page 39 is a reproduction of

```
1C00   4C 4C 1C 00 00 00 00 00 00 00 00 00 00 3C 3C 3C
1C10   3C 3C 3C 34 34 34 18 18 18 10 10 18 12 10 12 3C
1C20   3C 3C 34 34 3C 3C 3C 3C 08 08 08 05 25 08 22 00
1C30   22 01 01 01 01 01 08 02 08 02 06 06 06 06 06 05
1C40   06 05 06 01 01 01 01 01 00 01 00 01 20 87 1D AD
1C50   0B 1C C9 02 D0 03 4C BC 1C A9 30 8D 25 BC A9 00
1C60   8D 24 BC A9 34 8D 25 BC AE 0C 1C BD 0D 1C 8D 23
1C70   BC A9 00 8D 20 BC A9 3C 8D 25 BC BD 16 1C 8D 26
1C80   BC 20 9C 1D 20 62 1D D0 03 4C 13 1D 20 17 1D AD
1C90   25 BC 49 08 8D 25 BC 20 9C 1D AD 24 BC 8D 0A 1C
1CA0   A2 00 AC 0B 1C F0 10 30 07 C9 FF F0 BB 4C 13 1D
1CB0   C1 35 F0 B4 4C 13 1D 81 35 4C 68 1C A9 30 8D 25
1CC0   BC A9 FF 8D 24 BC A9 34 8D 25 BC AE 0C 1C BD 0D
1CD0   1C 8D 23 BC A9 00 8D 20 BC BD 1F 1C 8D 25 BC BD
1CE0   28 1C 8D 26 BC 20 9C 1D 20 62 1D F0 26 20 17 1D
1CF0   A2 00 A1 35 8D 24 BC AE 0C 1C BC 3A 1C B9 20 BC
1D00   5D 31 1C 99 20 BC A0 1D A2 FF CA D0 FD 88 D0 FA
1D10   4C CB 1C 20 87 1D 60 AD 05 1C 8D 22 BC BD 43 1C
1D20   F0 09 AD 06 1C 8D 20 BC 4C 52 1D AD 20 BC 0D 09
1D30   1C 8D 20 BC AD 06 1C 29 10 F0 08 AD 20 BC 09 08
1D40   8D 20 BC AD 06 1C 29 08 F0 08 AD 26 BC 09 01 8D
1D50   26 BC AD 06 1C 29 20 F0 08 AD 23 BC 09 08 8D 23
1D60   BC 60 E6 35 D0 02 E6 36 EE 05 1C D0 03 EE 06 1C
1D70   AD 06 1C 29 E7 8D 09 1C AD 05 1C CD 07 1C D0 06
1D80   AD 06 1C CD 08 1C 60 A6 35 A4 36 AD 03 1C 85 35
1D90   AD 04 1C 85 36 8E 03 1C 8C 04 1C 60 A0 80 88 D0
1DA0   FD 60
```

Fig. 1 Hex dump of the machine code -see text for details of how to obtain the assembler listing, should you need it.

```
LIST

 10 REM . . . EPROM SUPPORT PACKAGE
20 REM . . . M O BEDFORD MARCH 83
30 DIM C$(9)
40 DATA "NEW", "BASE", "HELP", "READ"
50 DATA "PROGRAMME", "VERIFY","TEST"
60 DATA "LIST", "HOOIFY"
70 FOR N=1 TO 9
80 READ C$(N)
90 NEXT
100 DIM H$( 15)
110 DATA "0 123456789ABCDEF"
120 READ HH$
130 FOR N=0 TO 15
140 H$(N) = MID$(HH$,N+ 1, 1)
 150 NEXT N
160 OIM T$(9)
170 DATA "2758", "2716","2516", "2732"
180 DATA "2732A" ,"2532","2764", "2564"
190 DATA "27128"
200 FOR N=1 TO 9
210 READ T$(N)
220 NEXT N
230 DIM S(9)
235 DATA 1024,2048,2048,4096,4096
240 DATA 4096,8192,8192, 16384
250 FOR N=1 TO 9
260 READ S(N)
270 NEXT
280 REM . . . START ADDRESS OF M/C ROUTINES
290 MC=7168
300 REM. . . START ADDRESS OF PROGRAMMER
310 PA=48160
320 HR = INT(MC/256)
330 LR = MC-256*HR
360 POKE PA+ 1,48
370 POKE PA,255
380 POKE PA+ 3, 48
390 POKE PA+2,255
400 POKE PA+7,48
410 POKE PA+6,255
700 PRINT CHR$(12)
710 PRINT "EPROM PROGRAMMER SUPPORT PACKAGE" 720
PRINT:PRINT

730 GOSUB 1000
740 GOSUB 2000
750 GOSUB 3000
755 GOSUB 13000
760 PRINT
770 INPUT "X";A$
780 IF A$="E" OR A$="EXIT" THEN STOP
790 FOR N=1 TO 9
800 IF A$=C$(N) OR A$=LEFT$(C$(N),1) THEN 820
810 NEXT N
820 ON N GOSUB 1000,2000,3000,4000,5000,6000,7000,8000,9000,900
830 PRINT
840 GOTO 770
900 REM...NO SUCH COMMAND
910 PRINT "COMMAND INVALID"
920 RETURN
1000 REM...(N)EW
1010 INPUT "EPROM TYPE";A$
1020 FOR EN=1 TO 9
1030 IF A$=T$(EN) THEN 1065
1040 NEXT EN
1050 PRINT "TYPE INVAILO"
1060 GOTO 1010
1065 POKE MC+12,EN-1
1070 RETURN
2000 REM...(B)ASE
2010 INPUT "BASE ADDRESS";A$
2020 GOSUB 10000
2030 IF A=99999 THEN 2010
2040 BA=A:BA$=A$
2050 RETURN
3000 REM...(H)ELP
3010 PRINT:PRINT
3020 PRINT "COMMANDS AVAILABLE :":PRINT
3030 PRINT "(N)EW";TAB(16);"(B)ASE"
3040 PRINT "(R)EAD";TAB(16);"(T)EST"
3050 PRINT "(P)ROGRAMME";TAB(16);"(V)ERIFY"
3060 PRINT "(L)IST";TAB(16);"(M)ODIFY"
3070 PRINT "(H)ELP";TAB(16);"(E)XIT"
3080 PRINT
3090 PRINT "TYPE = ";T$(EN);TAB(16);"BASE = ";BA$
3100 RETURN
4000 REM...(R)EAD
4010 POKE MC+11,0
4020 GOSUB 11000
4030 GOSUB 14000
4040 POKE 34,LR
4050 POKE 35,HR
4060 I=USR(X)
4070 GOSUB 13000
4080 RETURN
5000 REM...(P)ROGRAMME
5005 POKE MC+11,2
5010 GOSUB 11000
5020 GOSUB 14000
5030 POKE 34,LR
5040 POKE 35,HR
5050 I=USR(X)
5060 GOSUB 6015
5070 GOSUB 13000
5080 RETURN
6000 REM...(V)ERIFY
6010 GOSUB 11000
6015 LN=-1
6020 POKE MC+11,128
6030 GOSUB 14000
6040 POKE 34,LR
6050 POKE 35,HR
6060 I=USR(X)
6070 B=256*PEEK(MC+6)+PEEK(MC+5)
6080 IF B>FA THEN 6230
6090 A=PEEK(BA+B)
6100 GOSUB 12000
6110 B$=A$
6120 A=B
6130 GOSUB 12000
6140 C$=A$
6150 A=PEEK(MC+10)
6155 GOSUB 12000
6160 LN=LN+1
6170 IF LN<15 THEN 6210
6180 GET Z$
6190 IF ASC(Z$) = 13 THEN 6230
6200 LN=0:PRINT
6210 PRINT C$;"   EPROM = ";MID$(A$,3,2);"   MEMORY = ";MID$(B$,3,2)
6220 GOTO 6040
6230 GOSUB 13000
6240 RETURN
7000 REM...(T)EST
7010 POKE MC+11,1
7020 SA=0:FA=S(EN)-1
7030 GOSUB 14000
7040 POKE 34,LR
7050 POKE 35,HR
7060 I=USR(X)
7070 IF 256*PEEK(MC+6)+PEEK(MC+5)>FA THEN 7100
7080 PRINT "EPROM NOT ERASED"
7090 GOTO 7110
7100 PRINT "EPROM ERASED"
7110 GOSUB 13000
7120 RETURN
8000 REM...(L)IST
8010 GOSUB 11000
8020 PRINT
8030 LN=-1
8040 FOR N=BA+SA TO BA+FA
8050 LN=LN+1
8060 IF LN<15 THEN 8100
8070 GET A$
8080 IF ASC(A$) = 13 THEN 8170
8090 LN=0:PRINT
8100 A=N-BA
8110 GOSUB 12000
8120 B$=A$
8130 A=PEEK(N)
8132 Z$=" "
8134 IF A>32 AND A<128 THEN Z$=CHR$(A)
8140 GOSUB 12000
8150 PRINT B$;TAB(7);MID$(A$,3,2);TAB(12);Z$
8160 NEXT N
8170 RETURN
9000 REM...(M)ODIFY
9010 INPUT "ADDRESS";A$
9020 GOSUB 10000
9025 IF A=99999 THEN 9010
9030 B=A
9040 A=PEEK(A+BA)
9050 GOSUB 12000
9060 PRINT "VALUE = ";MID$(A$,3,2);TAB(16);"NEW VALUE = ";
9070 INPUT A$
9075 IF A$="X" THEN 9110
9080 A$="00"+A$
9090 GOSUB 10000
9095 IF A=99999 THEN 9060
9100 POKE B+BA,A
9110 RETURN
10000 REM...HEX DECODE
10010 IF LEN(A$)<>4 THEN 10070
10020 A=0
10030 FOR N=1 TO 4
10040 FOR I=0 TO 15
10050 IF H$(I) = MID$(A$,N,1) THEN 10080
10060 NEXT I
10070 A=99999:GOTO 10110
10080 A=A+I*16^(4-N)
10090 NEXT N
10100 GOTO 10120
10110 PRINT "INVALID"
10120 RETURN
11000 REM...START, FINISH ADDRESSES
11010 INPUT "START, FINISH ADDRESSES";A$,B$
11020 GOSUB 10000
11025 IF A=99999 THEN 11010
11030 SA=A
11040 A$=B$
11050 GOSUB 10000
11055 IF A=99999 THEN 11010
11060 FA=A
11070 IF SA<=FA THEN 11100
11080 PRINT "RANGE INVALID"
11090 GOTO 11010
11100 IF FA-SA+.99 <=S(EN) THEN 11130
11110 PRINT "RANGE/TYPE INCOMPATIBLE"
11120 GOTO 11010
11130 RETURN
12000 REM...HEX ENCODE
12010 A$=""
12015 JJ=16*16*16
12020 FOR J=3 TO 0 STEP -1
12030 I=INT(A/JJ)
12040 A=A-I*JJ
12050 A$=A$+H$(I)
12055 JJ=JJ/16
12060 NEXT J
12070 RETURN
13000 REM...ZEROISE PIA'S
13002 POKE PA+7,52
13004 POKE PA+6,48
13010 POKE PA+1,52
13020 POKE PA,0
13050 POKE PA+5,48
13060 POKE PA+4,255
13070 POKE PA+5,52
13080 POKE PA+4,0
13090 POKE PA+3,52
13100 POKE PA+2,0
13110 RETURN
14000 REM...M/C PARAMETERS
14010 IF SA>0 THEN 14030
14020 HI=255:LO=255:GOTO 14050
14030 HI=INT((SA-1)/256)
14040 LO=SA-1-256*HI
14050 POKE MC+5,LO
14060 POKE MC+6,HI
14062 IF SA+BA>0 THEN 14070
14064 HI=255:LO=255:GOTO 14090
14070 HI=INT( (SA+BA-1)/256)
14080 LO=SA+BA-1-256*HI
14090 POKE MC+3,LO
14100 POKE MC+4,HI
14110
14120 HI=INT( (FA+ 1)/256) LO=FA
14130 + 1-256*HI
14140 POKE MC+7,LO
14150 POKE MC+8,HI
15000 RETURN
OK    END
```

Fig. 2 The main BASIC program.

a printout obtained by running he EPROM programmer support package on a Tangerine Microtan system. Note that a base address of 2000 has been selected - this being the lowest reasonable-size area of RAM on the system, the BASIC program occupying about 6K and the machine code routine being located at 1C00.

In answer to the question about EPROM type, a response of 2716 was given. A 2716 EPROM was inserted into the ZIF socket when the first *? prompt was printed and this was tested for erasure using the (T)EST command. The program indicated that the device was not erased. At this point, the entire contents of the 2716 (0000-07FF) was transferred into computer memory using the (R)EAD command before listing the contents of a portion of this data by use of the (L)IST command. The (M)ODIFY command was then used to modify location 0007 before attempting to re-program this single byte in the EPROM using the (P)ROGRAMME command. It will be noticed that this was unsuccessful, a fact indicated by the verification message. This should come as no surprise in view of the fact that an attempt to re-program an non-erased device had been made and that programming can only set high bits low (ultra-violet erasure being required to set low bits high).

At this point the 2716 was replaced by a 2732 and the programmer was instructed of this change by use of the (N)EW command. Its entire contents (0000-0FFF) were read into memory and listed as before, by use of the (E)XIT command. Note that the (L)(ST command gives both the hexadecimal value of each byte and, where appropriate, the ASCII symbol.

```
EPROM PROGRAMMER SUPPORT PACKAGE


EPROM TYPE? 2716
BASE ADDRESS? 2000


COMMANDS AVAILABLE :

(N)EW            (B)ASE
(R)EAD           (T)EST
(P)ROGRAMME      (V)ERIFY
(L)IST           (M)ODIFY
(H)ELP           (E)XIT

TYPE = 2716      BASE = 2000

*? T
EPROM NOT ERASED

*? R
START, FINISH ADDRESSES? 0000,07FF

*? L
START, FINISH ADDRESSES? 0000,0008

0000    12
0001    13
0002    14
0003    15
0004    16
0005    17
0006    18
0007    19
0008    1A

*? M
ADDRESS? 0007
VALUE = 19       NEW VALUE = ? AF

*? P
START, FINISH ADDRESSES? 0007,0007
0007    EPROM = 09    MEMORY = AF

*? N
EPROM TYPE? 2732

*? R
START, FINISH ADDRESSES? 0000,0FFF

*? L
START, FINISH ADDRESSES? 0200,0210

0200    E9
0201    00
0202    8E
0203    52    R
0204    26    &
0205    48    H
0206    89
0207    14
0208    26    &
0209    50    P
020A    89
020B    16
020C    26    &
020D    40    @
020E    89

020F    18
0210    03

*? E

 BREAK IN  780
OK
```

Step-by-step fully illustrated assembly and fitting instructions are included together with circuit descriptions. Highest quality components are used throughout.

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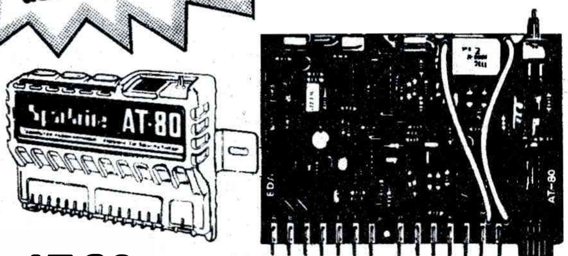

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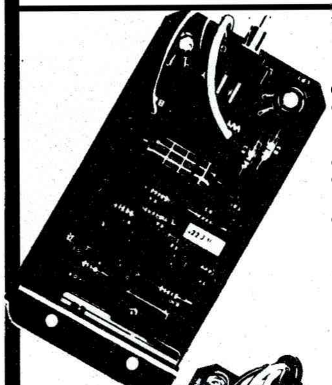

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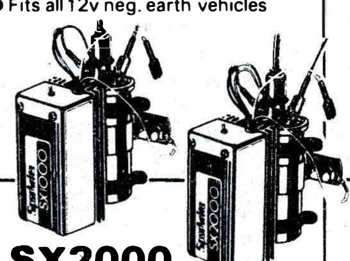

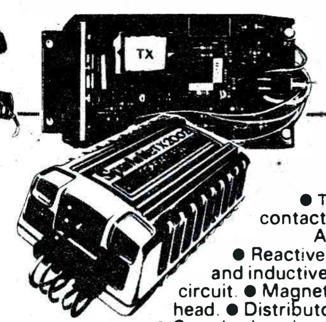

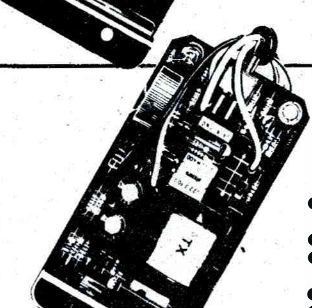

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- Fits all 12v neg. earth vehicles

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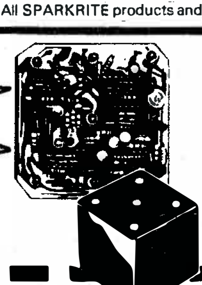

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1/3 OCTAVE GRAPHIC EQUALISER PART 2

We conclude this studio-quality unit with the constructional details. Design by Dave Tilbrook, with additional work by Phil Walker.

The third octave equaliser divides the audio frequency band into 28 segments so a total of 28 slider pots are used.

Cutting the required slots in a front panel is an extremely difficult task so we strongly recommend using the special case from Newrad - see Bylines for details. We've deliberately chosen to use fairly small switches and indicator on the front panel - if you use larger ones, you can always enlarge the hole sizes.

Construction of the PCB is not difficult. The usual precautions should be taken with the orientation of all polarised components such as electrolytic capacitors, transistors, diodes and ICs. Note that the two voltage regulator ICs are mounted in the same direction.

Check the component overlay for the correct orientation. It is probably wise to leave the insertion of the quad op-amps until last since these are FET devices and are therefore more sensitive to static electricity than the other components in the unit. Be careful when handling these devices before insertion on the board. Use an earthed soldering iron and discharge yourself by touching an earthed metal appliance before handling the ICs. The inputs are protected and should therefore be reasonably safe from damage by static electricity.

The method of construction we have chosen is to mount the slider pots directly on to the front panel (using short, countersunk M3 bolts) with the PCB behind.

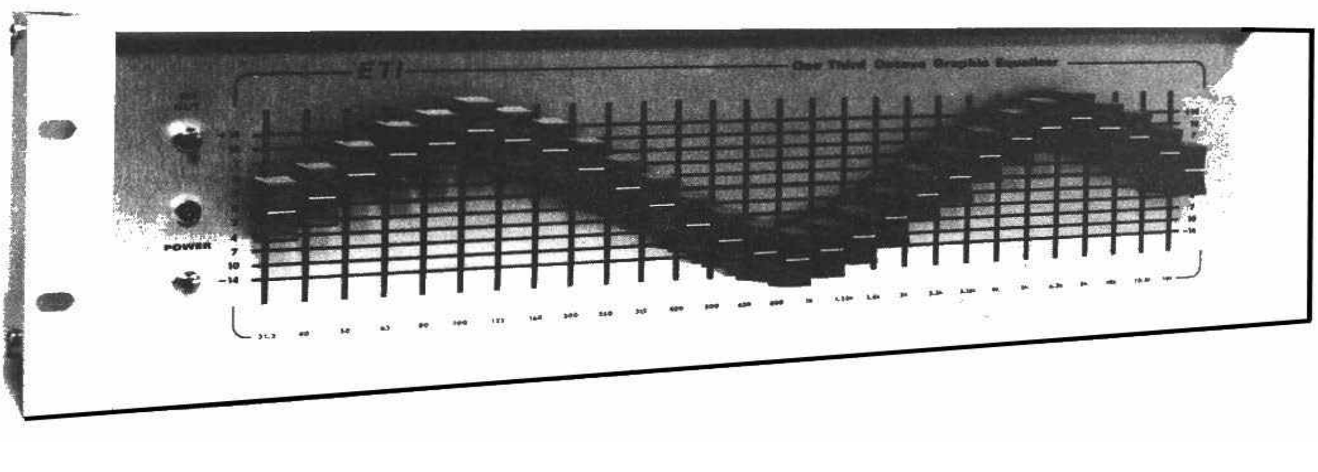
The potentiometer wipers are attached alternately to the top and bottom of the PCB; if you use a type of pot that has only one wiper connection (as we did), then you'll have to make sure that adjacent pots are reversed on the front panel.

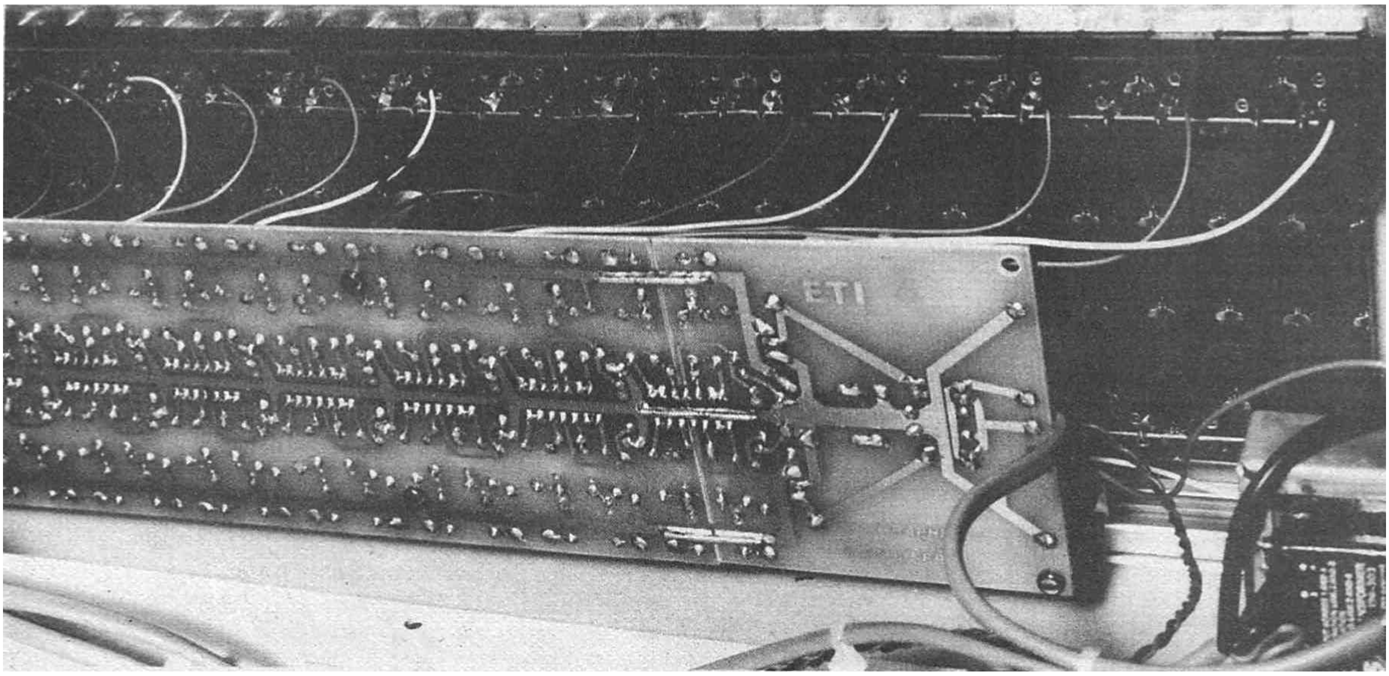
Interwiring

Before we mounted the PCB into the case, we soldered leads into the correct position on the PCB for joining onto the potentiometer wipers. Note that the tops and bottoms of the slider tracks should all be joined up before the board is mounted.

We mounted the board using metal struts and plastic pillars. The struts can be attached to the aluminium extrusion by sliding the head of a 1/2" (we really mean 12mm!) M3 bolt into the aluminium extrusion, and then clamping this in the correct position using a nut (or three, in our case, to get the spacing of the strut correct). If you don't use plastic pillars, you'll have to make sure that the PCB tracks are not inadvertently earthed by the fixing screws.

We've left the drilling of the holes in the rear panel to you, as you'll almost certainly decide to use different connectors, etc, from us! Because the case is fairly compact (neat, in ETI speak) you'll need to take care over the positioning of the fuse, mains input socket and transformer, to make sure that you





This photograph shows the connections between the slider pots on the front panel and the PCB - and the mounting of the front panel using struts and spacers. Note that we couldn't fit the prototype PCB into our equipment and had to make it in two sections - hence the join!

don't foul the PCB. Remember that the earth on the input and output sockets must be kept separate from the case. But make sure that the case and the transformer are well earthed - we suggest making doubly sure by removing paint or varnish around the earthing point(s) (on the inside, in the case!). To cut down mains hum, we used a screened twin cable for the internal mains lead - this needs to have adequate conductor and insulation thickness, though.

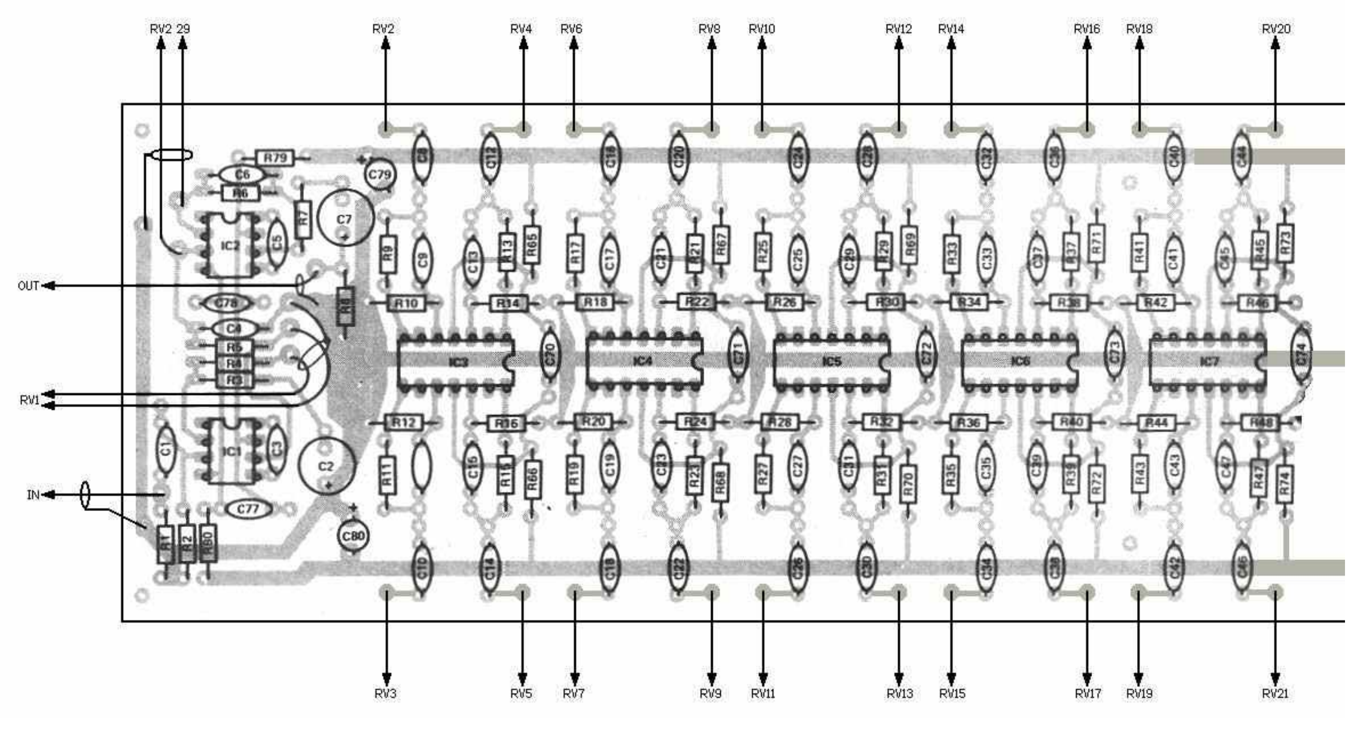


Fig 1 Overlay diagram for the PCB.

We used universal adhesive to glue on the pot knobs, otherwise they all kept falling off!

Power up

Once construction is complete, check all power supply wiring before powering up. This is especially important if a transformer has been included inside the case. In the latter case, make certain all 240 V connections are secure and check the chassis earth. If all is correct, power the unit up. The LED should light to indicate that the unit is on·

An equaliser in/out switch has been provided to ensure that a flat response can be obtained easily and without the necessity of changing the equalisation that may have · taken some time to set up. The equaliser is intended for use immediately before the power amplifier. If used in this. position the level control will probably not be used. In this case turn the control fully counterclockwise. The overall gain of the equaliser with the controls set at centre will be approximately unity. If the equaliser is intended for use from a typical line level output, the gain control can be used to supply the output levels needed by the power amplifier input.

PARTS LIST

RESISTORS (all ¼W, 5%)

R1, 5, 6	15k
R2	47k
R3, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, 61, 63	1k
R4	100R
R7	100R
R8	100k
R10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64	220k
R65-80	10R
R81	1k5
RV1	rotary pot, 10k log
RV2-29	slider pots, 100k or 50k linear (see Buylines)

CAPACITORS

C1, 10	470n
C2, 7	47u/25 V
C3	3p3 ceramic
C4, 6	33p ceramic
C5	4p7 ceramic
C8	680n
C9, 18	180n
C11, 20	150n
C12	390n
C13,22	120n
C14	330n
C15, 24	100n
C16	270n
C17, 28	68n
C19	56n
C21, 30	47n
C23,32	39n
C25,36	27n
C26	82n
C27, 38	22n
C29	18n
C31, 40	15n
C33	12n
C34	33n
C35, 44, 70-78	10n
C37, 48	6n8
C39	5n6
C41, 50	4n7
C42	12n
C43, 52	3n9
C45, 56	2n7
C46	8n2
C47, 58	2n2
C49	1n8
C51, 60	1n5
C53, 62	1n2
C54	3n3
C55	1n0
C57	680p polystyrene
C59	560p polystyrene
C61	470p polystyrene
C63	390p polystyrene
C64,65	10u polycarbonate
C66, 67	2200u/25 V electro
C68, 69, 79, 80	4u7/16 V tantalum

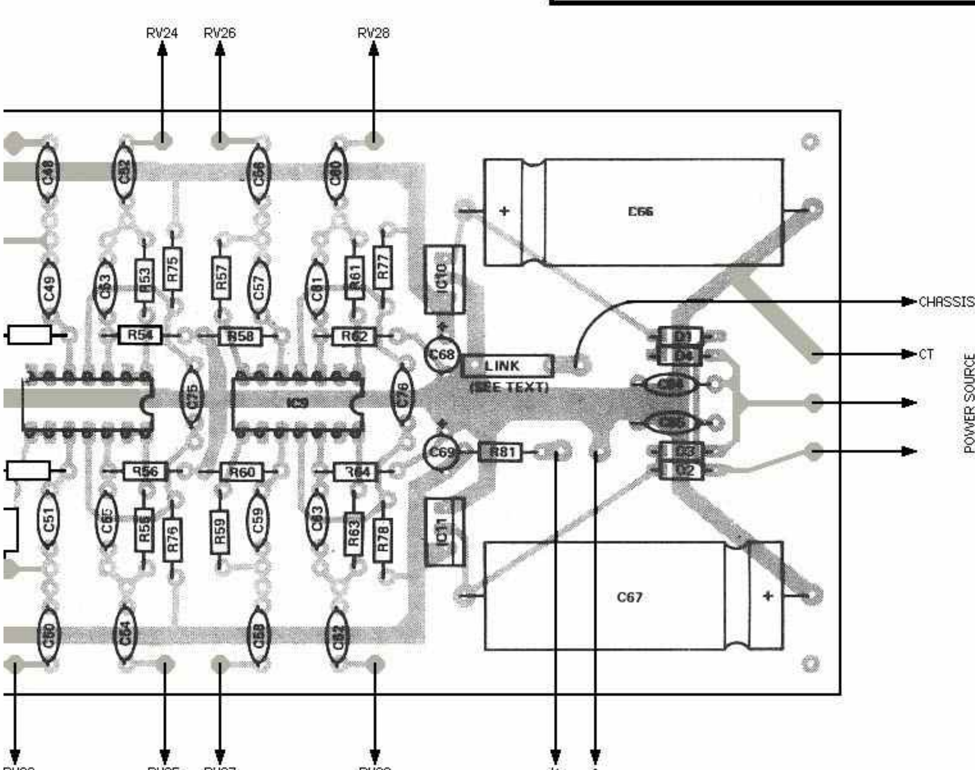
SEMICONDUCTORS

IC1, IC2	NE5534A (or N)
IC3-9	TL074
IC10	7812
IC11	7912
D1-4	1N4001
LED1	red LED

MISCELLANEOUS

T1	12-0-12V, 6 VA transformer
SW1	DPST mains switch
SW2	SPDT toggle switch

Mains neon (or LED plus 1k5 resistor; cable clamp; fuse (500 mA) and holder; insulated connector sockets to choice (jacks, phono, BNC, etc); 28 knobs for sliders; case (see Buylines); PCB; nuts, bolts, wire, etc.



BUYLINES

The case is available by post only from Newrad Instrument Cases Ltd, Tiptoe Road, Wootton, New Milton, Hants BH25 551 for the special price of £21.00 all inclusive to ETI readers only (this is for either the rack mounting version we used or one with plain ends - please state which you require when ordering). The PCB is, as ever, available through our PCB service. We've already mentioned the slight problem of obtaining the capacitors and how we solved it, last month. None of the other components should present problems, though as you'll be buying a number of slider pots, it's obviously worth shopping around for a good price. The cheapest we found were those from Rapid, and that's where we bought ours from.

OOPS!

Note that the value of R65-80 is 10R, not 1k0 as shown on the circuit diagram. We recommend that you switch the unit out of circuit (using the EQ OUT switch) before removing or connecting the supply, because it is capable of issueing a nasty squalk!

-CRICKLEWOOD -STOCKING PARTS OTHER STORES CANNOT REACH!

SERVICE SHEET

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We receive a very large number of enquiries. Would prospective enquirers please note the following points:

We undertake to do our best to answer enquiries relating to difficulties with ETI projects, in particular non-working projects, difficulties in obtaining components, and errors that you think we may have made. We do not have the resources to adapt or design projects for readers (other than for publication), nor can we predict the outcome if our projects are used beyond their specifications;

Where a project has apparently been constructed correctly but does not work, we will need a description of its behavior and some sensible test readings and drawings of oscillograms if appropriate. With a bit of luck, by taking these measurements you'll discover what's wrong yourself. Please do not send us any hardware (except as a gift!);

Other than through our letters page, Read/Write, we will not reply to enquiries relating to other types of article in ETI. We may make some exceptions where the enquiry is very straightforward or where it is important to electronics as a whole;

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Be brief and to the point in your enquiries. Much as we enjoy reading your opinions on world affairs, the state of the electronic in-dustry, and so on, it doesn't help our already overloaded enquiries service to have to plough through several pages to find exactly what information you want.

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May 81	February 83

Write for ETI

We are always looking for new contributors to the magazine, and we pay a competitive page rate. If you have built a project or you would like to write a feature on a topic that would interest ETI readers, let us have a description of your proposal, and we'll get back to you to say whether or not we are interested and give you all the boring details.

We don't bother with the bureaucracy for Tech-Tips - all you do is to send in your idea, stating clearly if you want an acknowledgment of receipt. If possible, please type your explanation of why the circuit is different, what it does and how it works, on a separate sheet from the circuit diagram·; both sheets should carry your name, address and the circuit title. We'll let you know (within a month or so) if we want to use your Tech Tip.

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3. Check your bank statement to see if the cheque you sent has been cashed.
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If you exhaust the above procedure and still do not obtain a satisfactory response from the sup-plier, then please drop us a line. We are not able to help directly, because basically the dispute is between you and the supplier, but a letter from us can sometimes help to get the matter sorted out. But please, don t write to us until you have taken all reasonable steps yourself to sort out the problem.

We are a member of the mail order protection scheme, and this means that, subject to certain conditions, if a supplier goes bankrupt or into liquidation between cashing your che-que and supplying the goods for which you have paid, then it may be possible for you to obtain compensation. From time to time, we publish details of the scheme near our classified ads, and you should look there for further details.

OOPS!

We have in the past published small corrections to projects on the letters page, and major corrections separately. From now on corrections will appear on this page, and will be repeated for several months (just to increase our embarrassment). If a correction is too large to fit on here, we will publish it just once, but will note the fact that a correction does exist, and that copies of it can be obtained from us provided you send in an SAE. But please request copies only if you really do *need* them; if this service is abused, we may be forced to withdraw it.

ZX A to D (Jan '83)
D2 is shown the wrong way round on the overlay; wires on the RH side of the switch SW1 should go to top contacts. Some of the early PCBs had an error: pins 2 & 4 of IC1 should go to pin 16 (top) *of* edge connector (published foil pattern is OK).

Stage Lighting Unit (Jan, Feb, April, May '83)

Transformer specs are as follows: Primaries all 250 V; secondaries T1: 0-6, 0-6 V, 12 VA tot; T2: 0-12, 0-12 V, 12 VA tot; D: 0-6 V, 3 VA. ICs 34, 35, 36 are 7805 SV regulators.

ZX Sound Board Design Comp. results, Feb '83)
The first line of the program has to be entered in reverse order to get it to go in (COS, GOSUB, COPY, ASN and RND are functions). The line should read:

10 REM :"Y -=?COS GOSUB 5 COP Y ?? ASN ?RNDF??RND

Alarm Module (March '83)
R21 Is 220k (parts list OK, circuit diagram wrong) Q5 is BC182L (left off parts list).

Max Min Thermometer (April '83)
A revised foil pattern was published in July ETI. To get original PCB to work, replace D4 and D5 with wire links, cut tracks from pins 7 and 8 on IC6, and solder 15k resistor across cut - remove ICs while doing this! (It's messy but it works.)

Real Time Clock (April '83)
Frequency of XTAL1 is 32.768 kHz.

NDFL Power Amplifier (May '83)
C13 is 33pF (parts list correct, circuit diagram wrong).
Table 1: lengths of wire quoted do not allow for lead lengths -add 40 mm or so to them. This is particularly important for L3. Resistors R29 and R30 can be wire wound types, it isn't necessary to use carbon types (their inductance will be small).

Flash Sequencer (July '83)
Q1 should be BC184L; Q2-5 should be BC182L.

Telescope (August 1983)
We had a shower of annotation falling off our diagrams! On Fig. 1, C19 (below IC14) was not labeled nor was Q2 (above R1), and there were two C23s -one should be IC22 and it doesn't matter which. In Fig. 5, IC1 2 was not labeled. Unfortunately, there was a mistake in the correction (blush!): C14 is the *22µF* tantalum on the -5 V line.

Universal EPROM Programmer (August 1983)
We had the same problem with falling annotation as above. On the overlay, IC7 is between SK2 and SK1; IC6 is between SK1 and C10; IC1 1 is between R7 and R10.

Z80 Controller Computer
Same problem yet again. On the overlay, SW1 is the rectangle beside IC5 and 6; a link through was missed to the right of pin 18 IC11.

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TECH TIPS

Dual Trace Unit
John Hesketh, Pontefract

There have recently been two circuits published in ETI which allow two waveforms to be displayed simultaneously on a single beam oscilloscope. Both of these circuits have drawbacks, namely poor preamp performance, inadequate control over waveform position, a tendency towards instability and poor switching circuitry. The design shown overcomes these problems and will display waveforms clearly over the frequency range DC to 200kHz.

The design may be divided into three sections, two pre-amplifiers (one for each channel) and a switching circuit. The switching circuit is identical to that in J. C. Harris's circuit (ETI Feb 82).

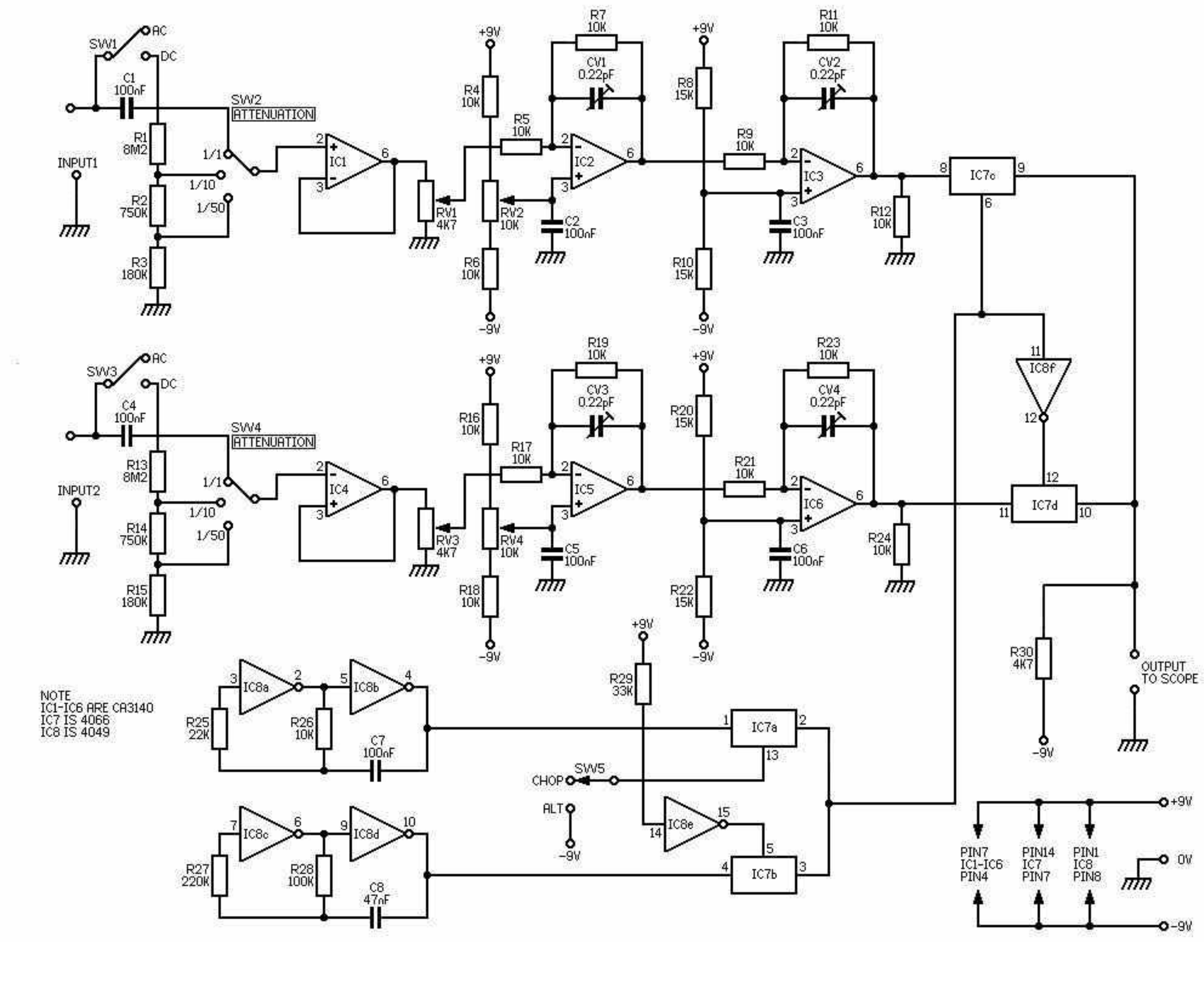
The input signal is applied to an attenuator network either via a 100n capacitor for AC coupling or directly for DC coupling. The attenuated signal is then fed to IC1 which is wired for a gain of one and functions as an impedance matcher. This stage gives the instrument a high input impedance (approximately 9MO). A portion of the output signal from IC1 is derived via RV1, which serves as an amplitude control, and is fed to IC2 and associate components which is also wired for a gain· of one. This stage provided a means of shifting the vertical position of the waveform by introducing a DC voltage onto the non-inverting input of IC2 via RV2. This stage inherently inverts the waveform and therefore a further inverting stage is employed (IC3 and associated components) to restore the original sense of the waveform.

The outputs from the preamplifier's IC3/6 are fed into the signal switching arrangement consisting of IC7 and IC8. The output from the electronic switch is then fed to the oscilloscope.

In order that a wide range of signal frequencies may be displayed, two modes of switching are employed. The two modes are 'chop' and 'alternate' and the mode of switching is determined by SW5. When displaying frequencies from DC to 15 kHz, it will be necessary to use the 'chop' mode but for frequencies above 15 kHz the 'alternate' mode should be used.

The settings of VC1-4 are quite critical at high frequencies (200 kHz), and the following procedure should be adopted in order to obtain the optimum setting of these trimmers. (The procedure is described for channel No 1 as channel No 2 is identical). Inject a 200 kHz 1Vp-p square wave into channel No 1 input and set the attenuator switch (SW2) to the 1/1 position. The setting of SW1 is unimportant. Set RV1 to maximum and RV2 to mid position. Connect an oscilloscope to the output of IC2 and adjust VC1 for a perfect square wave with no overshoot or corner rounding. Remove the oscilloscope and connect to the output of IC3. Adjust VC2 for a perfect square wave. Repeat the procedure for channel No 2.

Note that the circuit requires a split supply of± 9V.



Low-Cost Mains Time Delay Switch

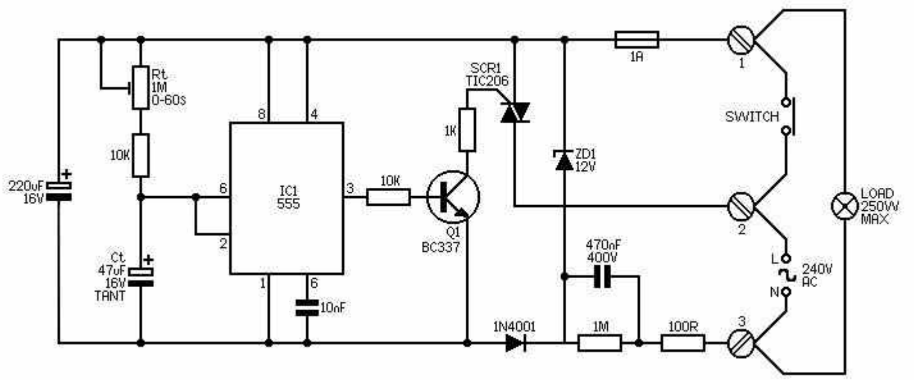
Alex Gray,
Emberton, Bucks

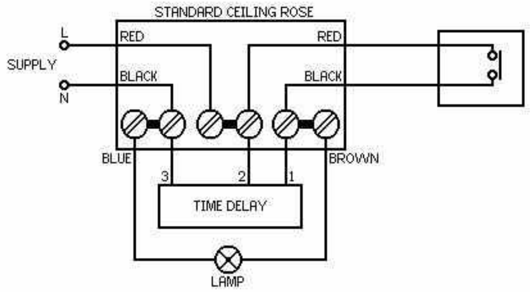
This circuit offers a cheap, reliable replacement replacement for mechanical. and pneumatic time-delay switches such as used for corridor lights. It can also be used to protect equipment which is upset by power being applied and removed too rapidly.

When the switch is closed and reopened, the load is switched on for a preset time -1.1 R_1 C_1. During this period, the circuit also switches on its own power. At the end of the time-delay both the load and the circuit are disconnected. In the event of a circuit failure, the push button will still allow the load to be switched on for safety (e.g. in corridor lighting).

If the switch is a normal latching type, the load will be powered as long as the switch is closed, subject to a minimum period. This prevents rapid cycling of the power on and off and may be used to protect equip-ment susceptible to damage from this situation.

There are only three connections and the circuit may be wired in at the ceiling rose of a conventional 'looped through circuit without any additional wiring.





The usual precautions with mains wiring must be observed. In particular, remember that, although the 555 is on a 12V supply, that supply is superimposed on 240V AC above earth. The switch and the 470nF capacitor must be types designed for mains operation.

Karnaugh Map Display

K. J. Beeden,
Crawley

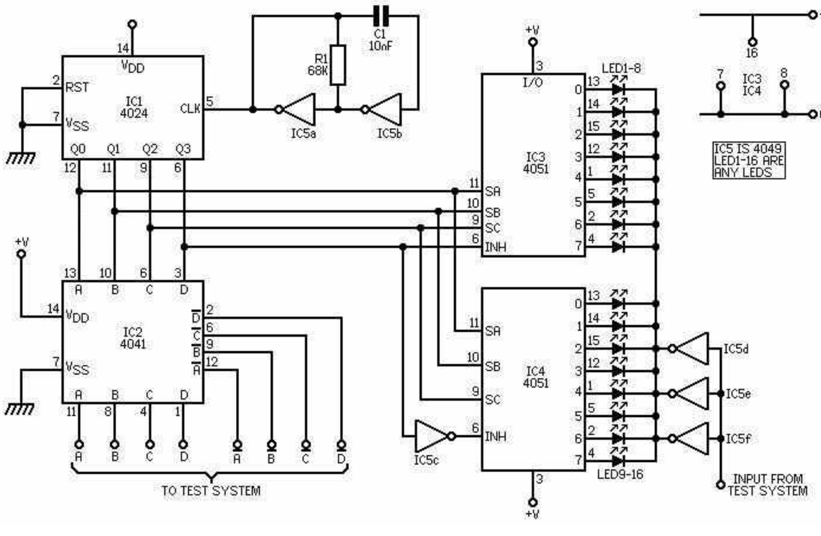
The Karnaugh map is a common way of representing the function of a four-input logic system. It is often taught in schools and colleges, when students are given a logic system and have to draw the Karnaugh map for it. This device allows the student to go away and test his map with the actual map generated by this device and a wired-up system on a breadboard.

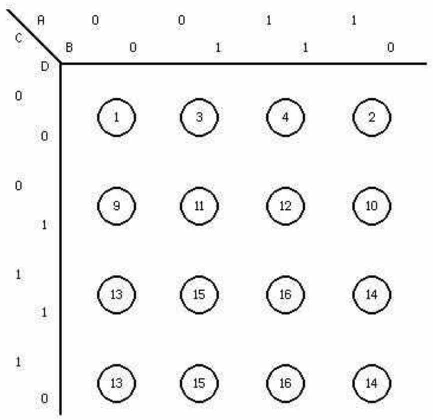
IC5a and b form an astable, which clocks the 4-bit binary counter IC1. The outputs of this are fed into the quad true complements buffer, IC2, providing buffered true and inverted outputs to the system under test. The counter outputs are also used to decode the display -the three LSBs are used as select lines for the eight-way analogue switches, IC3 and 4, and the MSB is used to select the chip by connecting the true value to INH IC3 and the inverted (by IC5c) value into INH IC4.

The output of the system is connected to the input of IC5d,e,f. Thus if the output of the system is high for a given 4-bit number, then the output of IC5d, etc, will be low, and so current will flow from the +ve supply, via the selected analogue switch (resistance of which is conveniently about 160R) through the appropriate LED. If the output of the system is low, then the output of IC5d, etc, will be high, and so no current will flow.

This means that an illuminated LED represents a "1" from the system, and an unlit LED a "0".

Figure 2 shows the arrangements of LED's 1-16 required to obtain the desired Karnaugh map display.





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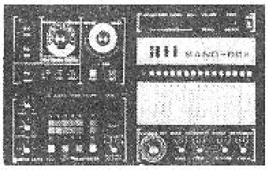

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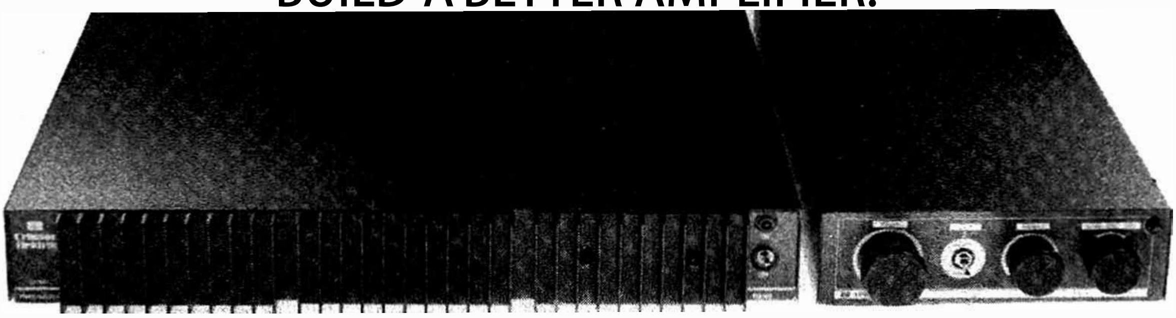

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THE DIGGER

No, no, it's nothing to do with tubes of amber nectar, billabongs, tucker bags or any other antipodean artifacts. Just a device for digging around in a digital circuit using an oscilloscope - a digital trigger. Design, development, and bad puns by Phil Walker.

The ETI Digger is a very simple device which will make fault finding on digital circuits very much easier. The basic unit is in reality an eight bit comparator which provides an output signal when the input. signal is the same as that set up on the unit's switches. The unit as described will handle up to eight logic inputs which will probably be sufficient for most purposes. However, it is designed so that additional units may be plugged into the first to expand the total capability in blocks of eight.

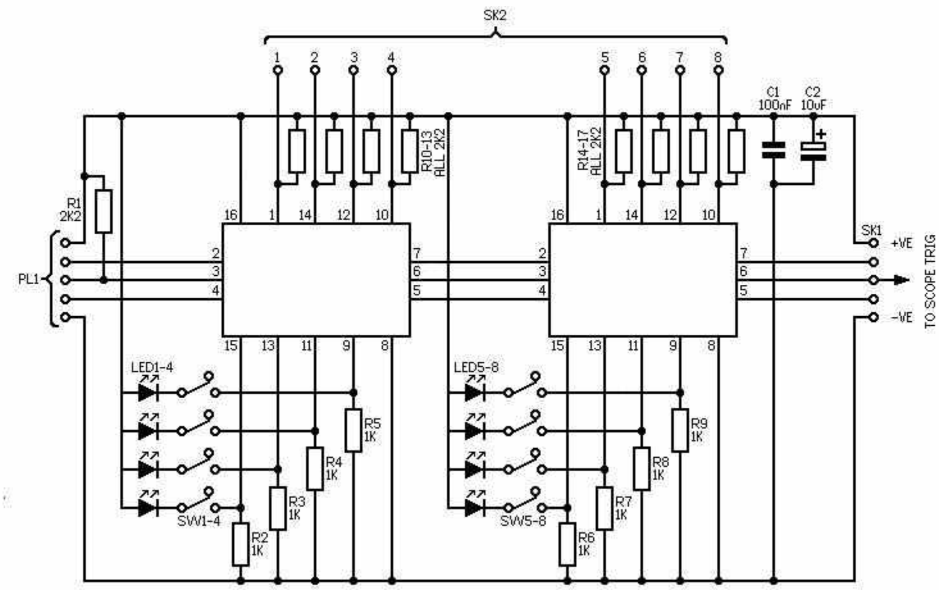


Fig. 1 Circuit diagram.

Use

The unit must be provided with a normal TTL type +5 volt power supply (probably conveniently derived from the equipment under test}. The output can then be taken to the external trigger input of your oscilloscope. In case you hadn't guessed, your next move is to set the scope to external trigger; you may have to adjust the trigger controls for best results, especially if the circuit under test contains ripple counters. The reason for this is that signal propagation delays in the devices will cause glitches in the output from the Digger unit. This is not a fault, as the input conditions are in fact true, even if only for a short time. Actually this property of the Digger could be quite useful if you suspect this action in your own circuit.

The leads from the device can be connected to the test circuit in any order but remember to set the switches in the corresponding order or your results will be wrong. It is a good idea to use the input nearest (he output as a clock input, as this will eliminate a good many ambiguities. Don't forget to set any unused input channels to HIGH or the unit will not trigger!

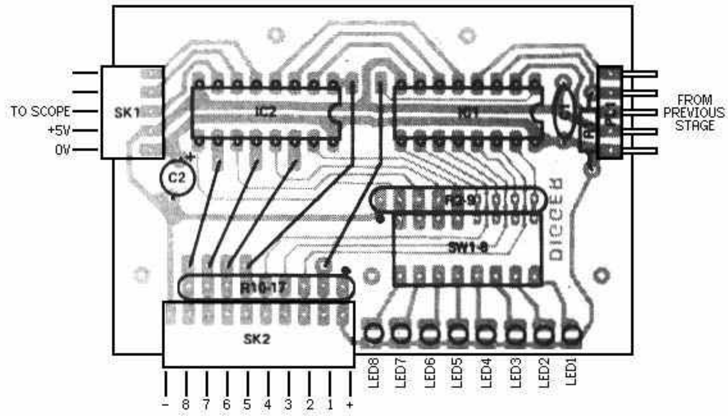
The Circuit

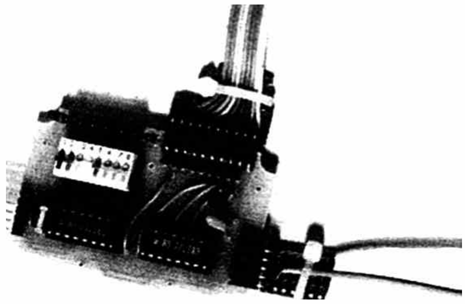
The circuit for this device is very simple. Most of the work is

HOW IT WORKS

Not much to say here really. The LED, switch and resistor combination on four inputs to each IC provides a low when the switch is open and a high when it is closed. Also when the switch is closed the LED will light showing that a high has been selected for that channel.

When the logic input pattern on the input pins matches that on the switches the output from each IC will change state and thus trigger a scope connected to the final output. The outputs from one IC will directly drive the cascade inputs of another and so extend the width of the comparison. The inputs from the test circuit are provided with pull up resistors so any unused input will appear as a high and this must be set on the cor-responding switch. Cl and C2 are pre-sent to decouple the supply rails. R1 is a pull up for the "=" cascade input.





Left: Overlay of the Digger; above: the Digger itself, less case.

PARTS LIST

RESISTORS (1/4 W 5% carbon film unless stated)

R1	2K2
R2 - R9	1K (SIL resistor pack 8 x 1K)
R10 - R17	2K2 (SIL resistor pack 8 x 1K)

CAPACITORS

C1	100nF ceramic
C2	10uF 16V electrolytic

SEMICONDUCTORS

IC1, IC2	74LS85
LED1 - LED8	3mm Red LED

MISCELLANEOUS

SW1 - SW8	8 pole SPST DIL switch

10 way PCB socket 0.1" pitch; 5 way PCB socket, 0.1 " pitch; 5 way right angle PCB plug 0.1" pitch; box (Vero G.P. plastic box 72 x 50 x 25 mm 202-21025K); PCB; 10, 5 way free plugs and 5-way socket for above.

done by the two ICs which are 74LS85 devices. These are TTL four-bit magnitude comparators, and give outputs which show whether one of the two four-bit binary numbers presented to their inputs is equal to, greater than, or less than the other. In addition to the normal inputs, there is also a set of inputs which take the outputs from another similar device. When these are connected, the final output depends on all the comparisons of all the inputs to the devices connected in this way.

The rest of the circuit is devoted to providing the requisite comparison inputs to the ICs and giving a visible indication of it. The method of doing this is to use resistors to hold the inputs normally at a low level, but with switches that can force them high via an LED which will light up to show that it has been selected. The logic inputs from the test circuit are provided with pull up resistors so as to define unused inputs.

Construction

Construction of the PCB is quite simple so long as the ICs are inserted the right way round. The LEDs and capacitors must likewise be put in correctly. If you are going to use resistor packs as we did, the end with the dot or similar mark is the common terminal. Verify this with a meter if in doubt. If you use discrete resistors, mount them vertically and join all the top ends to the common terminal with a piece of stripped solid-core wire.

It will be necessary to use a 16 pin wire-wrap type socket for the DIL switch so that it can be positioned through a hole in the box. The LED leads will probably be long enough without extension. We would also recommend using ordinary sockets for IC1 and IC2.

There are 5 links to insert on the board as marked on the overlay which connect the inputs to SK2. Use thin insulated wire for these. Mounting the PCB in the box is a little tricky. First make sure that the corners have been cut off at the marks shown and check that the board will fit into the box. We found it easier to fit the PCB upside down in the box (with the track side facing the lid), so that only a little of the side walls have to be cut away to allow SK1, SK2 and PL1 to fit. Also a rectangular cut-out must be made in the bottom of the box to allow SW1-SW8 through. Finally eight 3 mm holes should be drilled for the LED's.

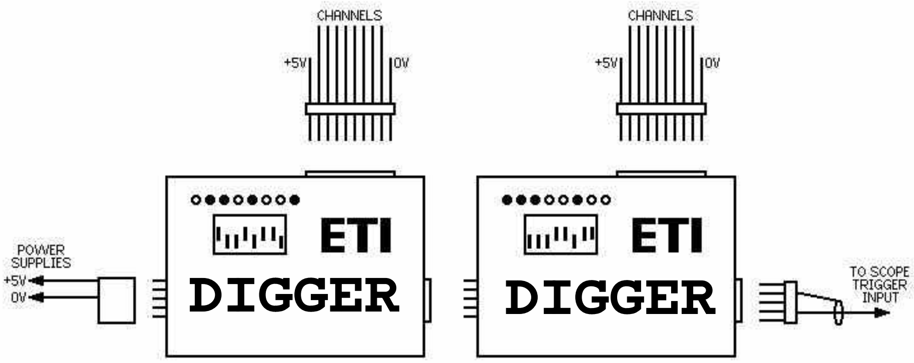
The PCB can now be bolted to the lid and the box put together. Connections to the outside world are made via the plugs and sockets. If you use right-angled plug parts, then a small piece of Veroboard soldered to them makes a robust connector. The socket should be a socket housing with crimp terminals.

For greatest convenience the power connections can be made via the free socket and PL 1 while the trigger output goes from SK1. The switch can be mounted either way round in its socket allowing you the option of the test leads coming out of the top or bottom of the device, while the switch position is still up for high, for example.

BUYLINES

Nothing in this project should cause much difficulty; the SIL resistors are fair-ly widely available from suppliers such as Watford, Cricklewood, etc. The con-nectors are available from Maplin, and the PCB is available through our very own service.

Two or more Diggers can be cascaded.



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13 cards 4.5" by 8" gives a total potential board area of over 400 square inches, enough for a couple of hundred chips or more; there's no real limit on what that could do is there? (It would leave a few of today's marvels a bit in the shade eh?)

But don't be scared, you don't have to build a Frankenstein's monster until you're ready. The first few cards are pretty straightforward: First the VDU-K, which can be connected to your own T.V. (or monitor), then the Z80A-CPU card, the brains; then dynamic RAM, and finally the Keyboard interface (to any standard parallel ASCII keyboard), and you've got a computer — with the ultimate resource: 9 empty slots for the future. (Perhaps use one of them for a 2400 baud tape interface or later floppy disks.)

Example prices (excluding VAT), everything is available separately and full after sales service in case you make a mistake: Z80A CPU card £10.95, Manual £1.50, Main Parts £13.41.

40 type-written pages of description, specification, price lists etc. are yours for the asking (a 25p stamp and/or SAE is a help, but not essential), or telephone if you prefer. You'll have to live with your computer for a long time, so make the effort and find out all about Interak now; a couple of minutes is all it takes to ask for a leaflet!

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AUDIOPHILE

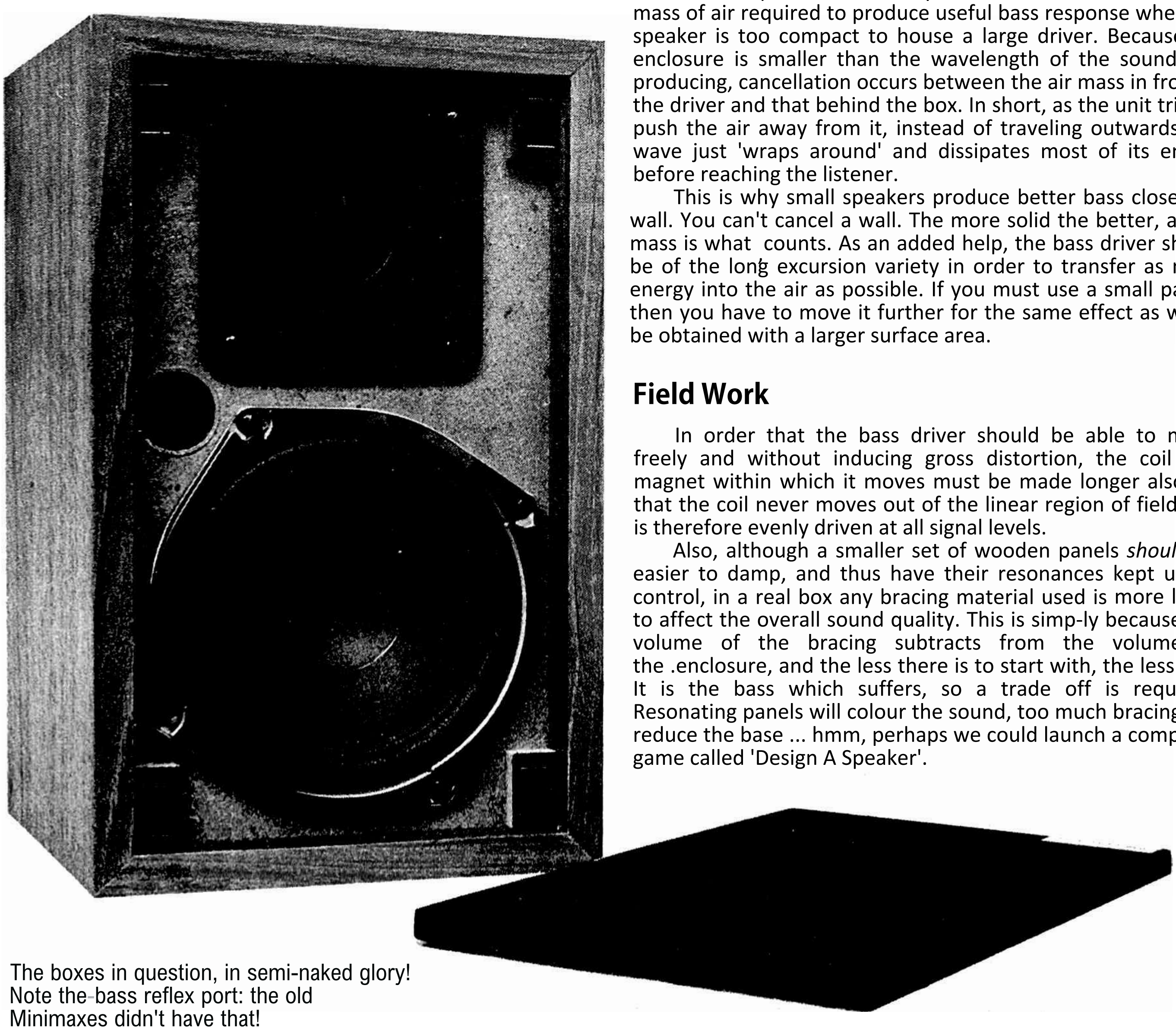
Audiophile returns with a look at a new version of an old favourite. Ron Harris (Who's he? -Ed) has been playing with little boxes.

What do you mean "Oh no, not again?" Thought you'd got rid of me, huh? It's not as easy as *that* my friends. Audiophile returns to ETI with a look at some new boxes with an old and revered name - Minimax 2.

The Minimax 2s are a two-unit ported design of tiny proportions. This is a complete redesign from the originals and the speakers have a lot to live up to.

All by themselves, the original Minimaxes practically rewrote the hi-fi gospel that speakers must be big to be credible. This led to a host of manufacturers taking a serious look at the idea of high performance small enclosures, witness the plethora of imitations there are now.

Presumably the idea behind the redesign is to re-establish the Videotones as the leading small speakers and the indications are that they are selling very well. Celestions magnificent SL6s have unquestionably taken this field a good deal further forward, but at a price. The Minimax 2s are considerably cheaper and are not intended to be directly competitive.



The boxes in question, in semi-naked glory! Note the bass reflex port: the old Minimaxes didn't have that!

Moving Experiences

The main problem with ·any small box is how to move the mass of air required to produce useful bass response when the speaker is too compact to house a large driver. Because the enclosure is smaller than the wavelength of the sound it is producing, cancellation occurs between the air mass in front of the driver and that behind the box. In short, as the unit tries to push the air away from it, instead of traveling outwards, the wave just 'wraps around' and dissipates most of its energy before reaching the listener.

This is why small speakers produce better bass close to a wall. You can't cancel a wall. The more solid the better, as the mass is what counts. As an added help, the bass driver should be of the long excursion variety in order to transfer as much energy into the air as possible. If you must use a small paddle then you have to move it further for the same effect as would be obtained with a larger surface area.

Field Work

In order that the bass driver should be able to move freely and without inducing gross distortion, the coil and magnet within which it moves must be made longer also, so that the coil never moves out of the linear region of field and is therefore evenly driven at all signal levels.

Also, although a smaller set of wooden panels *should* be easier to damp, and thus have their resonances kept under control, in a real box any bracing material used is more likely to affect the overall sound quality. This is simp-ly because the volume of the bracing subtracts from the volume of the .enclosure, and the less there is to start with, the less left! It is the bass which suffers, so a trade off is required. Resonating panels will colour the sound, too much bracing will reduce the base ... hmm, perhaps we could launch a computer game called 'Design A Speaker'.

In Use

Having now run briefly through the horrors of designing small speakers, how do the Minimax 2s measure up? Despite all the pitfalls do they actually produce a creditable result? In a word yes. The originals were very worthy units and the Mark 2s should carry on the tradition admirably.

I wired in the units, somewhat unfairly, in a direct comparison to my usual reference speakers, KEF105 II's which are anything but small. The Minimax was positioned off the floor, clear of walls and for a second attempt on a shelf flat against the wall to simulate more usual conditions of usage.

The amplifier was a Denon PRA2000/POA3000 Class A set-up and the record source provided by the well trusted TD160S/SME Ill carrying a Shure V1 SV cartridge.

To those of you who think it 'unfashionable' to use an SME rude words and expletives. Unaffected by the frantic pursuit of something new for the sake of it often to the detriment of the results the SME continues to out-perform the pretenders. So there!

On an absolute scale the Minimax 2 is a worthwhile product. Taking into account its size, it is positively brilliant. Its greatest asset is the ability to project the sound image away from the enclosures, out into the room: This makes it very easy to forget the boxes and the size of them.

Above: the trusted reference. An SME Ill doing it's bit whilst sat on a Thorens TD160S. A great deal of mud has been slung at several excellent products lately, including the SME. Ignore it. Let your own ears decide. The SME will stand up to ANY properly conducted comparison (i.e. scientifically). If you think I'm getting upset you could be right. I'm thoroughly cheesed off with unqualified, unprincipled and unsound review techniques. A mandatory qualification for producing some of this stuff seems to be that the applicant must be able to prove he has achieved brain death. End of tantrum.

The Wall

Used in 'free-space' i.e. clear of all room boundaries, the Minimax understandably loses body in its presentation. Given a wall to help out, however, it can make a nonsense of its dimensions.

The new high frequency unit appears to improve both the smoothness and the spread of the presentation. The image is now much less dependent upon the listener's position and is free of any noticeable frequency response irregularities. Integration between the two units is good and the mid-range has a good solid sound to it.

Someone used to big, free standing enclosures, with a good deal of power behind them, would of course notice the lack of bass extension at once. However, as a starting point in hi-fi, or as a compromise answer in a small room, the Minimax 2s have much to recommend them. At the low price of £75 per pair, they are very good value and should be listened to seriously if you are thinking of buying a pair of small speakers, for whatever purpose.

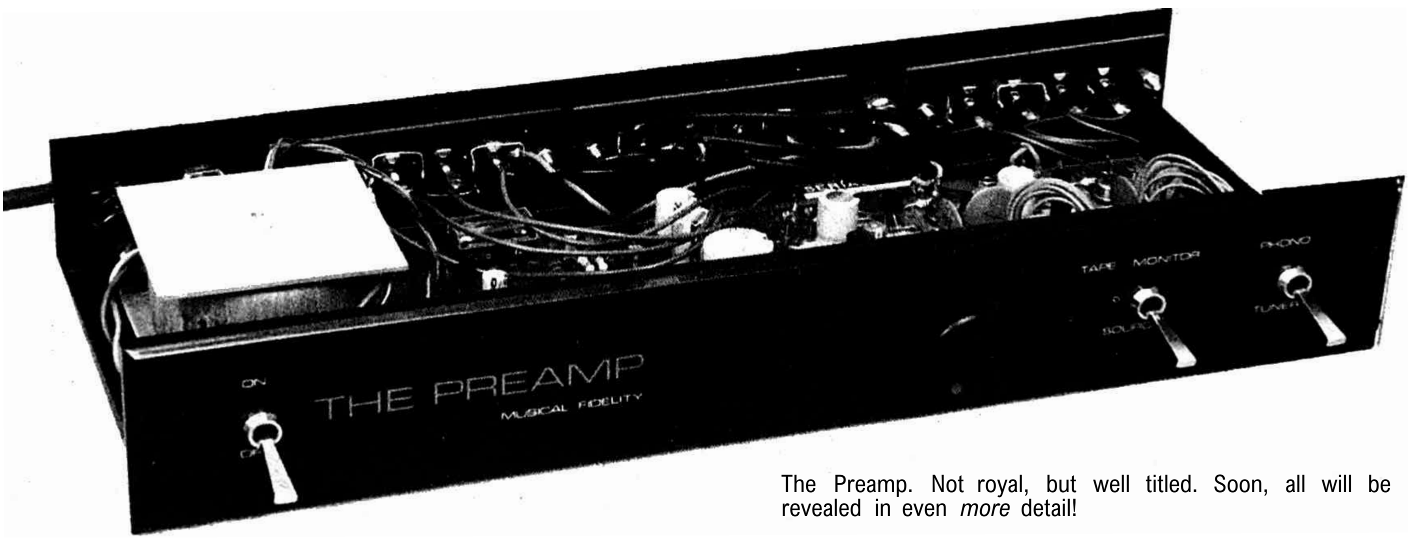
One word of caution, they are relatively inefficient and hooking up less than 20W a channel is unlikely to elicit the best results from these diminutive demons. would recommend around 50W per channel, despite the manufacturer's indrawn breath of cowardice. Take it easy on the volume, to the extent of not pushing in Status Quo full up, and you will be returned a smooth, well imaged sound with good hi-fi extension and more bass than you thought feasible from a box this size!

The Preamp And The Packing Case!

Also this month I was going to review Musical Fidelity's "The Preamp", an audiophile unit of modest cost and high aspirations. Due entirely to the fact that I am moving house and my entire reference system, nay life, is packed into cardboard boxes and is presently being shuffled through the lanes of Kent, I am unable to do so!

My apologies for this and as soon as normal service is resumed I will complete the findings. Meanwhile, have a topless photo.

Exit Ron Harris pursued by the office chapter of the Womens Liberation Movement, in a none-too benevolent mood.



The Preamp. Not royal, but well titled. Soon, all will be revealed in even *more* detail!

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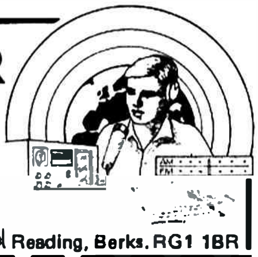

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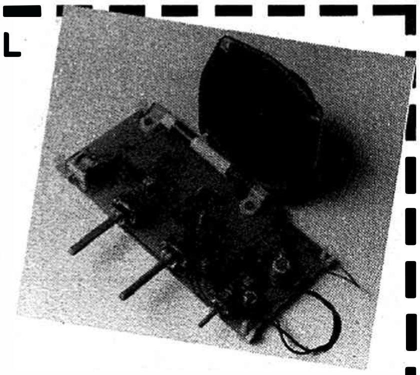

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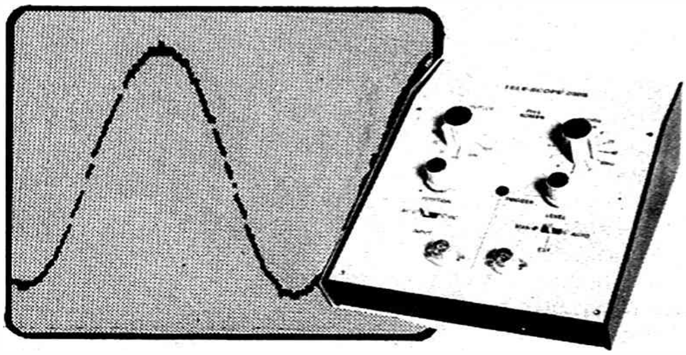

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PART TWO

The only way to give MARVIN a sense of proportion is to connect him with the outside world. Peter Grigson and David Harris show us how it's done.

No computer can talk to the outside world on its own - it needs interfaces to achieve this. As we've already mentioned, MARVIN is a modular computer, and so his interfaces are built on separate boards. There are two types of interface - the I/0 board, and the interrupt board, both of which we will now proceed to describe.

The I/0 Board

The I/0 board is seen by the CPU board as two I/0 ports, which we've labelled A and B. Each port has eight output lines (ie, one byte in either direction) making a total of sixteen lines and eight either direction per board. As we

HOW IT WORKS I/O BOARD

The circuitry divides into three parts - the control logic (IC1 and 2), Port A (IC3 and 4) and Port B (ICS and 6). In fact there are four ports per board the input, and to enable the relevant IC. Note that separate but sharing the same addresses.

The port selection logic is very simple; four AND gates are used to detect. when one of the ports is being addressed and to enable the relevant IC. Note that the selection signals are active low. Because the system is quite simple, it was not judged necessary to include cir-cuitry to avoid more than one port being enabled at once.

The output ports (ICs 3 and 5) are based on the 74LS373 octal 0-type transparent latches: while the EN G input is high, the outputs follow the in-puts. When EN G is taken low, the lat-ches will be set to the current data. There is also an output control which may be useful in some circumstances. When this is taken high, the outputs from the 74LS373 go into a high impedance state, irrespective of the latch contents. However, the latches themselves are unaffected by the output control, and they will retain their cur-rent data, or can be set to new data. R1 and R2 keep the output control (OC) inputs, to ICs 3 and 5 respectively, low in the case of no external control signal.

The input ports (ICs 4 and 6) use 74LS244s: these are octal buffer/line drivers with tri-state outputs (the out-cuts are connected directly to the data bus Internally, the buffers are in two groups of four, with separate gate inputs (G1 and G2), and when these inputs are taken low, whatever information is at their data inputs will be placed on to the data bus.

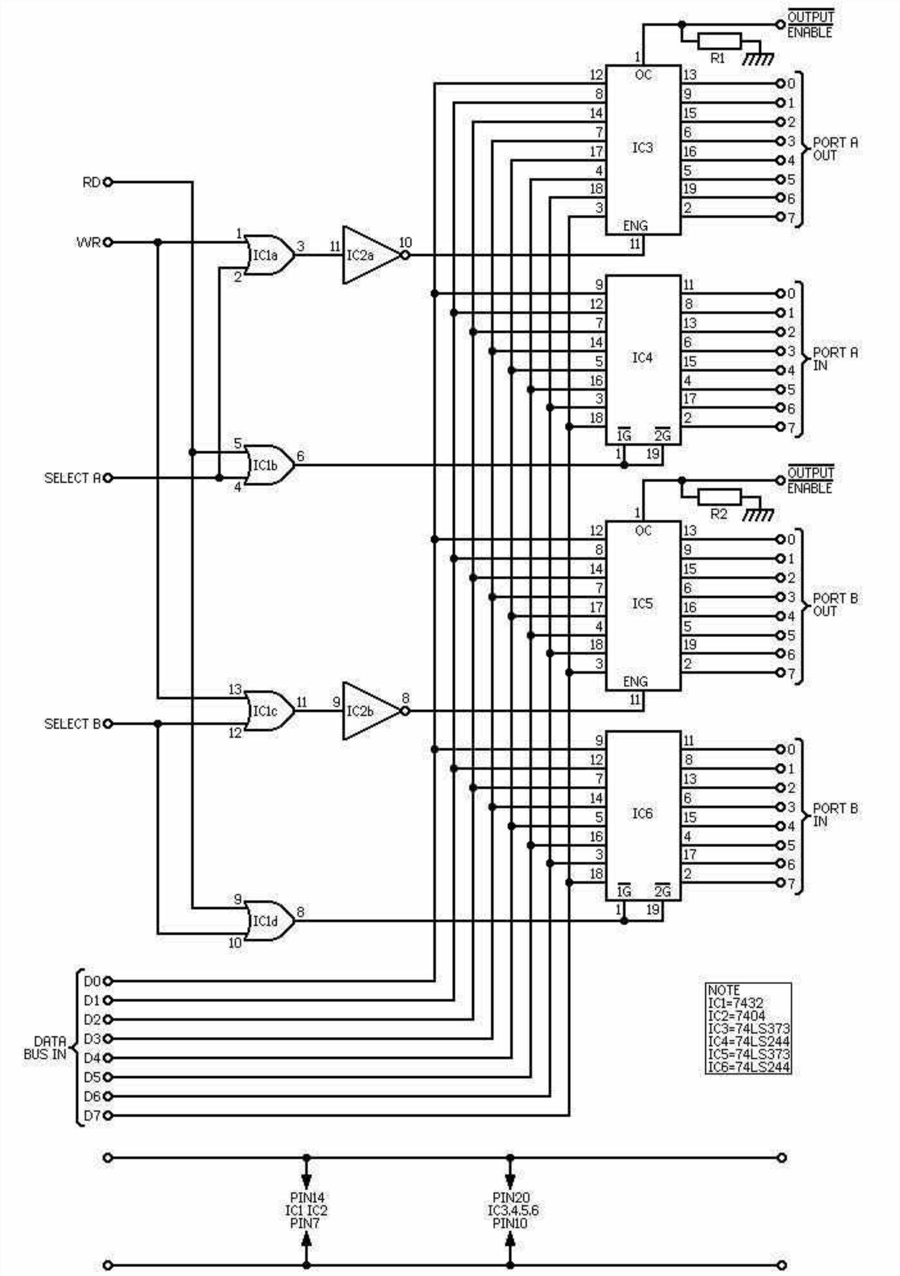


Fig. 1 Circuit of the I/0 Board.

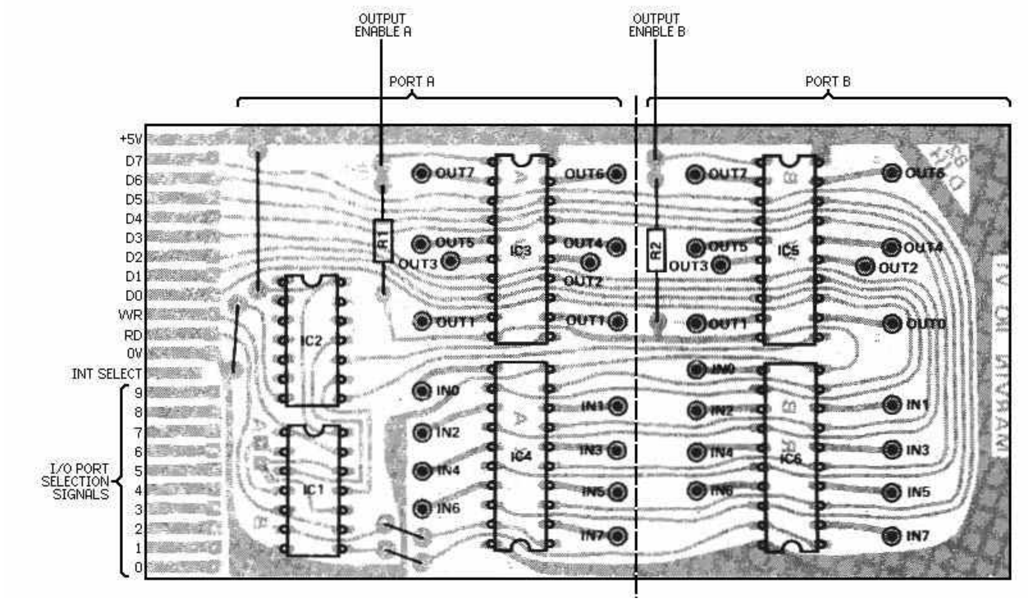


Fig. 2 Overlay of the I/0 Board: note that the connections to the edge connector are in the reverse order from the other two types of board. See text before inserting pins.

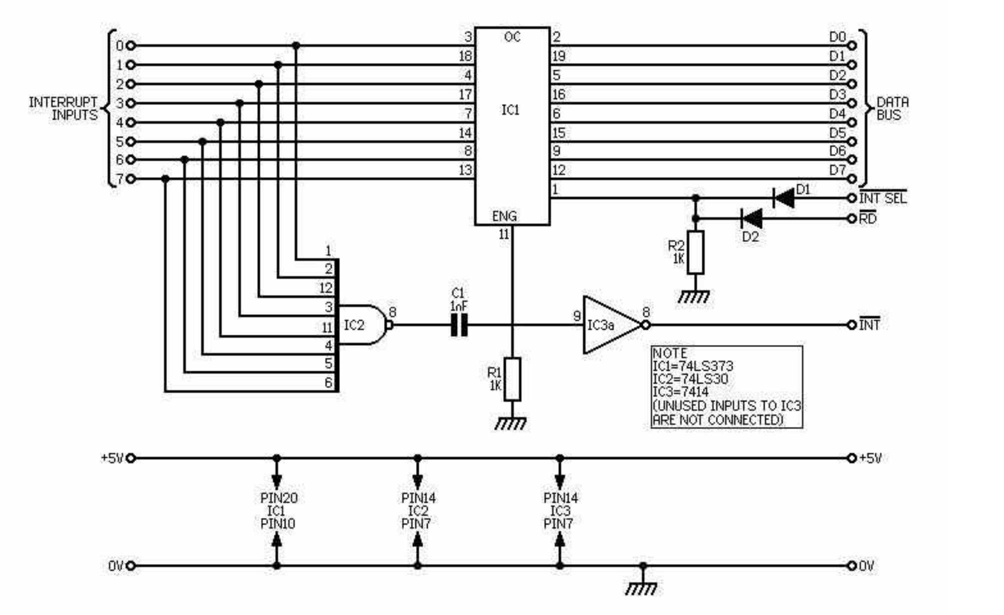


Fig.3 Circuit of the interrupt board.

PARTS LIST I/0 BOARD

RESISTORS (1/4W 5%)
R1, R2 1K

SEMICONDUCTORS

IC1	7432 or 74LS32
IC2	7404 or 74LS04
IC3, IC5	74LS373
IC4, IC6	74LS244

MISCELLANEOUS
PCB; four 20-pin DIL sockets; pins or edge connector as required

HOW IT WORKS INTERRUPT BOARD

All the inputs are fed to IC2, an eight-input NAND gate. In the normal state, all the inputs will be high, the output from IC2 will be low, and C1 will not be charged. INT SEL will be inactive, (high) so the OC input to IC1 will be high, disconnecting its outputs from the data bus (IC1 is a 74LS373, as used in the I/O card). The output to IC3a is high, so INT is inactive.

This scene of domestic bliss is rudely disturbed when any input line is pulled down to low. This makes the output of IC2 go high, pulling the node formed at the junction of C1 and R1 high until C1 charges via R1. This makes the output from IC3a go low for about one microsecond, pulling the INT line low and generating the interrupt to the CPU. Also, the EN G input to IC1 is taken high then back to low, which has the effect of latching the data of the input lines into its internal latches.

When the CPU wants to find out which line caused all the trouble, it takes INT SEL and RD low, which enables the outputs of IC1 and places its data on to the data bus.

mentioned last month, there can be up to five I/0 boards (i.e. ten ports) in use with the system as it is presently configured.

To write to a port, the CPU places the required data on the data bus and makes the WR and the relevant port selection line low. The data is actually latched into the port when one or both of these lines goes high again, and until this point the outputs will follow the input data. The data will remain set until that port is. written to again.

To change just one bit, the whole byte will have to be rewritten. to the port, with repeat data in the bits you don't wants to change.

The output control (OC) can be used to isolate the port from its output lines. This could be useful if the system receiving the output from MARVIN is to any extent autonomous, e.g. it contains another processor. Note, however, that the output lines should never be driven beyond TTL limits (with respect to Marvin's earth), otherwise damage may occur.

When an input port is selected, the inputs to it are buffered on to the data bus. Thus, while they are being accessed, they should be held stable to avoid errors.

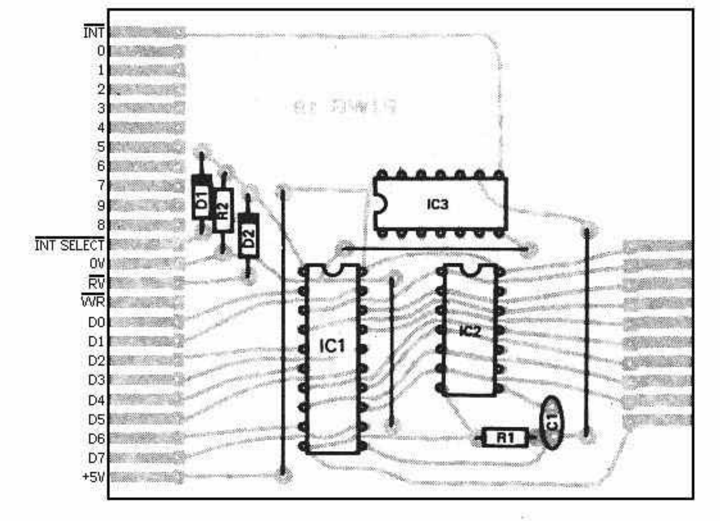
Note that there is no way for the I/0 board to signal the CPU board that it wishes to transfer data - like a shy little wallflower at a noisy disco, it has to wait until it's asked, and the CPU does the asking by taking RD and the relevant port selection line low.

Interrupt Board

This board is intended for use with external timing and triggering devices. Via this board, external equipment can make the CPU stop whatever it is doing and pay attention!

Eight interrupt input lines are

Fig. 4 Overlay of the interrupt board.



PARTS LIST INTERRUPT BOARD

RESISTORS (1/4 W 5%)
R1 1K

CAPACITORS
C1 1nF ceramic or polystyrene

SEMICONDUCTORS
IC1 74LS373
IC2 7430 or 74LS30
IC3 7414 or 74LS14
D1, D2 1N4001

MISCELLANEOUS
PCB; one 14-pin DIL socket; one 20-pin DIL socket; pins or edge connector as required

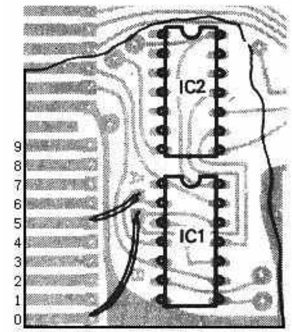


Fig. 5 An example of how the port addresses can be defined on the I/0 board itself. In this case, port A has address 5, port B has address 0. There is no need to use pins unless you will be changing around port addresses quite a lot -permanent wire links should do the job otherwise.

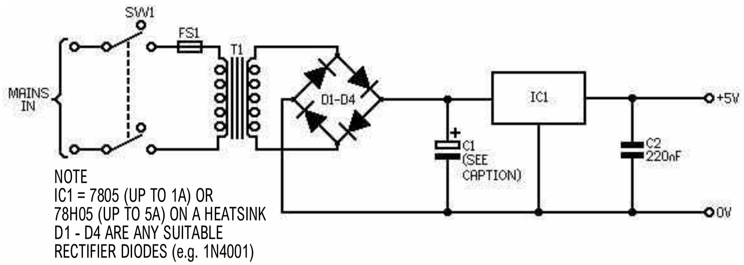


Fig.6 If you don't have a suitable power supply to hand, you'll have to build one. Here is a fairly standard circuit: allow current consumptions of 500 mA for the CPU board, 200 mA per I/0 board, and 100 mA for the interrupt board. The transformer should be able to supply more than enough current to meet the maximum demand, and C1 should be about 5000uF per amp of supply current drawn.

provided, and these should normally be at logic high. If any line is pulled down to low, the CPU will accept the interrupt provided it has executed an enable interrupts (EI) command since the last interrupt occurred or disable interrupts (D1) command was executed. The CPU will not accept further interrupts until El has been executed again.

The CPU will complete executing the current instruction, then go to the interrupt servicing routine in the operating system. As described in the "How It Works" section, the interrupt board latches the data on the interrupt input lines when one makes the high-to-low transition, and then the monitor instructs the CPU to read this data. This will consist of all 1s except for the bit that corresponds to the input that's causing all the fuss. According to which bit it is that is zero, the CPU will look for the address of the next instruction to be executed from one of eight memory locations in RAM.

Note that the board cannot generate another interrupt until the line that generated the first interrupt is reset to high (and any other lines that have gone high in the mean time have also been reset).

Construction

Construction of both these boards should be absolutely straightforward. We recommend using sockets for all but the simplest of the TTL gates (ie, don't bother for IC1 and 2 on the I/0 Board, or with IC3 on the Interrupt -Board). Don't forget to insert the wire links as shown, and if you're not bothering with edge connectors, you'll need to insert pins in the PCB next to the edge connector strips. In any case, you may wish to put pins in the positions marked on the I/0 board, for defining the address of the ports -but see the I/0 Port Identification Section first, and decide whether you'll be changing around the system much.

Making The Connections

Well, now you've got all the three types of board -how do you connect them up together? As we've already stated, you have a choice between using edge connectors (the rich hobbyists' option) or pins and ribbon cable. In either case, all three boards use exactly the same connections, but with two irregularities for the I/0 board: there is one less tab (INT is omitted), and the tabs are in the opposite order from the other two boards (thus if the boards were mounted in a rack, the I/0 board(s) would face in the opposite direction from the CPU and interrupt boards).

I/0 Port Identification

As we've already mentioned, the CPU sees the I/0 boards as two separate ports per board, and each of these two ports must have a unique address. Thus each port selection line (SELECT A and SELECT B in Fig 1) must be connected to just one port selection signal on the main board (in the top right hand corner of Fig.2 last month); furthermore, only one port must be connected to each selection signal. This can be achieved in two ways: either you can run individual lines from the selection signals on the CPU board to the selection inputs on the ports; or you can define the port number by connecting links or: the port PCBs, and Fig. 5 shows an example of this.

BUYLINES

The following will be available from ARK Electronics, 3 Barnhill, Pinner, Middlesex, HAS 2SY (please note this change of address).
EPROM containing the monitor program, 4 MHz clock, £6.00; 3 MHz (or lower) clock £4.00; Main board PCB, £6.00; Complete 4 MHz kit for the Main Board excluding the operating system EPROM £26.00.
I/0 Board PCB £1.50; Interrupt Board PCB £1.50.
Because the remaining components for the boards described this month are very easily obtainable, ARK have not judged it worthwhile making kits available from them.

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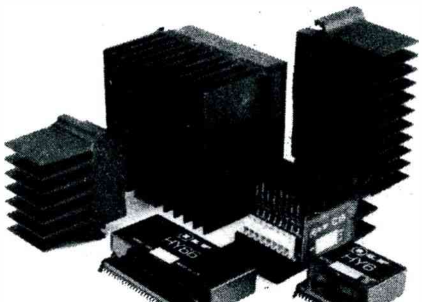

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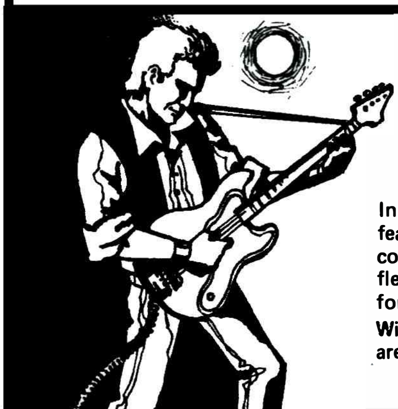

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HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

Protection: Full load line. Slew Rate: 15v/μs. Risetime: 5μs. S/N ratio: 100db.
Frequency response (−3dB) 15Hz – 50KHz. Input sensitivity: 600mV rms.
Input Impedance: 100K Ω . Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.38
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14,20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

Mounting Boards

For ease of construction we recommend the B6 for modules HY8—HY13 £1.05 (inc.VAT) and the B66 for modules HY66—HY78 £1.29 (inc. VAT).

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/μs. Rise time: 3μs. S/N ratio: 100db
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Input impedance: 100K Ω. Damping factor: 100Hz >400.

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PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

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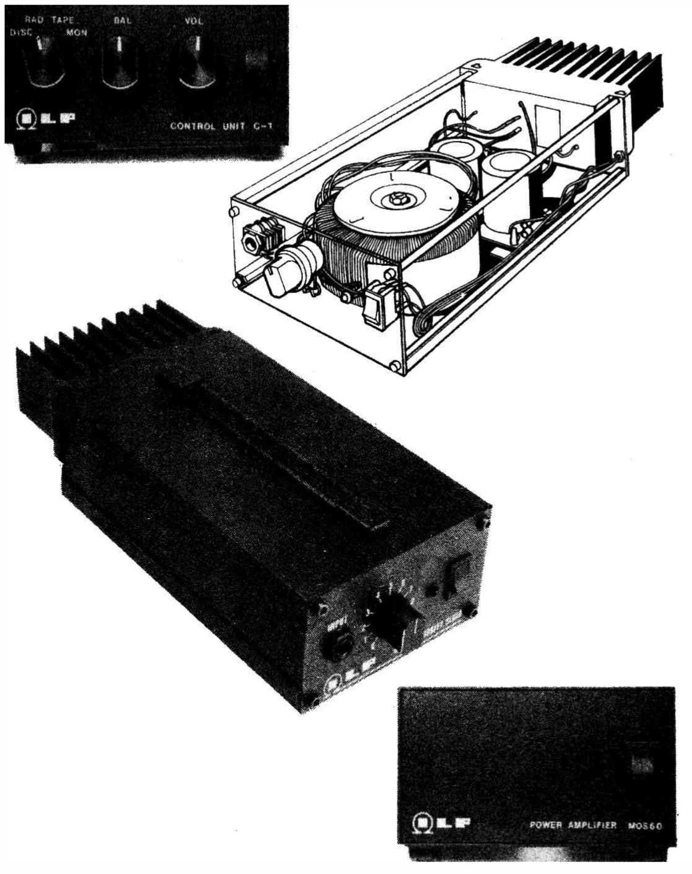

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US2X	120W/4Ω	Bipolar	Power	Slave	£79.95
US3X	60W/4–8Ω	MOS	Power	Slave	£69.96
US4X	120W/4–8Ω	MOS	Power	Slave	£89.95

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64K DRAM BOARD

Mucking around in memory? Seeking space? Look no further, here's a bounty (no connection with those distracting TV ads) of bits, rapacious in real-estate, for your 6502 or 6800 system to gorge itself on. Design and development by Bob Campbell.

Most microcomputer users find out fairly quickly that there is no such thing as too much memory. But even today with memory as cheap as it is, many systems are on sale with less, often considerably less than the 64K that most eight-bit microprocessors are capable of addressing. The independent suppliers are usually very quick to-provide units to fill this gap, but one system not well covered in this respect is the Tangerine Micron/ Microtan 65. Until recently, there was only the TAN RAM, but now there is the CMOS alternative. However, despite advantages in power consumption and battery back-up, the CMOS unit, like the TANRAM, is large and fairly expensive. More than one board is required to provide the maximum possible memory. The approach here is to use the highest density dynamic RAM chips readily available and allow the user to access all of it except where it would clash with essential EPROM, I/0 or CPU board RAM. This leads to an extremely flexible and cost ef-fective system. Although specifically designed for the Microtan 65 computer together with either a disc system or TUG's Eprom Storage Card (the MOS Disc concept) the design retains enough flexibility to accommodate almost any desired configuration of computer and operating system, the only prerequisite is a 6502 or 6800 CPU.

Design

The board uses the latest 64K by 1 bit dynamic RAM chips, TMS 4164-15. These are decoded into 64 1K blocks, with all but four of the blocks used in its standard configuration. Making almost 6 1/4% of the RAM effectively redundant may at first sight seem a little extravagant, however even allowing for this the cost per K is less than £1.00. If one adds the other savings on hardware, sockets, power supply requirements board space etc., the 64k chip route stands out above all the other alternatives.

The heart of the system is the 74LS608 memory cycle-controller (MCC). This chip generates all the signals the RAM requires to perform the two types of cycles necessary for proper operation. The MCC generates these signals from the CPU's clocks 01 and 02 together with the decoded signal RE, RAM enable. It is important not to confuse this signal with the Tanbus signal RAME. The only signals used from the bus are the address and data lines together with R/W, 01 and 02 and because of this and the use of a PROM address decoder, this board is very flexible. in design and easily adapted to suit other systems.

Dynamic RAMs

The two great advantages of dynamic RAM are its extremely low power consumption and its packing density. This is achieved by the design of the actual memory element which is in fact a very small capacitor. The logic level stored being defined by the presence or absence of a charge on that capacitor. Because all capacitors have a finite leakage, the charge on the capacitors must be periodically topped up. This procedure is called refreshing and is accomplished by performing what is known as a RAS only refresh cycle.

This RAS only refresh cycle consists of first setting up an eight bit address at the input latches and strobing RAS low, while maintaining CAS high. The complete chip is refreshed when all 256 row addresses have been treated similarly. Data retention is assured if all these 256 cycles are completed at least once every 4 msec.

Apart from the necessity to refresh every 4 msec there is one other penalty to pay for the 16 pin packing density and that is the multiplexed address bus. Figure 1 shows the internal architecture of the 4164.

To address every memory element within the IC, 16 address bits must be applied; These are separated into the row address and the column· address, each latched onto the multiplexed address bus

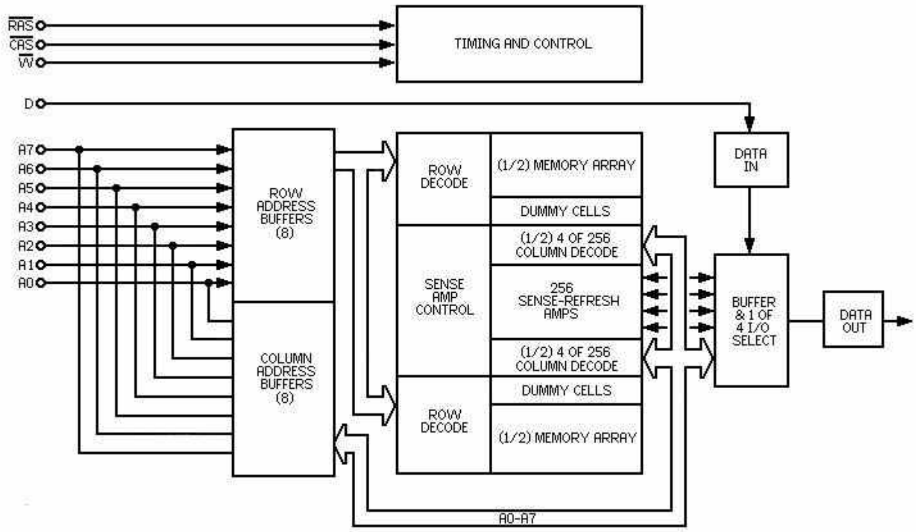


Fig.1 Internal architecture of the TMS4164 DRAMs used in the project.

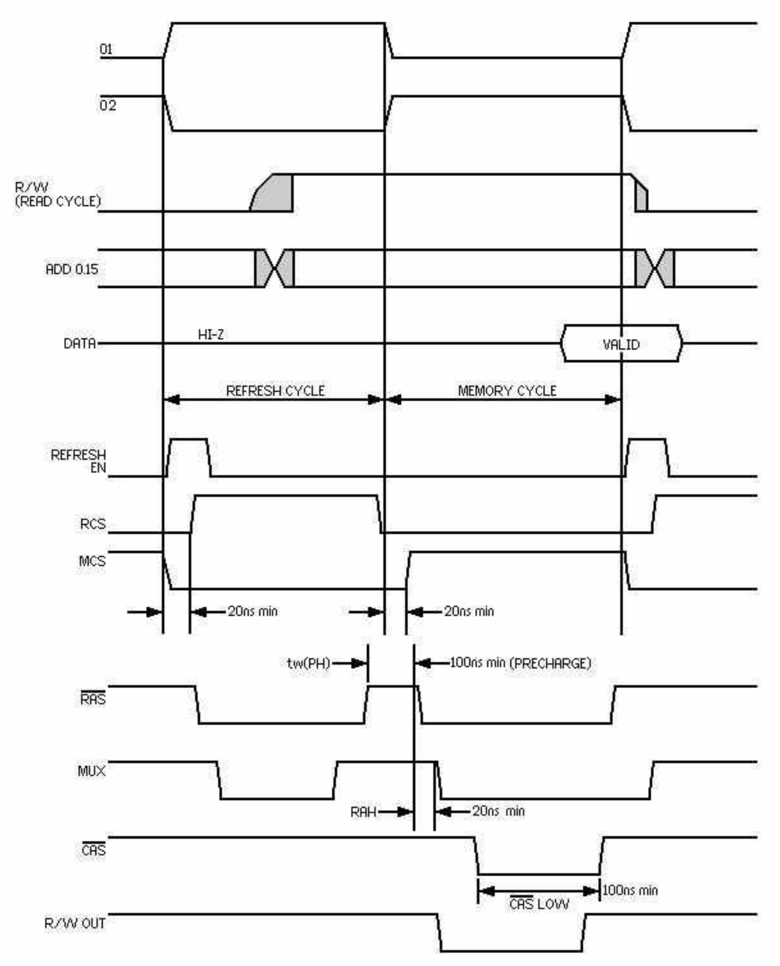


Fig. 2 Processor and memory cycle controller timing.

upon the appropriate signal RAS or CAS.

In full, the memory cycle consists of five stages. Firstly the row address pins and RAS pulled low. Then the address multiplexers are switched placing the other eight bits, the column address, onto the address pins and CAS pulsed low. This last operation enables the chip and, depending on the status of the R/W line, enables the input or output buffers, thus completing a read or write cycle.

There are two other possible types of cycle, the page mode read/write and the read modify write cycles. However since neither of these apply to the 6502 or 6800 type of processor it is not necessary to consider them further here.

It is important to note that the 6502 operates in what is known as the early write cycle where the R/W line is set up long before CAS goes low. This enables the data in (D) and data out (Q) pins to be connected together and thus have a common data bus.

Obviously the sequence and timing of the two cycles, refresh and memory, is extremely important. The RAS only refresh cycle is particularly significant for two reasons: firstly, it is necessary to perform it regularly (256 times every 4 msec), and secondly, it is effectively a dead cycle, when the CPU cannot access memory.

Refresh cycles can be carried out in either burst mode or hidden transparent mode. Burst refresh is a technique where all the memory elements are refreshed consecutively whilst the processor is held in a wait or halted state. This dead time is called the refresh overhead, which, more accurately, is defined as the ratio of the time taken to refresh all the memory elements and the maximum refresh interval. In well-designed systems with the 4 msec 64K rams this overhead can be as low as 2%. As the circuitry needed to maintain this type of refresh system is complex it is not commonly used outside the realms of very fast microcomputers, minis and mainframe systems.

The other technique, hidden refresh, is the more commonly used. This technique relies upon the fact that the CPU will always have a period within any instruction or machine cycle when it will not access the system bus, and one refresh cycle can be accomplished during this period. Thus after a maximum of 256 instruction cycles all the memory elements will have been serviced. This technique has the great advantage of a zero refresh overhead rate and is totally transparent to the CPU and thus the user.

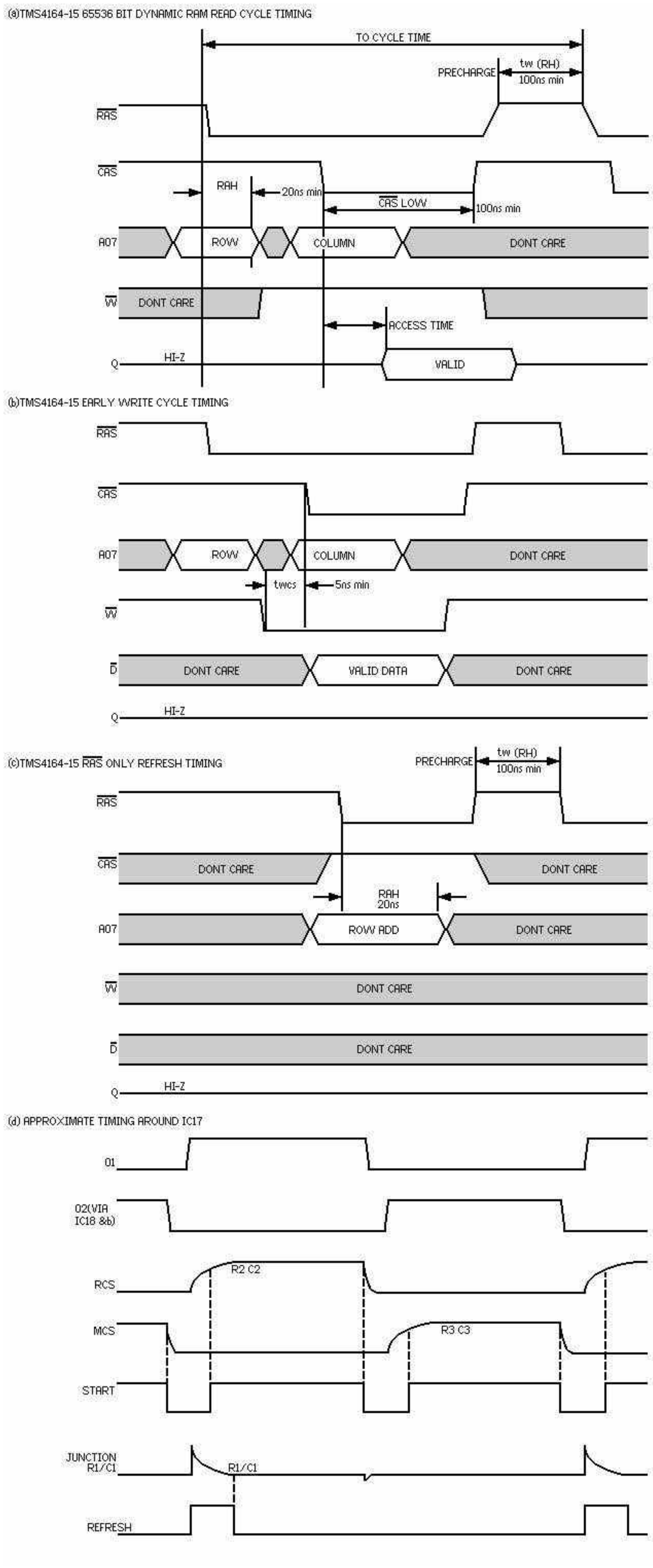
In this design the two cycles, refresh and memory, are sequenced by the main CPU clocks 01 and 02. While 01 is high, the CPU sets up the R/W and address lines, the rising edge of 02 signifying a valid memory address.This edge of 02 is normally used to enable the address and data buffers. Thus while 01 is high, the CPU is normally isolated from the system bus, and the refresh cycle can be accomplished during this period. In addition by using 01 to clock the eight bit refresh row address counter all 256 row addresses can be refreshed sequentially. Figure 3 shows exactly the relationship and timing of these events.

PROM Program Design

The memory map of the RAM board is controlled directly by the TBP24S10 PROM, which acts as a complex address decoder. Before programming the PROM, the desired memory map must be established. The minimum requirement for most systems will be the system monitor, the I/0 area and unless there is a serial VDU as the screen, some screen memory. Some systems use a relocatable area of memory for the screen RAM, the video controller accessing the system bus directly. If the target system is of this type then no provision should be made for the screen RAM in the PROM program. Remember the overriding factor when designing the memory map is that there must not be two components within the system which have the same address. Taking the standard configuration of the Microtan as our worked example, the minimum memory map is as shown in Fig 4.

Once you've determined the memory map(s) required, the upper six address lines should be written out bit fashion (bit by bit ... ?). Each bit corresponds to a PROM address bit; however because of the PCB board layout, the one-to-one

Fig. 3 Memory timing for various operations and approximate timing round the MCC.



respondance is not in numerical order.

In addition, by using the two extra PROM address lines A7 and A8, there is the facility to have up to four programs and therefore four memory maps resident on the board at one time, selectable by means of the DIL switch SW1. Using the two tables 1 and 2 it is possible to calculate all the PROM addresses which are required to be 'blown'.

Remember that PROMs are not erasable, once a memory location is altered from the "all 1's" condition, it cannot be reversed. There is however an escape route if a mistake is, made during programming. The program is created by blowing only the operative bits within the data word from a 1 to a 0.In this design, only one of the four bits available is used (bit 4). If an error is made during programming, then it is possible to use an alternative bit by breaking the PCB track at pin 9 IC15, installing a link to either pin 10, 11 or 12 (bits 1-3 inc.) and reprogramming the PROM using the appropriate data word. (Alternatively, this would make it possible to hold a total of 16 memory maps in the PROM).

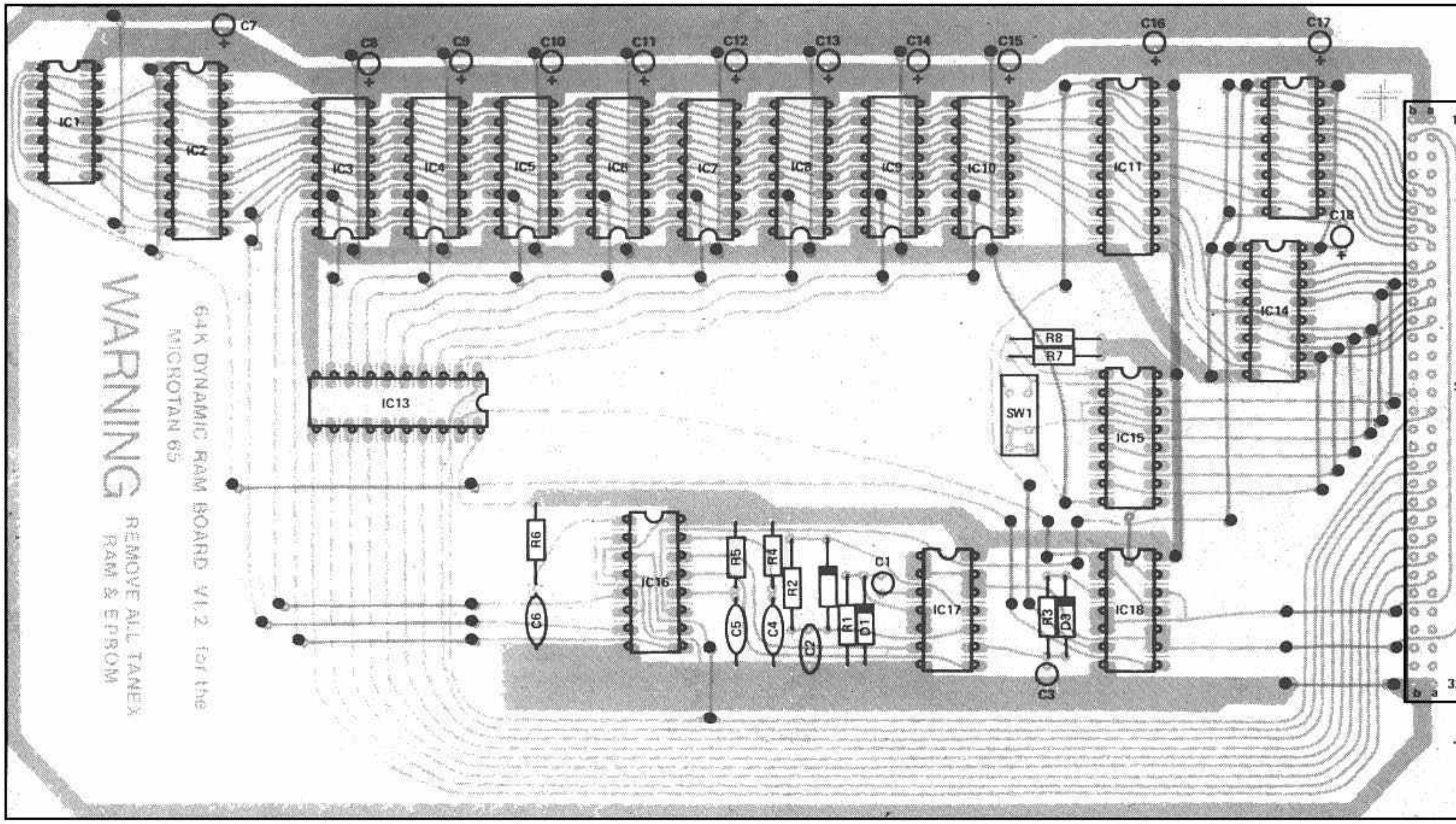
It is beyond the scope of this article to describe the methods for actually programming the PROM, suffice to say that the amount of programming by nature of it's use, is small, so it would be feasible to use the switchbox type of programmer.

Construction and Setting Up

The construction of the board is very straightforward, particularly if the PCB design presented here is followed exactly: there are, after all, only 18 ICs. The PCB is a double sided design but to keep costs down it doesn't use plated-through holes. To make the necessary interconnections, track pins or short lengths of wire must be soldered between the two in the positions marked on the overlay diagram with a black dot. These pins must be soldered in first,

AREA	HEX ADD	SIZE
A)TANBUG	FFFF F8OO	2K
RAM	F7FF C000	14K
B) I/O	BFFF BCOO	1K
RAM	BBFF 0400	46K
C) CPU BOARD RAM	03FF 0000	1K

Fig. 4 Minimum memory map for the Microtan.



PARTS LIST

RESISTORS

R1, R2, R3	1K hi-stab metal film 1%
R4, R6	4K3 hi-stab metal film 1%
R5	1K1 hi-stab metal film 1%
R7, R8	1K carbon 1/4W 5%

CAPACITORS

C1	100p ceramic plate 2% or better, or silver mica 1%
C2	150p ceramic plate 2% or better, or silver mica 1%
C3	68p ceramic plate 2% or better, or silvered mica 1%
C4	220p ceramic plate 2% or better, or silver mica 1%
C5	68p ceramic plate 2% or better, or silver mica 1%
C6	120p ceramic plate 2% or better, or silver mica 1%
C7, C17	10u tantalum
C8-C16, C18	1u tantalum

SEMICONDUCTORS

IC1	74LS393
IC2, IC11	74LS244
IC3-IC10	TMS4164-15p
IC12, IC13	74LS157
IC14	74LS245
IC15	TBP24S10
IC16	74LS608
IC17	74LS32
IC18	74LS00
D1, D2, D3	1N4148

MISCELLANEOUS

DIN 41612 64 way double-sided connector; DIL 2 pole on/off switch; DIL sockets: 3 off 20 pin, 12 off 16 pin, 3 off 14 pin; PCB.

BUYLINES

One or two not so easy to obtain items here. The TBP24S10 PROM and 74LS608 memory cycle controller chip were tracked down to Farnell Electronic Components Ltd, Canal Road, Leeds LS12 2TU. At £2.42 and £6.44 respectively plus 55p p&p plus VAT these shouldn't break the bank. The 1% metal film resistors are available from Rapid, Cricklewood, Watford and many others. The specified memories and other TIL devices are advertised by Midwich Computer Company Ltd. And, in case you hadn't guessed, the PCB will be available through our own service.

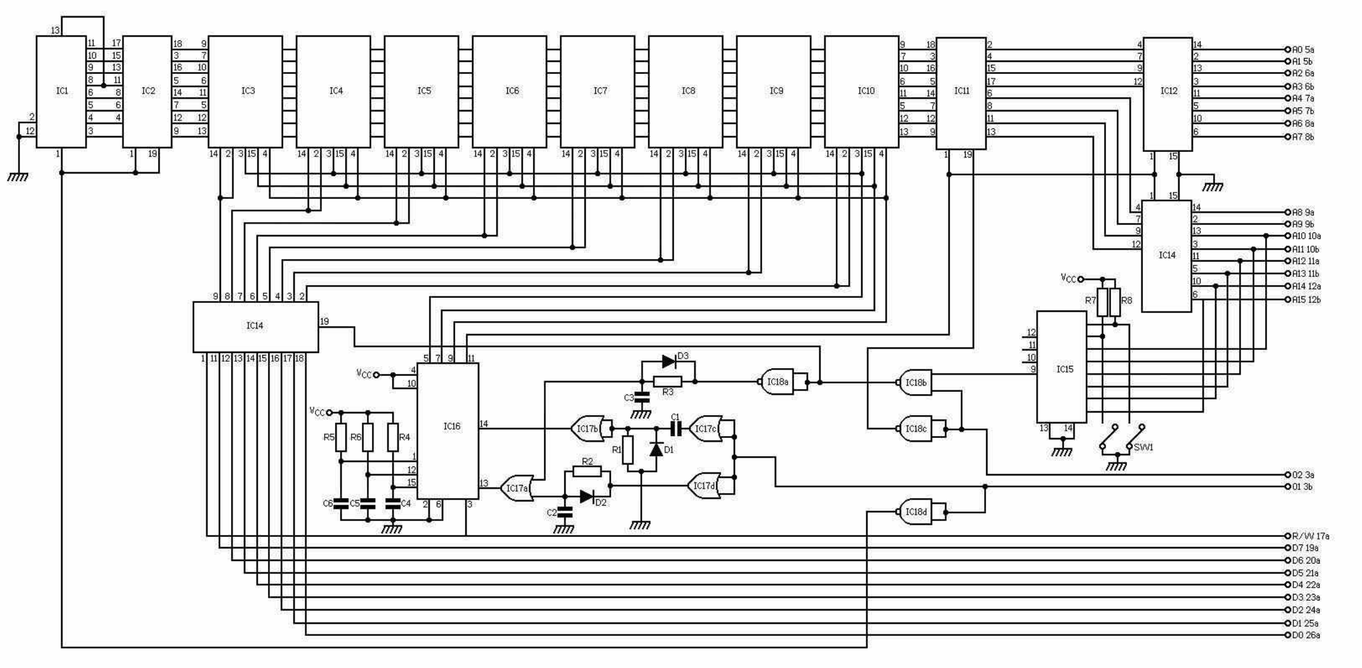
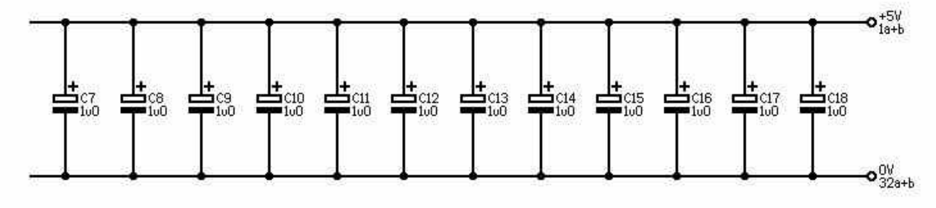


Fig. 5 Circuit diagram of the complete project.



Power lines & decoupling capacitors. 1u0 all tantalum. 10u tantalum or low leakage solid electrolytic.

prior to any other components, as there are some beneath the DIL sockets; I advise checking the continuity of each one thoroughly, as mistakes are difficult to rectify later. The remainder of the soldered components can be assembled in almost any order, but I've found that it pays to be systematic and to follow a list, checking off each component as it is soldered in.

All the usual checks should be carried out before the ICs are in-serted into their sockets. Particular attention should be given to avoiding solder bridges in the daisy chained RAM area of the board.

It is useful to insert the chips in three stages and perform some functional checks on the system at each stage. The first of these stages is to insert the PROM and all the TTL, with the exception of the 74LS608 (IC16) and the 7 4LS245 data bus buffer (IC14). Now powering up the board on the bus can be performed with all the Tanex RAM and EPROM still resident without the risk of any memory conflict occurring. This procedure will allow you to check the following items with the system running.

A dual beam oscilloscope is really desirable particularly if you have deviated from the timing component values for any reason. However it should be possible if you don't have access to a oscilloscope to use a good logic probe to check that all the appropriate signals are present.

The most relevant signals to check first are 01 and 02 and their complements 01, 02, RE and DBE should be active only when a valid address within your programmed memory map is accessed. Next check that the two address buffers, IC2 and IC11, are switching correctly

SYSTEM ADDRESS						HEX ADD.	COMMENTS
A15	A14	A13	A12	A11	A10		
1	1	1	1	1	1	FFFF	TANBUG
1	1	1	1	1	0	F800	
1	0	1	1	1	1	BFFF	I/O
1	0	1	1	1	1	BC00	
0	0	0	0	0	0	03FF	CPU BOARD RAM
0	0	0	0	0	0	0000	

Table 1 Revised system memory map.

Table 2. Programming sheet for the PROM.

64K DYNAMIC RAM BOARD PROM PROGRAMMING SHEET ... OF ... 4

SYTEM ADDRESS	SW1	SW2	11	10	13	14	15	12	HEX PROM ADD
PROM ADDRESS	8	7	6	5	4	3	2	1	BLOW TO 07
	0	0	0	0	0	0	0	0	00
	0	0	1	1	1	1	1	1	3F
	0	0	1	0	1	1	1	1	2F
	0	0	1	1	1	0	1	1	3B

exactly 180° out of phase with each other, and that the refresh address counter IC1 is functioning correctly as an eight-bit counter. The final check at this stage is to measure the pulse delay and shaper circuits formed by the diode/resistor networks and IC17. The three signals RAS cycle start (RCS), memory cycle start (MCS) and refresh (RFSH) should all correspond to the timing diagram in Figure 3. Any deviation should be adjusted by altering the value of the capacitor and/or resistor within the relevant RC network. However if the stated tolerances of the components are adhered to there should be no problems.

Having completed all the checks and adjustments so far the next stage is to insert the 74LS608 memory cycle controller, which should produce the necessary signals RAS, CAS, MUX and R/W. These four main signals should be checked against the timing diagrams in Figures 2 and 3. The important factors are the relationships between cycle start, CS, and RAS, MUX, CAS sequence and the RAS refresh cycle. The row address hold time RAH, CAS low and the precharge time are the major controlling times and are all programmable via the three RC networks on the 74LS608. Under standard conditions with the 750KHz Microtan system clock these times have quite a large latitude. However with faster clock rates the times become proportionally more critical. All these times can be calculated from the memory data sheets.

One fault which may occur at this point has the symptoms RAS permanently low, CAS, MUX and R/W permanently high. If this situation exists try shorting very briefly pin 12 to ground. If the controller then starts to function correctly then the 74LS608 is at fault. I understand from Texas that on a number of the older batches of chips there is a fault with the power-on-reset circuit, newer batches, I am assured, are all O.K.

Having checked that all the relevant signals are present at the RAM chip sockets, the RAM chips themselves can now be inserted. Power down first. These are very static sensitive so take all the usual precautions, they are also upside down in relation to the other ICs on the board.

Be warned that if they are inserted with pin 1 to the upper edge of the board they will be irrevocably damaged, and at £4.00 each a mistake could be very expensive. Finally insert the data buffer IC13. With construction and testing completed there is still one task to finish before the board is inserted back into the rack and powered up. Remove all Tanex RAM and EPROM, and all other memory map conflicts, for example the hires graphics board, failure to do this will probably destroy ALL the memory components in the system.

After powering up the board in the now "minimised" system, unless you've chosen to create a memory map option which retains the Tanex EPROM your system will be running in Tanbug or TUG bug. The quickest way to check the RAM from here is to boot up Basic and XBUG from disc or ESC and let it do the check. 47103 BYTES FREE should appear as the message header. Note some difficulties may be experienced because the F7F7 error jump will not exist immediately. This will show up only if an error occurs during the boot up procedure e.g. miss keying; simply RESET and start again to recover.

Assuming this initial check appears to be OK then a more comprehensive memory test routine should be performed; the one published in the November 1981 issue of Computing. Today is most suitable. However it should be noted that these types of test do not pick out the periodic bit drop out and only extensive usage in BASIC or similar will show up this problem.

Other Systems

The board relies only upon signals derived directly from the CPU 01, 02, R/W and the address and data buses. Since all these signals will be present in any 6502-6800 system, conversion is. relatively simple.

The only component that needs to be altered in anyway is the PROM which does all the decoding. The essential considerations are those concerning the design of the memory map and, in particular, possible address conflicts.

Remember no two components, be they RAM or I/0 should have the same address! A suggestion for those with a Microtan but no discs or ESC is to leave the XBUG EPROM resident (F000-F7FF) and us the tape routines instead.

HOW IT WORKS

As so much detail has been given in the general section, this 'How It Works' is going to be fairly brief. During 01 high the main bus buffers IC11 and IC13 are disabled, removing the RAM from the system bus. The refresh row address counter IC1 is connected directly to the RAM ICs (IC3-10) via the enabled buffer IC2. The rising edge of 01 is first buffered by two OR gates and then, via the pulse generator network D1, C1, R1, IC17, it applies a pulse to the REFRESH ENABLE pin (14) of the memory cycle controller IC16. The same rising edge is delayed by D2, C2, R2, IC17, before reaching the CYCLE START pin 13 of IC16. This delay is necessary to satisfy the refresh hold time of the memory cycle controller, and must be maintained at 20ns minimum. The MCC then responds by pulsing RAS low for a period of time determined by the RC network at pin 12, the row address hold time. The rising edge of RAS is the end of the refresh cycle.

The memory cycle starts with the rising edge of 02 (falling edge of 01) at which point the address bus buffer is enabled directly by 02 and assuming the address is within the memory map, the PROM output 04 is already high. This output combned with 02 produces via IC18 two signals DBE and RE.

DBE enables the data buffer IC13; RE delayed via 03, C1, R3, IC1 7 is fed to the CYCLE START input of IC16 the memory cycle controller. This last event causes the MCC to start the actual memory access cycle. The RAS output (pin 7) goes low then, after the programmed RAH time, the R/W line is allowed to pass through and the MUX output then goes low switching over the address multiplexers IC12 and IC14 to the column address. CAS then goes low for a period of time CAS LO. All three outputs RAS, CAS, MUX then go high. This point should coincide with the falling edge of 02 when the data from or to the RAM is latched by either the CPU or the memory depending on the status of the R/W line.

The next refresh cycle then occurs on the rising edge of 01 and so the system carries on until the power is removed.

Those who design their own PCBs should take care to heed the memory manufacturer's recommendations on decoupling and PCB layout around those chips. Particular attention should be given to the ground and power supply lines, which effectively surround each chip; the arrangement of interlocking fingers on the typical breadboard is definitely out. Similarly the decoupling of the TTL chips should be comprehensive enough to avoid too much power supply noise, a major culprit of periodic bit drop out.

Lastly, the 74LS608 MCC gets hot, but since the lead-frame is directly coupled with both the substrate and the ground pin, a large area of copper around pin 8 should alleviate the problem and improve reliability.

With regards to systems employing faster clock rates than 1 MHz, as long as, the RAH, PRECHARGE CAS low times and the refresh hold time for the MCC are satisfied (calculating them from the manufacturer's data sheets), no significant problems should occur.

READ/WRITE

Switch Troubles

Dear Sir,

I have recently had an unfortunate incident with an EPROM programmer, in which two PIRs and a 7805 regulator were destroyed. The incident happened when throwing a switch (which swapped a certain supply line between 25V and 5V). The result was that the programmer went dead, along with the 5V power supply and the two PIR's. (The 25V supply was not affected as it was simply two car batteries in series.) The cause was simple, when the switch was half way across when switching over, it joined the 25V and the 5V supplies with the aforementioned results.

To be honest I now consider myself lucky that the 5V power supply was only supplying the programmer, if it supplied the rest of the computer as well then I have no doubts. whatsoever that I would be left with a PCB of fried chips of the silicon sort of course.

To get to the point, I am now very wary about what switch I use for such purposes, and I would advise that others watch out for these type of switches, which should not really be sold.

Yours faithfully,
R. P. D. Mallett,
Sandwich, Kent

P.S: If you don't believe that a firm would make such a switch then try out the enclosed one. (You can keep it!)
P.P.S: Thanks for an excellent magazine!

This reader has demonstrated all too effectively that it's important to distinguish between make-before-break and break before-make types of switches! For instance, so far as we are aware, all toggle switches are break-before-make, and a large proportion (but not all) slider switches are make-before-break. In fact, it was a slider switch that was sent to us by the above correspondent.

Induction Loops

Dear Sir,

I was very impressed by the excellence of the article on 'Inductance Loops' by Vivian Capel in the February 7983 issue of Electronics Today. It is a very clear exposition of the way to design an induction loop for hearing-aid users and to decide on the amplifier and transformers required for most systems.

As manufacturers of every sort of audio transformer for more than 40 years we have been approached on many occasions to give advice on inductor installation, particularly in churches, where frequently there is a limited budget and the volunteer from the congregation who undertakes the work is generally non-technical. In future we propose to refer him to Mr Vivian Capel's article and to co-operate by supplying the most reasonably priced transformers for the project. These can be specially designed without additional cost to fit in with the usual PA system amplifier already installed or separate amplifier if desired. The transformer audio outputs we have encountered within the last year or so are mostly between 20 and 700 watts, although last year in a large theatre up north, we supplied four 700 watt transformers which were used presumably for the stall, circles and gallery areas.

Inductor loops are not new although in connection with deaf aids they have come into prominence of recent years. In about 1934 - nearly 50 years ago- the following pioneering experiments were carried out by the undersigned who was building a new house at the time. It was decided for the purpose of listening to radio to install a continuous twin wire cable behind the wainscottin around every room in the house with sockets provided so that a loudspeaker could be plugged in anywhere and this still exists. Whilst working on inductor devices for HM Services at that time, it occurred to me that by putting my twin wires in parallel and feeding the loops in the rooms from my amplifier with two LS5 valves for output, I was creating an audio magnetic field everywhere. I then took various annealed mumetal rods about 1/4" diameter and tried them on different search coils which were connected to my very sensitive S.G. Brown A type adjustable gap earphones normally used for my ham radio reception (my call sign then, and now was G205). Incidentally these phones had conical diaphragms like miniature moving coil speakers which were operated by a cantilever reed.

I found that by wearing the phones connected to the search coil I could sit in any room without being connected by wires and listen to the radio programs. It did occur to me that by having loops upstairs and downstairs I had a Helmholtz coil system which tended to give excellent magnetic field distribution, particularly in the middle of the room. (We use much smaller Helmholtz coils nowadays to determine the screening effect of mumet I can by taking voltages picked up by a search coil in air and then enclosed in the can).

All my experiments were published by me in an article in the Wireless World in the mid 1930's. I remember suggesting that the pick up device in cinemas and theaters could be in the form of a mumetal walking stick or umbrella stick fitted with a search coil, and for the ladies (shades of Queen Victoria) - a mumetal handle with search coil on lorgnette spectacles.

I do not claim to be the originator of induction loops but my amateur pioneering experiments were certainly carried out arid published more than 45 years ago.

Yours truly,
Dr G. A. V. Sowter,
Consultant to Sowter Transformers
PO Box 36, Ipswich IP1 2EG

Holophony

Dear E.T.I.

I was interested to read about Mr Zuccarelli and his Holophony in July ETI, and thought you might be interested to hear of my own experiments with the idea.

About 15 years ago, having built a stereo tape recorder, I then got to wondering why two microphones did not give a very clear recording when two ears were obviously adequate for us. The obvious difference seemed to be the ears.

I then conducted experiments at the dead of night under the bedclothes (not having an anechoic chamber!), trying to decide in the dark where the tick of a pocket watch appeared to come from. I discovered that the various lobes on the outer ear give us a means of judging direction of sound. By pressing down and 'blanking off' different bits of the ear I discovered which bit did which - those at the top tell us about sound above the head, and the bits at the back are to do with front-back direction, and so on.

I then modeled two Plasticine ears and fitted them to omni-directional mic inserts. Fitted to a paper-mache head (filled with cloth , to damp self resonance), the results were quite spectacular - especially using headphones.

I enlisted the help of a few school friends and found that the 'head' gave quite repeatable results. We found we had to put felt 'hair' on the back to aid front-back discrimination.

There seemed to be some variation in perceived results between different people - which seemed to be due to variations in the size of ear, and different hair lengths.

When I was at university, I excitedly announced my findings to my tutor - who was at one time an accomplished recording engineer - He Said: "Oh yes, they did all that research in the '30's at Bell Telephone Labs!" So there I rather left it - but I am sure the principle has possibilities, although there will always be greater or lesser variations between the dimensions of the head and ears used to record and the head and ears which receive the recording, and therefore some subjective variation of results.

As to the idea being new - it seems that truly nothing is.

Yours sincerely
Richard Buswell
Buswell Machine Electronics
Skelmersdale

We're now convinced that there is something more to the holophonic technique than we thought when we published Vivian Capel's report. This is due to Dave Bradshaw having had the opportunity of visiting Hugo Zuccarelli and hearing holophonic sound at first hand, through loudspeakers as well as headphones. We're hoping to do a full report on this at some stage in the future, time and space permitting, but in the meanwhile ETI readers might like to try explaining the results of the following experiment, that you can do for yourselves. It takes two people, one of whom we'll call the experimenter, and the other is the subject.

The subject should shut his or her eyes, and firmly jam a finger in one ear, so that all sound is excluded (so far as possible). The experimenter should take a box of matches (or a ring of keys) and shake it, moving it around the subject's head. The subject should be asked to point in the direction from which the sound is coming. Most people with normal hearing (provided their ears aren't blocked up with wax!) should be able to point approximately in the direction of the sound, even when it is on the other side of the head from the open ear. To make the conditions more stringent, you could start shaking the matches from this side, so that there is no possibility of the brain having a 'reference sound with which to refer the (ear lobe modified) sound to.

If any of our readers have access to an anechoic chamber we'd be most interested in hearing of the results of doing the above experiment in it. We'd also like to hear of anyone who has access to a conventional dummy head recording (Sennheiser did have such a recording, but their UK office was unable to help us).

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ETI PCB SERVICE

Up till now PCBs were always the hardest component to obtain for a project. Of course you could make your own, but why bother anymore! Now you can buy your board straight from the designers - us! As of this issue all (non-copyright) PCBs will be available automatically from the ETI PCB Service. Each board is produced from the same master used to build our prototypes, so you can be sure it's accurate, and will be finished to the high standard you would expect from ETI. In addition to the PCBs for this month's projects, we are making available some of the more popular designs from our recent past. See the list below for details. Please notes that NO OTHER BOARDS ARE AVAILABLE. If it's not listed, we don't have it!

ALWAYS QUOTE THE PCB CODE WHEN ORDERING PLEASE

1979

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- ☐ E/794-2 Click Eliminator 6.64
- ☐ E/796-1 Accented Beat Metronome 3.60

1980

- ☐ E/803-1 Signal Tracer 2.27
- ☐ E/808-1 CMOS Logic Tester. 2.64
- ☐ E/808-3 Ultrasound Burglar Alarm . 2.87
- ☐ E/8010-1 Cassette Interface 2.93
- ☐ E/8010-2 Fuzz/Sustain Box 3.27
- ☐ E/8011-5 RIAA Preamp 1.93
- ☐ E/8011-6 Audio Test Oscillator. . . 3.13
- ☐ E/8012-1 Musical Doorbell 2.80
- ☐ E/8012-3 Four Input Mixer 2.64

1981

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- ☐ E/8111-3 Phone Bell Shifter. 2.96
- ☐ E/8112-1 Alcohometer (2 boards) . 5.21
- ☐ E/8112-3 Bodywork Checker 1.75
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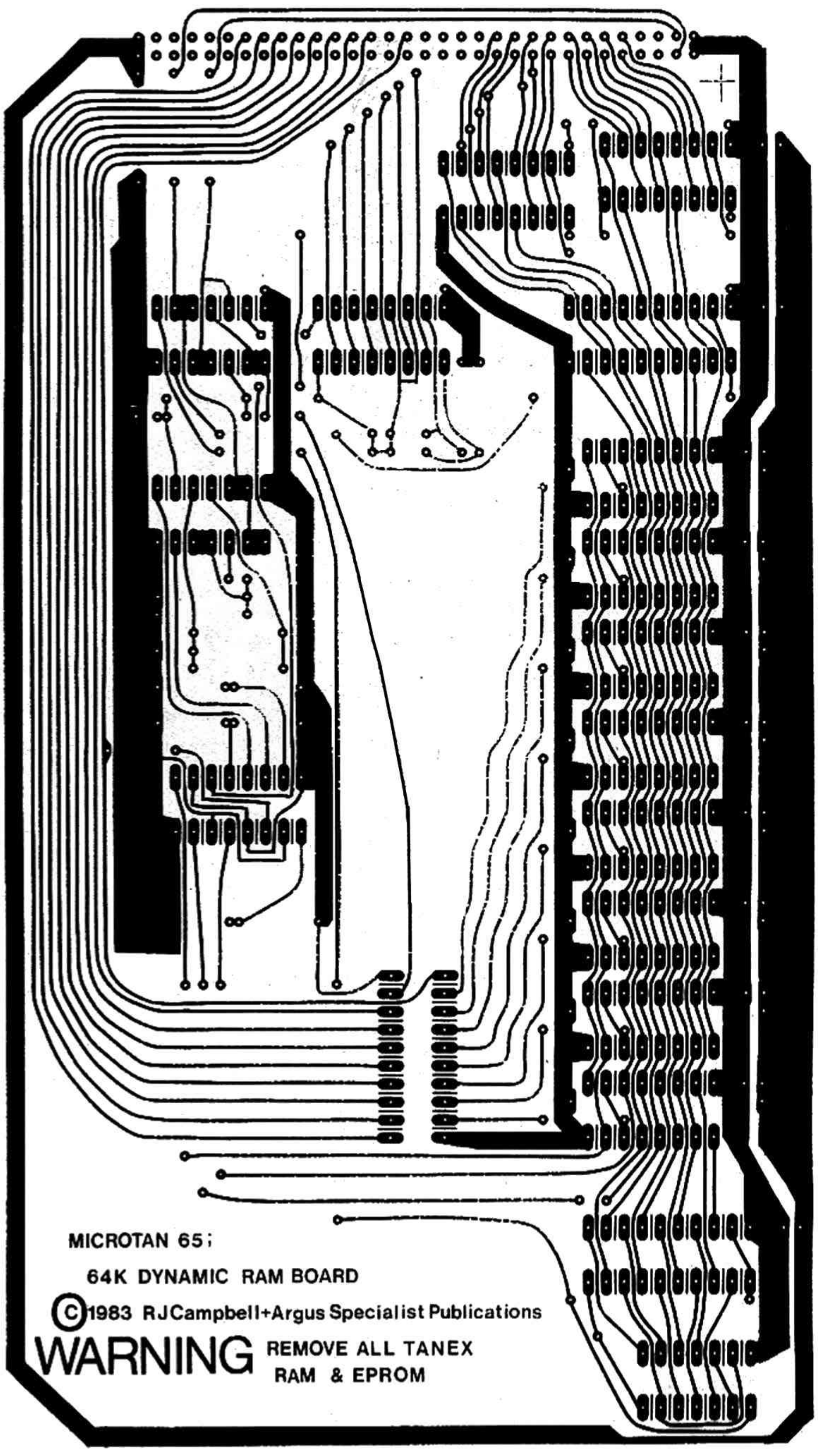

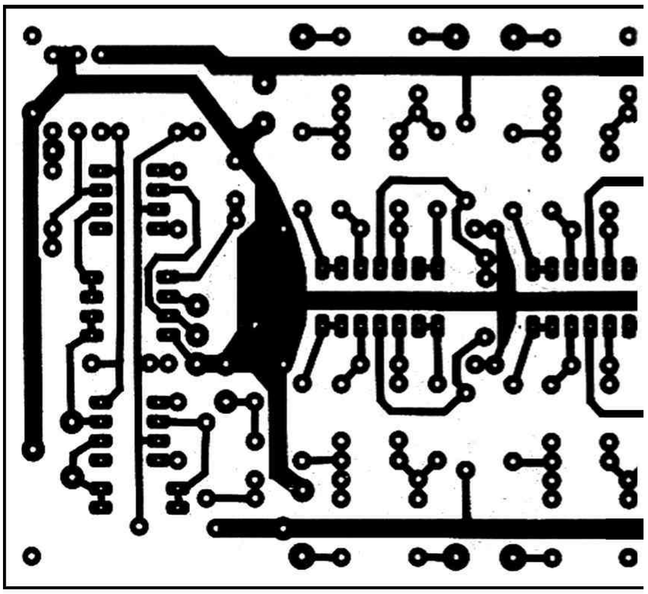

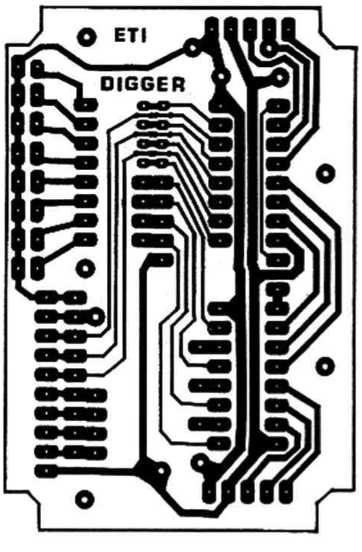

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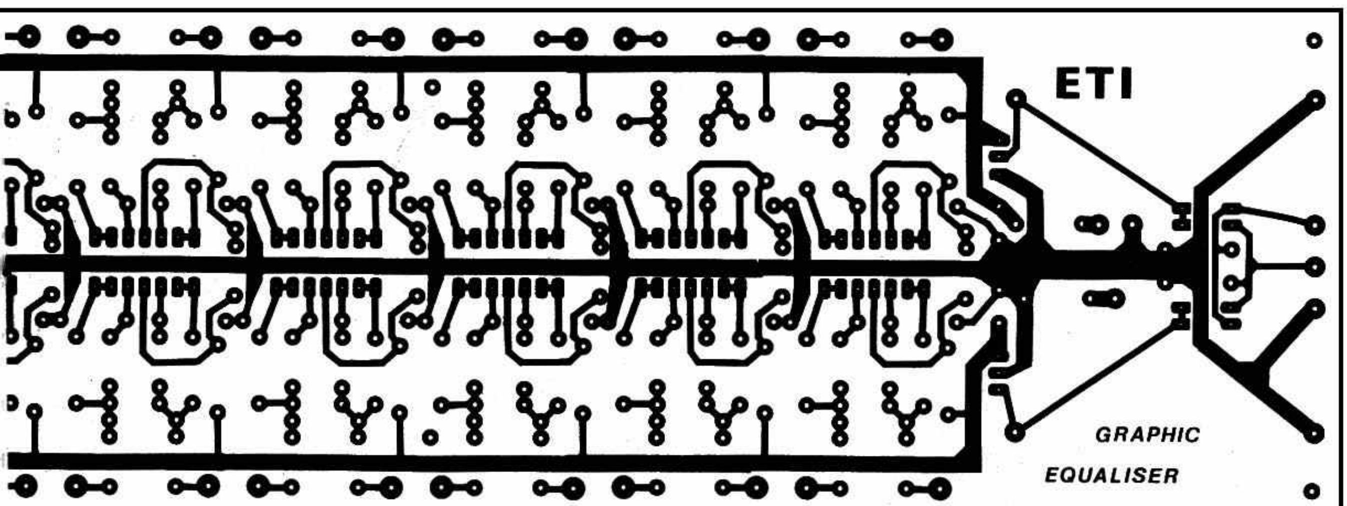

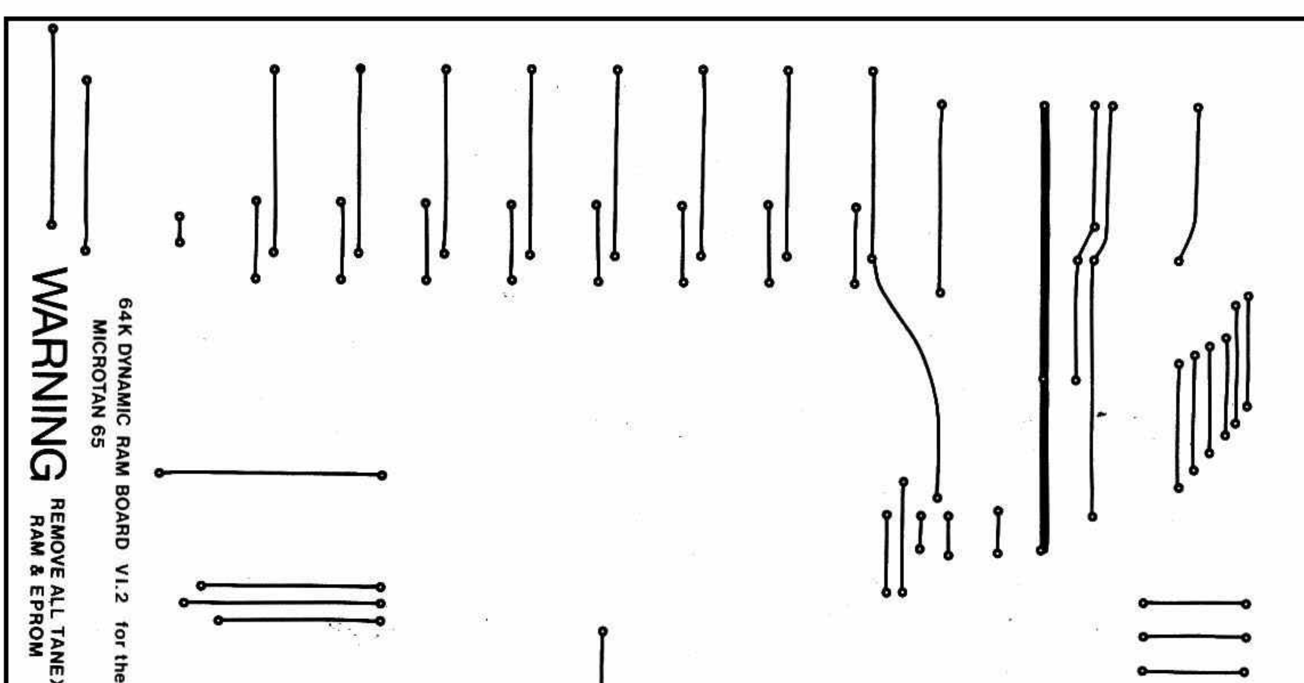

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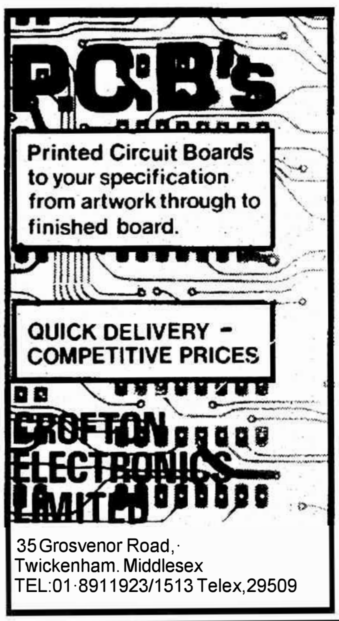

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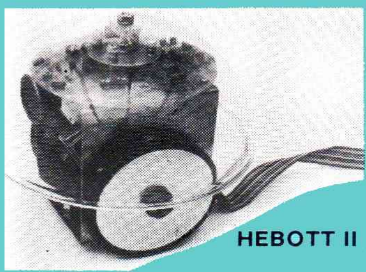

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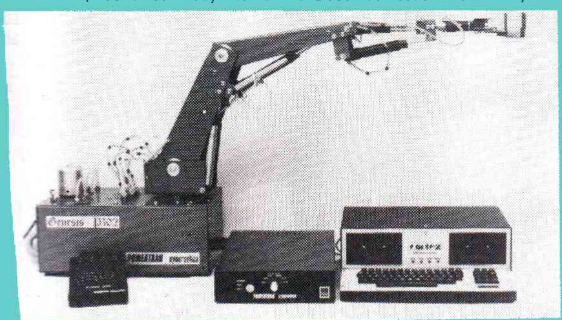

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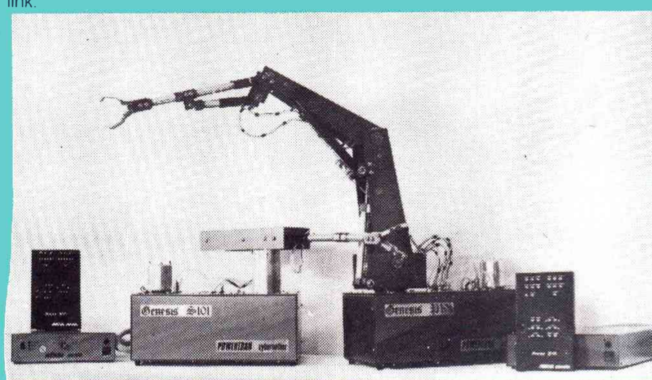
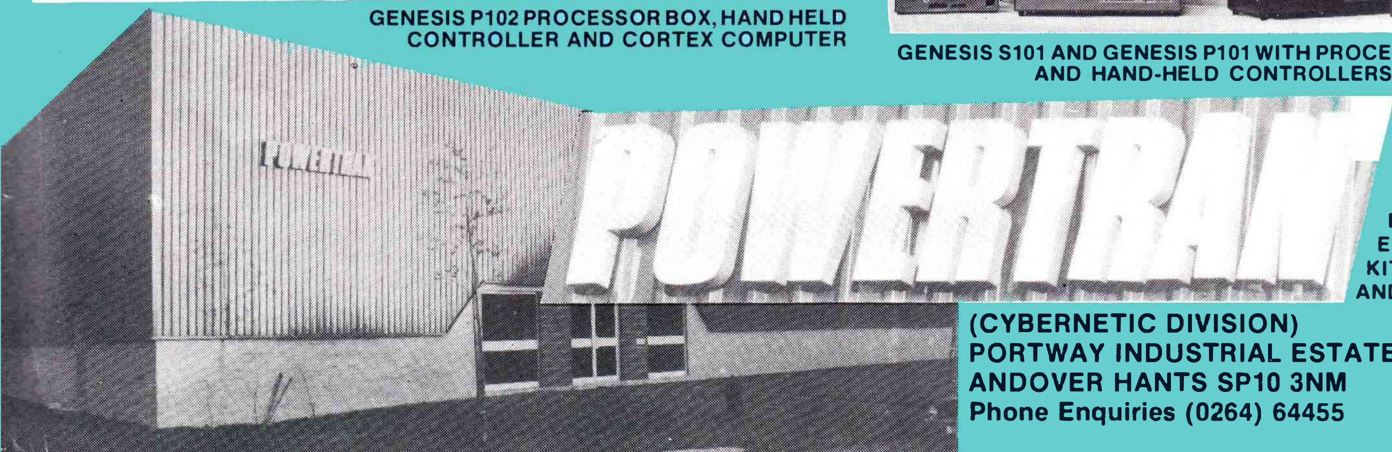


GENESIS S101 AND GENESIS P101 WITH PROCESSOR BOXES AND HAND-HELD CONTROLLERS



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* Projects for Book 8 were in an advanced state at the time of writing, but contents may change prior to publication (due 13th August 1983).

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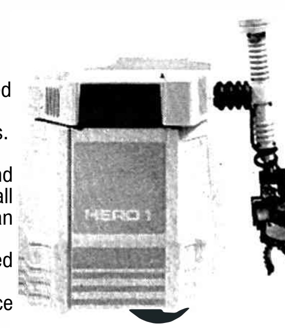

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