AN ARGUS SPECIALIST PUBLICATION

electronics today INTERNATIONAL

June 1983 85p

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PLUS

Switched Mode PSU

PseudoROM: A RAM In ROM's Clothing

Labs On A Chip

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TEST EQUIPMENT BUYING GUIDE

AUDIO....COMPUTING....MUSIC....RADIO....ROBOTICS...

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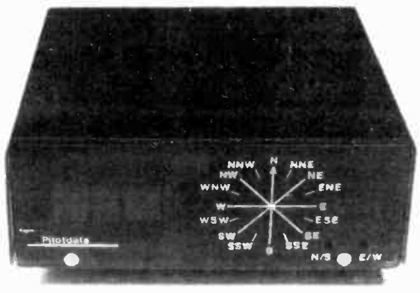
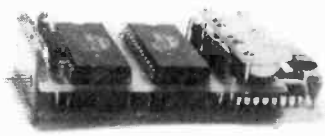
PROJECTS





INFORMATION

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TAG-END CAPACITORS: 64V: 2200 139p; 3300 198p; 4700 245p; 50V: 2200 110p; 3300 164p; 40V: 4700 180p; 25V: 2200 80p; 3300 98p; 4000, 4700 99p; 10,000 320p; 15,000 345p; 16V: 22,000 350p

POLYESTER CAPACITORS: Axial Lead Type 400V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8 11p; 10n, 15n, 18n, 22n 12p; 33n, 47n, 68n 16p; 150n 20p; 220n 30p; 330n 42p; 470n 52p; 680n 1uF 68p; 2u2 82p. 160V: 10nF, 12n, 39n, 100n 11p; 150n, 220n 17p; 330n, 470n 30p; 680n 38p; 1uF 42p; 1u5 46p; 2u2 48p; 4u7 58p. 1000V: 1nF 17p; 10nF 30p; 15n 40p; 22n 36p; 33n 42p; 47n, 100n 42p.

SIEMENS pcb Type Miniature poly Capacitors 250V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 10n, 15n 7p; 18n, 22n, 27n, 33n, 39n, 47n 8p; 39n, 56n 12p; 82n, 100n 11p; 100V: 100n, 120n 10p; 150n, 180n 12p; 220n, 270n 15p; 330n, 390n 20p; 470n, 560n 28p; 680n 30p; 1uF 34p 2u2 50p

POLYESTER RADIAL LEAD CAPACITORS: 250V 10n, 15n, 22n, 27n 6p; 33n, 47n, 68n, 100n 7p; 150n, 220n 10p; 330n, 470n 13p; 680n 19p; 1u 23p; 1u5 40p; 2u2 46p.

FEED-THROUGH CAPACITORS 1000pF/450V 8p

TANTALUM BEAD CAPACITORS 35V: 0.1uF, 0.22, 0.33 15p; 0.47, 0.68, 1.0, 1.5 16p; 2.2, 3.3 18p; 4.7, 6.8 22p; 10 28p; 16V: 2.2, 3.3 16p; 4.7, 6.8, 10 18p; 15, 36p; 22 30p; 33, 47 40p; 100 75p; 10V: 15, 22 26p; 33, 47 35p; 100 55p; 6V: 100 42p.

POTENTIOMETERS: Rotary, Carbon Track 0.25W Log & Lin values. 500Ω, 1KΩ & 2KΩ (Linear only) Single Gang 30p; 5KΩ-2MΩ Single Gang Log & Lin 30p; 5KΩ-2MΩ Single Gang D/P Switch 78p; 5KΩ-2MΩ Double Gang 89p

MYLAR FILM CAPACITORS 100V: 1nF, 2, 4, 4nF, 10 6p; 15nF, 22n, 30n, 40n, 47n 7p; 56n, 100n, 200n 9p; 50V: 470nF 12p.

SLIDER POTENTIOMETERS 0.25W log and linear values 60mm 5KΩ-500KΩ single gang 70p; 10KΩ-500KΩ dual gang 110p; Self Stick Graduated Bezel 40p

CERAMIC CAPACITORS 50V: Range: 0.5pF to 10nF 4p. 15nF, 22nF, 33nF, 47nF 6p. 100nF/30V 7p. 200nF/6V 8p.

PRESET POTENTIOMETERS 0.1W 50Ω 5MΩ Miniature Vertical & Horizontal 7p; 0.25W 100Ω 3.3MΩ horiz. larger 10p; 0.25W 200Ω 4.7MΩ vert. 10p

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POLYSTYRENE CAPACITORS 10pF to 1nF 8p; 1.5nF to 12nF 10p

SILVER MICA (Values in pF) 2, 3.3, 4.7, 6.8, 8.2, 10, 12, 15, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180pF 15p each; 200, 220, 250, 270, 300, 330, 360, 390, 470, 800, 800, 820 21p each; 1000, 1200, 1800, 2200 30p each; 3300, 4700pF 60p each

MINIATURE TRIMMERS Capacitors 2-6pF, 2-10pF 22p; 2-25pF, 5-65pF 30p; 10-88pF 35p.

RAM FOR BBC MICRO 4816AP 100ns 225p

RESISTORS Carbon Film Hi-Stab. 5%

	RANGE	Val	1-99	100+
¼W	2Ω-10M	E24	2p	1p
½W	2Ω-4M7	E12	2p	1p
1W	2Ω-10M	E12	6p	4p
2% Metal Film		E24	6p	4p
1% Metal Film		E24	8p	6p

100+ price applies to Resistors of each type not mixed.

RESISTORS NETWORK S.I.L. 7 Commoned: (8 pins) 100Ω, 680Ω, 1K, 2k2, 4K7, 10K, 47K 100K 25p; 8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K & 100K 28p; 13 Commoned 1K, 4K7, 10K, 47K & 100K 56p

TRANSISTORS

AC126/7	35
AC141/2	30
AC176	28
AC187	37
AC188	32
ACY19/21	75
ACY22/41	75
AD142	120
AD149	79
AD161	42
AD162	42
AF115/6	80
AF118	80
AF124/26	70
AF139	40
AF178	75
AF186	70
AF239	55
BC107	10
BC107B	12
BC108	10
BC108B	12
BC109	10
BC109B	12
BC109C	12
BC114/5	22
BC117/8	20
BC137/9	40
BC142/3	30
BC147B	9
BC148B	9
BC149C	9
BC153/4	27
BC157/8	10
BC159	11
BC160	45
BC167A	10
BC168C	10
BC169C	10
BC170	15
BC171/2	11
BC173	11
BC177/8	16
BC179	20
BC181	20
BC182/3	10
BC184	10
BC182L	10
BC183L	10
BC184L	10
BC188 6/7	25
BC212	10

BC212L	10
BC213	10
BC213L	10
BC214	10
BC214L	10
BC237/8	14
BC256B	30
BC307B	16
BC308	16
BC318	80
BC327/8	15
BC337/8	15
BC441/61	34
BC477	40
BC516/7	40
BC547/8	14
BC549C	14
BC556/7	15
BC558/9	15
BCY39/40	85
BCY45	50
BCY58/59	55
BCY70/71	16
BCY72	20
BCY78	24
BD114	190
BD121	95
BD124	115
BD131/32	48
BD133	70
BD135	45
BD136/37	40
BD138/39	40
BD140	40
BD144/45	198
BD158	55
BD205/6	110
BD245	45
BD378	75
BD517	75
BD645	80
BD695A	125
BD696A	125
BF115	35
BF154/8	25
BF184/5	38
BF194/5	12
BF198/9	18
BF200	80
BF224A	25
BF224B	29
BF245	30

BF256A	35
BF256B	45
BF257/8	32
BF259	35
BF336/7	40
BF594/5	30
BFR39/40	23
BFR41/79	23
BF494/5	30
BFR41/79	23
BFR80/81	25
BFR98	105
BFX29	28
BFX81	45
BFX84	28
BFX85/6	28
BFY50/51	23
BFY52	23
BFY53	23
BFY55/6	32
BFY64	35
BFY81	120
BFY90	80
BRY39	40
BSX20	30
BSX26/29	34
BU105	170
BU205	180
BU206	200
BU208	200
BUY69C	225
E421	250
MD8001	250
MJ2955	70
MJE170	150
MJE180	150
MJE340	64
MJE370	100
MJE371	100
MJE520	95
MJE521	95
MJE2955	99
MJE3055	70
MPF102	40
MPF103	30
MPF104	30
MPF105	30
MPF106	40
MPSA05	25
MPSA08	25
MPSA12	32
MPSA55	30

MPSA56	30
MPSA70	30
MPSU02	58
MPSU05	55
MPSU06	55
MPSU52	65
MPSU55	50
MPSU56	80
MPSU56	80
OC26	170
OC28	220
OC35	50
OC36/41	75
OC71/72	40
OC81/82	50
OC83/84	40
OC170/71	50
OC42	50
OC70	40
OC75/76	40
TIP29A	32
TIP29C	38
TIP30A	35
TIP30C	37
TIP31A	38
TIP31B	39
TIP31C	39
TIP32A	38
TIP32C	42
TIP33A	65
TIP33C	78
TIP34A	74
TIP34C	88
TIP35A	110
TIP35C	128
TIP36A	130
TIP36C	140
TIP41A	60
TIP41B	62
TIP42A	66
TIP42B	58
TIP120	70
TIP121/2	73
TIP141/2	105
TIP147	120
TIP2955	80
TIP3055	80
TIS43	32
TIS44/5	45
TIS88A	50
TIS90/91	30
UC734	65

VK101	80
VN10KM	65
VN46AF	78
VN66AF	80
VN88AF	94
VN89AF	98
ZTX107/8	11
ZTX109	12
ZTX212	28
ZTX300	13
ZTX302	16
ZTX303	25
ZTX304	17
ZTX326	30
ZTX451	23
ZTX500	14
ZTX501/2	16
ZTX603	18
ZTX650	25
ZTX531	25
ZTX550	25
2N697	23
2N698	40
2N699	40
2N706A	18
2N708	19
2N918	35
2N1131/2	24
2N1302	45
2N1671B	180
2N2160	295
2N2219A	28
2N2220A	28
2N2221A	28
2N2222A	25
2N2368	25
2N2369A	18
2N2483/4	27
2N2646	45
2N2904/5	28
2N2906/7	28
2N2907A	28
2N2926G	10
2N3053	28
2N3054	58
2N3055	48
2N3252	46
2N3441/2	140
2N3614/5	199
2N3702/3	10
2N3704/5	10
2N3706/7	10

2N3708/9	10
2N3713	140
2N3771	179
2N3772	195
2N3773	210
2N3819	22
2N3820	38
2N3822/3	45
2N3866	90
2N3903/4	15
2N3905/6	15
2N3906	17
2N4264	24
2N4286	15
2N4314	78
2N4400	18
2N4427	80
2N4871	55
2N5135/6	20
2N5138	18
2N5172	18
2N5179	45
2N5180	45
2N5190/1	75
2N5194	80
2N5305/8	30
2N5457/8	30
2N5459	30
2N5485	38
2N5777	45
2N5879	190
2N6027	32
2SA671	250
2SA715	60
2SC495	70
2SC496	70
2SC1061	250
2SC1096	85
2SC1162	30
2SC1173	125
2SC1306	100
2SC1307	150
2SC1449	85
2SC1678	140
2SC1679	180
2SC1923	50
2SC1945	225
2SC1963	90
2SC1957	90
2SC1969	140
2SC2028	85
2SC2029	210

2SC2078	170
2SC2091	85
2SC2314	85
2SC2166	185
2SC2335	225
2SC2547	30
2SC2612	225
2SD234	74
2SK45	90
2SK288	225
2SJ83	225
2SJ85	225
3N128	112
3N140	112
40315	90
40316	95
40324	100
40326/7	70
40347	90
40348	120
40360	80
40361/2	70
40407/8	75
40411	285
40412	90
40467A	130
40468	85
40594	105
40603	110
40673	75
40871/2	80

RF CHOKES Miniature PCB type 1uH, 2u2, 4u7, 10u, 22u, 33u, 47u, 100u, 220u, 330u, 470u 30p; 1mH, 1m5, 2m2, 4m7, 10mH 35p; 22m, 33m, 43m 60p; 100m 75p

DIODES

AA119	15
AA129	20
AAY30	15
BA100	15
BAX13	20
BY100	24
BY126	12
BY127	12
CR033	250
OA9	40
OA47	12
OA70	12
OA79	15
OA81	20
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	15
1N5404	16
1N5406	17
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

NOISE Diode Z5J 195p

VARICAPS

BA102	50
BB105B	40
BB106	40
BB109B	45
MVAM2	165

BRIDGE RECTIFIERS

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	96
6A/600V	125
10A/200V	215
10A/600V	298
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25A/600V	395
BY164	58
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3A 200V	54
3A 400V	56
8A 100V	60
8A 400V	69
8A 800V	115
12A 100V	78
12A 400V	82
12A 800V	135
16A 100V	103
16A 400V	105
16A 800V	220
25V 500V	220
25A 800V	295
12800D	120

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75154	125
75159	125
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75188/9	55
75322	140
75324	360
75361/3	150
75365	150
75450	86
75451/2	62
75454	70
75491/2	65

SCR THYRISTORS

5A/40V	32
5A 400V	40
5A 600V	48
8A 300V	60
8A 600V	90
12A 100V	78
12A 400V	96
12A 800V	188
BT106	150
BT116	180
C106D	36
TIC44	24
TIC45	29
TIC47	35
2N5062	32
2N5064	38
2N4444	130

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4027	100
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4164-200n	425
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2114-3	325
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8214	425
8216	100

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DS8830	110
DS8831	125
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AY-5-1317A	630
AY-5-1350	388
CA3011	130
CA3012	175
CA3014	275
CA3018	8,
CA3019	80
CA3020	210
CA3023	210
CA3028A	95
CA3035	255
CA3036	270
CA3043	275
CA3045	365
CA3046	70
CA3048	220
CA3059	285
CA3075	213
CA3080E	70
CA3081	190
CA3086	48
CA3089E	215
CA3090AQ	375
CA3123E	165
CA3130	90
CA3140	40
CA3160	95
CA3161	180
CA3162E	450
CA3189	200
HA1336W	240
HA1388	257
ICL7106	690
ICL7107	975

ICL7204	550
ICL7611	99
ICL7660	248
ICL8038CC	300
ICL8211A	150
ICM7205A	1150
ICM7207	475
ICM7215	1050
ICM7216AJ	£22
ICM7216B	£22
ICM7216C	£22
ICM7217A	750
ICM7224	785
ICM7240	300
CM7555	80
CM7556	160
LA3350	250
LA4031P	340
LA4032	295
LA4400	350
LA4422	320
LC7130	340
LC7120	300
LC7137	395
LF347	150
LF351	48
LF353	96
LF355	85
LF356	95
LF357	110
LF398	475
LM10	325
LM301A	24
LM307	45
LM308T	95
LM311	55
LM318N	160
LM319	195
LM324A	65
LM334Z	90
LM335Z	128
LM339	47
LM348	64
LM349	115
LM358	80
LM377	175
LM379	480
LM380	75
LM381N	145
LM382	115
LM384	160
LM386	90
LM387	120
LM389	95
LM393	45
LM558	75
LM725CN	325
LM733	70
LM1458	45
LM1871	325
LM2917	195
TAB1042	110
LM307	45
LM3302	75
LM3900	50
LM3909N	85
LM3911	125
LM3914	250
LM3915	250
LM3916	250
LM13600	110
LS7220	280
M253AA	1150
M51513L	230
M51515L	320
M51516L	475
MB3712	220
MB3756	440
MC1204	250
MC1301	79
MC1303	98
MC1304P	260
MC1310P	150
MC1445	250
MC145106	695
MC1465	50
MC1469	300
MC1494	694

MC1495	350
MC1496L	70
MC1596	225
MC1648	290
MC1709G	90
MC3302	80
MC3340P	120
MC3360P	120
MC3401	65
MC3403	75
MC3405	150
MC3423	80
MC4016	00
MF10	350
MFC6040	75
MK50398	635
ML924	275
MSM5526	820
NE515	275
NE529	225
NE531	140
NE534	150
NE543K	225
NE544	210
NE555	16
NE556	45
NE560	325
NE561	398
NE562B	410
NE564	420
NE565A	120
NE566	155
NE567V	140
NE570	410
NE571	400
NE5532	145
NE5534A	150
OM335	750
RC4136D	60
RC4556	45
S566B	225
SAB3209	425
SAB3210	325
SAB3271	485
SAB4209	585
SG3402	295
SL490	350
SL6270CD	150
SN76013	350
SN76023ND	240
SN76131	125
SN76227N	95
SN76477	420
SN76488	480
SP8629	299
TA7130	150
TA7204	175.
TA7205	90
TA7222	150
TA7120	160
TA7310	125
TAA621AX1	295
TAA661A	190
TAA700	275
TAA900	395
TAD100	159
TBA120S	70
TBA540Q	275
TBA550Q	330
TBA641BX or BX11	290
TBA651	190
TBA800	80
TBA810	95
TBA820	80
TBA920Q	200
TBA950	300
TBA990Q	350
TBA540	275
TC9109	775
TCA220	350
TCA270Q	350
TCA280A	220
TCA940	175
TCA965	145
TDA1004	290
TDA1008	310

TDA1022	499
TDA1024	115
TDA1034	350
TDA1490	350
TDA2002	325
TDA2004	495
TDA2020	320
TDA2030	295
TDB0701	420
TL170	50
TL061CP	40
TL062CP	80
TL064CN	98
TL071CP	24
TL072CP	45
TL074CN	100
TL081CP	24
TL082CP	45
TL083CP	75
TL084CN	90
TL091CP	55
TL507	110
UA2240	120
UA78540	230
UGN3020T	160
ULN2001	80
ULN2003	75
ULN2004	75
ULN2283	100
UPC575	275
UPC1025H	375
UPC1182	320
UPC1156H	275
UPC1366	195
XR2206	300
XR2207	375
XR2211	575
XR2216	675
XR2266	360
ZN414	80
ZN419E	180
ZN423E	130
ZN424E	130
ZN425E	345
ZN426E	300
ZN427E	600
ZN428E	410
ZN429E	210
ZN459	325
ZN1034E	200
ZN1040E	666
ZNA234E	850

TTL74

7400	11
7401	11
7402	11
7403	12
7404	13
7405	16
7406	20
7407	20
7408	14
7409	14
7410	14
7411	16
7412	18
7413	18
7414	24
7416	20
7417	20
7420	15
7421	20
7422	20
7423	20
7425	18
7426	18
7427	15
7428	26
7430	14
7432	22
7433	22
7437	25
7438	22

7440	16
7441	55
7442	32
7443	90
7444	90
7445	55
7446	80
7447	40
7448	45
7450	16
7451	16
7453	16
7454	16
7460	16
7470	35
7472	24
7473	28
7474	20
7475	25
7476	25
7480	48
7481	120
7482	85
7483	38
7484	70
7485	60
7486	20
7489	170
7490	20
7491	35
7492	25
7493	25
7494	35
7495	35
7496	35
7497	90
74100	80
74104	50
74105	55
74107	20
74109	25
74110	35
74111	55
74112	170
74116	60
74118	55
74119	80
74120	80
74121	25
74122	35
74123	35
74125	35
74126	35
74128	35
74132	30
74136	28
74141	55
74142	175
74143	210
74144	210
74145	50
74147	75
74148	80
74150	50
74151	40
74153	40
74154	55
74155	40
74156	40
74157	30
74159	80
74160	80
74161	48
74162	40
74163	40
74164	40
74165	48
74166	48
74167	150
74170	125
74172	250
74173	80
74174	54
74175	65
74176	40
74177	45
74178	80
74179	80

74180	40
74181	115
74182	60
74184	90
74185	95
74188	250
74190	48
74191	46
74192	44
74193	46
74194	40
74195	40
74196	48
74197	40
74198	80
74199	84
74221	54
74246	120
74247	120
74248	120
74249	120
74251	68
74259	150
74265	55
74273	150
74276	120
74278	100
74279	50
74283	60
74284	165
74285	165
74290	105
74293	80
74297	236
74298	100
74351	195
74365	30
74366	30
74367	30
74368	30
74390	75
74393	90
74430	95

74C

74C244	195
74C245	195
74C373	240
74C374	245
74C922	420
74C923	500

74S

74S00	30
S02	30
S03	30
S04	30
S05	60
S08	60
S20	40
S32	70
S74	75
S86	65
S112	80
S114	80
S132	110
S133	60
S138	100
S139	115
S157	225
S158	210
S188	140
S189	140
S194	195
S195	195
S201	250
S225	240
S241	250
S244	290
S251	170
S257	170
S262	860
S287	225
S288	210
S289	200

S301	360
S412	380
S470	325
S471	620
S472	1150
S475	800
S571	620

74LS

LS00	11
LS01	11
LS02	11
LS03	12
LS04	12
LS05	12
LS08	12
LS09	12
LS10	12
LS11	12
LS12	13
LS13	15
LS14	26
LS15	12
LS20	12
LS21	12
LS22	12
LS	75
LS254	80
LS26	12
LS27	13
LS28	14
LS30	13
LS32	13
LS33	16
LS37	15
LS38	15
LS40	13
LS42	28
LS47	35
LS48	45
LS49	50
LS51	14
LS54	14
LS55	14
LS63	120
LS73	18
LS74	18
LS75	20
LS76	18
LS78	18
LS83	38
LS85	42
LS86	18
LS90	24
LS91	60
LS92	32
LS93	23
LS95	40
LS96	95
LS107	40
LS109	23
LS112	22
LS113	20
LS114	22
LS122	36
LS123	36
LS124	90
LS125	24
LS126	25
LS132	30
LS133	30
LS136	24
LS138	25
LS139	28
LS145	70
LS147	100
LS148	75
LS151	40
LS153	40
LS155	30
LS156	36
LS157	25
LS158	30
LS160	32
LS161	37
LS162	35

LS163	35
LS164	43
LS165	50
LS166	52
LS168	84
LS169	00
LS170	70
LS173	50
LS174	36
LS175	36
LS181	90
LS183	105
LS190	36
LS191	36
LS192	36
LS193	37
LS194	35
LS195	35
LS196	45
LS197	46
LS221	55
LS240	55
LS241	55
LS242	55
LS243	55
LS244	50
LS245	70
LS247	50
LS248	55
LS249	55
LS251	30
LS253	32
LS257	30
LS258	35
LS259	55
LS260	22
LS261	100
LS266	20
LS273	54
LS275	125
LS279	30
LS280	90
LS283	40
LS290	40
LS293	40
LS295	75
LS298	80
LS299	150
LS320	200
LS323	160
LS324	168
LS325	295
LS326	240
LS327	240
LS347	95
LS348	90
LS352	62
LS353	62
LS356	240
LS363	140
LS365	28
LS366	32
LS367	28
LS368	35
LS367	60
LS374	55
LS375	50
LS377	85
LS378	80
LS379	110
LS384	395
LS385	250
LS386	54
LS390	46
LS393	42
LS394	00
LS396	150
LS398	140
LS399	150
LS445	100
LS447	100
LS465	75
LS490	200
LS540	75
LS541	80
LS624	80
LS640	180
LS641	180
LS645	180
LS668	125
LS669	120
LS70	100
LS73	550
LS74	550
LS87	350
LS99	99

SWITCHES

TOGGLE 2A 250V
SPST 33p
DPDT 44p

SUB-MIN TOGGLE
SPST on/off 54p
SPDT c/over 60p
SPDT centre off 85p
SPDT biased both ways 105p
DPDT 6 tags 75p
DPDT centre off 88p
DPDT biased both ways 145p
DPDT 3 positions on/on/on 185p
3-pole 2 way 205p

SLIDE 250V:
DPDT 1A 14p
DPDT 1A c/off 15p
DPDT ½A 13p

PUSHBUTTON 6A
with 10mm Button
SPDT latching 99p
DPDT latching 145p
SPDT moment 99p
DPDT moment 145p

Mini Non Locking
Push to Make 15p
Push to Break 25p

OIL SWITCHES
(SPST) 4 way 70p; 6 way 85p;
8 way 90p; 10 way 145p.
(SPDT) 4 way 190p.

ROTARY SWITCHES:
(Adjustable Stop type)
1 pole/2 to 12 way; 2p/2 to 6 way;
3 pole/2 to 4 way; 4p/2 to 3 way 45p
ROTARY: Mains DP 250V 4 Amp on/off 68p

ROTARY: (Mak-a-switch)
Make a multiway switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers
(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; 6-/2 way 65p
Mains DP 4A Switch to fit 45p
Spacers 4p. Screen 6p

ROCKER: 5A/250V SPST 28p
ROCKER: 10A/250V SPDT 38p
ROCKER: 10A/250V DPDT c/off 95p
ROCKER: 10A/250V DPST with neon 85p

THUMBWHEEL Mini front mounting
Decade Switch Module 220p
B.C.D. Switch Module 275p
Mounting Cheeks (per pair) 75p

VEROBOARD 0.1in

	clad	plain
2½ × 3¾	85p	–
2½ × 5	100p	–
3¾ × 3¾	100p	–
3¾ × 5	115p	
3¾ × 17	390p	98p
4¾ × 17	496p	275p
Pkt of 100 pins		55p
Spot face cutter		150p
Pin insertion tool		185p

VERO WIRING
PEN + spoool 340p
Spare spool 75p
Combs 8p

VQ Board 195p
DIP Board 395p
Vero Strip 95p

PROTO DECs
Veroblock 405p
S-Dec 360p
Eurobreadboard 520p
Bimboard 1 575p
Superstrip SS2 1360p

DALO ETCH RESIST PEN
Plus spare tip 90p

FERRIC CHLORIDE
1 lb bag Anhydrous 195p + 50p P&P

ULTRASONIC TRANSDUCER
40KHz 325 pr

IDC CONNECTORS

	PCB Plugs with latch Strt Pins	Angle pins	Female Header Plug	Female Card Edge Connect
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	–
20 way	145p	166p	125p	195p
26 way	175p	200p	150p	240p
34 way	205p	236p	160p	320p
40 way	220p	250p	190p	340p
50 way	235p	270p	200p	395p
60 way	–	–	230p	495p

EURO CONNECTORS

	Female Socket Strt. Pins	Female Socket Angle Pins	Male Plug Strt. Pins	Male Plug Angle Pins
DIN41617 31 way	170p	–	–	175p
DIN41612 2×32 A+B	275p	320p	220p	285p
DIN41612 2×32 A+C	295p	340p	240p	300p
DIN41612 3×32 A+B+C	380p	385p	280p	395p

PANEL METERS

FSD
60 × 46 × 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 AC
0-300V AC
"S"
"VU" 425p each

RELAYS

Miniature, enclosed, PCB mount.
SINGLE POLE Changeover
RL-91 205Ω Coil; 12V DC, 10V5 to 19.5V). 10A at 30V DC or 250V AC 185p
DOUBLE POLE Changeover. 6A 30V DC or 250V AC
RL6-100 53Ω Coil, 6V DC (5V4 to 9V9 190p
RL6-111 205Ω Coil, 12V DC (10V7 to 19V5) 195p
RL6-114 740Ω Coil, 24V DC (22V to 37V) 200p

AMPHENOL PLUGS
IEEE 24 Way 550
Centronics Parallel 36 Way solder 530
Centronics Parallel 36 Way IDC 495
Centronics 36 Way IDC Female 520p

COPPER CLAD BOARDS

Fibre glass	Single sided	Double sided	S.R.B.P. 9.5 × 8.5
6 × 6	90p	110p	95p
6 × 12	150p	195p	

DIL SOCKETS

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

EDGE CONNECTORS

	.1	.156
2 × 15 way	–	140p
2 × 18 way	180p	145p
2 × 22 way	198p	200p
2 × 23 way	175p	–
2 × 25 way	225p	220p
2 × 28 way	190p	–
2 × 30 way	245p	–
2 × 36 way	295p	–
2 × 40 way	315p	–
2 × 43 way	395p	–
2 × 75 way	550p	–

DIL PLUG (Header)

	Solder	IDC
14pin	40p	99p
16pin	49p	105p
24pin	88p	178p
40pin	250p	255p

ZIF DIL SOCKETS
24 pin 575p
28 pin 820p
40 pin 975p

RIBBON CABLE
price per foot

	Grey	Color
10 way	15p	28p
16 way	25p	40p
20 way	30p	50p
24 way	40p	65p
34 way	60p	85p
40 way	70p	90p
50 way	100p	135p
64 way	120p	160p

CRYSTALS

32.768KHz	100
100KHz	235
200KHz	288
455KH	370
1MHz	275
1.008M	275
1.28MHz	382
1.6MHz	395
1.8NHz	395
1.8432M	200
2.0MHz	225
2.4576M	200
3.278M	150
3.5794M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.80MHz	200
4.194304M	200
4.433619M	100
5.0MHz	180
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	160
6.5536MHz	225
7.0MHz	150
7.168MHz	250
7.7328MHZ	250
7.68MHz	200
8.0MHz	150
8.08333M	395
8.86723M	175
9.00MHz	150
10.0MHz	175
10.24MHz	200
10.7MHZ	150
12.0MHZ	175
12.528M	300
14.31814M	170
16.0MHz	200
18.0MHz	180
18.432M	160
20.0MHz	200
19.968MHz	150
24.0MHz	170
24.930MHz	325
26.69M	150
27.648M	170
27.145M	190
38.66667M	175
48.0MHz	170
100.0MHz	295
116.0MHz	250

BUZZERS, miniature, solid-state
6V: 9V & 12V 70p
PIEZO TRANSDUCERS
PB2720 55p

LOUDSPEAKERS
Miniature, 0.3W: 8Ω
2in, 3¼in, 2¼in, 3in 60p
2¼in 40Ω, 64Ω or 80Ω 80p

ASTEC UHF MODULATORS
Standard 6MHz 325p
Wideband 8MHz 480p

'WEMON' New Version WATFORD'S Ultimate Monitor IC
A 4K Monitor chip specially designed to produce the best from your: Superboard Series I & II, Enhanced Superboard & UK101. As reviewed by Dr A. A. Berk in Practical Electronics, June 1981.
Only £10

ETI PROJECTS
We stock most of the parts

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
Double ended DIP (Header Plug) Jumper				
6 inches	185p	205p	300p	465p
12 inches	198p	215p	315p	490p
24 inches	210p	235p	345p	540p
36 inches	230p	250p	375p	595p

IDC Female Header Socket Jumper Leads 24"

	20 pin	26 pin	34 pin	40 pin
Single ended	160p	200p	260p	300p
Double ended	290p	370p	480p	525p

ANTEX SOLDERING IRON
C-15W 455p CX17W 475p
CCN-15W 495p CX25W 510p
Spare tips, assorted sizes 65p
Spare elements 210p
Iron Stand with sponge 165p

SIL SOCKET
0.1" pitch
20 way
65p

'D' CONNECTORS

miniature	9 way	15 way	25 way	37 way
Male				
Solder lugs	80p	105p	180p	250
Angle pins	150p	210p	250p	385p
PCB pins	120p	130p	195p	295p
Female				
Solder lugs	105p	180p	200p	335p
Angle pins	165p	215p	290p	440p
PCB pins	150p	180p	240p	420p
Covers	90p	85p	90p	100p

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

25 way 'D' CONNECTOR (RS232)
Jumpe Lead Cable Assembly
18" long, Single end, Male 495p
18" long, Single end, Female 525p
36" long, Double Ended, M/M 1025p
36" long, Double Ended, F/F 1050p
36" long, Doubel Ended, M/F 995p

TRANSFORMERS:

3-0-3V; 6-0-6V; 9-0-9V; 12-0-12V; 15-0-15V @ 100mA 98p
pcb mounting. Miniature, Split Bobbin
3VA: 2x6V-0.25A; 2x9V-0.15A; 2x12V-0.12A; 2x15V-0.1A 200p
6VA: 2x6V-0.5A; 2x9V-0.3A; 2x12V-0.25A; 2x15V-0.2A 270p
Standard Split Bobbin type:
6VA: 2x6V-0.5A; 2x9V-0.4A; 2x12V-0.3A; 2x15V-0.25A 220p
12VA: 2x4.5V-1.3A; 2x8V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A 295p (35p p&p)
24VA: 2x6V-1.5A; 2x9V-1.2A; 2x12V-1A; 2x15V-0.8A; 2x20V-0.6A 330p (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-1A; 2x30V-0.8A 465p (60p p&p)
Specially wound for Multirail Computer PSUs
50VA: Outputs +5V/5A; +12V, +25V, −5V, −12V at 1A 575p (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x25V-2A; 2x30V-1.5A; 2x50V-1A 920p (75p p&p charge to be added over and above our normal postal charge).

VOLTAGE REGULATORS

1A	TO220 +ve	Plastic	–ve	Casing
5V	7805	40p	7905	45p
12V	7812	40p	7908	60p
15V	7815	40p	7912	45p
18V	7818	40p	7915	45p
24V	7824	40p	7918	45p
			7924	45p
100mA TO92 Plastic package				
5V	78LO5	30p	79LO5	80p
6V	78LO6	30p	–	
8V	78LO8	30p	–	
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

ICL7660 248p TAA550 50p
RC4194 375p TDA1412 160p
RC4195 160p 78H05 +5V/5A 550p
LM309K 135p 78H12 +12V/5A
LM317K 320p 580p
LM317KP 99p 78HG +5V to +25V
LM323K 460p 5A 599p
LM337 175p 79HG +2.25V to 24V
LM723 Var 38p 5A 686p

SOLDERCON PINS
Ideal for making SIL or DIL Sockets
100 pins 75p
500 pins 350p

ALUM BOXES

3 × 2 × 1"	65p
4 × 2½ × 2"	85p
4 × 2½ × 2½"	103p
4 × 4 × 2"	105p
4 × 4 × 2½"	120p
5 × 4 × 1½"	99p
5 × 4 × 2½"	120p
5 × 2½ × 1½"	90p
5 × 2½ × 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"	260p
12 × 8 × 3"	295p

● SPECIAL OFFER ●

	1+	50+
2764	450p	395p

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4008	32	4082	13	4553	245
4009	24	4085	50	4554	190
4010	24	4086	60	4555	35
4011	10	4089	125	4556	35
4012	16	4093	20	4557	320
4013	20	4094	70	4558	120
4014	46	4095	95	4559	395
4015	40	4096	70	4560	160
4016	20	4097	290	4561	104
4017	32	4098	75	4562	495
4018	45	4099	110	4566	165
4019	25	4160	95	4568	250
4020	42	4161	99	4569	175
4021	40	4162	99	4572	38
4022	40	4163	99	4580	480
4023	13	4174	99	4581	250
4024	32	4175	105	4582	99
4025	13	4194	105	4583	90
4026	80	4408	790	4584	40
4027	20	4409	790	4585	60
4028	39	4410	725	4597	330
4029	45	4411	675	4599	290
4030	15	4412	775	40085	90
4031	125	4415	480	40097	45
4032	80	4419	280	40098	42
4033	125	4422	770	40100	215
4034	140	4435	850	40101	130
4035	45	4440	999	40102	140
4036	275	4450	350	40103	175
4037	115	4451	350	40104	95
4038	110	4490	350	40105	105
4039	250	4500	675	40106	35
4040	40	4501	28	40107	60
4041	40	4502	60	40108	198
4042	40	4503	40	40109	80
4043	40	4504	75	40110	198
4044	40	4505	186	40114	240
4045	105	4506	35	40161	194
4046	46	4507	35	40163	50
4047	40	4508	130	40174	45
4048	40	4510	46	40175	50
4049	25	4511	45	40181	220
4050	25	4512	50	40182	90
4051	45	4513	199	40192	75
4052	60	4514	115	40193	70
4053	50	4515	115	40194	70
4054	85	4516	55	40195	75
4055	85	4517	275	40244	195
4056	85	4518	40	40245	195
4057	1915	4519	30	40257	195
4059	435	4520	50	40373	160
4060	45	4521	90	40374	160
4061	1195	4522	125	45106	595
4062	995	4526	70		
4063	85	4527	65		
4066	24	4528	70		
4067	245	4529	150		
4068	14	4530	90		
4069	16	4531	130		
4070	13	4532	70		
4071	13	4534	400		
4072	13	4536	275		
4073	16	4538	80		
		4539	90		

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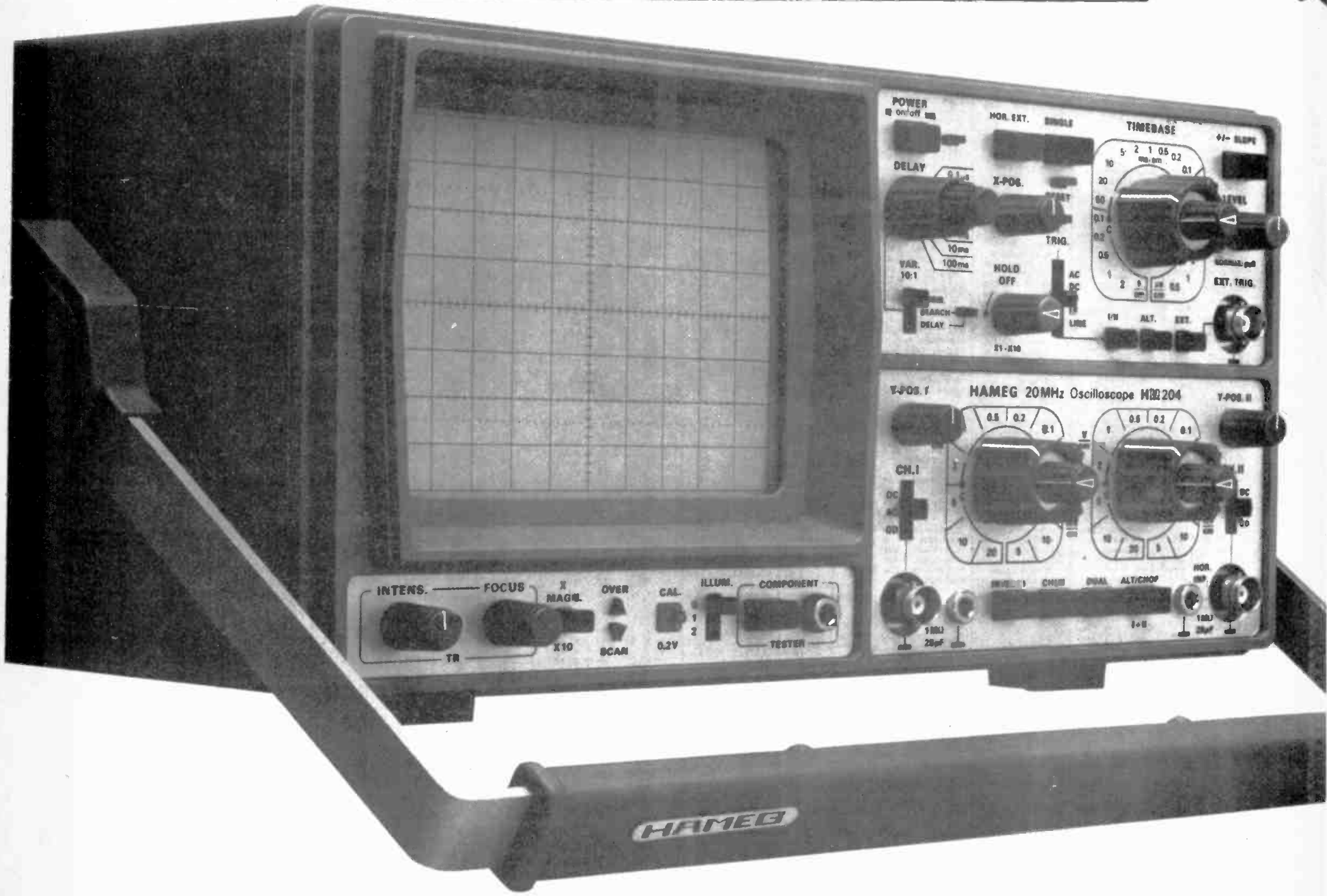
Send SAE for details.

NEXT MONTH

electronics today INTERNATIONAL



Portable Induction Loop

Following the degree of interest that our feature on Induction Loops aroused, Vivian Capel has designed a practical system. Now there's no excuse for the hard-of-hearing to be left out of things anymore.

Tech Tips Special

Eight pages of ingenious, novel, and money-saving designs from one of the country's largest design teams — yourselves.

Microcomputer Output Driver

Don't let your micro just sit there, contentedly passing information back and forth inside itself — get it busy working for *you*, with this 16-channel output driver.

TV Storage Scope

This little unit will enable you to utilise your TV screen to display oscilloscope waveforms. It's always seemed illogical that you have to use two CRTs for different jobs, hasn't it — now you can use just the one. Not only that, but the unit will store waveforms too, all for under £100.

Oscilloscope Survey

Just in case you're too lazy to build the TV Scope, we're taking a look at the options open if you want to buy one. And if you're too poor to afford a new scope, we'll be examining the state of the second-hand market too. If you're on the look-out for test equipment, don't miss the July issue of ETI.

LOOK OUT FOR THE JULY ISSUE ON SALE JUNE 3rd

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

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TS70 70 Thermal Switch
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With a microcomputer as an alternative keyboard the world is even greater adding bulk updating to viewdata computers an receiving telesoftware for implementation to any personal computer.

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An attractive stylish case is available to complement the finished kit.

Basic Teletext Kit (no box) £130 + VAT P/P £2.50
with box £144.95 + VAT P/P £3.00
box by itself £14.95 + VAT P/P 75p

PRESTEL ADAPTOR

NEW

A Prestel micro computer adaptor to give full autodialing to your microcomputer. All the usual Prestel facilities are added via this unit, plus many more, and, can operate to any viewdata computer.

You can shop from home, bank transmitt messages and receive software, which means that the uses your micro can be put to are limitless.

The unit is not restricted to just the UK, for at least 28 countries use the Prestel viewdata format, so you can also mail-order from anywhere. The Prestel unit is suitable for most micro computers even the ZX-81, so at the push of a button, the technology of tomorrow is in your home today.

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31 Way E. C. Plug	2.00
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DIGEST

Compressor/ Limiter Tips

Ian Martin, designer of the Compressor/Limiter project we ran last month, has written suggesting some setting up hints. He thinks it would be wise to check the operation of the DC side chain before inserting the VCA chips IC2, 5 and 7: if there was a fault in the side chain which resulted in no curent being passed into the control pins on IC7 (pins 1 and 16), it's possible that the output of IC2 and IC5 could swing to the positive or negative supply rail and damage the LM13600 which follows. For this reason we suggest that these ICs are removed and the input currents to pins 1 and 16 of IC7 are measured. These should be in the region of 66 uA (V_{MIN}/7k5), and V_{MIN} should be 0V5. Both these measurements should be made with no input signal present.

New From ILP!

15 VA transformers — all fully encased in ABS plastic shells with easy fixing by an M4 bush at the base. ILP are planning to extend this facility throughout the year to cover transformers up to 120VA. ILP Electronics, Graham Bell House, Roper Close, Canterbury, Kent CT2 7EP.

Two-way Tapping

Complete two-way 'live' telephone conversations can be recorded with the Ansafone 600. This microprocessor controlled unit switches from its usual role as a telephone answering machine to a two-way conversation recorder in less than a second. Ansafone, Lyon Way, Frimley Road, Camberley, Surrey.

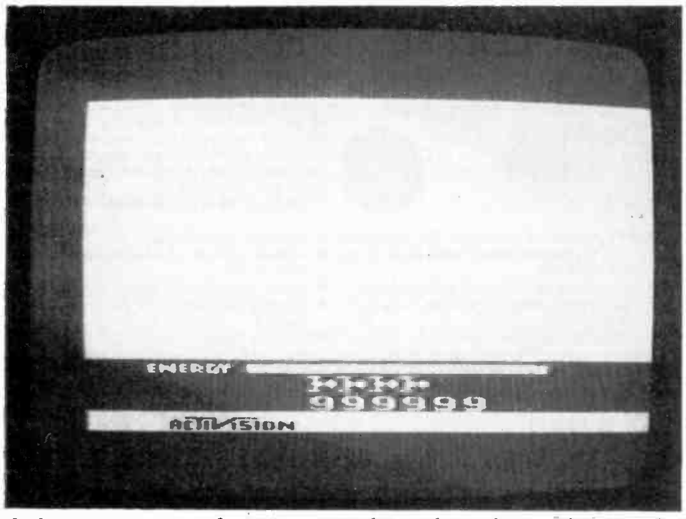
The Sinclair That Never Forgets

ROM-81 is a memory expansion unit for the ZX81 personal computer which enables the user to read useful routines and commonly used information, stored in U.V. erasable, programmable Read Only Memory. The unit is supplied without EPROMs as these are normally programmed and provided by the user.

Two 24 pin sockets allow either 2716 or 2732 EPROMs to be used. They can provide up to 8K of memory in 2K increments. The sockets are decoded to lie between 8K and 16K in the ZX81 memory map, which is just below the BASIC area. Separate 2K and 4 k decoding is link selectable to make it possible to vacate locations occupied by other peripheral cards.

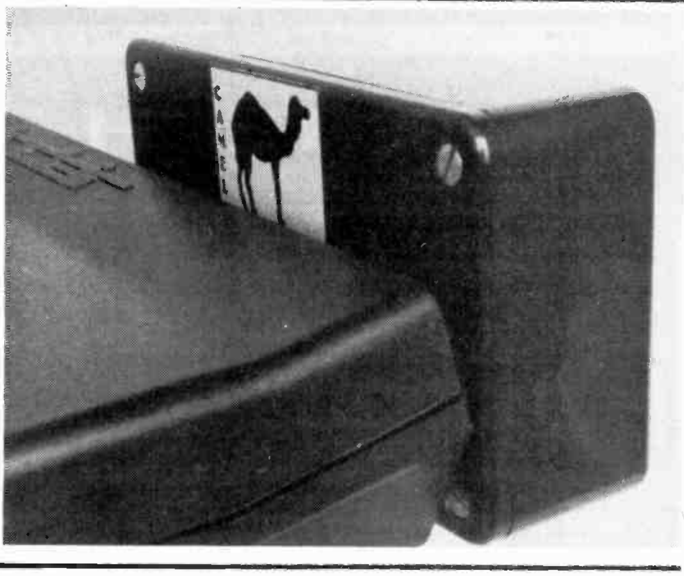
ROM-81 has additional circuits to allow the use of slow EPROMs. The most popular EPROMs have a maximum access time of 450 nS. This is too slow for the ZX81. A special Wait State circuit in ROM-81 automatically requests the CPU in the ZX81 to wait until data has been read. Wait States do very slightly decrease the speed of operation of the computer and affect precise calculations of delay loops. The key device has therefore been socketed. Removing it will prevent implementation of Wait States.

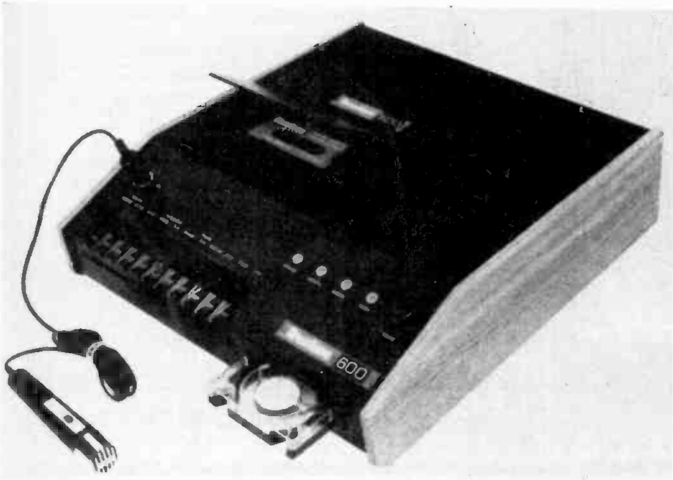
ROM-81 comes in a black ABS case with a screwed down cover for quick accessibility without vulnerability. It plugs on to the ZX81 with an adaptor at the rear of the box for further expansions. It is supplied with easy to follow User Notes which give the programs for data retrieval. (But what is the camel for? — Ed).



Megamania Mangled

We did it! We penetrated the deep mysteries of what lies beyond the magic million of Megamania (new readers will not be aware that this is the best game in the Universe). After a finger-mangling fight with the Atari joystick during a game that dragged on for an hour and a quarter, Peter "I'll beat it if it kills me" Green finally got to 999,999 with four spare lives, as evidenced by this photograph. The result was something of an anticlimax, as the game simply latches up. No fanfare, no screen message of congratulations, no dancing girls — the game just dies, its little software counter overloaded. Pity, that — now we can only score it 9½ instead of 10.





New Catalogue From Toolmail

The new 1983 Toolmail 128-page full colour catalogue is now on sale, offering better value than ever before. With 600 new items and over 2,000 tools illustrated, the product range available must be larger than any specialist tool shop. Prices are still really competitive and all items are available for immediate delivery through Toolmail's efficient nationwide mail order service.

In addition, there are many new features in the 1983 Toolmail catalogue. Of particular interest are the three £1 vouchers to be found on page 128. Valid until July 31, 1983 they are each redeemable on any order in excess of £10.

A further Toolmail venture for 1983 is the opening of the Sevenoaks Tool Room in March. Many of the tools in catalogue will be available there. Others may be ordered there through the regular Toolmail service for delivery by post. Customers may also redeem their Toolmail vouchers at the Sevenoaks Tool Room.

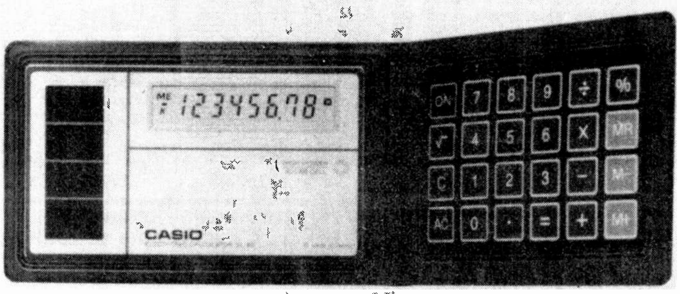
The catalogue is available in all major newsagents price £1. Copies are also available direct from Toolmail (1982) Limited, PO Box 46, Maidstone, Kent ME15 8EQ.

Centronics Interface For Spectrum

If you're frustrated with the limitations of the ZX printer or would like to utilize your Spectrum for business use you can now link your Spectrum to Centronics type printers with the use of a Kempston Centronics Interface.

A major feature is the recognition of LLIST and LPRINT by the interface. This allows programs to be listed directly from your Spectrum and also allows you to print-out direct from listings (BASIC only) without the need of special user calls. It is also possible to send out control codes to the printer giving the facility of different characters, i.e., condensed, expanded, etc. The interface is supplied cased and ready to use by simply plugging directly into a Centronics type printer, eg all Epsons including MX-80 F/T III, Seikosha 100 A, OKI Microline 80 etc, and also includes driving software which allows up to 128 characters per line (depending on printer type).

There is also a range of business software from Hilderbay Ltd which can be used in conjunction with Centronics type printers, i.e., accounts, stock control, etc. The interface complete with connecting lead will be priced at £45 including VAT (mail order £1 p&p) which includes a 12 month guarantee. Kempston (Micro) Electronics are at 180a Bedford Park, Kempston, Bedford MK42 8BL.



Look, Mum, No Keys!

Casio's latest miniature calculator SL80 has no keys in the conventional sense. Instead it has flat, sensor-touch pads which respond to finger pressure. The keyboard itself, forming part of an integrated protective wallet, is as large as the whole of a normal credit card calculator, so individual keypads are generously proportioned and well spaced making the calculator much easier to operate.

SL80 has no batteries either, saving the consumer the expense and inconvenience of having to replace a battery. Power comes from built-in solar cells, needing light intensity of only 50 lux. For the untrained 50 lux is the equivalent of a dull light for normal reading!

This tough, maintenance-free little instrument is coming into the shops at a recommended retail price of only £10.95. Casio Electronics Co Ltd, Unit 6, 1000 North Circular Road, London, NW2 7JD.

Bite A Computer!

Husky, the world's first portable microcomputer, will be on show at this year's Hanover Fair, April 13-20, where it will be demonstrating its indestructible computing power to a deadly Amazonian piranha, immersed in a tank of water at UCSL Microsystems' stand (B5604) in CeBIT Hall 1 (but don't try typing anything in while it's there!).

Husky is now in use for data capture and portable data processing applications by scientific, commercial and military users in Europe, the United States and other countries.

Husky's applications range from guided missile support to brewery stock-taking. Husky's large memory — up to 144K — allows it to be used independently for long periods. Husky is the first portable microcomputer to offer IBM's 2780 synchronous package, allowing direct communication with mainframe computers.

Husky is designed and manufactured in Britain by DVW Microelectronics, a member of the AIDCOM International group of companies.

Shorts

● The latest catalogue from Stotron Ltd has arrived in our offices; rather curiously it's dated 1982, but never mind, it's full of goodies. You can obtain your copy from Stotron Ltd, Haywood Way, Ivyhouse Lane, Hastings, East Sussex, TN35 4PL, telephone 0424 442160.

● Since MAC has been chosen as the UK's system for future direct satellite broadcasting (see ETI March 83), it's reassuring to know that it's been successfully demonstrated in Germany. About 100 telecommunications engineers saw Multiplex Analogue Component pictures which had been sent from the IBA Engineering Centre near Winchester, England, via the European Orbiting Test Satellite stationed 36,000 km above West Africa. The demonstrations included a direct comparison with conventional PAL-encoded colour signals.

● Gould Power Supplies UK, of Raynham Road, Bishop's Stortford, Herts, have expanded their Econoflex range of switch-mode power supplies with the addition of the EX24/5. Not surprisingly, this is a 24 V, 5 A output unit. The power output is floating and fully regulated to within 0.2%, protection circuitry is incorporated, and the input can be 110 or 220 V AC.

● Hardly a month goes by without some new information from those busy chaps at OK Industries UK Ltd. This time they've produced a new brochure describing their range of PacTec enclosures, which are moulded from impact-resistant ABS in a range of sizes from small to medium. Various colours and accessories are available. Copies of the 22-page catalogue are available from OK at Dutton Lane, Eastleigh, Hants, SO5 4AA (telephone 0703 610944).

● Remember Zemco? They manufacture in-car microprocessor equipment and we've mentioned their products before in Digest. Anyway, the US parent company has bought out the UK operation in order to do their own marketing: the good news is that this move will result in a hefty 30% cut in prices, as well as a further financial investment in service facilities. Zemco UK's office is at 66 Earlsdon Street, Coventry CV5 6EJ (telephone 0203 79969), and readers interested in cruise controls and in-car computers are directed thence.

● Accelerate your Apple with the Accelerator II from Pete & Pam Computers, New Hall Hey Road, Rossendale, Lancs, BB4 6JG (telephone 0706 227011). For £299 you get a plug-in board containing a 6502C processor and 64K of memory which will boost the speed of the Apple II Plus from 1 MHz to 3.58 MHz. It can run all native Apple II software.

● Calling all radiologists, radiographers and clinicians — the second London Course in Whole Body Tomography (whatever that is!) will be held from 7-10 June 1983. Further information may be obtained from one of the organisers, Dr Janet Husband, CT Scanning Unit, Royal Marsden Hospital, Downs Road, Sutton, Surrey SM2 5PT (telephone 01-642 6011 ext. 496). The course is approved under HM67/27 for study leave purposes.

● A 50-page two colour catalogue is now available from STC Meridian, West Road, Harlow, Essex CM20 2BP. The range of products includes such components as picture tubes and microphones, buzzers, sounders, re-entrant horns, counters, timers and relays, as well as vacuum fluorescent displays, DC-to-DC converters, display drivers, infra-red diodes, phototransistors, LED and LCD displays, and printers.

● Flexible Switch Technology Ltd can now offer a low-profile QWERTY keyboard with an overall thickness of less than 2 mm. The keyboard is fully sealed and comes complete with connectors on two flexible tails. All you have to do is plug them in to a suitable drive board. Two types are available: flat membrane switches or FST's new 'click' effect tactile buttons. You can have any colour you like as long as it's blue, black or white. Flexible Switch Technology are at Unit 31, Middlefield Industrial Estate, Sunderland Road, Sandy, Beds SG19 1RB (telephone 0767 80332).

● Sharp PC-1251 owners can now buy a spreadsheet program which allows as many as 26 columns, 100 rows, and over 200 'cells' on the sheet. You can either use it as a tool for solving the "what if" type of question, or as a mini-database with up to 100 names and telephone numbers. The program, called Easi-calc 1251, requires the CE125 printer-recorder and costs £14.95 including VAT from Elkan Electronics, 11 Bury New Road, Prestwich, Manchester M25 8JZ (telephone 061-798 7613).

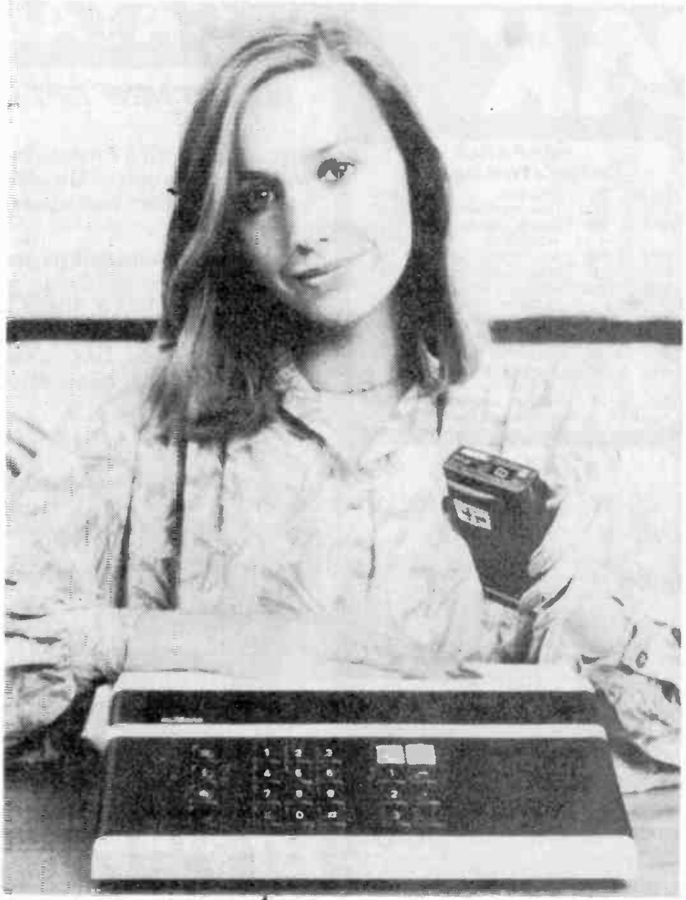
● Two new books have been added to the successful 'Understanding . . .' series from Texas Instruments. The titles are 'Understanding Electronic Control of Energy Systems' and 'Understanding Telephone Electronics', and each costs £3.95 plus £1.50 postage and packing from Texas Instruments Ltd, PO Box 50, Market Harborough, Leicestershire.

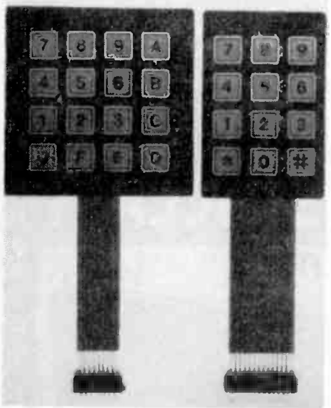
ZX81 Music Board

We've just discovered (since the prototype was tested using a Memotech RAMpack) that it isn't possible to plug peripherals into the back of Sinclair's RAMpack. Have no fear, you can still use the Music Board: all the completed boards and kits sold by Petron Electronics will be modified so that the Sinclair memory can be plugged in *behind* the Music Board. Problem solved.

ORIC Overload

Tangerine Users Group (TUG) have asked us to bring to the attention of ORIC-1 owners that they are receiving several thousand enquiries per month, thereby creating an overload condition in the organisation. Although they are making every effort to respond as quickly as possible, delays of up to 14 days are inevitable, during this period of reorganisation.





New Crimson Factory

Due to successful and increasing trading Crimson Elektrik has opened a new factory to handle sales and production of all modules, kits and industrial amplifiers.

From the same date the Leicester factory will only be handling production and sales of the prestigious 600 series hifi amplifiers, available only through specialist retailers. All enquiries other than for the 600 series should now be addressed to: Crimson Elektrik, 500 King Street, Longton, Stoke-on-Trent ST3 1EZ.

High-Tech Pager

A new version of an economical radio paging system for on-site or wide-area use has been launched by Multitone Electronics, using technology currently unique to the company.

The system, called 'Readout', is a single or dual-format encoder (control unit) that can operate both analogue and digital pagers. This means that users with analogue equipment can protect past investment in their existing receivers and still upgrade their system to take advantage of the latest high-speed digital technology.

Up to 500 digital pagers can be added to an existing system without any need to replace the transmitter, aerial and associated wiring.

One of the key new features on FM systems is 'receiver out of range'. This prevents pager wearers from being out of contact without being aware of it. When taken out of range of the transmitter, a pager emits a low-frequency buzz warning.

Another new feature is transmitted steering, developed to enable users to add a new digital system to an analogue system on another radio frequency. The dual-format 'Readout' can steer calls for the analogue receivers to the existing AM transmitter and calls for the new digital receivers to a new FM transmitter. Multitone is the only manufacturer that can supply an encoder to provide this facility.

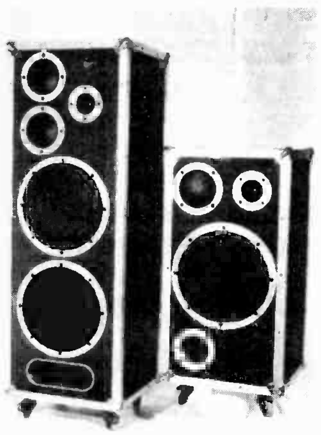
For further information contact: Multitone Communications Systems Ltd, 6-28 Underwood Street, London N1 7JT. Tel: 01-253 7611.

Membrane Keypads From Velleman

Velleman have introduced a new range of membrane keypads, available with 12 keys (type KB12) or 16 keys (type KB16). Both versions are offered with standard legend or with blank keys to enable customer to print their own legend.

These multi-layer keyboards are manufactured by Velleman using high quality materials with the top layer being polycarbonate film which resists scratching, dust and water. Termination is by insulated flat cable and a suitable PCB connector with 2.54mm (0.1 inch) spacing is supplied. Ratings are 24 V and 25 mA maximum.

A data sheet with full technical specification is available upon request. Price including VAT and postage is £8.44 for both versions (1 off quantity) with discounts available for larger quantities. Velleman (UK) Limited, PO Box 30, St Leonards on Sea, East Sussex, TN37 7NL.



Yet More Speakers From Wilmslow

New from Wilmslow Audio, PROKITS provide a range of speakers for the home constructor which are ideal for small venue discos, public address, parties, etc. Combining Wharfedale's design expertise with Wilmslow Audio's kit know-how, they offer true hi-fi quality sound together with high sensitivity to make optimum use of the amplifier power available.

The kits contain everything required for the construction of the speakers except adhesives. Only a few simple tools are required. Six models are offered: E50PRO (100 watts), E70PRO (150 watts), E90PRO (200 watts), E50PRO SUPER (150 watts), E70PRO SUPER (175 watts), E90PRO SUPER (300 watts). The PRO SUPER range is fitted with special hand-built bass units and the crossover networks are fitted with thermal overload protection for the treble units and for the complete system. The photograph shows the E50PRO and the E90PRO.

Prices range from £218.95 per pair for the E50PRO to £425 per pair for the E90PRO SUPER. Details from Wilmslow Audio Ltd, 35/39 Church Street, Wilmslow, Cheshire SK9 1AS. Telephone 0625 529599.

A New Name

Kenema Associates is a newly formed O.E.M. company now launching a comprehensive range of products for the Oric-1 computer. Included in this range is a 'Multipurpose/Personnel Records File'. This powerful software permits the mass storage and file handling of confidential information on personnel or products. The package is priced at £15.00.

Also supporting the range is an 'Oric-1 Keyboard Trainer' software package and a growing number of games, books, and accessories for the Oric-1 owner including Oric-1 American T-Shirts. Kenema Associates Ltd, 1 Marlborough Drive, Worle, Avon BS22 0DQ.

Large Format Clock/Counter

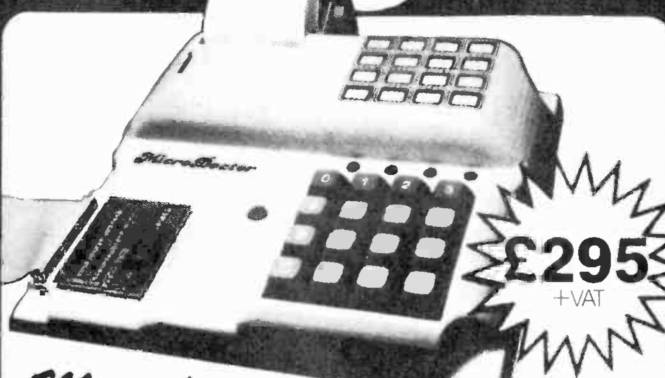
A new range of digital counters and clocks using high brightness 3½ inch vacuum fluorescent character display tubes is now available from Greatech Electronics Limited. The digital counters, two, three and four digits accept BCD input with optional blanking and remote display data input control.

The clock model is available in a twelve or twenty-four hour version with a mains frequency locked crystal controlled oscillator powered by a battery (rechargeable) during mains failure. (One of these may even be enough to help the Editor of a certain sister electronics magazine get to work on time!)

The display tube's brightness is adjustable and available in white, green, red and yellow. A variety of other colours can be provided by filtering and contrast enhancement provided to suit particular applications. Greatech Electronics Ltd, Hay Lane, Braintree, Essex.

ETI

No Compromise



£295 +VAT

Microdoctor

is an alternative to AUTOMATIC TEST EQUIPMENT which can be very expensive. MICRODOCTOR is perfectly adequate for diagnosing faults in microprocessor boards or computers in the REPAIR SHOP or on the PRODUCTION LINE. Reports are PRINTED on the integral thermal primer. Tests supported are CHECKSUM, RAMTEST, WAIT, READ, WRITE, I/O READ, I/O WRITE, DUMP IN HEX, DUMP IN ASCII, TEST DATA LINES (for shorts between data, address and rails), SEARCH (for two specified bytes), MAP (print a memory map of ROM, RAM, I/O and EMPTY SPACE). Supports both multiplexed and non-multiplexed address/data. Standard software will also DISASSEMBLE in Z80 mnemonics — other disassemblers cost extra. Programs for board-testing can be written in MINUTES — and retained for MONTHS even if the power is switched off (CMOS RAM is backed-up with rechargeable battery). Capacity is 15 different programs of 12 tests each. Included are two PROBE CONFIGURATION CARDS (One Z80, other uncommitted), PROBE with 24 inch cable and 40-pin DIL plug — and POWER SUPPLY.

OPTIONAL EXTRAS

6502 Disassembler Card	£35.00
6800 Disassembler Card	£35.00
8085 Disassembler Card	£35.00
Clip-over PROBE (only needed if uP is soldered-in)	£35.00
Thermal Paper (10 Rolls)	£9.00
Spare configuration cards	£6.50

£99 +VAT

The Menta Z80 Development System

uses the MOST POWERFUL LANGUAGE OF ALL — direct ASSEMBLER MNEMONICS. MENTA has VISUAL AIDS to program development which the big systems lack: a TV display of PROGRAM, REGISTERS and STACK, single-step operation (watch the cursor move from instruction to instruction, see the register-contents change, observe stack operations, etc.) BUGS can be fixed immediately without reassembling. Full speed operation is supported too — with or without BREAKPOINTS. Designed originally for the Schools' Council to teach microprocessing. MENTA is a complex CONTROLLER in its own right, like any other Z80 system, with practical, commercial applications in ROBOTICS. Features include CASSETTE INTERFACE, ASSEMBLER/EDITOR, serial DISASSEMBLER.
24 bits of I/O — also TV FLYLEAD, POWER SUPPLY and COMPREHENSIVE MANUAL with SOURCE-CODE LISTING.

MODULES AVAILABLE

Universal Input/Output Device	£21.00
Analogue to Digital Converter	£18.00
Digital to Analogue Converter	£14.00
D.C. Motor and Current Buffer	£12.00
Switching Input Module Analogue/Digital	£10.00
Pupil Reader	£3.00
Teacher's Guide	£2.50

£1950 +VAT

Thandar TA 2080 20mhz Logic Analyser

Dataman Designs Retrofit for TA2080

Gives R.S. 232 output facility for printed STATE and TIMING diagrams. Also DISASSEMBLES in Z80, 6502 or 6800 mnemonics on-screen or to printer.

£295.00

Olivetti Typewriter Interfaces

for ET121 and ET221 machines which permit the typewriter to be used as a DAISY WHEEL PRINTER for computers implementing the RS232, IEEE 488 (PET) or CENTRONICS PARALLEL busses, almost all computers in fact. Great for word processing and letter-writing! Same price, fitting free if requested (you pay carriage on typewriter if we fit).

£195.00

Ultra-Violet Eprom Erasers from £33.00

£169 +VAT

Softy Eprom Programmer/Emulator

SOFTY has functions equal, at least, to equipment which sells for over £500. SOFTY EMULATES AND PROGRAMS 2716, 2732, 2532 EPROMS. (The type is selected by a personality switch. SOFTY will copy any of these EPROMS to any other). SOFTY has a HEX KEYPAD, a fast CASSETTE INTERFACE, a MEMORY MAP TV DISPLAY with powerful editing — such as INSERT, DELETE, SHIFT-BLOCK and many other facilities — too many to list here. RS232 SERIAL and CENTRONICS PARALLEL routines for INPUT and OUTPUT are standard. The price includes TV FLYLEAD, POWER SUPPLY and ROM EMULATOR CABLE WITH 24 PIN DIL PLUG. SOFTY is used as a DEVELOPMENT SYSTEM for new products or just as a STAND-ALONE EPROM PROGRAMMER.

Adequate performance at sensible prices

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AUTOCOMPASS

Don't say we aren't good to you! Not only is this a unique and cheap-to-build project featuring some unusual techniques, but it also gives an insight into a little-known area of binary numbers. Design by Nigel Collier.

This novel project describes the operation and construction of an electronic compass specifically designed for use in automobiles. The unit can distinguish 16 different headings, and uses a dot matrix LED display to register the car's heading in nautical point and quarterpoint notation — for landlubbers this means N, NNE, NE, ENE and so on. The display dims automatically as the ambient light level drops.

The whole assembly, which is simply compensated for accurate readings inside the metal body of the car, is housed in an elegant matt black box, complete with a fixing bracket which enables it to be positioned almost anywhere in the car.

Finally, the sensor itself is designed using an apparently newly-discovered set of binary numbers!

The Circuit

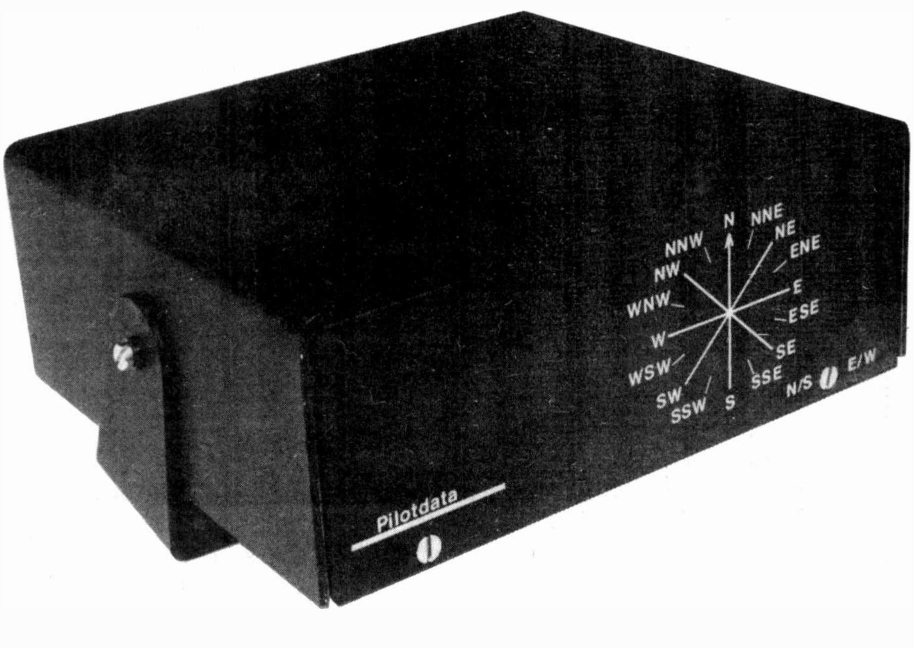
The unusual sensor, details of which are given later, generates a four-bit code, with each of the 16 possible numbers corresponding to a different heading. The remainder of the logic circuitry is based around a 2716 2K EPROM (at last, a non-computer-orientated use for an EPROM).

The EPROM contains the data necessary to give meaningful alphabetical displays as the perceived heading is updated. A listing of the data contained in the EPROM can be obtained from us on receipt of an s.a.e., for those amongst you with access to an EPROM programmer. Don't worry if you haven't, though; ready-blown EPROMs will be available (see Buylines).

The display consists of two 7 x 5 dot matrix displays type DL5735, manufactured by Litronix. These are arranged to form three adjacent display sections with areas of 5 x 5, 4 x 5 and 5 x 5.

Sensor Design

The operation of the sensor can best be described by looking at Fig. 1. The central pillar, topped by the pivot needle, is made from transparent perspex and houses the incandescent light source. Balanced on the pivot needle is the compass



PARTS LIST

Resistors (all ¼W, 5% except where stated)

R1	1k0
R2-6,9	4k7
R7	10k
R8	not used
R10,34,35	470R
R11-15, 21-25,33	2k7
R16-29,26-30	30R, ½W
R31,32	15R, 1W

Potentiometers

PR1,2	100R miniature horizontal preset, ¾W rating

Capacitors

C1	220nF polyester
C2	470uF 6V3 axial electrolytic
C3-6	47nF polyester
C7	2n0 polystyrene
C8	2u2 63 V axial electrolytic
C9	1n0 polystyrene

Semiconductors

IC1	2716 single rail EPROM (+5 V)
IC2	4017B
IC3,4	4001B
IC5	7472
IC6	7475
IC7,8	74LS367
IC9	7805
IC10	ULN2003
Q1-10	BC212L
Q11	BC182L
Q12-16	OP500 phototransistor
DISP1,2	DL5735 dot matrix LED display

Miscellaneous

LDR1	ORP12
L1-4	500 turns of 40 swg enamelled copper wire on 1M0 1W resistor (see text)

PCBs (see Buylines); sensor (see Buylines); case (see Buylines); mounting hardware, wire etc.

BUYLINES

A ready-built sensor, complete with phototransistors, is available for £8. The two double-sided PCBs, both with silk-screened component identification, are available for £6.50 the pair. Customer-supplied EPROMs will be programmed for 40p plus postage. Preprogrammed 2716 EPROMs are available for £3.00. An Autocompass case plus silk-screened perspex front panel is available for £4.00. Finally, a complete kit of parts, down to the last nut and bolt, will be supplied for £35.00 plus £1.50 postage and packing. All the above are available from Pilotdata Ltd, 2 Derwent Close, Wokingham, Berks.

mask — this is free to both rotate and tilt. A toroidal magnet, magnetised through its major diameter, is fixed to the mask. Thus the mask will always orientate itself in the same direction (with respect to the Earth's magnetic field) as the car's heading changes.

The mask pattern is designed such that the four phototransistors arranged around the circumference of the mask can unambiguously encode the sensor heading. For those who are interested in this sort of thing, a full description of the coding method used is given in the box entitled 'Cyclic Binaries'.

This form of coding, rather than a standard four-bit coding for four phototransistors positioned in a vertical line, was necessary to stop

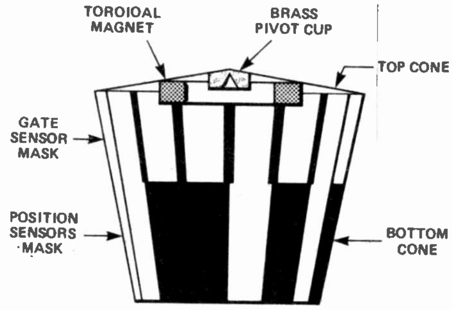
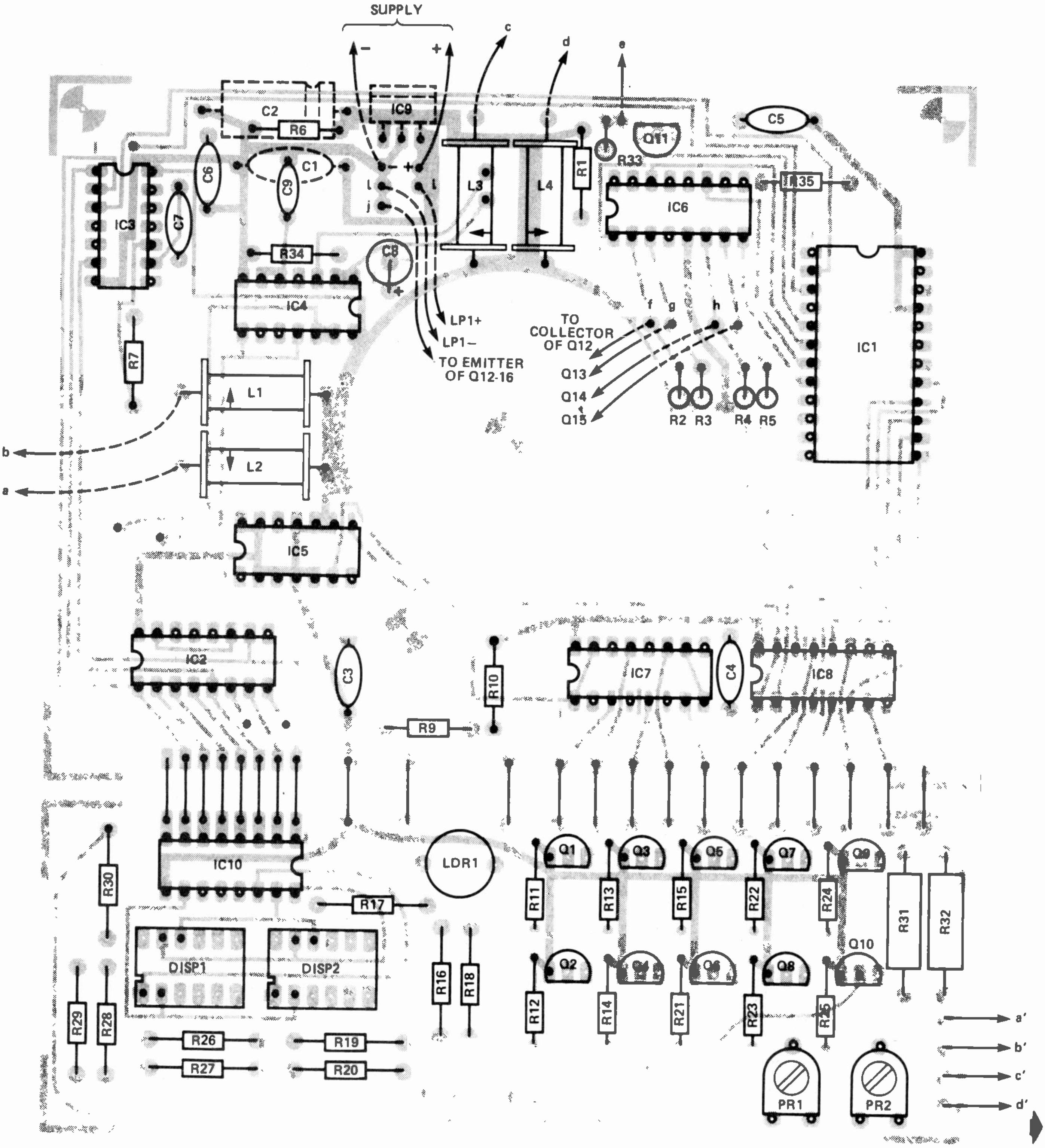


Fig. 1 (Right) The sensor mask.
Fig. 2 (Below) Component overlay.



erroneous coding occurring as the mask tilts (as it is inclined to do as the car accelerates or corners). The fifth phototransistor, Q16, reads another part of the mask, and only allows the logic circuitry to update the sensor heading when the four 'position' phototransistors are nicely matched with a mask section.

The whole assembly is fluid-damped to stop unnecessary oscillations. A somewhat incongruous loop of silicone tube is fixed onto the side of the housing. This is not a way of getting rid of spare balloons from the Christmas party — it is present to absorb any changes of volume of the damping fluid that occur with changes in temperature.

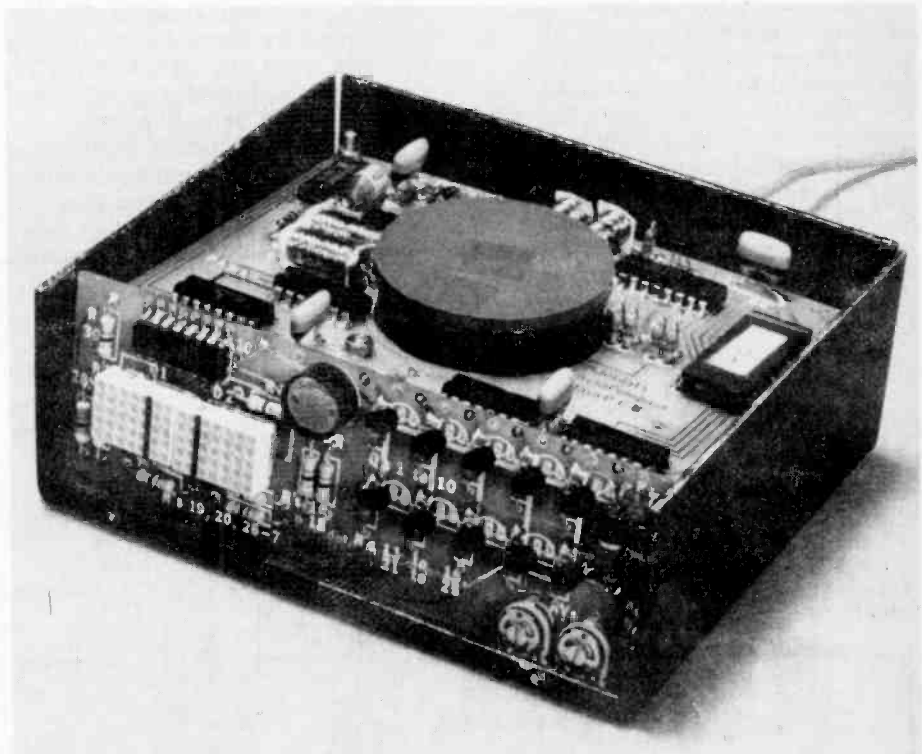
Construction

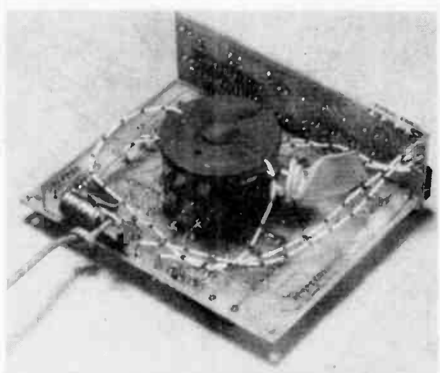
Because of the difficulties involved in the making of the compass mask, it is not recommended that the average home constructor should attempt to build his (or her) own sensor from scratch. Ready-built and tested sensors are available from Pilotdata at the address given in Buylines. We doubt if many of our readers are keen on metal-bashing either, given that Pilotdata can supply the case assemblies ready-screened and painted, but dimensions are available from us if you send a stamped addressed envelope (A4-size).

From an electronic point of view there are few problems posed by the construction — however, you will need a soldering iron with a very fine bit.

The main PCB is double-sided but not plated-through. There are seven points where isolated tracks on opposite sides of the board need to be joined with a linking pin — these are shown with a dot on our overlay and a 'p' on the silk-screened legend on the manufactured boards. Any other component lead or IC pin indicated with a dot should also be soldered both sides. The 10 terminal pins for the off-board connections must be all pushed through from the component side of the PCB. The voltage regulator and its two associated capacitors, C1 and C2, are shown in dotted outline on the overlay and must be soldered onto the underside of the PCB. The leads of the voltage regulator should be carefully pre-bent such that the mounting hole of the regulator is 19 mm below the underside surface of the PCB and flush with the edge of the board when soldered in position. Using an epoxy adhesive, fix a 5/16" 6BA screw into the regulator mounting hole with the screw thread protruding out backwards from the body of the PCB.

The four coils are wound on 1 megohm, 1 W resistors. Each resistor is prepared by glueing onto each end a 9 mm square plastic or cardboard pad to retain the wire.





These two internal shots should help with construction.

ZX81 PROGRAM TO GENERATE 16 BIT CYCLIC BINARIES

```
 10 PRINT "ENTER NO.: ";
 20 INPUT N$
 30 PRINT N$
 40 LET P = 1
 50 DIM A$(16,4)
 60 LET A$(P) = N$
 70 LET N$(1) = N$(2)
 80 LET N$(2) = N$(3)
 90 LET N$(3) = N$(4)
100 LET N$(4) = "0"
110 FOR C = 1 TO P
120 IF N$ = A$(C) THEN GOTO 210
130 NEXT C
140 LET P = P + 1
150 LET A$(P) = N$
160 IF P < 16 THEN GOTO 70
170 FOR N = 1 TO P
180 PRINT N, A$(N)
190 NEXT N
200 STOP
210 LET N$(4) = "1"
220 FOR C = 1 TO P
230 IF N$ = A$(C) THEN GOTO 270
240 NEXT C
250 GOTO 140
260 LET P = P - 1
270 LET N$ = A$(P)
280 LET N$(4) = "1"
290 FOR C = 1 TO P
300 IF N$ = A$(C) THEN GOTO 260
310 NEXT C
320 GOTO 150
```

CHANGES TO GENERATE A 32 BIT CYCLIC BINARY

```
 50 DIM A$(32,5)
 95 LET N$(4) = N$(5)
100 LET N$(5) = "0"
160 IF P < 32 THEN GOTO 70
210 LET N$(5) = "1"
280 LET N$(5) = "1"
```

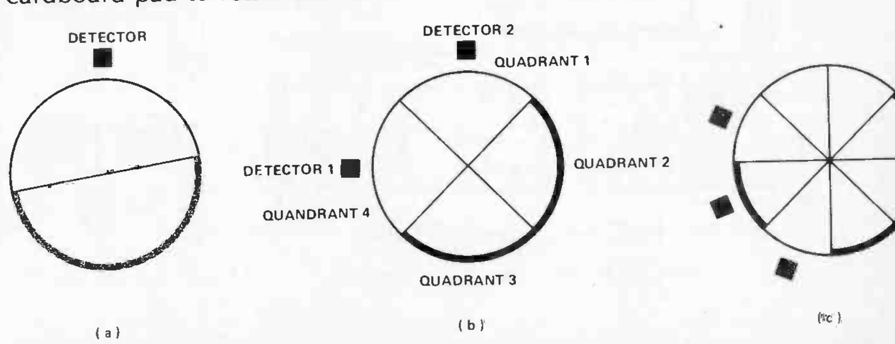


Fig. 3 Using cyclic binaries to detect shaft position.

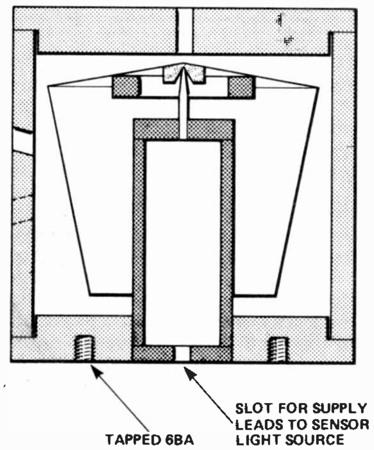
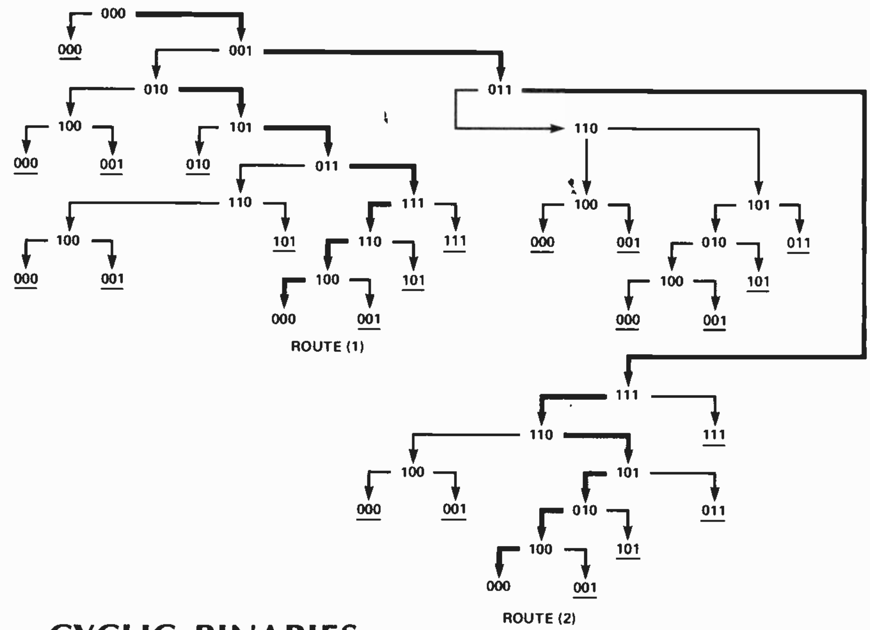


Fig. 4 (Above) A cross-section through the sensor housing.

Fig. 5 (Right) Generating the cyclic binary for Fig. 3c.



CYCLIC BINARIES

The mask pattern of the compass sensor owes its existence to a group of numbers which the author has called 'cyclic binaries'. So far as we are aware, this intriguing set has so far been ignored by the mathematicians, though if anyone knows otherwise, we would be delighted to hear from them.

Consider a cross-section of a shaft (Fig. 3a) whose circumference is half white and half black. A single detector is sufficient to determine which side of the shaft is nearest the detector, by detecting the local shaft colour.

Using the same shaft, let us now introduce a second similar detector such that the angle subtended by the two detectors at the axis of the shaft is 90° (Fig. 3b). The position of a point on the shaft can now be narrowed down to one of four quadrants. This table gives the truth table for the four possibilities:

Q1	Q2	Quadrant
Black	Black	1
Black	White	4
White	Black	2
White	White	3

In these examples the detectors are obviously binary detectors: we can call black a 0 and white a 1. Thus in Fig. 3b the shaft's rotational position has been encoded as a two-bit number.

Can we extend this system to three numbers, so as to encode for eight sectors? We can, but the shaft's pattern now becomes a bit more complex (Fig. 3c). As in the case for one or two detectors, the pattern is unique (ignoring simple rotations and mirror images) in generating a separate three-bit number for each of the eight sectors. Note that the detectors now subtend angles of 45° to their neighbours.

Now the colouring of the three-sensor shaft pattern can be represented by an eight-bit binary number arranged in a circle thus:

0 0
0 1
1 1
0 1

I propose to write this number thus:

11100010_C

The subscript C signifies that the binary is cyclic, ie its end is joined to its start. (Note that it doesn't matter at what point in the number you start, or in what direction you proceed: 10001110_c is the same number).

Now for four detectors with 22.5° separation: the arrangement used in the Autocompass. The shaft pattern is now divided into 16 sectors: are there any patterns which yield a unique four-bit number for each of the discernable rotational positions? The answer is obviously yes, since one is used in the compass sensor. In fact there are six such numbers (not counting rotations and reflections), and these six can be split up into three pairs. Each pair consists of a number and its inverse (ie each 1 becomes a 0 and vice versa). The pairs are:

0110101111000010_C and inverse
1000011010111100_C and inverse
1000010111101001_C and inverse

As far as we know, perfect cyclic binaries (ie ones that generate unique positional data for each of their sectors) can be found for any number of sensors. For the sake of interest, the table below shows perfect cyclic binaries for five, six and seven sensors.

FIVE BIT.
$00000111110111001101011000101001_C$
SIX BIT:
$0000001111110111100111010111000110110100110010110000101010001001_C$
SEVEN BIT:
$0000000111111101111110011110101111000111011011101001110010111000011011001101010110100011001001100010110000010101001010000100100 01_C$

How can perfect cyclic binaries be generated? Consider the case of determining the cyclic binary for three sensors. Figure 5 shows the search tree involved: we have arbitrarily started from '000'. If the shaft rotates one position from right to left, the new number will be '00?'. The least significant digit can be 0 or 1, but if it is 0, we have a repeat of the first number, so it must be a 1. The tree shows the continuation of this process. Every underlined number is a repeat.

The completed tree shows two routes through all eight numbers and back to the starting number. Selecting the first digit of each number along the routes, we get:

00010111_C (Route 1)
00011101_C (Route 2)

ie both routes yield the same number.

For larger cyclic binaries, drawing the tree out becomes impractical, but the search method is ideally suited to adaptation to a computer program. We've given a program here, in BASIC, which has been written for a ZX81 and will perform a tree search to generate 16-bit cyclic binaries — all you have to do to start it is enter a four-bit number.

The most obvious drawback of using cyclic binaries for determining the rotational position of a shaft is that an additional gating phototransistor is necessary. This would be superfluous if the cyclic binary was also Gray-coded. Gray-coded binary number sequences are special in that any two adjacent numbers in the sequence only differ by one binary digit. The following table shows a representative Gray coding sequence to illustrate the property:

000
001
011
010
110
111
101
100
000 etc.

Do 'super-perfect' Gray-coded cyclic binaries exist? We think not, but this judgement is based on a very limited investigation.

If you wish to search for superperfect cyclic binaries, here are a couple of hints. First, note that the detectors do not need to be adjacent (though any rotationally symmetrical arrangement of detectors will lead nowhere). Second, looking for cyclic Gray-coded sequences will be easier than looking for Gray-coded cyclic binaries (if you get the distinction!). Good luck.

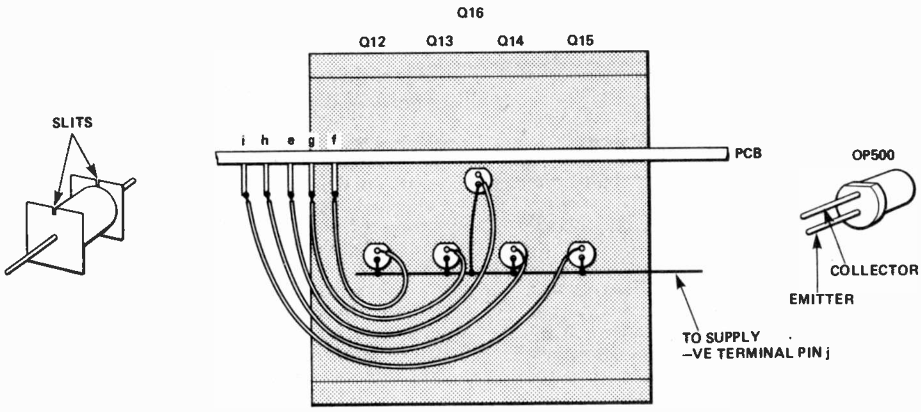


Fig. 6 (Above) Coil and sensor details.

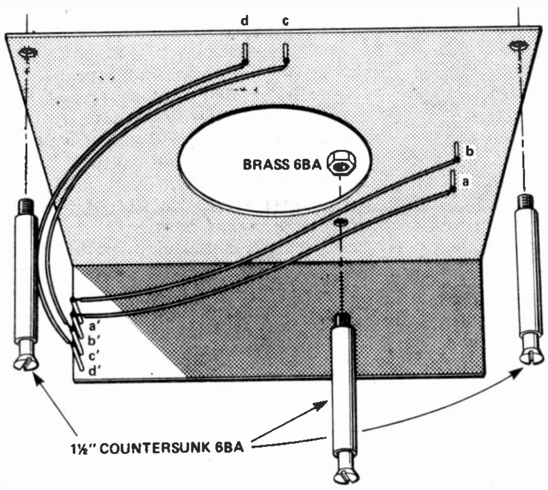


Fig. 7 (Left) The PCB fixing bolts fit here.

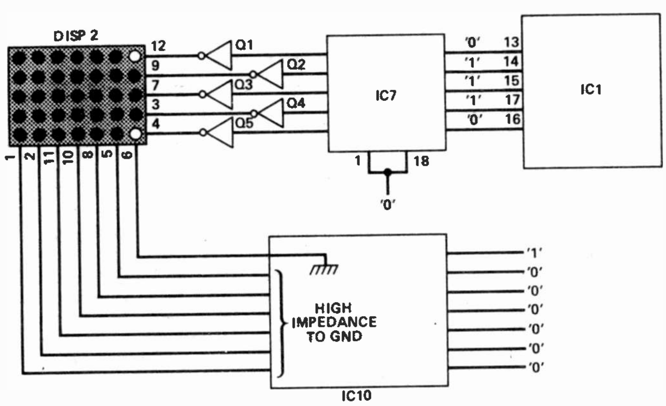


Fig. 8 (Below left) Circuit operation shown frozen at one point in the multiplexing.

Q12-16 are phototransistors attached to the compass sensor. The voltage present at the collector of any one of the phototransistors is pulled up to a logic 1 level by the resistors R2-5 and R33, so long as the phototransistor in question is shaded from the sensor light source by the compass mask. Once exposed to light, a phototransistor will turn on and its collector voltage will drop to a logic 0.

IC6 is a four-bit bistable latch. So long as phototransistor Q16 is shaded, the latch outputs will present the inverse of the latch inputs. However, once Q16 is exposed to light, the latch will hold the last four-bit input, irrespective of any further changes in input. In other words, IC6 is a memory device, supplying IC1 with information concerning the sensor position at the last positional update. Table 1 shows the output of IC6 with reference to the sensor positions.

The rest of the logic circuit converts the four-bit output of IC6 to an alphanumeric display of the sensor heading. IC3c,d are configured with R7 and C7 as an astable multivibrator. With the values chosen, this generates a

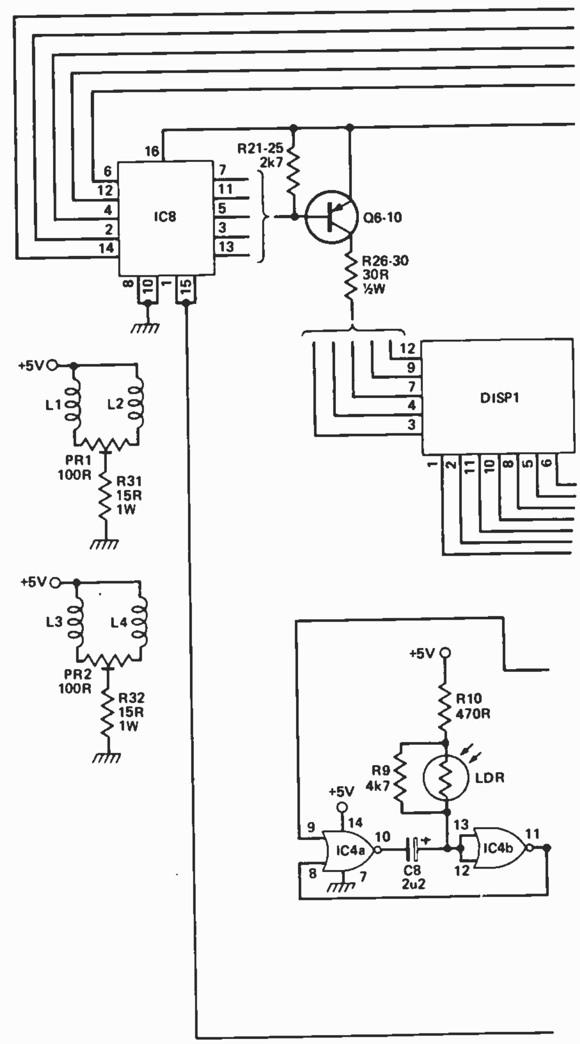


Fig. 9 Autocompass circuit diagram.

TABLE 1

IC6 OUTPUT VERSUS SENSOR HEADING

SENSOR HEADING	A3 (PIN 1)	A2 (PIN 14)	A1 (PIN 11)	A0 (PIN 8)	DECIMAL
N	1	1	1	0	14
NNE	1	1	1	1	15
NE	0	1	1	1	7
ENE	1	0	1	1	11
E	1	1	0	1	13
ESE	0	1	1	0	6
SE	0	0	1	1	3
SSE	1	0	0	1	9
S	0	1	0	0	4
SSW	1	0	1	0	10
SW	0	1	0	1	5
WSW	0	0	1	0	2
W	0	0	0	1	1
WNW	0	0	0	0	0
NW	1	0	0	0	8
NNW	1	1	0	0	12

HOW IT WORKS

square wave of about 25 kHz, which is fed to the clock input of IC2.

IC2 is a 4017 counter-divider: only one of the chip's 10 outputs can be high at any one time. Every positive transition of the clock signal advances the high output to the next pin in sequence, from right to left in the circuit diagram. Once pin 6 is driven high it activates the monostable multivibrator configured around IC4a,b. The monostable is, in effect, a pulse stretcher. The output of the monostable (pin 11) is normally low. When pin 9 of IC4a goes high, the output simultaneously goes high. As IC4b pin 11 is connected to the 4017 clock inhibit (pin 13), this immediately stops any further clocking of the 4017's outputs.

The length of time that IC4b pin 11 remains high is dependent on the resistance of the LDR. The more light that falls on the LDR, the lower is its resistance, the quicker C8 charges, and the shorter is the resultant length of the output pulse. Once pin 11 returns low again, the 4017 is free to continue clocking on the next positive clock signal transition. When IC2 pin 11 goes high, it drives the reset pin (pin 15) high which starts the whole cycle again by sending pin 3 high. To summarise, the 4017 outputs sweep from pin 3 to pin 5; then there is a delay with all the relevant outputs of the 4017 low, this delay being dependent on the ambient light level, before the cycle repeats. It can therefore be seen that the delay constitutes a display brightness control.

IC10 is a seven-stage Darlington driver. As each input of IC10 goes high, so the corresponding output is grounded, which in turn grounds the cathodes of the five LEDs in the relevant row of each display matrix. This constitutes one-half of the display multiplexing process.

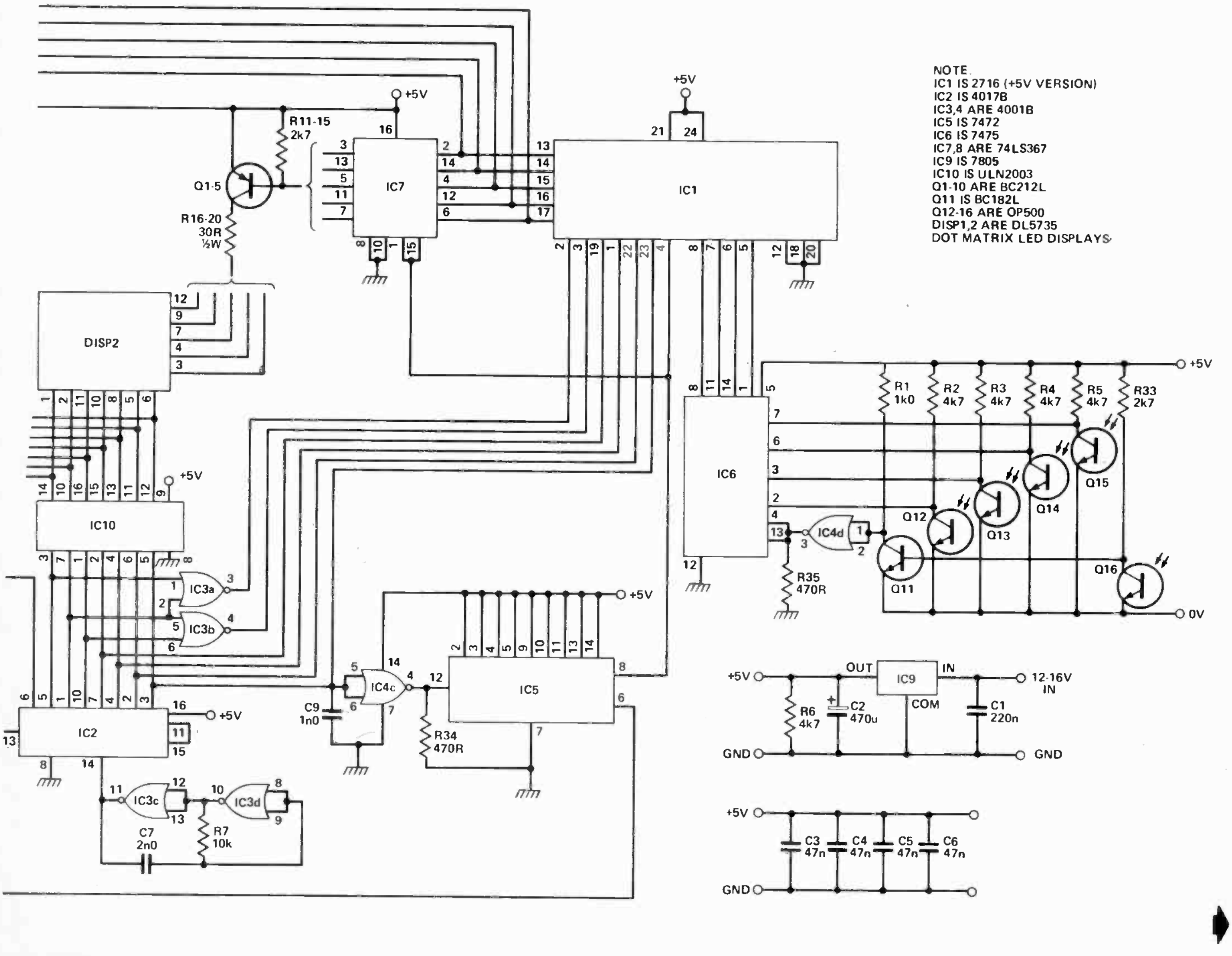
IC1 is an EPROM which produces a specific eight-bit output at pins 9-11, 13-17 (only the latter five being used) depending on the state of the 11 address input pins. We have seen that pins 5-8 of IC1 depend on the sensor heading, being driven by the outputs of IC6. The remaining seven address lines define the position of the multiplexing cycle.

The two dot matrix displays together have 14 vertical columns: the 4017 cycles through seven states. Therefore the multiplexing circuit must service one display at a time. This is organised by IC5, a flip-flop. Every time the 4017 starts a new cycle by sending pin 3 high, the outputs of IC5 (pins 8,6) change state. Pin 8 is always the inverse of pin 6. IC5 pin 8 addresses pin 4 of the EPROM: thus pin 4 high means 'multiplex display 1', while pin 4 low means 'multiplex display 2'.

The remaining six address lines of IC1 are driven by the outputs of IC2. The two NOR gates IC3a,3b compress the information on IC2 pins 10,1, and 5 to the two lines on pins 2 and 3 of IC1.

IC7 and IC8 are tristate buffers. They are gated on by the two outputs of IC5 such that only one is on at a time. Both receive the data output from IC1, and each in turn uses the data to supply current to the anodes of the LEDs in its display via the current amplifiers Q1-10.

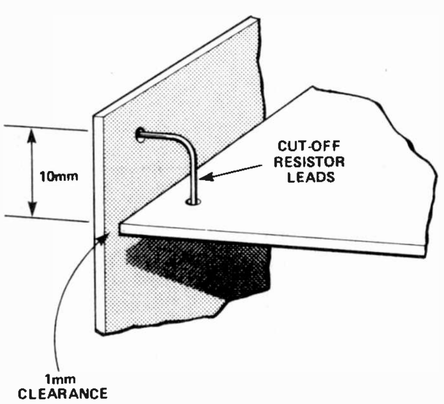
To help show what is going on, Fig. 8 shows the multiplexing at one instant of time. Note that Q1-10 act as inverters, so a 0 at the output of the EPROM defines an LED which is lit. In this case the display could be showing the last column of, say, "NNE".



The wire is 40 gauge enamelled copper wire, and 500 turns are needed on each resistor — this won't take you as long as it might seem! Remember to scrape off the insulation from the free ends before attempting to solder them to the resistor leads. Each pair of coils consists of one which has been wound 'right-handed' and one which has been wound 'left-handed'; ie they are not capable of superimposition, one being the mirror-image of the other. Label the two types unambiguously.

The display has four terminal pins but does not require any linking pins: all through-board connections here are made by soldering the necessary component leads on both sides (again indicated by dots). After soldering the terminal pins, which again are inserted from the component side, solder in the LED dot matrix displays. Mount them so that their pins only protrude about ½ mm from the rear of the PCB: this allows sufficient clearance to solder to the tracks on the front of the PCB. Save the clipped leads from the resistors — they will be ideal later for joining the two PCBs together.

The boards are mounted so that the main PCB lies 10 mm below the top edge of the display PCB, and 1 mm free of the underside of the display PCB. The diagram shows the method used to join the boards (Fig. 10).



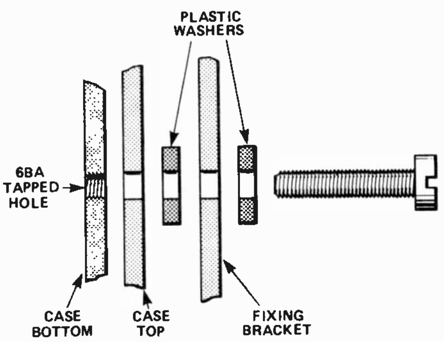


Fig. 10 It goes together like this . . .

The interwiring of the coils to the display PCB and the sensor to the main PCB is straightforward: just keep the wiring short and neat and remember that all the wiring is taken from the underside of the PCBs. Note that the phototransistors protrude from the sensor towards the back of the instrument.

The assembly of the two PCBs and the sensor fits snugly into the case bottom, being fastened in place with three 1½" screws which have slide-on spacers. Two 6BA x 3/16" countersunk screws fix the sensor housing to the case bottom, and a further two attach the perspex fascia. The case top and fixing bracket are attached using two 6BA x ½" screws, as shown in Fig. 10. Note that the fixing bracket can either be fixed underneath the unit as shown in the photos, for dashboard mounting, or the other way up so that the compass may be hung from the car roof.

Setting Up

When benchtesting the completed PCB assembly, remember to adequately heatsink the 5 V regulator. The display is multiplexed, and so the DC current through each LED can exceed 100 mA (though for a few microseconds only, of course). But, were the oscillator to be inoperative then it would be perfectly possible to blow up the display. So play it safe — temporarily disconnect the 5 V supply to the display PCB by desoldering the ninth board-linking pin from the right-hand side (viewed from the front) and check on an oscilloscope that the waveforms are what they should be (see Fig. 11).

If you don't have an oscilloscope, don't despair: an LED with a 200R resistor in series will suffice. Ground the appropriate end and touch the LED's anode end to the output pins of the 4017 (pins 1, 2, 3, 4, 5, 6, 7, 10). When operating correctly, the LED should glow very dimly (you may need to turn off the lights to detect it). If, on the other hand, one of the channels lights the LED brightly, with the remaining channels off, then you have a fault. However, with reasonable care in construction, the compass should work first time.

The only adjustment required is the setting of the bias coils to null out the car's magnetic field. Using a map (or a second compass outside the car), position the car so that it is pointing north. If the Autocompass does not read north, it is because of the car's field component which lies at right angles to the car's long axis. We can nullify this component by rotating the pot labelled 'N/S' until the compass reads north.

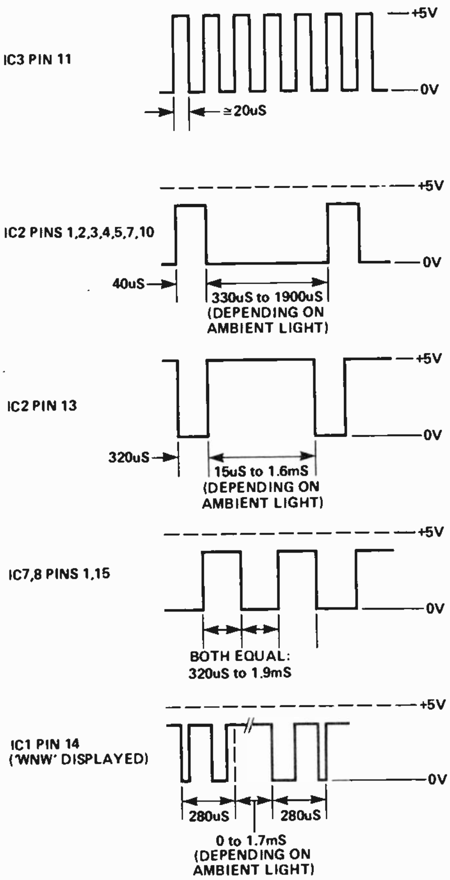


Fig. 11 Some test waveforms.

Now the car must be positioned to point east. If the compass does not read east, it can only be because of the car's field component which lies parallel to the car's long axis. So adjust the 'E/W' pot to neutralise this component, and the compass is compensated.

Installation

The Autocompass has been designed to be easily fixed into a car, but there are a few cautionary points that must be made. First, keep it away from any loudspeakers, as they possess strong magnets which can overcome even the compensation circuits. Second, ensure that the top of the box is as level as possible in its final position — the sensor will tolerate quite a bit of tilt, but if it is level at rest then its operational range will be enhanced. Finally, the display can consume about 800 mA with the display flat out, so an in-line fuse may be desirable.

ETI

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75183 0.50
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TL064 0.98
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TL068 0.32
TL071 0.29
TL072 0.47
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14	10	26	35
16	10	29	40
18	13	33	50
20	15	37	60
22	17	38	65
24	21	46	70
28	24	55	80
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4000 0.10
4001 0.10
4002 0.12
4006 0.42
4007 0.14
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

74LS SERIES
00 0.11
01 0.11
02 0.11
03 0.12
04 0.12
05 0.12
08 0.12
09 0.12
10 0.12
11 0.12
12 0.12
13 0.12
14 0.25
15 0.12
20 0.12
21 0.12
22 0.12
26 0.12
27 0.12
28 0.12
30 0.12
32 0.12
33 0.12
37 0.12
40 0.12
42 0.28
47 0.35
48 0.45
49 0.12
51 0.12
54 0.12
55 0.12
73 0.18
74 0.16
75 0.18
76A 0.17
78A 0.18
83A 0.36
85 0.42
86 0.16
90 0.22
91 0.60
92 0.32
93 0.22
95B 0.40
109A 0.27
112A 0.20
113A 0.20
114A 0.22
122 0.28
123 0.34
125A 0.24
126A 0.25
132 0.34
136 0.25
138 0.25
139 0.27
145 0.57
148 0.70
151 0.40
153 0.40
155 0.30
156 0.35
157 0.25
158 0.30
160A 0.32
161A 0.35
162A 0.35
163A 0.35
164 0.40
165A 0.50
166A 0.60
173A 0.55
174 0.40
175 0.36
181 0.90
190 0.35
191 0.35
192 0.35
193 0.35
194A 0.35
195A 0.35
196 0.45
197 0.45
221 0.46
240 0.55
241 0.55
242 0.55
243 0.55
244 0.55
245 0.70
248 0.55
249 0.55
251 0.30
253 0.35
257A 0.30
258A 0.35
259 0.55
261 1.00
266 0.20
273 0.54
279 0.30
283 0.40
290 0.39
293 0.39
365 0.27
366 0.27
367 0.27
368 0.27
373 0.62
374 0.62
375 0.35
377 0.60
378 0.60
379 0.90
386 0.35
390 0.45
393 0.45

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16 PIN 1.65
24 PIN 2.40
40 PIN 3.80

Double Ended

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LABORATORIES ON A CHIP

Silicon is turning out to have more uses than just a conventional chip material. It can be chemically machined to form a wide variety of structures, perhaps even miniature laboratories with built-in computers. Stephen McClelland explains.

What could be a new era of Lilliputian engineering is quietly unfolding thanks to a different kind of silicon chip development. Now, microscopic mechanical structures, some less than the thickness of a human hair, can be fabricated in silicon just like standard transistors and integrated circuits.

Silicon has been used for some time to create pressure and strain gauges but present techniques can produce nozzles, valves and sensors of all types. The manufacture of complex 3D mechanics in silicon is now being contemplated. Researchers at Stanford University, California — who dub these operations 'micromachining' — have even been able to place most of a gas chromatograph on a flat silicon wafer 5 cm in diameter. This sort of result indicates that complete electromechanical and electronic systems can be made in silicon less expensively and yet more accurately than conventional techniques would allow. The processing methods so well established in the integrated circuit industry will be capable of producing simultaneously large numbers of components in a silicon wafer with a consequent cost reduction.

All this is possible because of continuous improvement of silicon integrated circuit technology, particularly in the area of pattern definition and photolithography (the generation and transfer of a small enough mechanical pattern onto the silicon to be machined) and etching (the chemical dissolution of selected areas of silicon).

Photolithography And Etching

Photolithography has been propelled forward because of demands made by high density electronic chips which are approaching VLSI (Very Large Scale Integration) complexity. At the moment it is possible to design patterns, 200 x or 500 x larger than life, which will eventually produce a minimum feature size of 2 or 3 μm quite routinely. Next generation equipment will allow such features to be cut less than 1 μm, making it possible to fabricate, easily, novel optical components such as diffraction gratings in silicon. But the key to micromachining has been the variety of etching techniques that carve detail on the silicon surface.

Some (isotropic) etchants merely dissolve silicon at equal rates in all directions, but some show anisotropic behaviour; that is, they preferentially etch only certain crystal planes of silicon. By etching faster in certain directions than others — and the relative difference in speed can be two orders of magnitude — predictable three-dimensional shapes can be cut.

What is cut depends on both the etchant used and the crystallographic orientation of silicon used. We describe the crystallography of silicon numerically using Miller indices, which essentially state the orientation of a plane of a silicon atomic lattice by defining its intercepts with a hypothetical set of axes (Fig. 1). From the micromachining point of view the most important planes are the (100), (110) and (111) in the (cubic) silicon lattice. Etchants like potassium hydroxide or an ethylene diamine/pyrocatechol mixture essentially migrate much faster in the (100) direction than they do in the (111) direction because the packing density of silicon atoms is much lower in the 100 direction. The result when etching is that a V-shaped notch is formed in a (100) slice where the sides of the 'V' are the slower-etching (111) planes.

But the groove can be very accurately reproduced and its sidewalls will always make an angle of 54.74° with the surface of the silicon. Moreover the depth of the groove is directly related to the width of the surface opening etched, since etching effectively stops at the (111) planes which intersect the sides of the opening. Wafers are typically of the order of a few tenths of a millimetre thick and so it takes a few hours to etch a deep groove, or, if the surface detail is wide enough, a nozzle-shaped hole right through the slice.

Nozzles, Valves And Beams

Dr. Ernest Bassous' group at IBM has patented a variety of nozzle structures, based essentially on this technique, which are intended for projecting very fine ink sprays in high resolution printers. Although accurate dimensioning can be achieved by simply etching right through the silicon as described above, Bassous has found that better

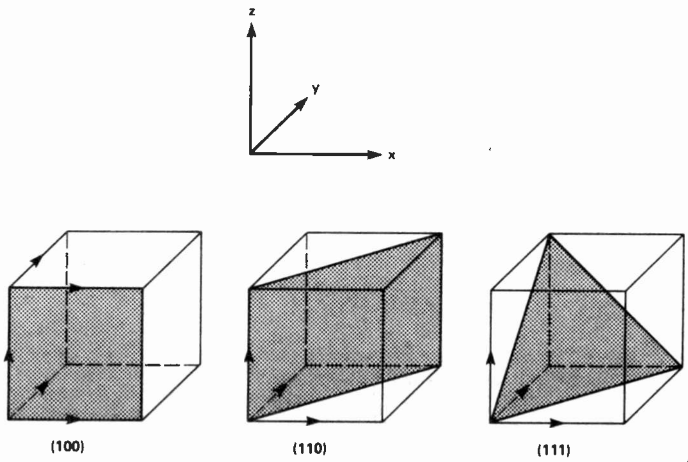


Fig. 1 The three basic index planes of silicon.

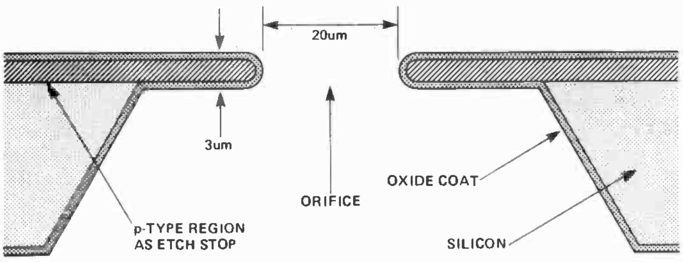


Fig. 2 The smallest nozzle in the world? IBM Research Labs made this silicon nozzle.

nozzles can be made by employing the natural resistance to etching of heavily-doped P-type silicon. A thin layer of this is formed at the back of the wafer, uniform except where orifices are required. The wafer is then etched anisotropically from its upper surface. Etching is terminated only by the thin P-barrier but punctures the slice completely in its unprotected regions. After cleaning and silicon dioxide regrowth the final structure is shown in Fig. 2. It has an orifice typically less than 20 μm wide set in a membrane only 3 μm thick.

Another IBM researcher, Kurt Petersen, takes membrane manufacture further. He allows the etch to deliberately undercut the overlying silicon dioxide layer and so produces an ultra-thin, springy, 'diving board' structure made entirely of oxide. The 1 mm thick membranes can be easily — but not irreversibly — bent by an electric field and IBM has used them as electronically controlled scanning mirrors to reflect illuminated data from a single character generator on to a ground glass screen for display purposes. IBM also foresees applications for them in high-isolation electromechanical switches.

A flexible structure is also the basis of Dr Lynn Roylance's miniature accelerometer to study heart wall motion. In the Stanford laboratories she made a 3 x 2 x 0.6 mm cantilevered beam unit entirely from etched silicon. The beam bends in response to applied acceleration with considerable sensitivity — it can detect an acceleration from 0,01 g to 50 g, with a 1% accuracy. The actual detecting elements for this kind of transducer are usually of a *piezorestive* variety. This means that the resistance of a diffused element (usually p-type) changes when it is mechanically stressed. However, these resistive elements are usually quite sensitive to temperature changes, which is why they usually take the form of a Wheatstone Bridge circuit.

Engine-eering

Silicon transducers, if they're small and light enough, can find their way into a whole spectrum of applications. They have been mounted on heart walls, on turbine components in aircraft and may well be shot into space on planetary probes. But most engineers belive that the traditional benefits of silicon processing (ie mass-produced, low cost, high precision techniques) will only really show when micromachining is adopted by a mass-production industry.

The US car industry could be just such a sponsor. Silicon sensors have been edging their way onto the Detroit production lines in a drive for higher fuel efficiency through better monitoring techniques in automobiles, although not as widely as predicted. William Wolber, a Michigan sensor specialist, describes the place of silicon components in the automobile industry as a 'useful addition' but warns that improvements in processing will continually be required if silicon is to be competitive. At present, the US industry wants to monitor a variety of

MICROMACHINING SILICON

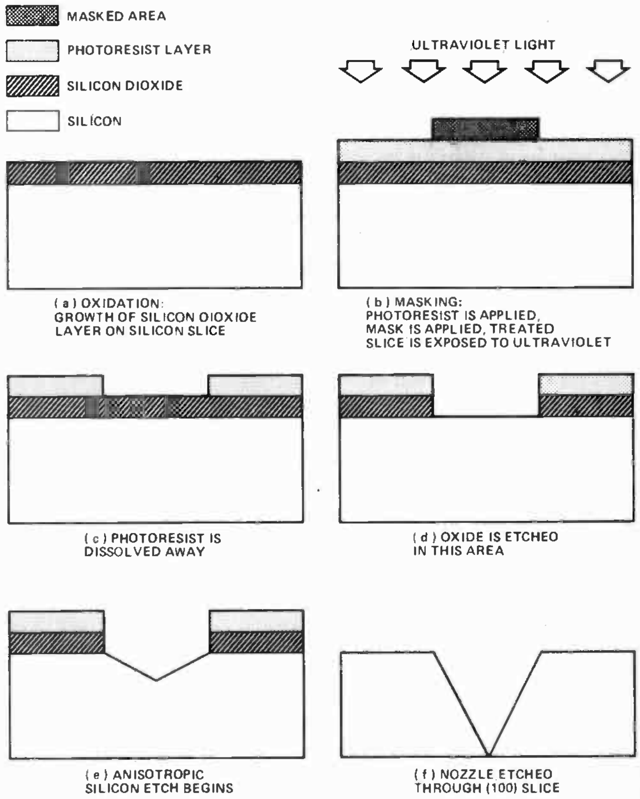
Standard silicon processing techniques basically involve one or more repeats of an oxidation-etch-diffusion cycle, outlined below:

- **Oxidation — A layer of silicon dioxide is grown on the silicon wafer by heating it in an oxygen stream. This layer will act as the pattern definition layer for the rest of the process (a).**
- **Etching — The wafer is now coated with photoresist (a light-sensitive compound) which is exposed to light via a master negative glass plate on which are detailed the features to be machined (b). Unexposed parts of the resist (underlying the negative) are then easily rinsed off, but the exposed, hardened resist remains. This serves to protect the underlying oxide from dissolution when the wafer is treated with hydrofluoric acid. Unprotected oxide is dissolved off leaving bare silicon (c,d).**

If the wafer is now treated with an etching solution that dissolves silicon but not oxide, the silicon will be eaten away beneath the oxide window exclusively (e). If the etchant is *isotropic* the rate of etching will be the same in all directions. If the etchant is *anisotropic* it will etch in a preferential direction, eg potassium hydroxide solution will produce a V-groove in (100) orientated silicon and a vertical walled profile in the (110) direction (f).

For many devices, the process ends here or is cycled through again after a complete re-oxidation of silicon, depending on the profiles required. For more complicated structures (eg Dr. Bassous' membrane-nozzle described in the article) and to make electronic devices such as integrated circuits, gaseous impurities (eg boron compounds) are carefully allowed to diffuse into the silicon, through oxide windows like those made previously.

After the micromachining has been fully performed, the silicon wafer is split into individual silicon chips each containing a copy of the micromachined device.



Cross-section of silicon wafer, or slice, showing the procedure for cutting a simple nozzle through the wafer. Dimensions are not to scale.

variables in the engine including air and coolant temperatures and fuel metering. The latter is derived from the determination of the manifold absolute pressure by silicon strain gauge techniques.

Chromatography On A Wafer

Perhaps the most spectacular development to date, however, has been the fabrication of a gas chromatograph system on a single silicon wafer, by Dr Stephen Terry and his colleagues at Stanford. Gas chromatography, the separation of a mixed sample gas back into its components, can be broken down into three separate stages:

- sample injection from the outside world
- sample separation in a long thin column
- detection and quantity measurement of each individual component.

The sample gas is injected into the system mixed with a carrier gas, typically nitrogen. Separation occurs in the column and is determined by the relative migration rates of each component in the sample. These in turn, are influenced by both the carrier gas velocity and the relative adsorption/desorption parameters of the components, in a so-called stationary phase, a substance which lines the walls of the column. With a sufficiently long column, the individual components emerge as separate entities ready to be detected by a suitable transducer.

The Stanford instrument cleverly reduces the large-scale complexity required for such an instrument with micromachining. In particular, the separator column (which has to be long to achieve good separation) is coiled into a spiral groove 1.5 m long but only 200 μm by 30 μm in cross-section. It is sealed after etching with a Pyrex cover slip to make a closed capillary column. Once again, the etching is patterned through a grown silicon dioxide overcoat to define the spiral.

The components are detected by a simple, yet very effective, thermal conductivity sensor. This is essentially a nickel film resistor heated by an electric current. The temperature it actually reaches for a constant current depends on the thermal conductivity of the gas stream passing through the device.

The results of the chromatograph are impressive, especially when compared to larger laboratory instruments. It has been used so far to analyse hydrocarbon mixtures and does this very efficiently with a fast time constant — which means that sample peaks can be as short as one tenth of a second compared with the width of several seconds realized by standard laboratory instruments. This in turn means the instrument can provide better resolution of the sample.

Material Benefits

But, of course, one need not be restricted to silicon for micromachining. With slight modification, other materials can be used as long as they are compatible in basic ways with the planar process for making chips. With a little imagination, the number of applications can match the number of different materials. And some are highly exotic. The gas chromatograph discussed above, for example, has been suggested for planetary probes and what are essentially entire chip-based 'laboratories' are now being actively researched. In the space of a few millimetres, such a chip could collect, treat and analyse a sample, even to the extent of heating or micro-refrigerating it through use of the Peltier effects. For ambitious experiments on space probes, the above could be combined with gas detectors, magnetic and electric field detectors and pressure and temperature detectors, all in silicon with the advantage of suitable signal processing electronics fabricated simultaneously. **ETI**

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TL071/81 25p
TL072/82 45p
TL074 100p
TL083 75p
TL084 90p
TL094 200p
TL170 50p
TL430C 70p
TMS 1601 £12
UA1003-3 935p
UA2240 150p
UAA170 170p
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ULN2004 75p
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ULN2802 200p
ULN2804 150p
UPC575 275p
UPC592H 200p
UPC1156H £3
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XR2206 300p
XR2207 375p
XR2211 575p
XR2216 675p
XR2240 120p
ZN414 80p
ZN419C 180p
ZN423E 130p
ZN424E 130p
ZN425E 350p
ZN426E 300p
ZN427E 590p
ZN428E 410p
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15V	7815	40p	7915	50p
18V	7818	40p	7918	45p
24V	7824	40p	7924	45p
5V 100mA	78L05	30p	79L05	50p
6V 100mA	78L06	30p		
8V 100mA	78L08	30p		
12V 100mA	78L12	30p	79L12	60p
15V 100mA	78L15	30p	79L15	60p

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78P05 900p
LM317K TO3 250p
78HGKC 600p
LM317T 100p
78H05KC 550p
LM337T 225p
78GUIC 200p
LM323K 3A 5V 450p
79GUIC 225p
LM723 150mA Adj 30p
79HGKC 700p
ICL7660 200p
LM350T 350p
LM305AH 250p
TL494 300p
78H12 600p
78S40 225p
SG3524 300p

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OCP71 180p
ORP12 120p
ORP60 120p
ORP61 120p
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TIL31A 120p
TIL32 55p
TIL81 90p
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MCS2400 190p
ILQ74 240p
MOC3020 150p
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TIL112 70p
TIL113 70p
TIL116 70p

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TIL212 Yel 15p
TIL220 Red 10p
TIL222 Gr 12p
TIL228 Ye 15p
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FND500 90p
FND507 90p
MAN3640 200p
MAN4640 200p
NSB5881 570p
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TIL321/3 130p
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TMS1601 £12
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68B21 220p
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68B40 600p
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8155 350p
8156 350p
8205 225p
8212 110p
8216 100p
8224 110p
8226 250p
8228 270p
8243 280p
8250 850p
8251 250p
8253 390p
8255 250p
8256 £36
8257 400p
8259 400p
8271 £36
8279 440p
8284 350p
8288 £11
8755 £16
9902 £3
TMS4500 £14
Z80P10 250p
Z80AP10 280p
Z80CTC 250p
Z80ACTC 280p
Z80ADART 700p
Z80ADMA £10
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2107B 500p
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2112-A 300p
2114-2L 100p
2147 450p
4027-3 300p
4116-15 120p
4116-20 80p
4118-3 450p
4164-2 400p
4816APZ-3 270p
5101 300p
5516 750p
310P 3 420p
6116LP-3 750p
6514-45 550p
6810 120p
7489 210p
74S189 225p
74S201 350p
74S289 175p
93415 600p
93425 600p

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74S188 325p
74S287 350p
74S288 225p
74S387 325p
74S471 650p
74S473 650p
74S474 650p
74S570 650p
74S571 650p
74S573 950p

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2532 370p
2532-30 £7
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2716(+5v) 250p
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2732-35 425p

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CRT5037 £18
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SFF96364 £8
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TMS9927 £18
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AM25LS2521 £2
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AM26LS32 125p
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DP8304 460p
DS3691 300p
DS8830 140p
DS8831 140p
DS8832 250p
DS8833 225p
DS8836 150p
DS8838 225p
LF13201 450p
MC1488 55p
MC1489 55p
MC3418 950p
MC3446 300p
MC3480 850p
MC3486 500p
MC3487 300p
MC4024 325p
MC4044 325p
MC14411 675p
MC14412 750p
75107 90p
75110/12 160p
75114/15 160p
75121/22 140p
75150P 120p
75154 140p
75182 90p
75361 150p
75363 150p
75365 150p
75451/2 65p
75453/4 72p
75491/2 70p
8T26 120p
8T28 120p
8T95/96 90p
8T97/98 90p
81LS95/96 90p
81LS97/98 90p
9602 220p
9637AP 160p
ZN425E-8 350p
ZN426E-8 350p
ZN427E-8 600p
ZN428E-8 500p

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FD1793 £23
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FD1797 £28
8271 £36
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100KHz 250p
200KHz 280p
Freq in MHz
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1.008 275p
1.5 450p
1.8432 210p
2.00 225p
2.45760 210p
2.5 250p
2.662 250p
3.276 150p
3.5795 100p
3.686 300p
4.00 150p
4.194 200p
4.43 110p
4.608 250p
4.915 250p
5.0 175p
6.0 150p
6.144 150p
7.0 150p
7.168 175p
8.00 175p
8.86 175p
10.00 175p
10.5 250p
10.7 150p
12.00 150p
14.318 175p
14.756 250p
15.00 200p
16.00 200p
17.7 200p
18.00 200p
18.432 150p
19.968 150p
20.00 200p
26.690 150p
27.145 200p
38.6667 175p
48.0 175p
55.5 400p
116 300p
145.80 250p
15.068 £2
124.00 £2

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MK3805 £TBA

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16 pin	11p	22 pin	22p	40 pin	30p

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14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

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BC107/8 13p
BC109C 14p
BC117 20p
BC147/8 9p
BC149 10p
BC157/8 10p
BC159 11p
BC169C 12p
BC172 12p
BC177/8 17p
BC179 18p
BC182/3 10p
BC184 11p
BC187 30p
BC212/3 11p
BC214 12p
BC237 15p
BC327 16p
BC337 16p
BC338 16p
BC461 25p
BC477/8 30p
BC516/7 40p
BC547B 14p
BC548C 12p
BC549C 16p
BC557B 14p
BC559C 16p
BCY70 18p
BCY71 22p
BD131 75p
BD132 50p
BD135/6 40p
BD139 40p
BD140 40p
BD189 60p
BD232 60p
BD233 75p
BD235 85p
BD241 60p
BD242 60p
BD379 60p
BD380 60p
BD677 40p
BF244B 35p
BF256B 50p
BF257/8 32p
BF337 30p
BFR39 25p
BFR40/1 25p
BFR79 25p
BFR80/1 25p
BFR96 180p
BFX29 40p
BFX30 27p
BFX84/5 40p
BFX86/7 27p
BFX88 27p
BFX89 108p
BFY51/2 24p
BFY56 33p
BFY90 80p
BRY39 45p
BSX19/20 24p
BU104 225p
BU105 190p
BU108 250p
BU109 225p
BU126 150p
BU180A 120p
BU205 200p
BU208 200p
BU406 145p
BUX80 600p
BUY69C 350p
E310 50p
MJ802 400p
MJ2501 225p
MJ2955 90p
MJ3001 225p
MJ4502 400p
MJE340 50p
MJE2955 100p
MJE3055 70p
MPF102 40p
MPF103/4 30p
MPF105 30p
MPSA06 30p
MPSA12 50p
MPSA13 50p
MPSA20 50p
MPSA42 50p
MPSA43 50p
MPSA56 32p
MPSA70 50p
MPSA93 40p
MPSU06 63p
MPSU07 60p
MPSU45 90p
MPSU65 78p
TIP29A 35p
TIP29C 40p
TIP30A 35p
TIP30C 40p
TIP31A 40p
TIP31C 45p
TIP32A 40p
TIP32C 40p
TIP33A 70p
TIP33C 80p
TIP34A 90p
TIP34C 120p
TIP35A 120p
TIP35C 140p
TIP36A 140p
TIP36C 150p
TIP41A 50p
TIP41C 55p
TIP42A 60p
TIP42C 65p
TIP54 160p
TIP120 75p
TIP121 75p
TIP122 80p
TIP142 120p
TIP147 120p
TIP2955 78p
TIP3055 70p
TIS93 30p
ZTX108 12p
ZTX300 13p
ZTX452 45p
ZTX500 15p
ZTX502 16p
ZTX504 18p
ZTX552 55p
ZTX652 60p
ZTX752 70p
VN66AF 72p
VN10KM 60p
VN66 80p
2N697 25p
2N698 45p
2N706A 30p
2N708 30p
2N918 45p
2N930 18p
2N1131/2 36p
2N1613 25p
2N1711 25p
2N2102 70p
2N2160 350p
2N2219A 25p
2N2222A 25p
2N2369A 17p
2N2484 25p
2N2646 40p
2N2904/5 25p
2N2906A 25p
2N2907A 25p
2N2926 9p
2N3053 25p
2N3054 55p
2N3055 35p
2N3442 140p
2N3553 240p
2N3584 250p
2N3643/4 48p
2N3702/3 10p
2N3704/5 10p
2N3706/7 10p
2N3708/9 10p
2N3773 200p
2N3819 20p
2N3820 40p
2N3823 30p
2N3866 90p
2N3902 700p
2N3904 15p
2N3906 16p
2N4037 65p
2N4123/4 27p
2N4125/6 27p
2N4401/3 25p
2N4427 90p
2N4871 50p
2N5087 27p
2N5089 27p
2N5172 27p
2N5191 90p
2N5245 40p
2N5401 60p
2N5459 30p
2N5460 40p
2N5485 36p
2N5875 250p
2N6027 30p
2N6052 300p
2N6059 325p
2N6107 65p
2N6247 190p
2N6254 130p
2N6290 65p
2SC1306 100p
2SC1307 150p
2SC1957 90p
2SC1969 150p
2SC2028 80p
2SC2029 200p
2SC2078 160p
2SC2335 200p
2SC2612 200p
3N128 120p
3N140 120p
3N141 110p
3N201 110p
3N204 200p
40290 250p
40361/2 75p
40408 90p
40409 100p
40410 100p
40594 120p
40595 120p
40673 75p
40871/2 100p

DIODES

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BYX36300 20p
OA47 8p
OA90/91 9p
OA95 9p
OA200 9p
OA202 10p
1N941 4p
1N916 7p
1N4148 4p
1N4001/2 5p
1N4003/4 6p
1N4005 6p
1N4006/7 7p
1N5404/5 14p
1N5404/7 19p
IS920 9p

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1A 400V 25p
1A 600V 30p
2A 50V 30p
2A 100V 35p
2A 400V 45p
3A 200V 60p
3A 600V 72p
4A 100V 95p
4A 400V 100p
6A 50V 80p
6A 100V 100p
6A 400V 120p

0A 400V 200p
25A 400V 400p

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400mW 9p
1W 15p

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6A 500V 88p
8A 400V 75p
8A 500V 95p
12A 400V 85p
12A 500V 105p
16A 400V 110p
16A 500V 130p
T2800D 130p

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8A 600V 140p
12A 400V 160p
16A 100V 180p
16A 400V 180p
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SWITCHED MODE POWER SUPPLY

There's a lot of unnecessary mystique surrounding the design and construction of switched mode power supplies: here's one anybody can build. Design by International Rectifier.

The advantages in using a switched mode power supply instead of a linear power regulator are well-known (if you *don't* know them, turn to Configurations in the April '83 ETI). However, the simplicity with which a linear regulator may be designed makes this configuration the most popular solution for low power applications.

The availability of low cost switching components (switching regulator ICs, magnetic components and high frequency MOSFET switches) is increasing the tendency for design engineers to choose switched mode PSUs in their equipment. The design presented here is the work of International Rectifier and shows how such a supply may be designed quite simply by using IR HexFETs with their following desirable properties:

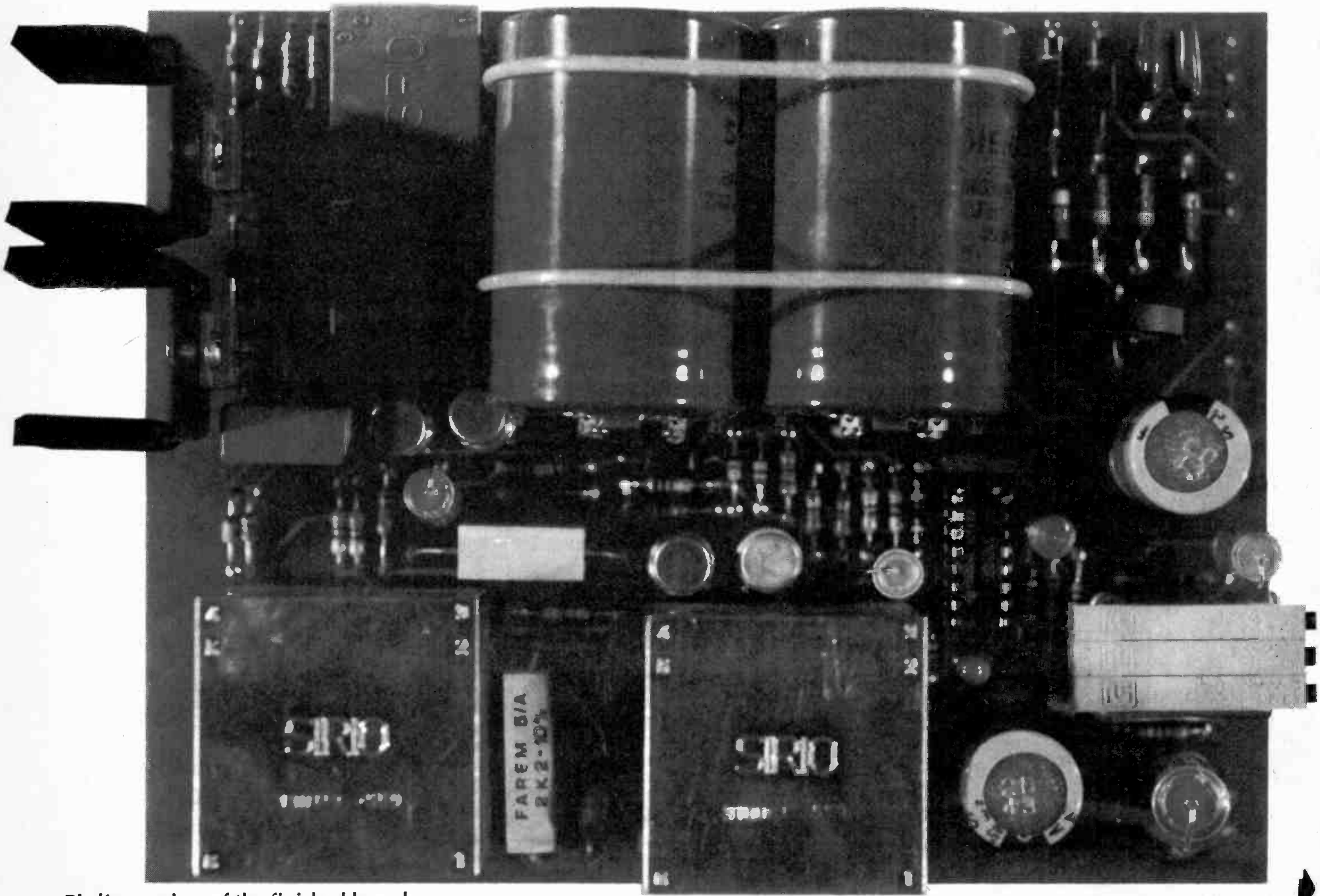
- no secondary breakdown
- high input impedance
- fast switching speed
- no current hogging
- no minority storage time

The project is built on a single double-sided PCB with plated-through holes, which carries all the components except the rectifying diodes and the auxiliary power supply for the controller IC.

Acknowledgements are due to Ing. Bernadi, Ing. Cavalleri and the technicians of the D.T. Application Laboratory of Telettra-Vimercate for their contributions to the design of this power supply.

System Description

This power supply uses a half-bridge configuration that can be made to operate from either 120 or 240 V AC (the half-bridge configuration was explained in more detail in the



Bird's eye view of the finished board.

Designer's Notebook feature on page 63 of the April '83 ETI).

The circuit uses two high voltage HexFETs to drive a transformer directly from the rectified mains at a frequency of 75 kHz. The transformer output is rectified and the output voltage is stabilised by changing the duty cycle of the switching waveform with a PWM inverter circuit. This function is performed by the SG3524 (IC1) and its external components.

The power supply for the control circuit (marked on the circuit diagram as the auxiliary voltage) is obtained from the mains using a 12 V, 3 W transformer and a bridge rectifier.

The HexFETs are 400 V devices in a TO-220 package and are driven by transfonmers so as to provide voltage isolation between the primary and secondary circuits — this is necessary because the controller IC is grounded at the load.

The power supply can be divided into four main sections:

- High power voltage stage
- Low voltage power stage
- Driving circuitry
- Control circuitry

Each of these parts will be looked at separately. Figure 1 shows the complete circuit diagram of the switched mode power supply.

High Voltage Power Stage

The mains voltage is rectified by a bridge consisting of diodes D1-4 and is filtered by C3 and C4. C3, C4, and C5, together with the HexFETs Q1 and Q2 and the transformer T1 form the half-bridge inverter. The DC voltage across C3 and C4 is applied in alternate directions to the primary of T1 as Q1 and Q2 switch commutatively. The theoretical waveforms (both voltage and current) that appear across each HexFET are indicated in Fig. 2. The full DC voltage appears at the HexFET drain only when the MOSFET is completely cut off. A 400 V HexFET allows a 15% margin in voltage, giving a lower loss during the conduction time due to a lower on resistance.

The current flowing in the transformer primary is a square wave defined by:

$$I_p = \frac{I_o}{N} + I_\mu$$

where Io is the output current, N the primary/secondary winding ratio and I_μ the magnetising current. The working current for each HexFET at maximum loading is about 1 A so the choice of a device with a 400 Vbreakdown voltage and a current capability of 2 A is more than adequate. For this switched mode power supply the IRF722 HexFET is

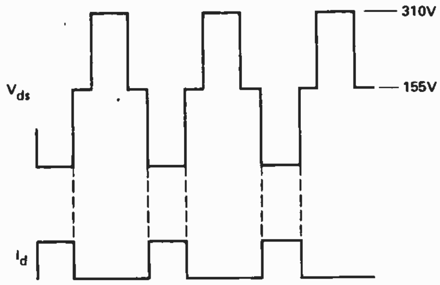


Fig. 2 Theoretical waveforms.

used, which is supplied in a plastic package.

The transformer is constructed using a Siemens pot core. The number of turns on the primary winding is defined by:

$$NP = \frac{Vdc}{4Bm.f.Ae}$$

where Vdc is the peak voltage across C3 or C4, f the frequency of operation, Bm the peak operating flux density in webers/square meter amd Ae is the effective core area in square meters.

The number of turns on the secondary winding is determined by this equation-

$$\frac{Ns}{Np} = \frac{Vs}{Vp}$$

where Vs is the voltage on the secondary including all losses due to

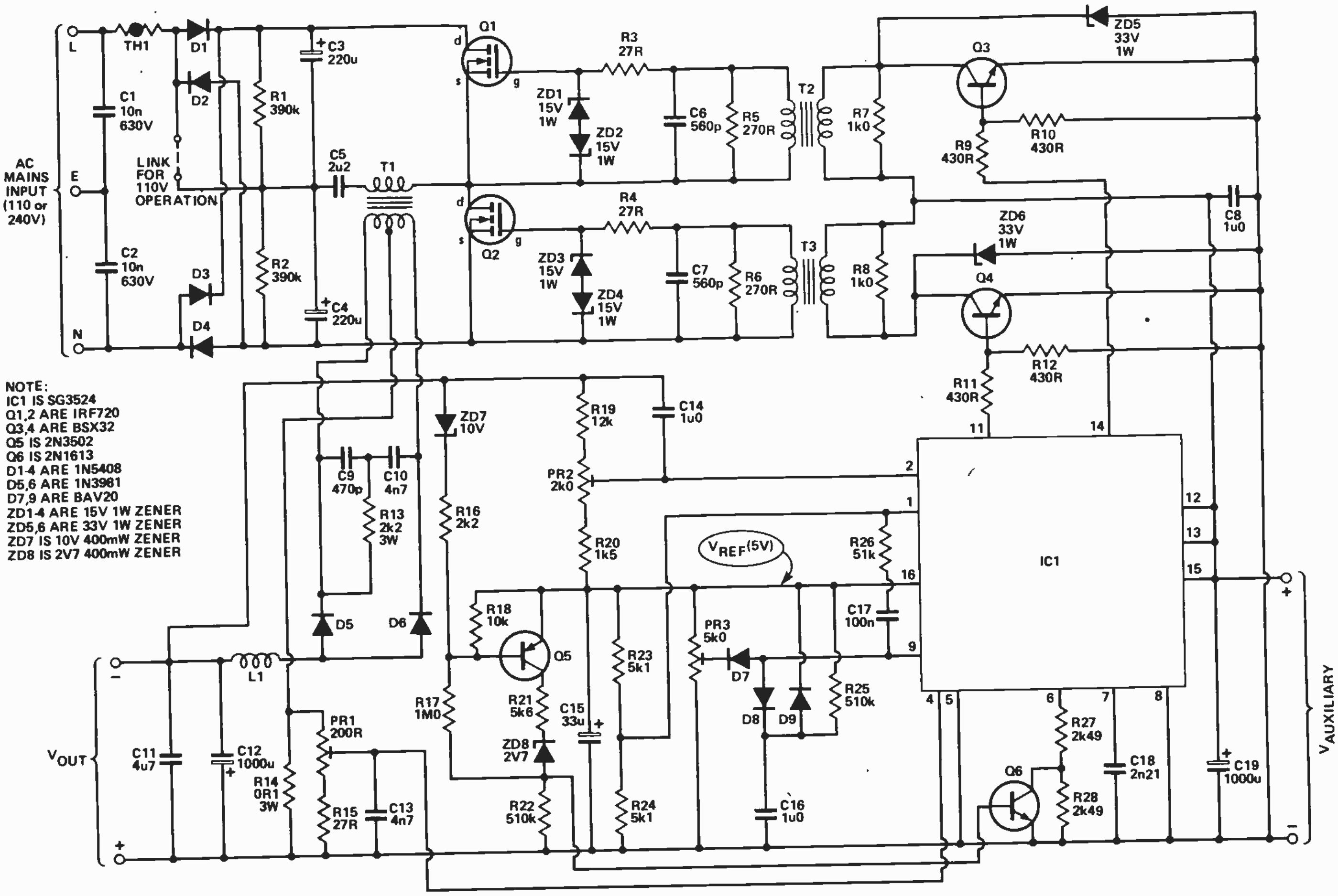


Fig. 1 Circuit diagram.

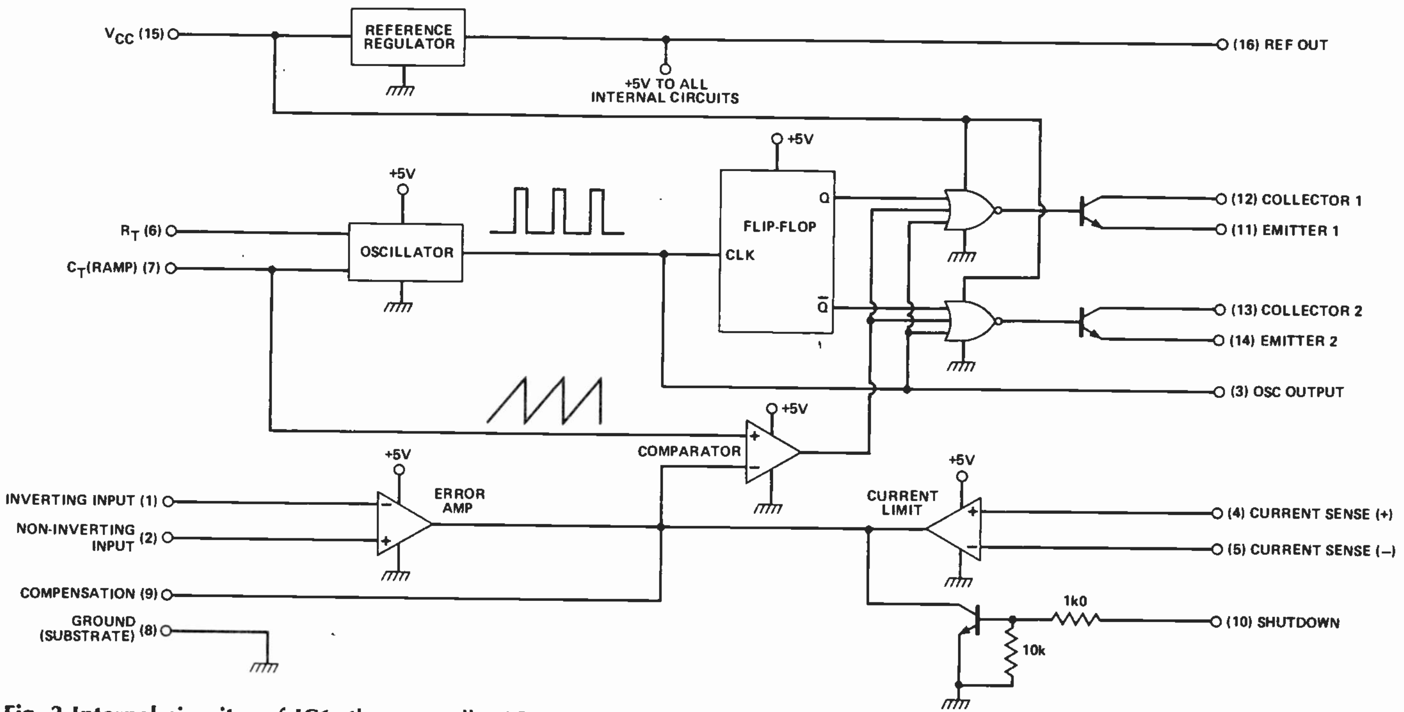


Fig. 3 Internal circuitry of IC1, the controller IC.

diodes, inductor, the current-sensing resistor and the dead time (see later), and Vp is the voltage on the primary when the system is working at the minimum allowable mains voltage and including all losses due to capacitor ripple and the input circuitry.

Low Voltage Power Stage

The output voltage at the secondary of T1 is rectified by the high speed diodes D5 and D6 and filtered by an LC section (L1, C12). The inductor value, L, must be chosen higher than the critical value so that current circulation will be stopped, ie:

$$L > L_c = \frac{V_o.T_{off}}{2.I_{o.min}}$$

Vo and Io.min are, respectively, the output voltage and the minimum output current (500 mA in this design). The capacitor value is determined by the following equation:

$$LC = \frac{V_o}{\Delta V_o.8.f^2(\eta - 1)}$$

where ΔVo is the desired variation in output and η is the ratio between the on and off switching times. To give an output with very low dynamic impedance, the value of C12 is chosen several times higher than the calculated value.

The additional components R13, C9, C10 and C11 are included to damp high-frequency ripple.

Driving Circuitry

The HexFETs are driven by the two transformers T2 and T3. The primary of T2 or T3 loads a small switching transistor Q3 or Q4, which is driven directly by the output of the controller IC. To clamp the over-voltage generated by T2 or T3 during the turn-off of Q3 or Q4, the zener diodes ZD5 and ZD6 are connected in parallel with the transistors on the secondaries of the transformers.

Two zeners are connected back-to-back forming a clamp which limits any gate-to-source voltage spikes to ±15 V. The gate series resistors R3 and R4 damp any unacceptable oscillations.

Control Circuitry

The control circuitry consists of a switching regulator IC (an SG3524) and a few other components. The IC provides all the functions necessary to produce a stabilised DC output voltage with a limited DC output current by controlling the duty cycle of the switching power MOSFETs. The control circuitry may be broken down into the following functions:

- Oscillator
- Dead time
- Soft start
- Short circuit protection
- DC output voltage stabilisation.

Oscillator

The frequency of the oscillator is set by R27 and C18 at 150 kHz. Figure 4 shows the relationship between resistance, capacitance, and the oscillator period. The timing resistor R27 is connected to ground through R28, which is shunted by transistor Q6. This configuration allows the frequency to be halved by the automatic short-circuit protection, as described later.

Dead Time

To avoid the simultaneous conduction of two HexFETs during the transition time, the IC generates a blanking pulse. The width of this dead time is controlled by the value of the timing resistor CT (C18) as shown in Fig. 5. To adjust this width an external circuit consisting of PR3 and D7 is added.

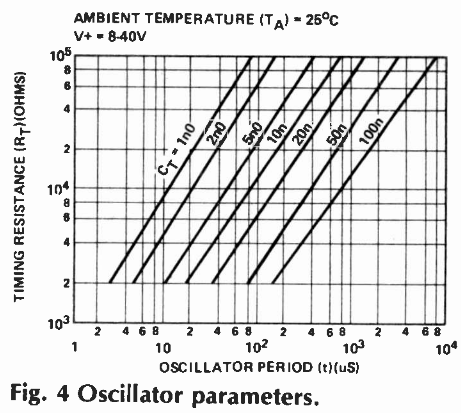


Fig. 4 Oscillator parameters.

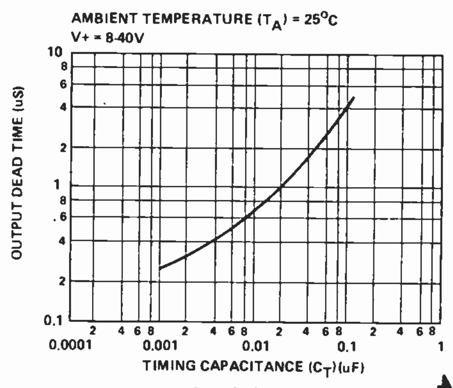
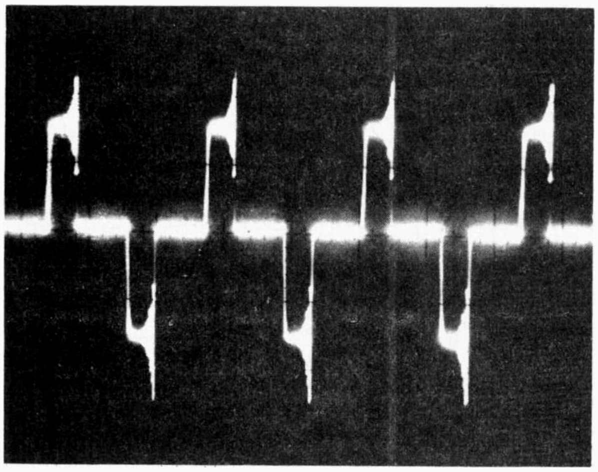
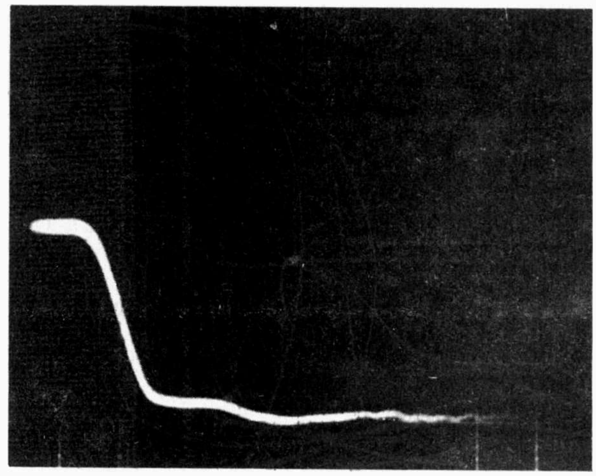


Fig. 5 Setting the dead time.



The drain voltage waveform (50V/div and 5 uS/div).



The drain voltage turn-on waveform (50 V/div and 50 nS/div).

Soft Start

A few components (C16, D8, D9 and R25) provide a low duty cycle initially so that at start-up, a high current flow into the HexFET and the consequent possibility of saturating the transformer core is avoided.

Short Circuit Protection

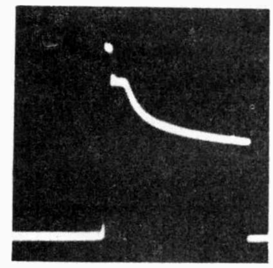
This operation is performed by sensing the current flowing in the load via R14. The voltage developed across the resistor is fed back into the current limit sense amplifier included in the IC. The current limit can be adjusted by means of the preset potentiometer PR1. R14 *must* be non-inductive to prevent any possiblity of instability.

To protect the switched mode power supply from a short circuit on the secondary, the circuitry built round Q5,6 and some other components is included. The function of this circuit is is to change the value of RT (by adding R28 to R27) and thus halving the frequency of operation. In fact R28 is normally shunted by Q6, but when the output voltage drops lower than 5 V Q6 is switched off. By halving the frequency, the conduction angle is increased to allow a better performance by the IC.

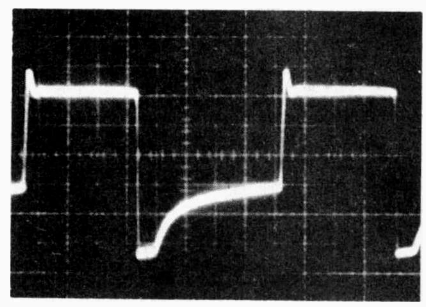
DC Output Stabilisation

The control circuit is grounded at the load and the voltage sense for the feedback is direct. Through PR2, R19 and R20, a fraction of the output voltage is fed back into the internal error amplifier of the IC. The error amplifier is working in the common mode configuration (Fig. 5) and the gain at open loop is equalised with the network R26 and C17 to compensate for roll-off due to the LC filter on the output.

It's inevitable when travelling a little off the beaten path of circuit design that components will be required which are not readily available. Such is the case for the switched mode power supply and consequently we are arranging for a supplier to stock them. Prices and addresses will be included in next month's article, which deals with the construction of this project.



Signal at the collector of Q3, Q4.



To verify the correct functioning of the unit, check that this waveform is present at the gate of the HexFET.

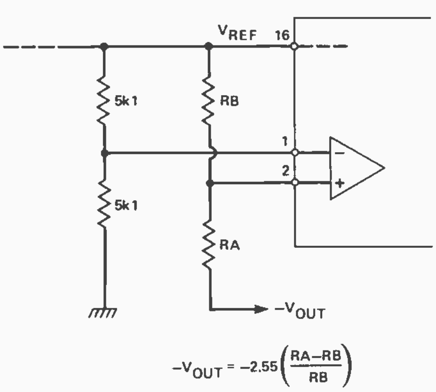
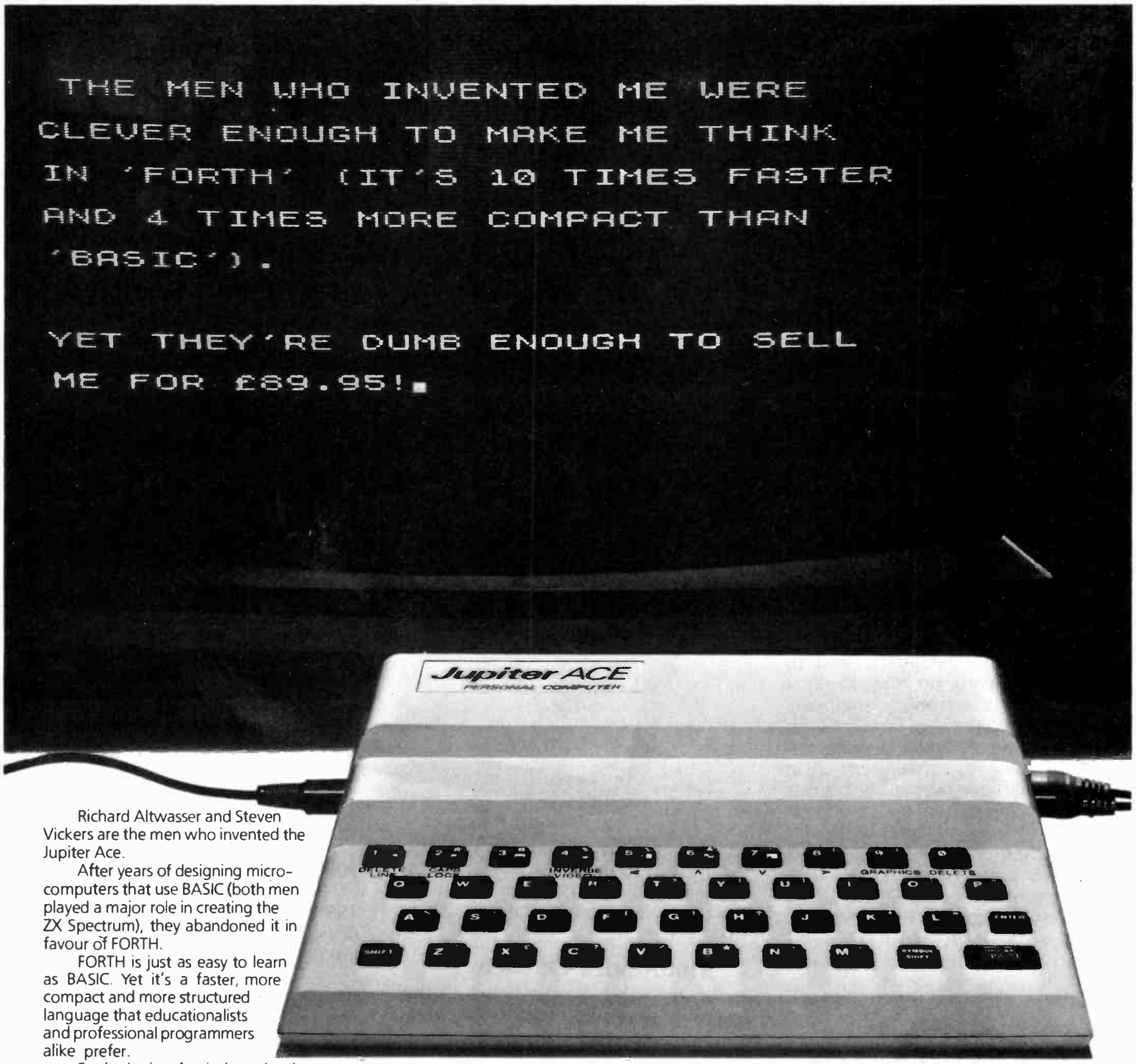


Fig. 6 Error amp operation.

SPECIFICATIONS

Input voltage range:	110 or 220 V ±10%
Output voltage:	12 V
Output current:	4 A
Line regulation:	0.01% at 4 A for +10% –20% line variation
Load regulation:	±1% from 500 mA to 4 A
100 kHz ripple:	10 mVpp 220 V input 4 A output
150 kHz ripple:	20 mVpp 220 V input 4 A output
Overall efficiency:	Approximately 80% at full load
Short circuit current limit:	5A5



Richard Altwasser and Steven Vickers are the men who invented the Jupiter Ace.

After years of designing microcomputers that use BASIC (both men played a major role in creating the ZX Spectrum), they abandoned it in favour of FORTH.

FORTH is just as easy to learn as BASIC. Yet it's a faster, more compact and more structured language that educationalists and professional programmers alike prefer.

So the Jupiter Ace is the only microcomputer you can buy that is designed around FORTH.

Using it, there's little fear of accidentally 'crashing' programs halfway through and having to start all over again (a common fault with BASIC). The Jupiter Ace's comprehensive error checking sees to that.

The Jupiter Ace has a full-size keyboard, high resolution graphics, sound, floating point arithmetic, a fast, reliable cassette interface, 3K of RAM and a full 12 month warranty.

You get all that for £89.95. Plus a mains adaptor, all the leads needed to connect most cassette recorders and T.V.'s, a software catalogue (35 cassettes available, soon to be 50), the Jupiter Ace manual and a free demonstration cassette of 5 programs

The Jupiter Ace manual is a complete introduction to personal computing and a simple-to-follow course in FORTH, from first principles to confident programming.

Plug-on 16K and 48K memory expansions are also available, at very competitive prices. (There'll be a plug-on printer interface available soon, too.)

It'll take you no time at all to realise how clever Richard and Steven were to design the Jupiter Ace around FORTH. And even less time to realise what a silly price £89.95 is to charge for it.

Technical Information

Hardware
Z80A; 8K ROM; 3K RAM.

Keyboard
40 moving keys; auto repeat; Caps Lock.

Screen
Memory mapped 32 col x 24 line flicker- free display upper and lower case ascii characters.

Graphics
High resolution 256 x 192 pixel user defined characters.

Sound
Internal loudspeaker may be programmed for entire audio spectrum.

Cassette
Programs and data in compact dictionary format may be saved, verified, loaded and merged. All tape files are named. Running at 1500 baud.

Expansion Port
Contains D.C. power rails and full Z80 Address, data and control signals. Can connect extra memory peripherals.

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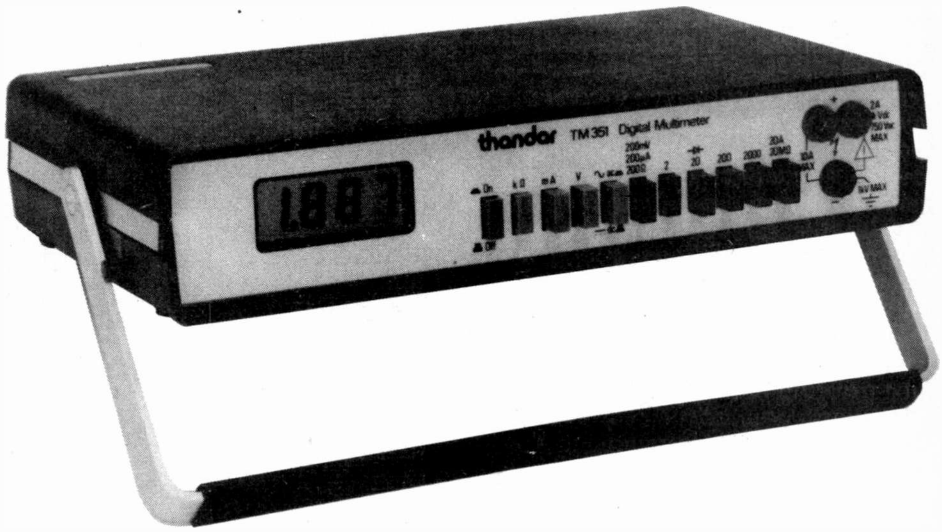
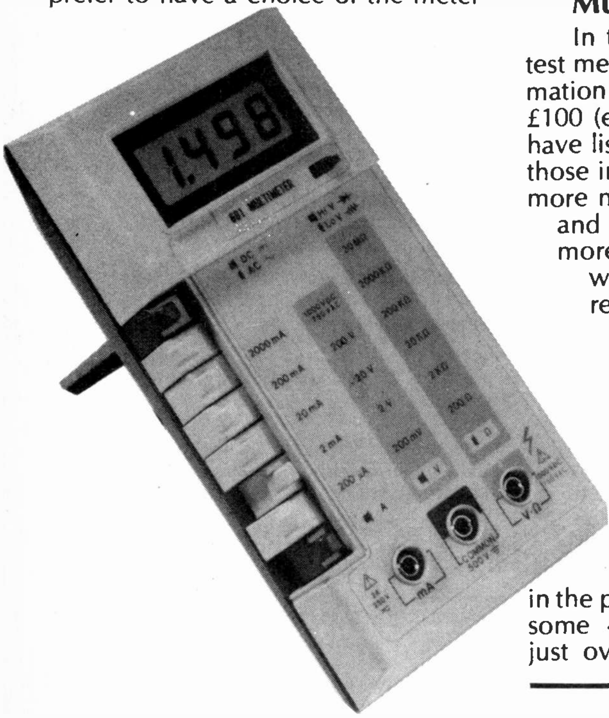
BUYER'S GUIDE TO

We've been getting testy with test gear, and in particular DMMs. Here are specs on over 30, and info on more besides. You'll find

The price of DMMs has fallen so much that you can now buy a reasonable quality instrument for the same price as a relatively cheap moving coil multimeter. So why doesn't everybody use DMMs and put the moving coil meter manufacturers out of business? Firstly, the cheap end of the market is likely to be dominated by moving coil meters for some time to come because the market is too small (unlike that, for example, of watches) for economics of scale to reduce the prices drastically. Secondly, and to an extent following on from the first reason, most electronics engineers and hobbyists are more familiar with moving coil meters and so have a certain preference towards them. And finally, there are some occasions when a moving coil meter can be far more useful than a digital — for instance, when you're measuring a voltage that's varying by around 10% per second, when you'd find yourself completely bedazzled by the flicker of digits on a DMM. Most engineers prefer to have a choice of the meter for the job, so don't throw away your old test meter just because you're going to buy a nice new DMM.

The Thandar TM 351





Multi-tudes Of Meters

In the table, we've listed all the test meters we were able to get information on, up to a maximum price of £100 (excluding VAT). Note that we have listed some meters as similar to those in the table. There were rather more meters than we bargained for, and we dread to think how many more leaflets will have arrived between our writing and your reading this! Some comments on the table will be helpful.

All the test meters in the table are 3½ digit types, ie the maximum scale reading is 1999. You can obtain meters with more digits, but we did not come across any in the price range, though we did find some 4½-digit hand-held meters at just over £100. So, for example, a 200mV voltage range on our meters will have a maximum reading of, in fact 199.9mV, and will be, at best, able to distinguish (or resolve) voltages that are 0.1mV different.

Accuracies

The accuracies quoted in the table are for guidance only. For two reasons we cannot quote exactly

The HC (well, sometimes) 601 (left) and the MIC-3300A (right): both these meters (and their relatives) turn up at a variety of sources.

TEST EQUIPMENT

information on the latest in other types of test gear on page 48 too. Next month, oscilloscopes.

comparable figures for different meters: different manufacturers quote their error specificaitons in different ways, though most use the method we have adopted of quoting a percentage of the reading plus a number of digits (some quote a percentage of full scale as well as or instead of the number of digits); and different ranges of the same quantity may have different errors. For example, Keithley quote an error of 1% plus 1 digit for the 2, 20 and 200mA DC ranges of the 130, yet 2% plus 1 digit for the 2A and 10A ranges. Also, some go further and quote different errors for different frequencies on the AC ranges. So, given the space available we can do no more than give a very broad indication, and we strongly recommend that once you have narrowed down the field to those instruments you are most interested in, you should get full specs from the manufacturers or agents. You should also note that some meters have accuracy guarantees, ie, provided that the meter is used within specified temperature and humidity, and is not abused, then the meter should stay within the specifications for at least a year. Therefore it's likely that these meters will be fairly conservatively specified.

The Elemic Digital 9: the 8 and 10 are very similar in looks

The 2000 range of Avometers: from l to r, the Digiminor 2000, the 2001 and the Vehicle Test 2002. The photograph really is the right way up.

You should decide what accuracy you actually need. It isn't that often that it's necessary to measure quantities to 1%, in fact, for most purposes, 5% is perfectly adequate. However, what you might need to do is to distinguish between quantities that differ by, say, 1%, and this is a relatively straightforward task for virtually any DMM.

Note that for maximum DC and AC voltage ranges, the maximum volts is always less than the maximum reading that the display is capable of. The maximum for AC is specified as volts RMS, very often 700V RMS, which will mean a peak voltage of 1000V for a sinusoidal waveform.

Features

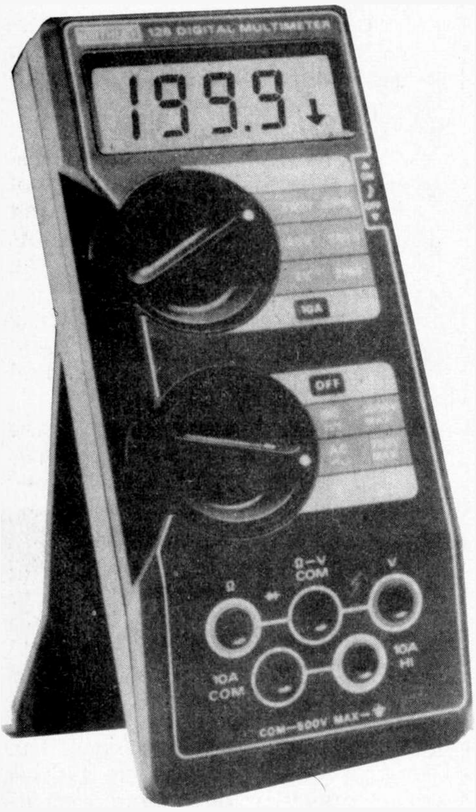
Most of the features are self-explanatory, though you may be a little surprised that feature F, folds for protection, really does mean that the

DIGITAL MULTIMETERS

	Voltage DC Ranges (number of ranges in brackets)	Accuracy on DC Volts % of reading + digits	Voltage AC Ranges (number of ranges in brackets)	Accuracy on AC Volts % of reading + digits	Frequency Range (Hz) for Stated Accuracy	Current DC Ranges (number of ranges in brackets)	Accuracy on DC Current	Current AC Ranges (number of ranges in brackets)	Accuracy % of re
Avometer DA211	200mV to 1000V (5)	0.8+1	200V, 1000V (2)	1.2+10	45 to 500	200uA to 10A (5)	1.2+2	–	–
Avometer DA212	200mV to 1000V (5)	0.25+1	200mV to 750V (5)	0.75+3	45 to 500	200uA to 1A (5)	0.75+5	200uA to 1A (5)	1.2+4
AVO Digminor 2000	2V to 1000V (4)	0.25+1	2V to 1000V (4)	1.0+3	40 to 450	20mA, 2A (2)	1.0+1	20mA, 2A	2.0+3
Avometer 2001	200mV to 1000V (5)	0.25+1	200mV to 1000V (5)	1.0+3	40 to 1k	200uA to 10A (6)	0.75+1	200uA to 10A (6)	1.5+3
BBC MA2D	200mV to 650V (5)	1.0+1	200mV to 650V (5)	1.5+3	NS	2mA to 10A* (5)	1.0+1	2mA to 10A* (5)	1.5+3
BBC MA3D	200mA to 650V (5)	1.0+1	200mV to 650V (5)	1.5+2	15 to 4k	2mA to 10A* (5)	1.0+1	2mA to 10A* (5)	1.5+2
Beckman T110	200mV to 1000V (5)	0.25+1	200mV to 750V (5)	1.0+3	NS	200uA to 10A (6)	1.0+1	200uA to 10A (6)	1.5+3
Beckman TECH 310	200mV to 1500V (5)	0.25+1	200mV to 1000V (5)	0.75+3	45 to 2k	200uA to 10A (6)	0.75+1	200uA to 10A (6)	1.5+3
Eagle TS 500	2V to 1000V (4)	1.0+1	200V, 500V (2)	2.0+1	NS	2mA to 200mA (2)	1.5+1	–	–
Eagle TS 750	200mV to 1000V (5)	0.8+1	200mV to 700V (5)	1.0+2	NS	200uA to 10A (16)	1.5+1	200uA to 10A (6)	3.0+2
Eagle TS 3500	200mV to 1000V (5)	1.0+1	200mV+600V (5)	1.0+1	NS	20mA to 1A (3) (+10A with shunt)	1.0+1	20mA to 1A (3) (+10A with shunt)	1.0+1
Elemic Digital 10	200mV to 1000V (5)	0.2+1	200mV to 1000V (5)	0.5+1	10 to 5k	200uA to 10A* (6)	0.2+1	200uA to 10A*(6)	0.5+1
Fluke 8022B	200mV to 1000V (5)	0.25+1	200mV to 750 (5)	1.0+3	45 to 450	2mA to 2A (4)	0.75+1	2mA to 2A (4)	2.0+3
Hansen HD30/B	200mV to 1000V (5)	1.35+1	2V to 600V (4)	2.3+1	40 to 500	200mA (1)	2.0+1	200mA (1)	3.0+1
Hansen HD31	200mV to 1000V (5)	0.8+1	2V to 750V (4)	1.2+1	40 to 500	200mA, 10A (2)	1.8+1	200mA, 10A (2)	2.0+1
HC601	200mV to 1000V (5)	1.0+2	200mV to 750V (5)	2.0+5	45 to 400	200uA to 2A (5)	2.0+1	200uA to 2A (5)	2.0+5
HC703	200mV to 1000V (5)	1.0+2	200mV to 750V (5)	0.6+3	45 to 1k	200uA to 2A (5)	0.25+1	200uA to 2A (5)	2.0+2
Keithley 128	2V to 1000V (4)	0.5+1	2V to 750V (4)	1.0+1	45 to 500	10A (1)	1.5+1	10A (1)	2.0+1
Keithley 130	200mV to 1000V (5)	0.5+1	200mV to 750V (5)	1.0+5	45 to 500	2mA to 10A (5)	2.0+1	2mA to 10A (5)	3.0+5
Lascar DP2010	2V to 500V (4f)	1.0+1	2V to 500V(4)	2.0+5	NS	2mA to 2A (4)	3.0+1	2mA to 2A (4)	4.0+1
Lascar LMM100	200mV to 1000V (5)	0.1+1	200mV to 1000V (5)	0.75+5	NS	200uA to 2A (5)	0.25+1	200uA to 2A (5)	1.0+5
MDS D350	200mV to 1000V (5)	0.75+1	2V to 600V (4)	1.0+2	40 to 500	200mA (1) (20A with shunt)	1,0+1	200mA (1) (20A with shunt)	1.25+1
MIC-3300A	200mV to 1000V (5)	0.8+1	200V, 750V (2)	1.2+3	40 to 500	200uA to 10A (6)	0.8+1	–	–
MIC-6000	200mV to 1000V (5)	0.5+1	200mV to 750V (5)	1.0+2	40 to 600	200uA to 10A (6)	0.8+1	2mA, 200mA, 10A (3)	1.5+1
Micronta 22-191	200mV to 1000V (5)	1.0+1	2V to 500V (4)	1.5+2	45 to 1k	2mA to 200mA (3)	2.5+1	2mA to 200mA (3)	2.5+2
Micronta 22-192	200mV to 1000V (5)	1.5+2	2V to 500V	1.5+2	45 to 1k	200mA (1)	2.5+1	200mA (1)	2.5+2
Pantec Pan 2001	200mV to 1000V (5)	0.2+1	200mV to 750V (5)	0.5+1	NS	200uA to 10A (6)	0.2+1	200uA to 10A (6)	0.5+1
Sabtronics 2015A	200mV to 1000V (5)	0.1+1	200mV to 1000V (5)	0.5+1	40 to 40k	200uA to 10A (6)	0.3+3	200uA to 10A (6)	0.5+1
Sabtronics 2035A	200mV to 1000V (5)	0.1+1	200mV to 1000V (5)	0.3+2	NS	200uA to 2A (5)	0.3+1	200uA to 2A (5)	0.25+1
Sifam DMM 2200B	2V to 1000V (4)	0.3+2	2V to 1000V (4)	0.4+2	45 to 700	2mA to 2A (4)	0.7+2	2mA to 2A (4)	1.0+3
Sifam DMM 2500	200mV to 1000V (5)	0.3+2	200mV to 1000 (5)	0.4+2	45 to 700	2mA to 2A (4)	0.7+2	2mA to 2A (4)	1.0+3
Thandar TM 351	200mV to 1000V (5)	0.1+1	200mV to 750V (5)	0.5+2	50 to 1k	200uA to 10A (6)	0.3+1	200uA to 10A (6)	1.0+2
Thandar TM 354	2V to 1000V (4)	0.75+1	200V, 500V (2)	1.0+2	50 to 500	2mA to 2A (4)	1.0+1	–	–
Trio DL-705	2V to 1000V (4)	0.5+2	2V to 1000V (4)	1.0+2	40 to 1k	20mA, 200mA (2)	1.0+2	–	–

...on AC Current ...ding + digits	Frequency Range (Hz) for Stated Accuracy	Maximum Voltage Burden on Current Ranges	Ohms Ranges, in Ohms (number of ranges in brackets)	Accuracy on Ohms Ranges	Features (see Key)	Type of DMM/Type of Display	Similar Models	Accessories Supplied (see Key)	Price, Excluding VAT	
	–	300mV (10A 500mV)	2k to 2M (4)	1.0+2	BDHMNO	hand	–	bt	56.50	Avometer DA211
	45 to 1k	250mV (1A 600mV)	200 to 20M (5)	NS	KLMO	hand/LCD	–	bt	79.90	Avometer DA212
	40 to 2k	500mV	2k to 20M (3)	1.0+1	BCDGMNOS	hand/LCD	–	bkt	69.40	AVO Digiminor 2000
	40 to 450	500mV	200 to 20M (2)	0.25+1	BCDGMNOS	hand/LCD	Vehicle Test 2002	bkt	85.40	Avometer 2001
	NS	NS	2k to 20M (5)	2.0+1	BKMNO	hand/LCD	MA1D	t	68.00	BBC MA2D
	15 to 4k	NS	2k to 20M (5)	2.0+1	BFKMO	hand/LCD	–	t	99.00	BBC MA3D
	NS	750mV	200 to 20M	0.5+3	BCKLM	hand/LCD	T100	bt	59.00	Beckman T110
	45 to 400	700mV	200 to 20M	0.5+1	BDKMNS	hand/LCD	–	bt	95.00	Beckman Tech 310
	–	NS	2k to 2M (4)	1.5+1	BGMO	hand/LCD	–	ct	29.95	Eagle TS500
	NS	NS	200 to 20M (6)	1.0+1	BKMOS	hand/LCD	–	ct	49.95	Eagle TS750
	NS	NS	2k to 20M (5)	1.0+1	KMPS	hand/LCD	–	cst	74.95	Eagle TS3500
	10 to 5k	200mV	2k to 20M (5)	0.2+1	BDKMO	hand/LCD	Digital 8, Digital 9	bct	83.00	Elemic Digital 10
	45 to 450	250mV (2A 900mV)	200 to 20M (6)	2.0+1	ABDHMNO	hand/LCD	8021B	bt	99.00	Fluke 8022B
	40 to 500	NS	200 to 2M (5)	1.35+1	CDKOR	hand/LCD	HD30	bft	38.70	Hansen HD30/B
	40 to 500	NS	200 to 20M (5)	0.8+1	CDKOR	hand/LCD	–	bft	51.26	Hansen HD31
	45 to 400	250mV (2A 700mV)	200 to 20M	0.6+4	ABDHLMOS	hand/LCD	HC6010	bt	34.00	HC601
	NS	250mV (2A 700mV)	200 to 20M	0.2+3	ABDHLMOS	hand/LCD	HC7030	bt	44.00	HC703
	45 to 500	300mV	200 to 20M (4)	0.5+1	ABCDKMN	hand/LCD	135A	bt	119.00**	Keithley 128
	45 to 500	300mV (2A 700mV)	200 to 20M (5)	0.5+1	AKMO	hand/LCD	131	t	99.00**	Keithley 130
	NS	NS	2k to 2M (4)	1.0+1	BDGMO	hand/LCD	DP2010K	t	27.40	Lascar DP2010
	NS	NS	200 to 20M (5)	0.2+1	ABHO	bench/LCD	LMM1001	t	75.20	Lascar LMM1000
	40 to 500	300mV (2V with S)	200 to 2M (5)	0.75+3	CHLOR	hand/LCD	–	bcst	69.00	MDS D350
	–	350mV	200 to 20M (6)	0.8+1	ABDKMNOT	hand/LCD	–	ft	42.00	MIC-3300A
	NS	350mV	200 to 20M (6)	0.5+1	ABCDKMNO	hand/LCD	–	ft	46.00	MIC-6000Z
	NS	NS	200 to 20M (6)	2.0+1	CDKMOS	hand/LCD	–	t	47.78	Micronta 22-192
	NS	NS	200 to 2M (5)	2.0+1	CDKORS	hand/LCD	–	t	64.95	Micronta 22-192
	NS	NS	200 to 20M (6)	0.5+1	BKMO	hand/LCD	–	t	79.83	Pantec Pan 2001
	NS	NS	200 to 20M (6)	0.1+1	HLMO	bench/LCD	2010A	t	83.00	Sabtronics 2015 A
	NS	NS	200 to 20M (6)	0.25+1	BHLMO	hand/LCD	–	t	62.00	Sabtronics 2035A
	45 to 700	200mV	2k to 20M (5)	0.3+2	BKMO	hand/LCD	–	bft	43.43	Sifam DMM 2200B
	45 to 700	200mV	200 to 20M (6)	0.3+2	BHMO	bench/LCD	–	bt	66.04	Sifam DMM 2500
	50 to 1k	NS	200 to 20M (6)	0.2+1	DHMO	bench/LCD	TM353, TM355	bt	99.00	Thandar TM351
	–	300mV (2A 900mV)	2k to 2M (6)	0.75+1	BDGMO	hand/LCD	–	t	39.95	Thandar TM354
	–	NS	2k to 20M (6)	0.5+2	HO(R)	bench/LED	–	bft	92.00	Trio DL-705

meter folds in two down the centre. Meters with low power ohms ranges can be useful for measuring resistance values with the components still in circuit because the test voltage they apply is 0V5 or less, which is too low to turn on transistor or diode junctions. Not all manufac-



Keithley's 128 — the 135 has an extra digit.

turers specify the maximum test voltage that their meters will apply, so we may have missed some meters that apply less thant 0V5 on all resistance ranges (feature N).

Prices

Note that these do not include VAT. Before ordering, you should check the price with the suppliers — it may be possible to get a better price than we've quoted by shopping around.

Similar Brands

These are brands that share a similar specification, with differences from the meter in the table as detailed below:

AVO Vehicle Test 2002 (£97.00): limited basic ranges, but wide selection of special accessories specially for automotive testing;
BBC MA1D (£54.00): same ranges as MA2D (except no 10A current ranges), lower accuracy;
Beckman T100 (£49.00): same ranges as T110 (except no continuity buzzer), lower accuracy;
Elemic Digital 9 (£58.95): same ranges as Digital 10, lower accuracy;
Digital 8 (£52.50): as Digital 9 but no 10A ranges;
Hansen HD30 (£36.48): as HD30B but no continuity buzzer;
HC6010 (£37), **HC7030** (£47): as HC601. HC703 but with 10A ranges;
Keithley 135 (£225): similar to 128 but with 4½ digits and higher accurancy;
Keithley 131 (£139): similar to 130 but with higher accuracy;
Lascar DP2010K (£19.95 special offer): kit version of DP2010;
Lascar LMM1001 (£79.95): as MM100 but with higher accuracy;
Sabtronics 2010A (£71.00): as 2015A but with LED display;
Thandar TM353 (£75.00): similar to TM351, but lower accuracy, no 10A range and rotary switch range selection;
Thandar TM355 (£75.00): similar to TM351, but lower accuracy and LED display.

Key to DMM Features
A = accuracy guarantee
B = single battery operation
C = continuity beeper
D = diode test facility
F = folds for protection
G = slider switch range/mode selection
H = push-button range/mode selection
K = rotary switch range/mode selection
L = low power ohms range
M = manual ranging
N = low power ohms on all ranges
O = overload protection
R = autoranging
S = stand
T = transistor test facility

Key to accessories supplied
b = battery
c = carry case
f = sapre fuse
k = test clips
s = high-current shunt
t = test leads

* = 20A for limited period

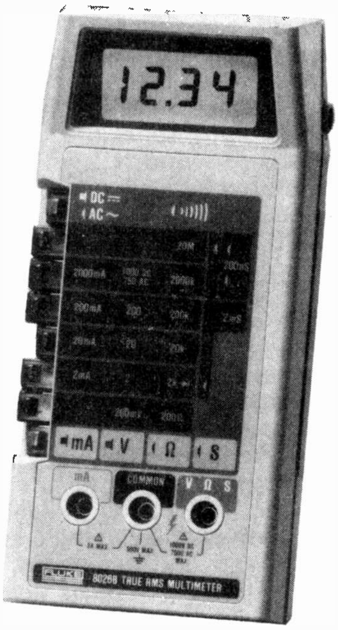
** = likely to be discounted

NS = not specified

Addresses

AVO
Thorn EMI Instruments Limited, Archcliffe Road, Dover, Kent CT17 9EN
BBC
available through:
John Minster Instruments Ltd, 137/139 Sandgate Road, Folkestone, Kent CT20 2DE; and: House of Instruments Ltd, Clifton Chambers, 62 High Street, Saffron Walden, Essex, CB10 1EE
Beckman
available through:
Farnell Electronic Components Ltd, Canal Road, Leeds, LS12 2TU; and, Audio Electronics, Cubegate Ltd, 301 Edgware Road, London W2 1BN
Eagle International TS750
Precision Centre, Heather Park Drive, Wembley, HA0 1SU
Elemic
available through:
Black Star Ltd, 9A Crown Street, St Ives, Huntingdon, Cambs PE17 4EB
Fluke (GB) Ltd
Colonial Way, Watford, Herts WD2 4TT
Hansen
available through:
Audio Electronics, Cubegate Ltd
HC601, HC703, etc
These are available through a number of suppliers, and are often sold as 'own brands', with or without the HC prefix. However, you should check that the specs are the same as those we quote which are for the House of Instruments Ltd version.
Keithley Instruments Ltd
1 Boulton Road, Reading, Berkshire RG2 0NL
Lascar Electronics Ltd
Module House, Whiteparish, Salisbury, Wiltshire SP5 2SJ
MDS
Micro-Data Systems, Coach Mews, St Ives, Huntingdon, Cambs PE17 4BN
MIC —6000 Z
available from:
House of Instruments Ltd
Micronta
available through Tandy high street shops.
Pantec Pan
available through: Audio Electronics, Cubegate Ltd.
Sabtronics
available through: Black Star Ltd; and, Stotron Ltd, Haywood Way, Ivy House Lane, Hastings, East Sussex TN35 4PL. (Stotron also sell the Taisei DM2350, which bears a remarkable similarity to the MDS D350, though the specs are slightly lower, for £48.00).
Sifam Limited
Woodland Road, Torquay, Devon TQ2 7AY
Thandar Electronics Limited
London Road, St Ives, Huntingdon, Cambs PE17 4HJ
Trio
available from:
House of Instruments Ltd

Fluke Hand-held True RMS DMM.



Fluke has expanded its best-selling range of 3½ digit hand-held digital multimeters with the the introduction of a version with true RMS measurement capability. Fluke pioneered true RMS measurement on hand-held DMMs with their recently launched 4½ digit family and have now introduced this useful facility to their 3½ digit range.

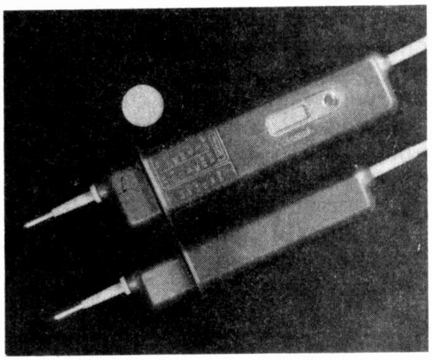
Called the 8026B, this new model provides all the facilities and performance of the 8020B series models such as 0.1% basic DC accuracy, high speed continuity bleeping for open/short continuity testing, and conductance which allows high resistance measurements from 20 Mohms to 10,000 Mohms to be made.

True RMS capability is most useful when measuring non-sinusoidal waveforms as in digital equipment, e.g. modems, terminals and monitors as well as in motor and thyristor circuits, noise measurement etc. Conventional meters using only averaging techniques can introduce errors of up to 30% or more in such applications.

Other features of the 8026A, which is priced at £180 + VAT, include a heavy duty 600V dual-fuse system to protect against high-energy input signals, a very rugged design, non-skid rubber feet and a tilt bail for ease of use in the field. The new instrument comes with a two-year guarantee and labour warranty and a one-year calibration cycle. For further information, contact Fluke (GB) Limited, Colonial Way, Watford, Herts. WD2 4TT. Tel: 0923 40511.

New Source for Digicheck

The Steinel Digi-Check, a voltmeter and ohmmeter of a rather novel design, is now available from Electronic and Computer Workshop Ltd, 171 Broomfield Road, Chelmsford, Essex CM1 1RY.



Temperature Measurement From Your DMM

Anyone who has access to a digital multimeter can now use it as a versatile wide range temperature measuring instrument using standard type K thermo-couples, by adding the DVM/TC Interface Unit, which costs £36 (+ £1.35 p&p + VAT) from the makers.

This new device, at considerably lower cost than a dedicated instrument, has a temperature range of — 50C to 1100°C and incorporates automatic cold junction compensation. Thermocouples are attached through a miniature compensated socket. A basic thermocouple and mating plug are supplied as standard with the instrument. The output of 1mV per degree centigrade is via a 0.75 metre coiled lead fitted with 4mm plugs. Long term stability is claimed to be excellent and the low battery drain allows it to be used for continuous monitoring if necessary.

Full details are available from the manufacturers Graham Bell Instrumentation, PO Box 230, 39 Derbyshire Lane, Sheffield, S8 0TH. Tel: 0742 582370.

Enhanced Logic Analyzer

Two optional enhancements for their Model 632 Logic Analyzer announced by Zicon Instruments of Norwich.

The Model 632 is designed as a high performance, low cost instrument for use in trouble-shooting synchronous logic systems. It has sixteen data channels, two qualifiers and a clock input which, coupled with its integral hexadecimal display, allows it to be used "free-standing" in the analysis of microprocessor systems. The unit also provides oscilloscope outputs which are used to generate the familiar timing diagram.

In its standard form, the Model 632 is capable of capturing 128 16-bit words at speeds up to 4MHz with 64 words pre-trigger.

Data can be recorded using either edge of the external clock; and a clock qualifier allows (for example) only-memory reads or only-data outputs to be recorded. The trigger word is set by four thumbwheel switches in hexadecimal code with disable/enable selection for each switch. A 1-X-0 trigger qualifier expands the trigger word to 17 bits or it may function as an external trigger.

The stored data can be examined in one of two ways. The integral 4-digit hexadecimal display shows one word at a time with its position in memory relative to the trigger word indicated by a 2-digit cursor display extending from —64 to +63. A timing diagram output is also provided which generates a 16-channel display on any general purpose oscilloscope with trigger and cursor position markers.

An optional 12 MHz memory speed (Option 11) is now available on this model. As a further enhancement (Option 12), Zicon Instruments have designed and produced a dedicated IEEE-488 bus data pod for use with Model 632. This probe connects directly to the bus and permits the monitoring of bus activity in either state or timing format with 8 input lines switchable between handshake and management lines or flying leads for user connection.

Current prices are: Model 632 £1095; Option 11 £295; Option 12 £295. Zicon Analyzers are distributed by STC Instruments Ltd of Harlow and Elex Systems of Bracknell. Zicon Instruments Ltd, 23 Meteor Close, Airport Industrial Estate, Norwich NR8 6HQ. Tel: Norwich (0603) 400083.

High-Current Clamps For Beckman Multimeters

A range of three current clamps is now available to extend the AC and DC current ranges of all Beckman Instruments' multimeters. The ranges are 10 to 150A RMS AC (model CT-231, £19.00 inc. VAT), 10 to 1000A RMS AC (model CT-232, £98.50 inc. VAT) and 0 to 600A AC and DC (model CT-233, £69.00 inc. VAT, available June).

With the multimeter in the 200mA AC position, the CT-231 displays the current directly in amperes. With the CT-232, the multimeter is set in the 2A AC position and the current reading is multiplied by 1000. Depending on DC or AC measurement, the multimeter using the CT-232 is set to either 200mV or 2V DC or AC position, the readings being directly in amperes and amperes/1000 respectively. (The clamps should be usable with other brands of DMM — Ed.). Beckman Instruments Ltd, Mylen House, 11 Wagon Lane, Sheldon, Birmingham B26 3DU. Tel: 021-742 7761.

Low Cost Capacitance Meter

A portable LCD digital capacitance meter costing £49.50 plus VAT marketed by Semiconductor Supplies, Sutton, has a 0.1 pF to 2000 uF range covering virtually all electronics engineering applications. A 3½ digit display is provided.

The DM 6013 is supplied with an instruction manual, alligator test leads and a spare 0.2A fuse. For further information contact Semiconductor Supplies International, Dawson House, 128/130 Carshalton Road, Sutton, Surrey SM1 4RS. Tel: 01-643 1126.

National Agreement

Wessex Electronics Ltd of Bristol has been appointed by National Panasonic (UK) Ltd to market National measuring and testing equipment.

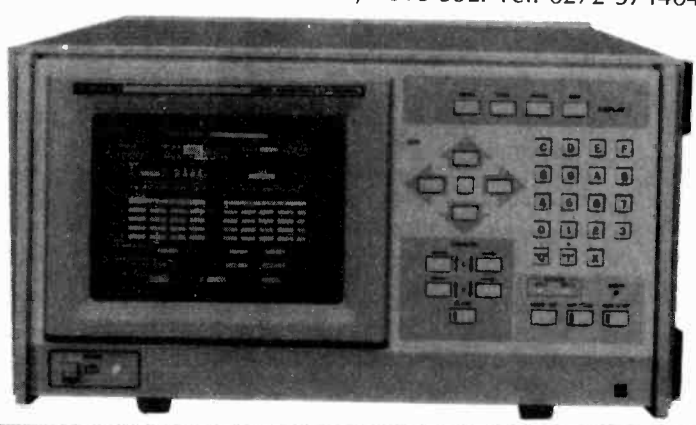
Among the products Wessex will be distributing is a 20 MHz, 32 channel logic analyser. The VP-3620A is a dedicated unit catering to a wide range of industrial needs. It contains a logic state analysing function for self-contained microprocessor operation analysis and a logic timing function for the evaluation of peripheral operations. With its multifunction capability, National's logic analyser is also able to display the traced data in disassembled mnemonic mode corresponding to each microprocessor in use.

The National Panasacope will also be available from Wessex. The new oscilloscope (VP-5512A) offers DC to 100 MHz with an alternate sweep function. There is four channel, eight trace capability so that a large number of signals can be simultaneously observed. The Panascope features an advanced dome-meshed CRT and an auto-fix circuit for easy triggering. Ideal for field or lab use, the Panascope has a tv sync separation circuit for video signals and variable hold off function for trigger stabilisation.

Advanced technology utilised in the Panascope, such as reduced number of parts for greater reliability and epoxy circuit boards for heat and shock resistance are also featured in the logic control series oscilloscopes (VP-5520B and VP-5530B) manufactured by National and to be marketed by Wessex. Both the VP-5520B and the VP-5530B offer multi-trace capability and facilitate accurate signal measurement up to 200 MHz and 300 MHz respectively.

Making up the initial complement of National products to be marketed by Wessex Electronics is a new generation A4 digital graphic plotter. Offering six colour graphics and plotting speeds up to 400mm/sec, the plotter (VP-6801A) allows great versatility in the creation of graphs and line definitions. The VP-6801A features a high level of intelligence to simplify the external programming required to generate complex graphs, shapes and alphanumerics. Computer interfaces available include both GP-IB and RS-232C, thus allowing the VP-6801A to be used as a computer graphics device as well as for instrumentation graphics. Wessex Electronics Limited, 114-116 North Street, Downend, Bristol, BS16 5SE. Tel: 0272 571404.

National's VP-3620A Logic Analyser



Platinum Digital Thermometer

A pocket-sized, digital thermometer, with +/— 0.1 degrees C accuracy over an extended temperature range from —200 to +800 degrees C, is announced by Ancom Ltd. The Ancom BLR-800 offers a one degree C resolution, very good repeatability and a stability figure of 0.01 degrees C per degree C, with a wide range of standard platinum RTD temperature sensor probes. These include models for measurement of air temperature, liquid immersion, surface temperature, hypodermic insertion and fast response types. The sensors are available with conformity to British and DIN standards in grades A, B, C, D and E and are simply connected to the instrument by a three-way plug/socket.

The BLR-800 uses a low power 3½ digit LCD for data display, which also displays a low battery sign.

Calibration is very simply carried out by the user, using boiling water and melting ice references.

For further information please contact Ancom Limited, Devonshire Street, Cheltenham GL50 3LT, Tel: 0242 513861.

ETI

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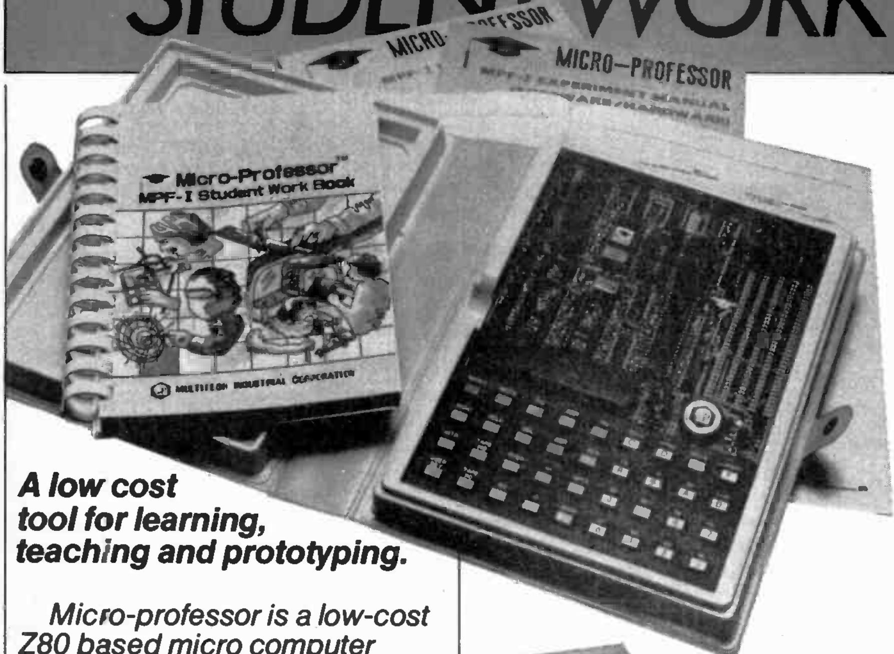

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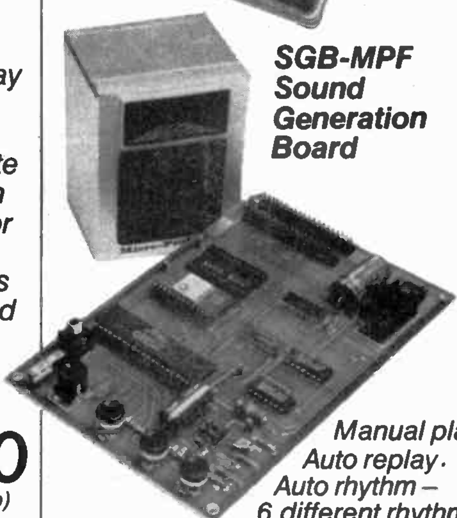

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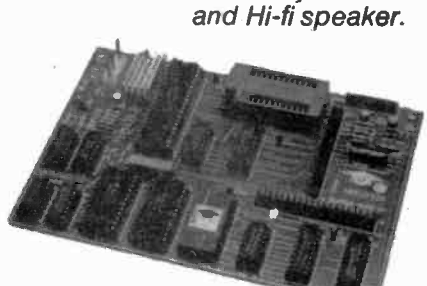
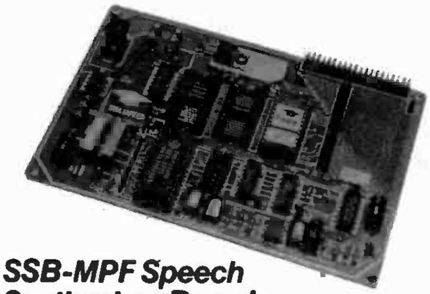


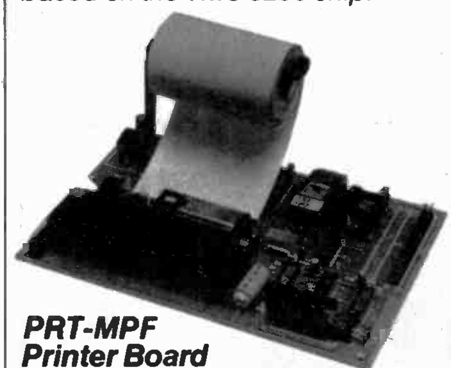
EPB-MPF EPROM Programming Board

For all +5V 1KB/2KB/4KB EPROMS Read/Copy/List/Verify Capability.



SSB-MPF Speech Synthesizer Board

A vocabulary of up to 400 words based on the TMS 5200 chip.



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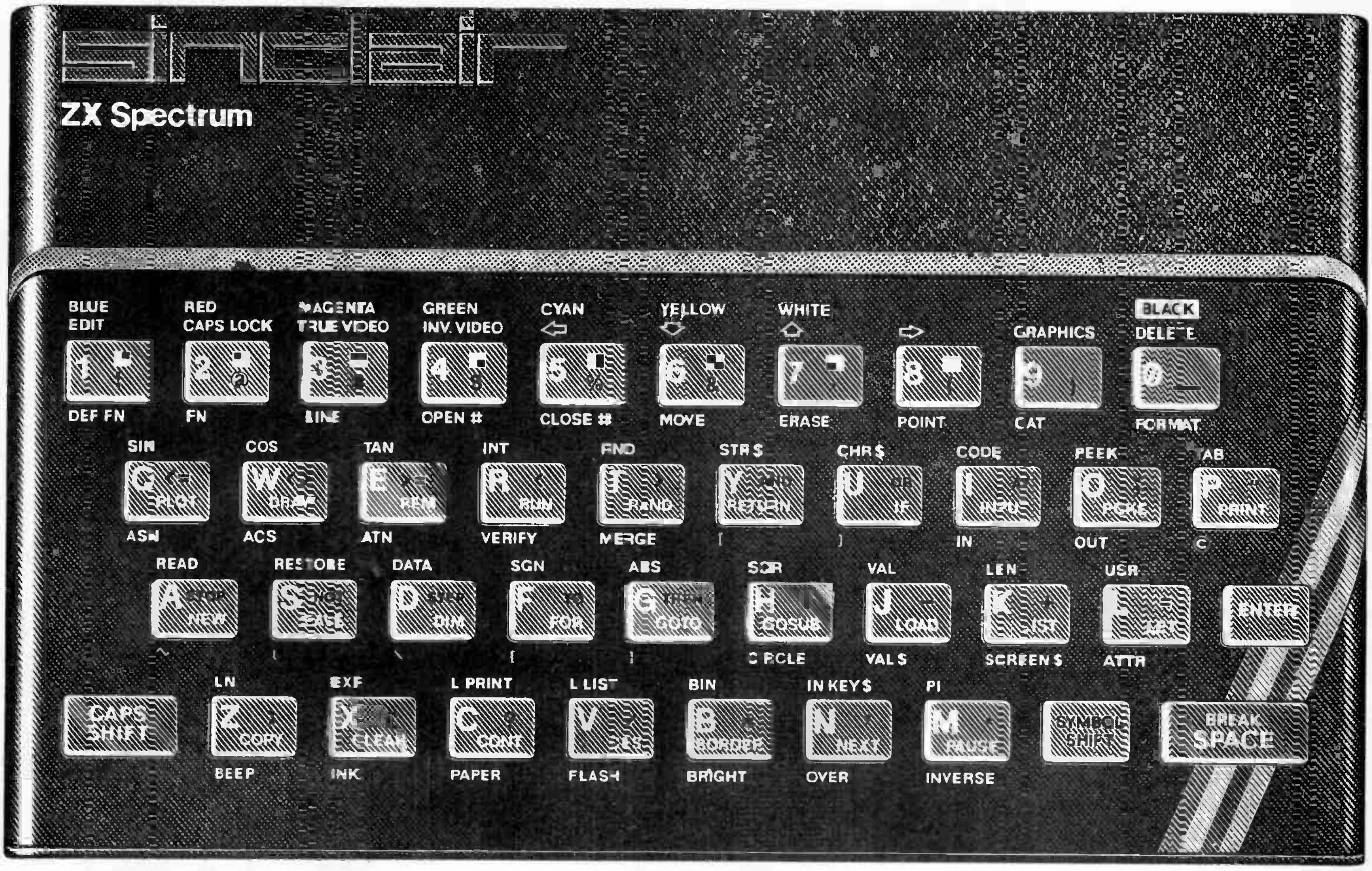

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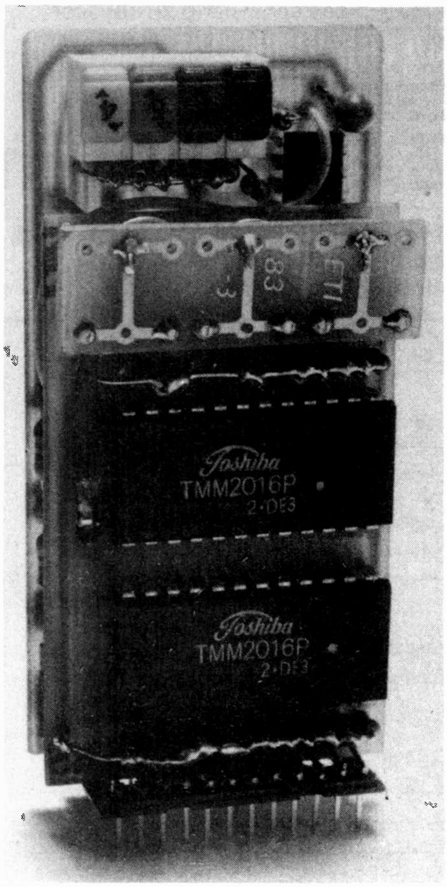
PSEUDOROM

EPROMs never forget but they're a damned nuisance to reprogram. RAMs are easy to overwrite but they lose their contents on power-down. ETI, naturally, has combined the best of both worlds. Design by Phil Walker.

The ETI PseudoROM now offers the home constructor a device having the capacity of the larger ROM and EPROM chips, but with the programmability of RAM, which can be inserted into the existing ROM socket of your microcomputer. This makes it possible to develop large and complex operating software in one module which only occupies the same physical board area as the eventual ROM or EPROM (if used).

Another advantage is that the access time of the module is only 50 nS or so slower than the memories it contains (if you're using both the 74HC32 and the 74HC138). This will be somewhat less than the normal 450 nS spec of many EPROM devices advertised, and could enable you to run your system at a higher clock frequency (processor permitting), so increasing throughput.



Here's a fine, upstanding project . . .

The Circuit

The circuit used in this project is essentially very straightforward and consists of four 2K by 8 bit CMOS RAM chips, connected to an address decoder to make an effective 8K by 8 bit memory. By means of a small battery and some extra circuitry this sizeable chunk of memory will retain its data even when unplugged from its socket. To make it even more useful the unit is constructed such that it can be used as four areas of 2K by 8 read/write memory or alternatively four sections of 2K, two sections of 4K or a single section of 8K by 8 read-only memory. All these modes are selectable by the integral switches, except that 8K by 8 is only available when inserted into a 28 pin socket.

The point of this versatility is that the unit can be programmed in an existing RAM socket (or one can be provided) at any time and then transferred to an EPROM or ROM socket without losing data (as long as the write protect switch is used). This means that quite large sections of operating systems or special software can be modified and tested without the delays of erasing and reprogramming EPROMs or losing data in system crashes.

2-4-8K

The only difference between the 4K and 8K versions of this unit lie in the type of DIL plug used, the size of socket into which it is plugged and the numbering of the input/output pins on the circuit diagram. For memory simulation up to 4K only 24 pins are needed, while for 8K all 28 pins are required. The easiest way of inserting the unit correctly is to identify the 0 V pin and make sure it goes into the 0 V pin position in

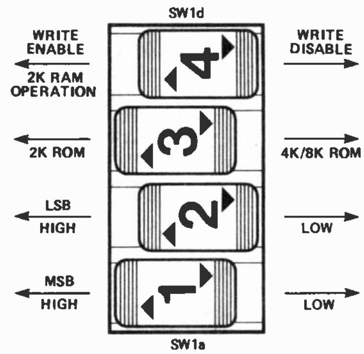
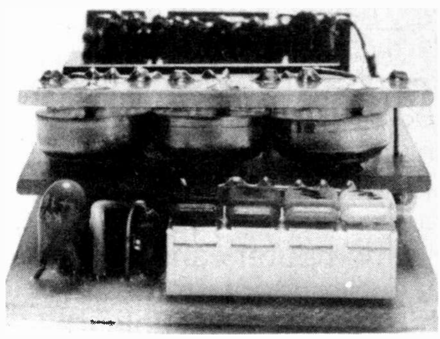


Fig. 1 Switch operations for the PseudoROM.

the socket used. For 24 pin sockets this is pin 12, for 28 pin sockets it is pin 14. Note that for 28 pin plugs and sockets the equivalent functions will occur on pin numbers having a value of 2 greater than those of 24 pin sockets, with the exception of +5 V on pin 28 and A12 on pin 2 (this latter address line goes to the connection marked (2*) on the circuit diagram).



View from the top.

BUYLINES

The 74HC series logic ICs which are required for this project are fairly new to the hobbyist scene and appear so far only to be stocked by Ambit International, 200 North Service Road, Brentwood, Essex CM14 4SG. The DIL switch shouldn't cause any problems but if you do have difficulty Maplin stock a suitable type. The mercury cells should be obtainable from most high street chemists and photographic shops, while the PCBs are available using our PCB Service order form on page 95.

HOW IT WORKS

The essential part of the circuit consists of IC1-4. These are 6116 CMOS 2K x 8 RAMs, which have the property of consuming very little power when not in use. However, for this to happen pin 18 (CS) of each device must be at a logic high level and preferably within a few per cent of the supply voltage. Also, the remaining device pins should be held close to either supply rail. R1-19 hold the address and data pins of the RAMs close to 0 V (via R29) when the unit is unplugged, or to the positive supply rail when in position.

ZD1, R28,30,31 and Q1 sense the presence of a suitable external power supply. When this is found the inputs to IC5a go low which causes its output to go low also. This then enables IC5b, IC5c and IC6 to operate. IC5c acts as a buffer for the OE control (pin 20), while IC5b buffers the WE function (normally pin 21). IC6 is used both to buffer the CS input and to use the two most significant address lines to select which RAM device is to be activated. SW1a and SW1b with their associated resistors provide default addresses to IC6 when direct inputs are not available. SW1d selects either ROM or RAM type operation whilse SW1c selects 2K or 4K/8K ROM simulation.

D1 isolates the memory power supply from that of the host machine when the main power is off and is a germanium device for minimum voltage drop. Likewise, D2 isolates the backup battery from the main supply when not in backup mode. When the external supply fails, the control signals to the RAM ICs are all forced to logic HIGH and the battery will be able to maintain the data in the RAMs for a long time.

Construction

Examine the overlay diagram and photographs *very* carefully . . . The unit consists of three PCBs mounted one on top of another. These must be assembled correctly and put together in the right order as there may be no second chance. We suggest that you follow the procedure here so that it goes together correctly, but read it carefully before starting.

Start with the smallest PCB: this is the battery connector. Take three thin brass shims about 0.1" (2.5 mm) wide by 0.6" (15 mm) long and solder each to the central bar of each pattern on the PCB such that they overlap one edge by 0.4" (10 mm) or so. Bend the overlapping length round the edge of the PCB so that it lies near the non-track side. This will form the positive contact for each cell. Alternatively, any springy material to hand may be soldered into the centre hole to do the job. In fact we used contacts from a piece of edge connector.

Next solder six lengths of 20 swg copper (or paper clip) wire into the holes nearest the free end of the battery connector described above. These wires will connect to the next board down and complete the battery holder.

The middle-sized PCB should be assembled next: this will form the middle of the sandwich. Be very careful to get the right value resistors in the right holes. There are nineteen 47k resistors and one 1k0 resistor on the board, all of which mount vertically. Insert them into their holes and solder into position as close as possible to the board. DO NOT CUT ANY OF THE LEADS OFF.

Using two 2½" (60 mm) lengths of 22 swg wire, connect the free ends of each line of resistors together and pass the remainder of the wire through the hole shown on the overlay; solder into position but

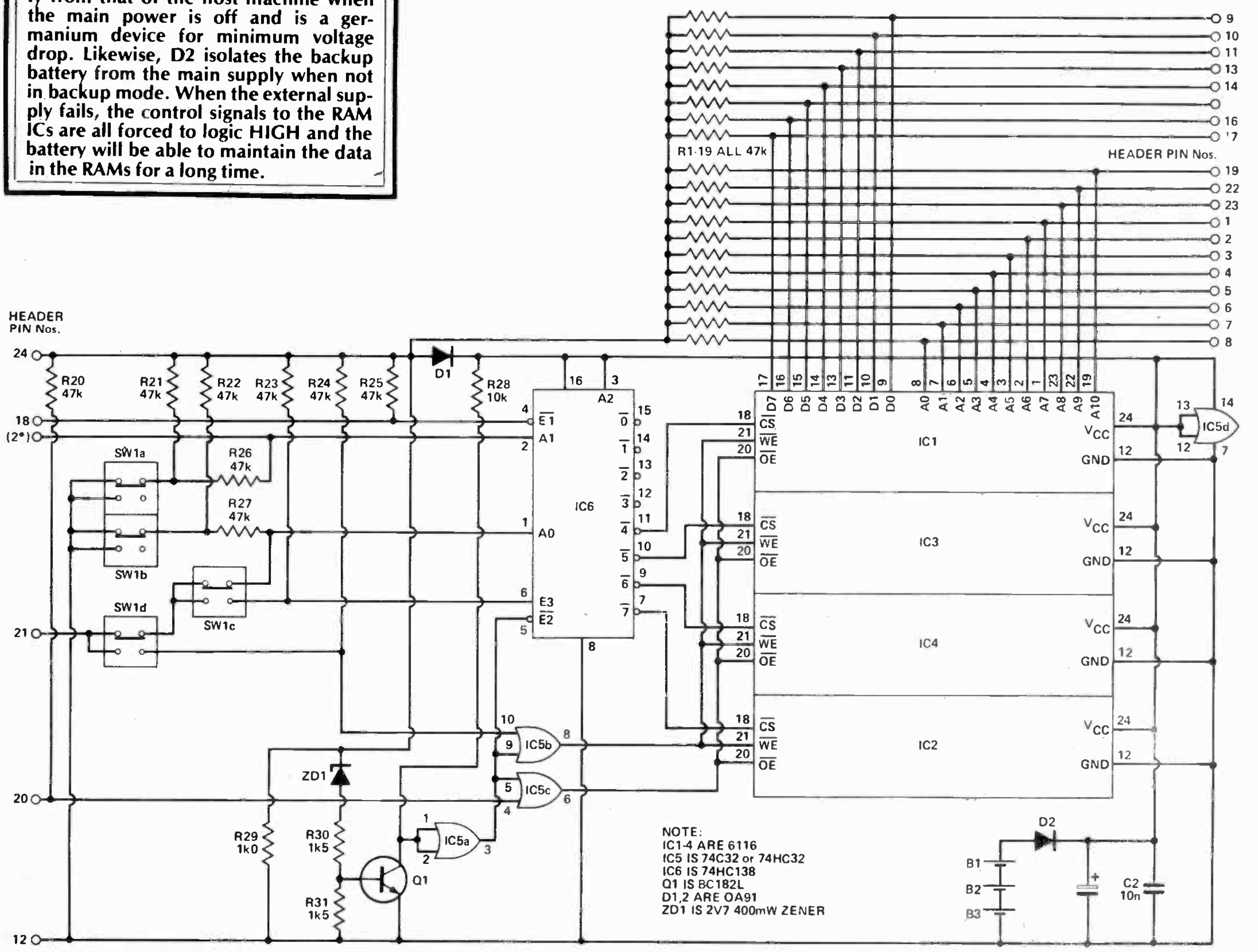


Fig. 2 Complete circuit diagram for the PseudoROM. All the header pin numbers refer to the 24-pin version: add two to all the numbers for the 28-pin version except for the pin marked (2*). This is left unconnected on the 24-pin version.

DO NOT CUT OFF. There are seven more links to be made to the lower board which should consist of 1" (25 mm) lengths of 22 swg wire. A useful tip — squeeze the end of the wire with pliers to help it stay in the hole when soldering. Now mount D2 on the PCB making sure that the polarity is correct.

The next step is to assemble the battery connector onto this board. First insert some 22 swg tinned copper wire into the three holes in the middle PCB which lie in the centre of the cell positions. Solder them into position and crop off close to the track side and to about $\frac{1}{4}$" (6 mm) on the component side. Bend this short wire towards the edge of the PCB and flatten it (. . . GENTLY . . .). These form the negative battery contacts. Now take the small PCB and insert the six wires from it into the corresponding holes in the medium-sized PCB. Put three of the specified mercury cells in position and adjust the two PCBs until the cells are held reasonably firmly in their correct positions. Solder the link wires into position and crop them close to the PCB; then remove the cells.

Solder 12 $\frac{1}{2}$" (12 mm) lengths of 22 swg wire (14 lengths for a 28-pin plug) into the row of holes on the edge of the PCB (starting at the R29 end) such that the wire projects on the component side. Now carefully insert the two memory devices into the PCB and solder them into position. MAKE ABSOLUTELY SURE THEY ARE THE RIGHT WAY ROUND and TAKE FULL PRECAUTIONS AGAINST STATIC DAMAGE. Crop the IC leads close to the foil side.

The largest PCB can now be assembled. First insert all the resistors, diodes, capacitors and transistor. Note that six of the resistors (all 47k) are mounted vertically as before with their free ends connected together and to a hole in the PCB. This time, however, the leads can be cropped close to the PCB. Next fit the DIL switch SW1, the two 74 series CMOS devices, and the remaining two memories. REMEMBER THAT ALL THE ICs ARE SENSITIVE TO STATIC. Make sure that they are the correct way round before soldering them in. Finally on this PCB, use four lengths of THIN insulated wire to make the long links shown on the overlay (W-W, X-X, Y-Y, Z-Z).

Having reached this stage it would be advisable to recheck all the solder joints on all the boards with a magnifying glass for accidental blobs, splashes or other faults.

From now on it will be virtually impossible to rectify any constructional errors. So check again!

Take the smaller PCB assembly and crop the wires projecting on the foil side so that the three links nearest the battery holder are virtually full length but the longest is at the edge and the shortest is farthest from it. Next crop the two lines of resistor leads and links so that the longest are about $\frac{3}{4}$" (18 mm) and the shortest are about $\frac{1}{2}$" (12 mm), graded evenly across the board width. This is done to make the next operation easier.

Now the tricky bit. With great care feed the wires from the smaller PCB assembly into the corresponding holes in the larger PCB. Make sure that the wires are straight when you do this and don't allow the long links to cross each other on top of the memories. It should be possible to get the two PCBs down to about $\frac{1}{4}$" (6 mm) apart. If you can't do this it may be that the transistor or capacitor is in the way. Rectify this before carrying on. The transistor must be very close to the board. If this is not the problem one of the links may be bent. This is a fault, as when properly assembled all the links between boards are straight.

When this stage has been reached successfully, solder all the inter-board links and crop off the excess wire.

The end is now in sight. Examine the connector end of the assembly you have made and offer up the 24 or 28 pin plug you wish to use. It may be necessary to file a little material off one of the PCBs so that the plug will lie square against the two PCBs when the pins are soldered in position. Do this now if necessary.

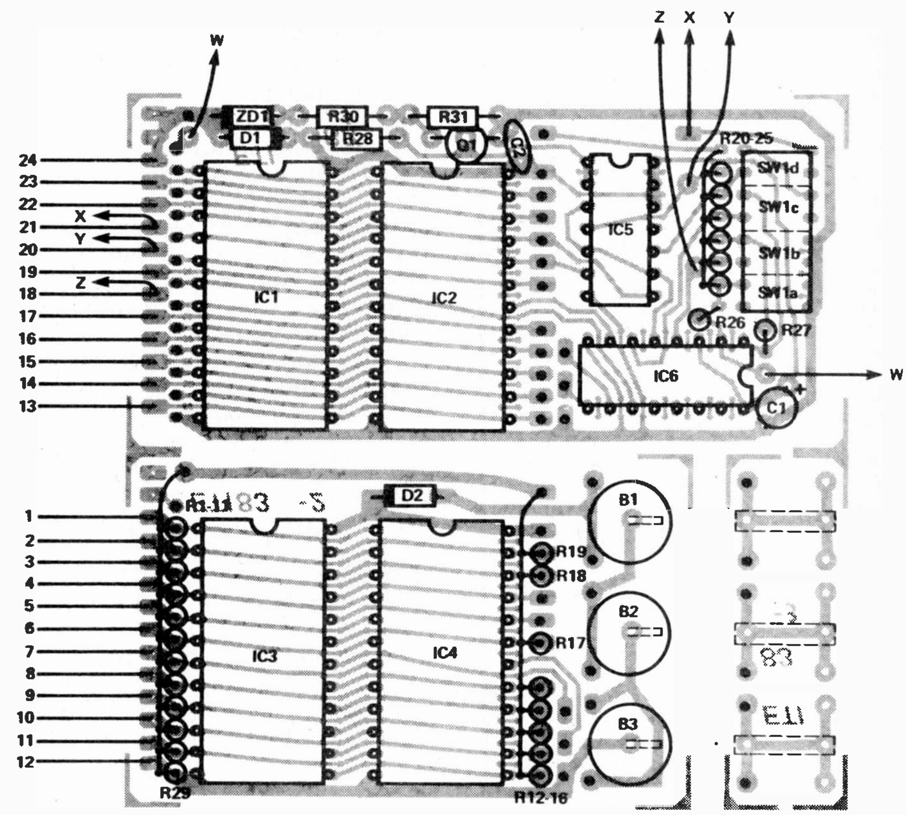


Fig. 3 Component overlay for the PseudoROM. Remember to separate the three boards *before* soldering!

PARTS LIST

Resistors (all $\frac{1}{4}$W, 5%)	
R1-27	47k
R28	10k
R29	1k0
R30,31	1k5
Capacitors	
C1	4u7 16 V tantalum
C2	10nF disc ceramic
Semiconductors	
IC1-4	6116
IC5	74C32 or 74HC32
IC6	74HC138
Q1	BC182L
D1,2	OA91
ZD1	2V7 400 mW zener
Miscellaneous	
SW1	quad SPDT DIL switch
B1-3	PX675 mercury cell

PCBs (see Buylines); 24 pin (or 28 pin) DIL header plug; wire, thin brass shim or other contact material.

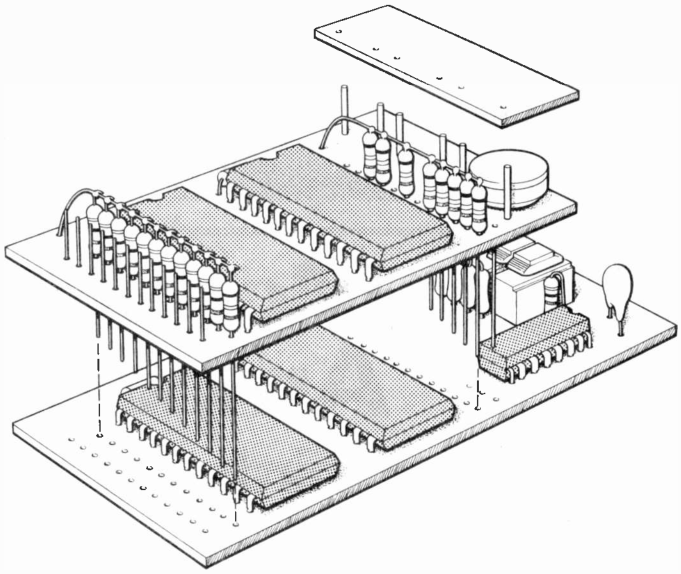
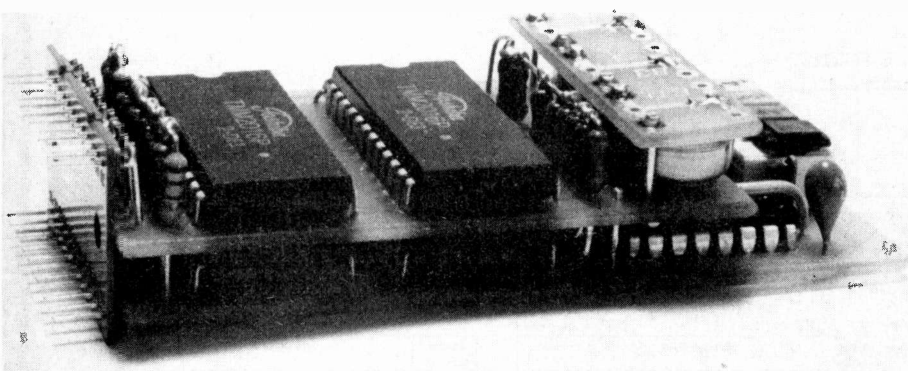


Fig. 4 An exploded view to help you through the traumas of construction. Compare with the photo below.

If there is a large blob of solder on any of the three pads where the links have been soldered already, remove some of it with a solder sucker or piece of fluxed braid. This is to allow the plug pins to seat down onto the PCB foil. Align the tags of the plug labelled with pins 13 to 24 (or 15 to 28 for the larger plug) against the pads along the edge of the largest PCB in the assembly. Solder them carefully to the pads such that pin 24 connects to the innermost of the three joined pads (or pin 28 joins to the outermost in a 28 pin plug). This should cause the remaining pins to be forced against the link wires coming from the middle PCB. With any luck they will be in the right place to be soldered but check first. Pin 12 (or 14 on 28-way plug) should lie next to R29 (1k0). If all is correct then solder them into position and crop off any excess wire.

The assembly should now be complete and after inserting the mercury cells is ready for use. These cells should be inserted with the flat or outer part of the case nearest to the small PCB. This is the POSITIVE terminal. The rounded stud is negative and goes to the middle PCB. Make sure the batteries are pushed well in so that they locate against the pairs of supporting struts and do not touch each other. Otherwise one battery will be shorted out.



The assembled project is neat and compact — at least it should be if you've done things correctly.

Using the PseudoROM

It is recommended that the unit is only inserted or removed from its socket when the equipment using it is switched off. To make use of the unit the data must first be written into it in 2K blocks. For this a 24 pin socket must be provided with a R/$\overline{W}$ signal on pin 21 and other signals as for a standard 2K EPROM. SW1d should be set to connect the pin 21 input through to IC5b and SW1a and SW1b set to select the 2K segment to be used. Data can now be entered into the unit. Change the SW1a and SW1b settings to load up the other segments as required, remembering that SW1a is the MSB and SW1b the LSB of the address.

When placed in a suitable 24 or 28 pin ROM socket, SW1d should be set so that pin 21 (23) is no longer connected to IC5b: this prevents accidental overwriting of the data. SW1c can now be used to select either 2K ROM simulation (connecting to IC6 pin 6) or 4K in a 24 pin socket and 8K in a 28 pin socket (connecting to IC6 pin 1). Whichever mode is selected, the segment select addresses selected by SW1a and SW1b will be overridden by the relevant external address lines. This saves much extra switching but anomalies may occur if the 2K ROM mode is selected in a 28 pin socket.

Note that this module is only suitable for use in EPROM sockets with single rail power supplies and the $\overline{CE}$ or $\overline{CS}$ signal on pin 18 (20 for a 28 pin socket) and the $\overline{OE}$ signal on pin 20 (22 for a 28 pin socket). Pin 21 (23 for a 28 pin socket) must be logic high level: A11 address or $\overline{WE}$ as appropriate for the mode used. Unfortunately this rules out some devices such as the three-rail TMS2716, the TMS2532, and under some circumstances the TMS2516. If in doubt, consult the data sheets for your particular device and circuit.

Warning: DO NOT TRY TO PROGRAM THIS UNIT IN AN EPROM PROGRAMMER — the high voltage will damage it permanently. And take care when handling the device out of its socket — once assembled it's unlikely that any of the CMOS chips will be blown by static, but if it should happen, your guess is as good as ours how to replace them.

ETI

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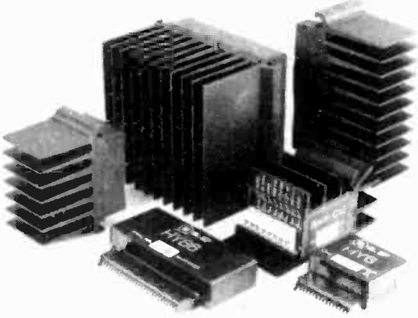

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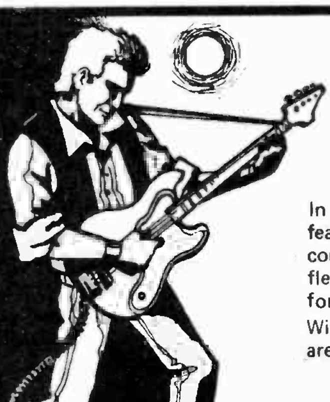

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Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 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: 500mV 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	£15.36
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.

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PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.83
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	[illegible]
PSU 75X	2 x MOS248, 1 x MOS368	[illegible]

Please note: X in part no. indicates primary voltage. Please insert "O" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

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	[illegible]
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	[illegible]	[illegible]
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	[illegible]	[illegible]

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
Frequency response (−3dB). 15Hz − 100KHz. Input sensitivity: 500mV rms
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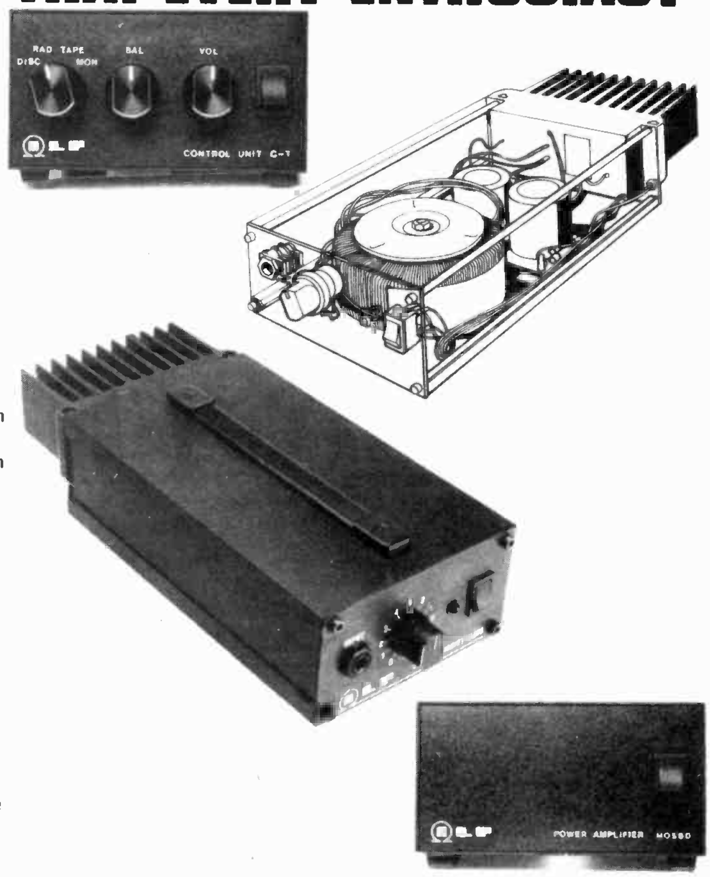

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Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

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UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
UP6X	60W/4–8Ω	MOS	Mono	HiFi	£64.95
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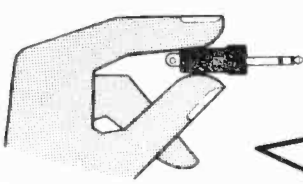

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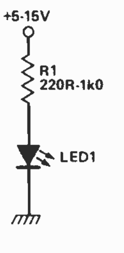
CONFIGURATIONS

Ian Sinclair has seen the light! Now he wants to illuminate the rest of us. In case you hadn't already guessed, this month's topic is opto-electronics.

Opto-electronics is a word that hadn't been thought of a few years ago, but which is now used to describe a set of devices that are important enough to merit a part of this series all to themselves. An opto-electronic device is one which makes use of light as part of its electronic function, so this label includes all varieties of devices that convert light signals into electrical signals or the other way round.

The simplest opto-electronic devices of the electricity-to-light type are the familiar LEDs. Familiar they may be, but even experienced engineers are not always aware of their eccentricities. Like any other diode the LED has an anode and a cathode, and passes current in the forward bias direction; this is when the light is emitted. What is not nearly so well known is that the peak reverse voltage of these diodes is very low; if you get an LED the wrong way round in a circuit, it's usually curtains for the LED when the voltage is switched on. A typical value of peak reverse voltage is 3 V, so practically any circuit that will operate the LED when it is connected the right way round (Fig. 1) will blow it up if it happens to be the wrong way round.



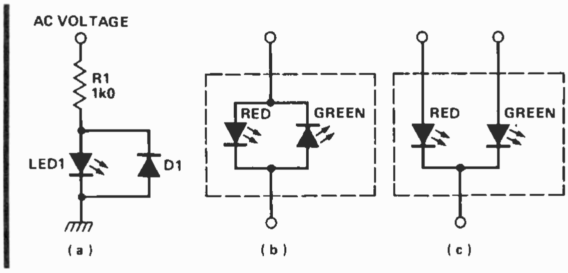


Fig. 1 (Right) The basic LED operating circuit. A current-limiting resistor must always be used unless the output resistance of the driving circuit is high.

Fig. 2 (Left) LED operation. (a) For use with AC, a silicon diode must be connected across the LED terminals as shown. (b) The two-colour LED uses two LED junctions connected in opposite directions. (c) The tri-colour LED uses separate LEDs with a common cathode connection.

In addition, the forward voltage across the LED is very much higher than the 0V6 that we merrily assume for a silicon diode. For gallium arsenide, the material used for many types of LEDs, the forward voltage is more like 2V1 to 2V4, so that LEDs are of little use in very low-voltage circuits — they won't, for example, work from a 1V5 cell.

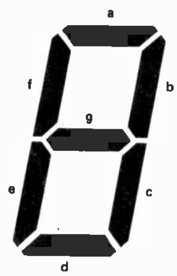
Current Affairs

One of the major snags about LEDs is that they consume a surprising amount of current. Manufacturers quote 'adequate' light output for red LEDs with 5 to 25 mA, and for the green/yellow varieties with 10 to 40 mA. This wouldn't be missed in a circuit operating at 5 V, 2.5 amps, but it can be quite a drain on battery equipment, often considerably more than all the CMOS ICs in a circuit intended for battery operation.

LEDs can be used with AC supplies providing there is a diode connected in reverse across each LED (to prevent excessive reverse voltage) as well as the usual current limiting resistor (Fig. 2a). Bi-colour LEDs consist of a package of two LEDs in one casing, connected in inverse parallel so that current in one direction will give a light of one colour, while the other colour is achieved by reversing the current (Fig. 2b). In this circuit, one LED protects the other against reverse voltage. Tri-colour indicators (Fig. 2c) use two diodes with a common cathode connection and separate anode leads, so that three colours can be indicated, one in each lead, plus yellow when both LED sections are activated. Personally, for indicating when mains voltage is on, I much prefer the old-fashioned neon.

On Display

When it comes to digit displays, LED types have quite a lot of competition. The traditional seven-segment display (Fig. 3) comes as a common anode or a common-cathode type (Fig. 4), and each type needs a separate limiting resistor in each driver lead. The normal method of use is to connect the display to a decoder chip such as the 7448 or 7447, which in turn takes the digital information in as BCD signals — four bits per digit. The snag again is the current consumption, 10-20 mA per segment, which means that displaying a figure '8' uses 7 x 20 mA — 140 mA just to



No.	SEGMENTS LIT
0	a b c d e f ·
1	· b c · · · ·
2	a b · d e · g
3	a b c d · · g
4	· b c · e f g
5	a · c d · f g
6	a · c d e f g
7	a b c · · · ·
8	a b c d e f g
9	a b c · · f g

Fig. 3 Layout of the seven-segment display, with segment guide. An eighth segment, the decimal point, is often added.

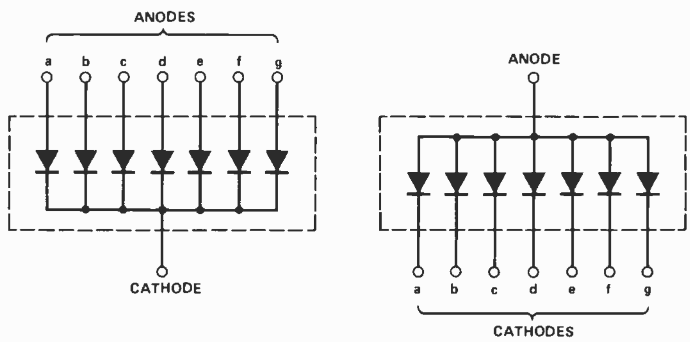


Fig. 4 Internal connections for common anode and common cathode displays. Whichever type is used, there must be a separate limiting resistor for each segment.

display one digit! While mains-powered equipment isn't too upset by this size of current, the LED seven-segment display did not last very long in battery-powered devices, even when multiplexing was used. Multiplexing means that only one digit at a time is activated, the digits being switched on in sequence fast enough to present the appearance of all the digits being illuminated at once.

Oddly enough, the forward voltage for the segments of an LED seven-segment display tends to be lower than for diodes, around 1V3 to 1V7. At temperatures above about 25°C, the maximum current has to be reduced by 0.3 mA per degree to avoid over-dissipation of the junction in each segment.

One competitive display that seems to be much less well-known is the filament seven-segment display. This can use as little as 5 mA per segment, and looks surprisingly bright — it can be driven by a decoder directly with no limiting resistors, and for many purposes is superior to LED displays. The usual reason for preferring solid-state displays is long life, but the quoted life of more than 100,000 hours for the filament type of display is pretty competitive, and some LED displays are notorious for short life — one frequent candidate for replacement in my experience is the display used in the old KIM microprocessor units.

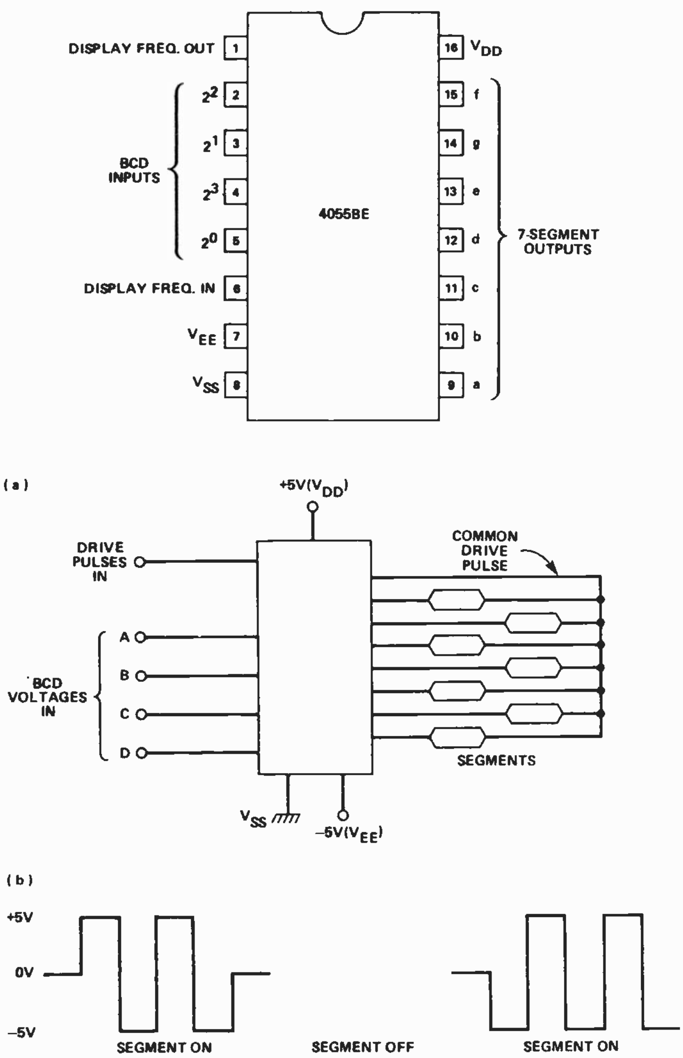


Fig. 5 Driving LCD displays. The common lead of the LCD display must not be earthed; it has to be returned to the driver IC. The waveform (b) applied is AC with no trace of DC.

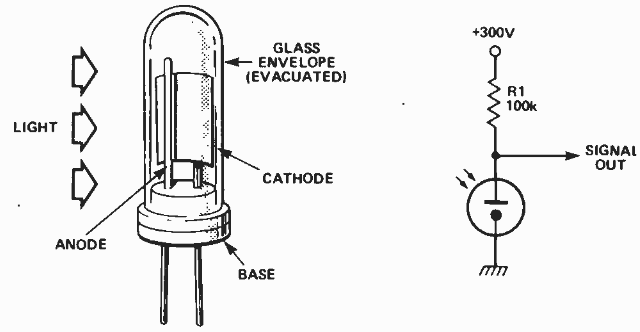


Fig. 6 The vacuum photocell, and a typical circuit arrangement.

Oldies But Goodies

The two older types of displays which are also worth considering are the electron-beam type and the gas-discharge type. The electron beam display uses a miniature cathode wire to emit electrons, which will then be attracted to any positive anode. The anodes are coated with phosphors (similar to the phosphors used in cathode ray tubes), and any anode which is positive to the cathode by a sufficient voltage will glow. A 24-40 V supply is needed, which usually means the use of an inverter when low-voltage batteries are used, as in calculators. The display is easy to read, and uses less current than the LED type — I still prefer a calculator using this type of display to one using the more-common LCD display.

The gas-discharge display is an older type which uses the principle of the neon light — ionisation of a low-pressure gas in an electric field. Like all gas-discharge, this needs a high operating voltage, around 150-250 V, but the operating current is very low: only 0.7 mA per segment in a typical application. The display is very bright, and is worth considering for mains-operated equipment whose display has to be viewed under difficult illumination conditions, such as alternate brightness and darkness. A driver IC is available nowadays — in times past (dare we say the Dark Ages?), the major handicap of using this type of display was the lack of suitable driver transistors.

Liquid Light

Last among the displays, of course, there is the LCD. A good LCD can give a dense black indication against a light grey background, is clearly visible in bright light, and reasonably visible even in low illumination conditions. There's a lot of variation between displays, however, even from the same manufacturer, and some are poor, with low contrast and very slow response to changing digits. Prices also vary considerably — one catalogue I have lists the price of a calculator-size display as being twice as much as I would have to pay for a complete calculator using a similar display!

Operating conditions for these displays are very different from those of other types of displays, because they have to be operated from high-frequency AC supplies. For this reason, displays either come with all the necessary circuitry for generating their driver pulses built in, or they can be used with a standard chip intended for this purpose. It's particularly important not to apply DC to the segments of an LCD display, because this can kill the display very rapidly.

On The Receiving End

Moving to the other end of the opto-electronics business, we find the photocells. Vacuum photocells and photomultipliers are rather specialised, and we'll only touch briefly on these types. They rely on photocathodes, surfaces which emit electrons into a vacuum when they are struck by light. The anode which collects the electrons (Fig. 6) must be at a fairly high voltage (100-500 V), and the currents are small: microamps rather than milliamps. Photomultipliers obtain greater sensitivity and increased output by using secondary multiplication, meaning that the electrons from the cathode (Fig. 7) are accelerated to surfaces, called dynodes, which will release electrons each time an electron strikes the surface. If each of these multipliers releases two to five electrons for each striking electron, spectacular gain can be achieved which, unlike amplification of signals by conventional methods, is practically noise-free.

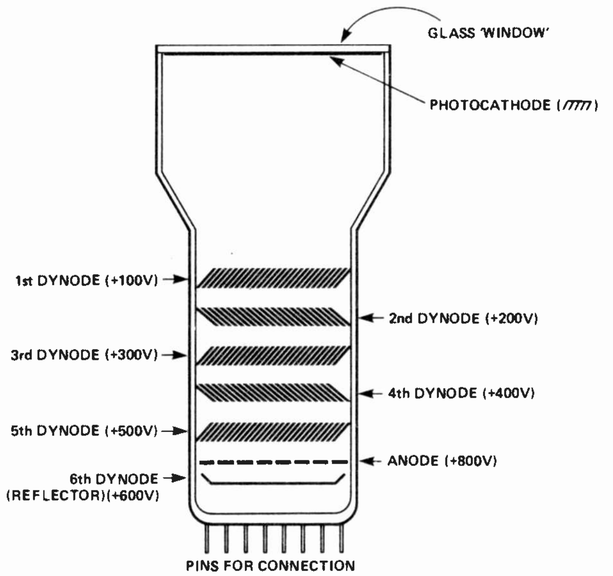


Fig. 7 Cross-section of a photomultiplier, used for detection of very low light levels.

The more familiar solid-state light-to-electrical-signal devices that we use are the solid-state photodetectors, of which the most commonly used is the cadmium sulphide cell. The ORP12 is the standard device of this type, often called an LDR (light dependent resistor). The cell consists of a strip of cadmium sulphide whose resistance decreases as light falls on it. The resistance in the dark is high, up to 10M, and the resistance can fall as low as 100R in bright sunlight. A less well-known aspect of these cells is that they can withstand a fairly high voltage, around 100 V; subject to their dissipation limit of 200 mW, meaning that you might need a limiting resistor connected in series. The cadmium sulphide cell is a slow-acting device, needing about 350 mS for the resistance to fall on exposure to light, and around 75 mS for the resistance to rise again when the light is shut off. The response to different colours is generally similar to that of the human eye, but the cadmium sulphide is much more sensitive to red and infrared, which is why its use in cameras is now less common than it was some 10 years ago.

Fun With Photodiodes

Other light detectors need some degree of amplification. Photodiodes are diodes of fairly conventional construction, with a transparent window over the junction,

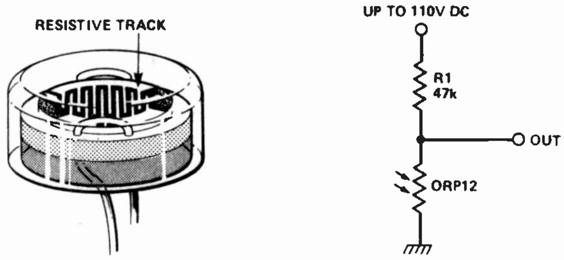


Fig. 8 The photoresistive cell or light-dependent resistor (LDR).

which are used reverse-biased. For such a diode, the reverse leakage current increases as the intensity of light on the junction is increased. This current is small, ranging from around 1 nA in darkness to almost 1 mA in very bright light, so that amplification is usually necessary, as in the circuit of Fig. 9. The response time is about 250 nS, so that the op-amps shown in Fig. 9 would have to be replaced by a transistor circuit, using high-speed switching transistors, if you wanted to use the photodiode for high-speed signals. Combined photodiode/op-amp packages can be bought for medium-speed applications.

The old-style phototransistor, which was a transistor formed with a window above the base-collector junction, is a thing of the past: what is now called a phototransistor is a combination of silicon photodiode and transistor in one package. This combines a sensitivity that is much greater than that of a photodiode alone with a good fast response time, giving typically a 2 MHz bandwidth. This is particularly useful for receiver use in light-beam transmission systems.

Last in our catalogue for the month come the opto-isolators, which consist of a combination of LED and phototransistor in a single package. These components are embedded in clear plastic, which allows light transmission but which is a good electrical insulator. It's easy to achieve isolation to at least 4 kV, with reasonable signal transmission. For an ordinary isolator, the output signal will be about 20 per cent of the amplitude of the input, but when a Darlington phototransistor is used, the output can be three times or more the amplitude of the input. It's just the device I was looking for 25 years ago when I wanted to modulate the grid of a cathode-ray tube which was working at −4 kV!

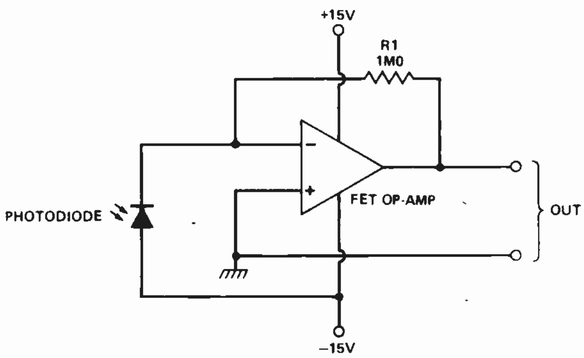


Fig. 9 Using a photodiode in conjunction with a FET op-amp. The FET type is needed because of the very high impedance of the photodiode circuit.

ETI

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In the cut-throat world of consumer electronics, one of the questions designers apparently ponder over is "Will anyone notice if we save money by chopping this out?" In the domestic TV set, one of the first casualties seems to be the sound quality. Small speakers and no tone controls are common and all this is really quite sad, as the TV companies do their best to transmit the highest quality sound. Given this background a compact and independent TV tuner that connects direct to your Hi-Fi is a must for quality reproduction. The unit is mains-operated.

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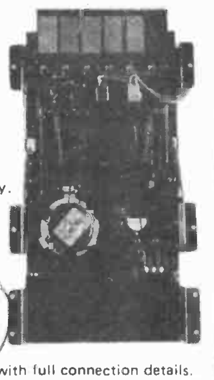

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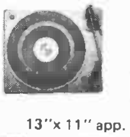

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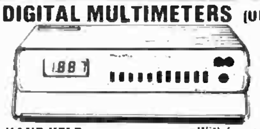

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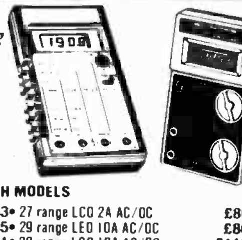

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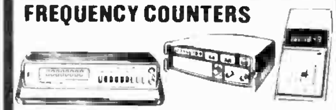

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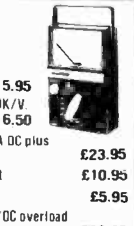

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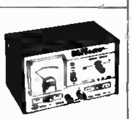

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IMMERSIBLE HEATER

This simple-to-construct project has done sterling service as a temperature controller in a common fish tank heater but has wide application. Design by Jonathan Scott.

If this project did not run directly on 240 V we would call it a simple project. It contains only one IC, a triac and very little else, yet it is a full zero-crossing switch system capable of controlling up to 1500 W of heating power that may be employed to regulate the temperature of a room, a fish tank or a bowl of yoghurt-in-the-making.

At this point, let us stress that the PCB *is operating at live mains potential* as the IC is designed to run directly on the mains without transformer isolation, so *be careful.* You should never touch any of the components while the circuit is plugged in, nor try to adjust the setpoint preset pot.

The triac must be of 400 or more volts rating, and it must be of at least 4 A current rating as the PCB is designed to take the type which comes in a bolt-on package, and these start at 4 A. This over-rating, if you are only planning to have around 150 W of heater, as we did, allows you to dispense with a heatsink. There is not reason why you shouldn't have a higher rating still if the thing physically fits in place. With a heatsink, the type we found most common at the suppliers (and used) is rated at 6 A and will thus run up to 1500 W.

The thermistor you use will depend upon how much you wish to pay, how robust a component you need, and how you wish to connect it thermally to the load, as well as the temperature you are going for. We used both a cheap rod type, and a type G23. The latter is a small, but strong, glass bead type with a wide temperature range — but a £5-plus price tag! The G23 is a professional type, but reliable and predictable. As we point out later, a failure of the thermistor is not likely to cause anything but a cooling of the load, so unless you are willing to pay the price and need the reliability, use a cheap type. It is only necessary to have a resistance of 2k0 to 60k at the regulated temperature. We used a type having a resistance of 47k at 25°C, costing only 40p or so.

Once you have obtained the thermistor, it is necessary to select R4 and PR1 to suit. These must together be able to equal the resistance of the thermistor at the temperature you are going for. Now, the G23 has a resistance of 2k0 at 20°C and a temperature coefficient of so many ohms-per-degree. As we were going for 20-25 degrees in that model, we chose 820R for R4 and 5k0 for PR1, ensuring that we could reach 2k0 or a bit less. In general, if the thermistor is a cheap type, you had best measure its resistance while at the temperature you need. If it comes with specifications it will be possible to calculate the resistance at a given temperature.

So, having selected these components, you should assemble them on the PCB in accordance with the overlay diagram. Take care to get the polarity of the IC, capacitor and triac correct. Note that the metal tag of the triac is the MT2 connection, and the lead to the load is taken via a lug on the bolt holding it to the PCB.

The final piece of constructional detail is the mounting of the thermistor. It is important to have it in close thermal contact with the item you are trying to heat. In our constructional example we are regulating the temperature of the liquid surrounding the tube within which the controller and the heater are immersed. It is thus only possible to regulate the tube temperature, as we cannot put the (live) sensor in the liquid. The sensor was pressed against the tube and seated in a blob of thermal compound of the type used for mounting transistors on their heatsinks. This meant that it was held at the temperature of the outside as much as possible, rather than at the temperature of the heater and controller themselves.

As the design of the housing is largely up to the individual constructor, there is very little to say about the physical makeup of the project. If you are copying the format shown in the pictures,

THE ZERO CROSSING SWITCH TECHNIQUE

In normal phase control switching the switching element, an SCR or triac, is triggered into conduction at some time during each half cycle. The moment of switching is varied, so that the duration of the applied voltage pulse, which corresponds to the fraction of the cycle left at the point of triggering, is varied. This is a simple and direct method which does vary the applied power fairly smoothly (see Fig. 1). Unfortunately, the sudden application of voltage tends to produce a lot of electromagnetic radiation due to the sudden current change in the load circuit. This is responsible for a lot of radio frequency interference, or RFI.

In ZCS the switching element is only allowed to change to the conducting state when the supply voltage is crossing the zero-voltage point — hence the name. This means that there are no sharp voltage transitions across the load, and so no RFI. The penalty paid is that only whole half cycles are applied to the load. The system is thus not readily applicable to lighting applications as the lights flicker badly due to the relatively long periods between conduction and isolation (see Fig. 2).

For applications where the system has sufficient inertia, such as heating, this system is by far the superior technique. As the required functions are available within a single, relatively cheap IC it is practicable to built a ZCS system with almost the same ease as a proportional system.

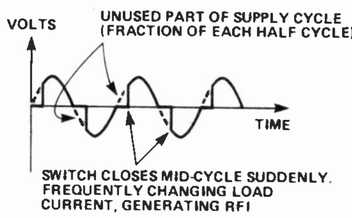


Fig. 1

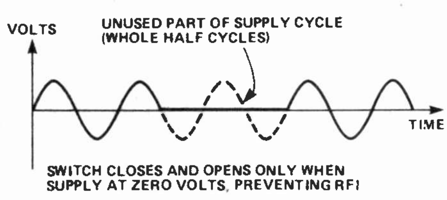
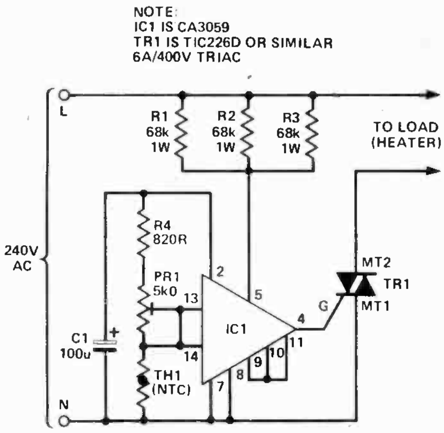


Fig. 2



BUYLINES

This simple project uses very few parts, most of which are commonly stocked items. However, to choose a suitable thermistor it will be necessary to check in the mail order companies' catalogues; they don't bother putting these items in their magazine ads. Maplin stock the G23, plus a suitable selection of cheap rod thermistors. We got our fish tank heater in the local pet shop, but if you do this it's advisable to check the various types in the shop, making sure that you can get into it and that there's room for the PCB. The PCB can be obtained from the PCB Service using the order form on page 95.

Fig. 3 The circuit. Simple, what?

assembly is rather straightforward. The only point to note is that you will have to take particular care to see that the tube is sealed against the accidental entry of liquid. Here, Silastic or a similar silicone sealant comes in very useful.

It is necessary to set the preset pot before sealing up the immersible tube. This is done be carefully setting the system up with water coming up to the point on the tube above where the sensor is located. Then, allow a couple of hours of undisturbed operation and measure the liquid temperature with a thermometer. Adjust the preset pot (mains unplugged!) and repeat. If you measured the thermistor beforehand, while at the correct temperature, you can adjust the pot/R4 combination to give you that resistance straight away and there should be no need to make a second adjustment of the pot. If at some later stage you wish to change the set point, Silastic is easy to peel away and you can reseal the tube when the adjustment is made and checked.

We do not advise you to leave an access hole to permit adjustment of the pot because, firstly, someone might try and do that with the power on *(poof!)* or more likely the liquid will find a way of invading the tube and quietly ruin the components.

HOW IT WORKS

Most of the functions of this temperature controller are contained inside the IC, so let's take a look at the zero-voltage switch IC first.

Three zero-voltage switches are made by RCA — the CA3058, CA3059 and CA3079. They are all designed to control a thyristor in a variety of AC power switching applications for AC input voltages of 24, 230, 230 and 277 V at 50, 60 and 400 Hz. Each incorporates four functional blocks as follows (refer to the block diagram here):

- Limited-Power Supply — permits operation directly from an AC line.
- Directional On/Off Sensing Amplifier — tests the condition of external sensors or command signals. Hysteresis or proportional-control capability may easily be implemented in this section.
- Zero-Crossing Detector — synchronises the output pulses of the circuit at the time when the AC cycle is at zero voltage point; thereby eliminating radio-frequency interference (RFI) when used with resistive loads.
- Triac Gating Circuit — provides high-current pulses to the gate of the power controlling thyristor.

In addition, the CA3058 and CA3059 provide the following important auxiliary functions:

- A built-in protection circuit that may be actuated to remove drive from the triac if the sensor opens or shorts.
- Thyristor firing may be inhibited through the action of an internal diode gate connected to Terminal 1.
- High power DC comparator operation is provided by overriding the action of the zero-crossing detector. This is accomplished by connecting pin 12 to pin 7. Gate current to the thyristor is continuous when pin 13 is positive with respect to pin 9.

Because the CA3079 does not incorporate the built-in protection circuit, the CA3058 or CA3059 have been specified for this project. If the project is used to control a fish tank heater, one doesn't want to boil one's finny friends in the event of a thermistor failure!

Now we know what's inside the IC, how is it put to work in the circuit?

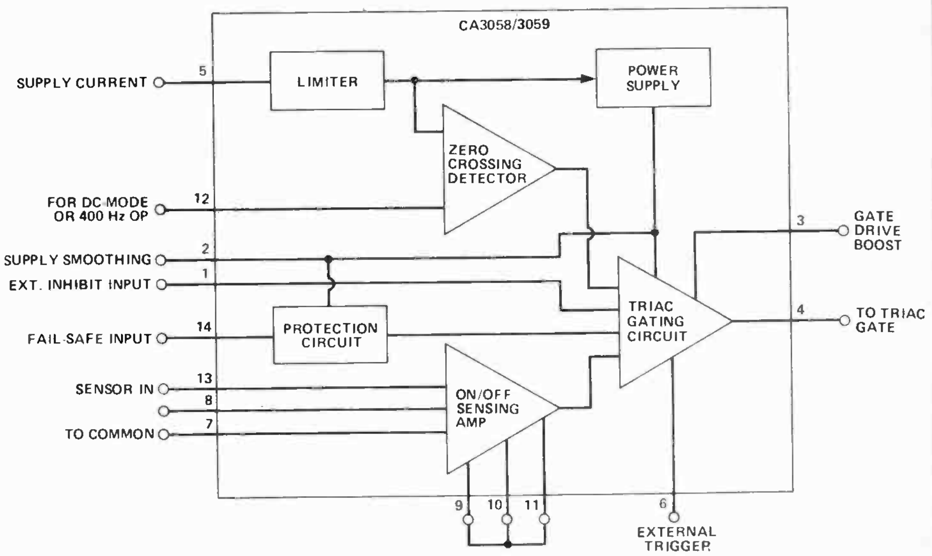
Initially, consider the triac to be turned off. Some current flows into pin 5 of the IC and this is limited by R1-3 and rectified within the IC to provice about 8 V DC for the operation of the circuit. Capacitor C1 smooths this supply. Inside the IC are a number of separate sub-circuits centered on a comparator ('ON/OFF SENSING AMP'). Connection of pins 9, 10 and 11 uses internal resistors to establish half supply rail (about 4 V) as one of the levels to be compared. When the voltage on pin 13 exceeds half rail potential the comparator activates a circuit which turns the triac on at the next supply zero, and each subsequent zero until the voltage falls below half rail.

Clearly then, PR1/R4 must be selected so that they add up to the resistance of the sensing thermistor at the temperature for which it is desired to regulate. Thus, when the temperature reaches the preset point, the voltage across TH1 corresponds to half rail potential on pin 13.

Pin 14 allows the protection circuit to detect when TH1 goes either open circuit or short circuit by looking at the voltage at the junction of R4 and TH1. If this voltage nears the DC supply rail or the local common (N), there has been a failure, and the firing of the triac is inhibited until the condition is removed.

The supply dropping resistors R1-3 are used instead of a single resistor purely for size considerations. All that is required is that they deliver 10 to 50 milliamps to the IC's rectifier-regulator.

The sensing thermistor must be a negative temperature coefficient type (NTC), as its resistance must drop with increasing temperature in order to reduce the voltage on pin 13 as the temperature is brought towards the set-point. There is sufficient excess supply current to allow it to draw at least one milliamp if necessary. Thus, any of the common small bead types with a few kilohms of resistance at the setpoint may be used. The total permissable sensor resistance range is 2k0 to 100k.



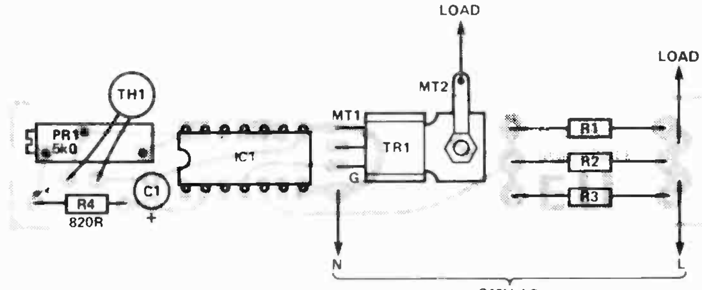


Fig. 4 Component overlay.

PARTS LIST

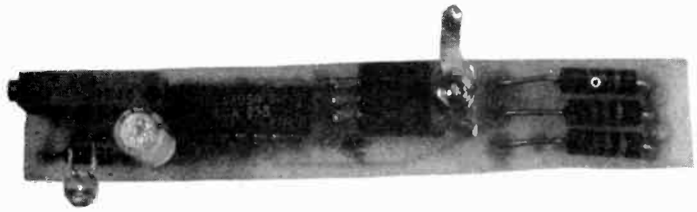
Resistors (all ½W, 5% except where stated)
R1-3 68k 1 W
R4 820R (see text)

Potentiometer
PR1 5k0 multiturn cermet preset

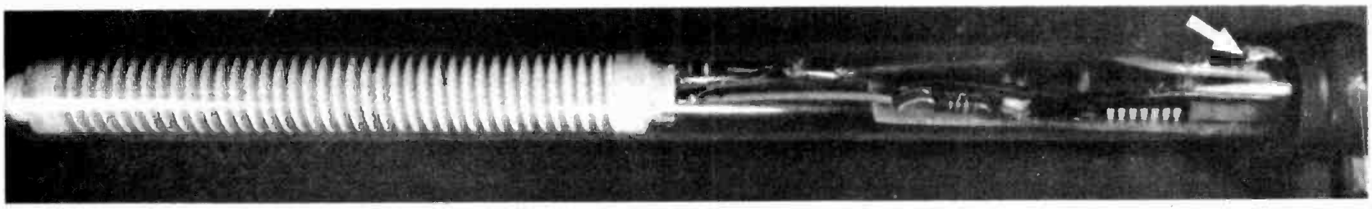
Capacitor
C1 100μF 16 V tantalum

Semiconductors
IC1 CA3059
TR1 6 A, 400 V triac eg TIC226D or similar

Miscellaneous
TH1 thermistor to suit application eg G23 glass bead type (see text)
PCB (see Buylines): solder lug; hookup wire; heating element etc.



Naked and clothed. At top is the naked PCB (approximately life size) to compare with the component overlay. The lower picture shows the completed immersible temperature controller from a common fish tank heater. The arrow shows the positioning of the thermistor sensor.



ETI

DATA SHEET

M108/M208 SINGLE CHIP ORGAN

Given the great popularity of the Victory organ that we've been featuring in ETI since February, it isn't surprising that there have been many enquiries about further information on the SGS-Ates chips that form the heart of the project. This Data Sheet should clear up most of the questions.

The M108/M208 is a single chip organ featuring solo and/or accompaniment modes. It accepts 61 keys arranged in a 12 × 6 matrix; a scanning cycle takes 576 microseconds and all keys pressed are accepted. There are two keyboard formats: either 61 keys (solo) or 24 plus 37 (M108), 17 plus 44 (M208) keys (accompaniment and solo) with the possibility of automatic chords of the 'accompaniment' section. There are internal anti-bounce circuits.

A top octave synthesizer is incorporated for the generation of three 'footages'. More than one chip can be employed with synchronisation through the reset input. There are separate analogue outputs (for each foot) for solo, accompaniment and bass sections (square wave of 50% duty cycle) with the average value constant. Each section also has 'key down' and 'trigger' outputs. Sustain is provided for the last keys released in the solo section.

There are several choices of operating mode in the accompaniment section:

- Manual, with or without memorisation of the selected keys (free chords with alternate bass),
- Automatic, with or without memorisation of the selected key (priority to the left for automatic chords and bass arpeggio). When in automatic mode there are again several possibilities:
- Major or minor third
- With or without seventh.

The chip operates from a standard single supply of +12 V ±5%, with a low dissipation of less than 600 mW. All inputs are protected from electrostatic discharges.

General Characteristics

The characteristics of the M208 are similar to those of the M108; the only difference is the keyboard split, which is 24+37 for the M108 and 17+44 for the M208 when used in 'accompaniment + solo' mode.

The circuit comprises:

- Two pins for clock input; one for the matrix scanning, the other for the incorporated Top Octave Synthesizer (TOS); by connecting both the clock inputs to the same matrix scanning clock (1000.12 kHz), the three footages generated are 16′, 8′ and 4′.
- Six inputs from the octave bars (keyboard and control scanning).
- Three multiplexed data inputs for addressing the bass selection. These inputs normally come from the outputs of an external memory (negative or positive logic with control inside the chip).
- Eight signal outputs divided by section: three for the solo section (16′, 8′, 4′), four for the accompaniment section (16′ or root, 8′ or 3rd, 4′ or 5th, 8th/7th according to operating mode), one for the bass.
- Twelve outputs for the matrix scanning.
- Five trigger and key down outputs: $\overline{KPS}$ (key pressed solo), $\overline{TDS}$ (trigger decay solo), $\overline{KPA}$ (key pressed accompaniment), $\overline{NPA}$ (pitch present in accompaniment outputs), $\overline{TDB}$ (trigger decay bass) respectively. These outputs, in conjunction with an external time constant, allow the formation of the envelope of the sustain and percussion effects. The duration of the trigger pulses is approximately 9 milliseconds
- One input (reset) to synchronize the device or more than one device (with the same keyboard scanning and using a single contact per key). The reset action, provided by an

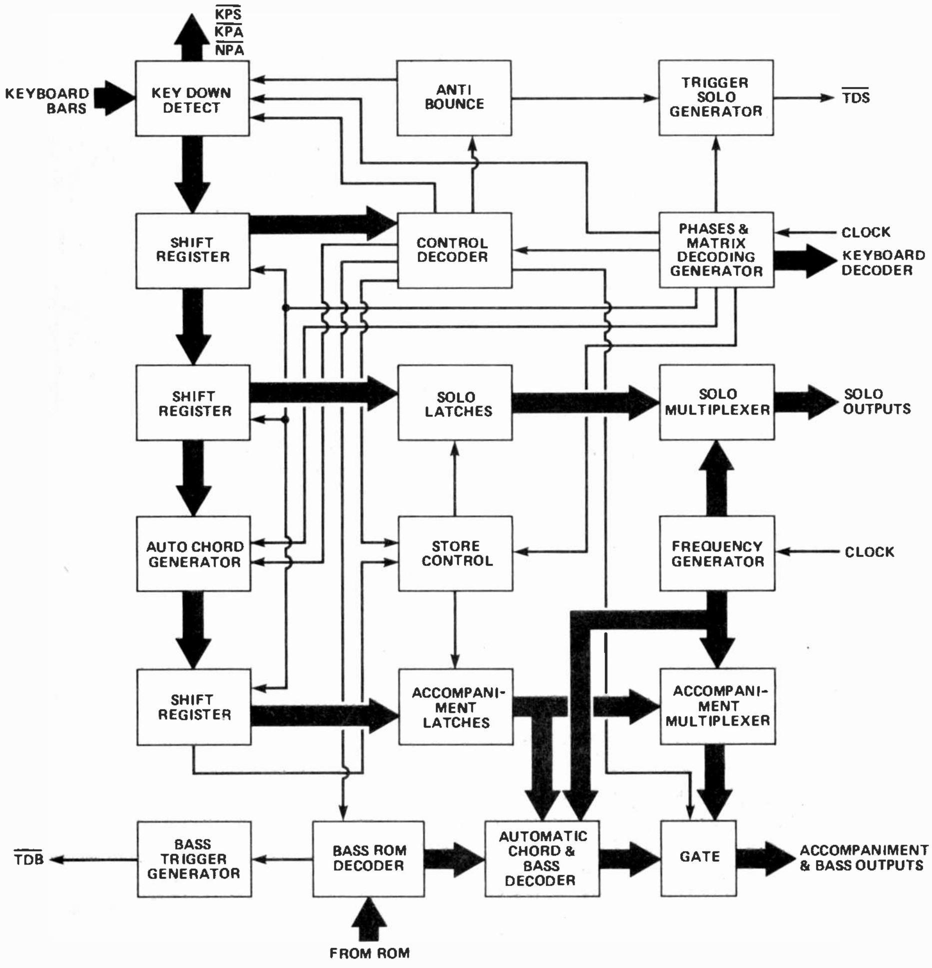


Fig. 1 Block diagram of the IC.

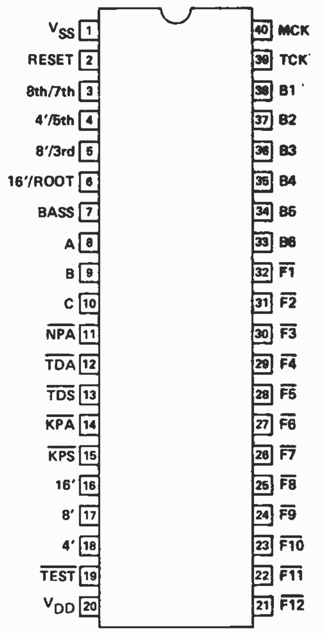
external circuit, is of the power-on reset (high active) type and its duration must be approximately 0.5 milliseconds.

- One TEST pin (in use it must be connected to V_{DD}).
- Two supply pins.

Features

The main feature of this chip is the possibility of formating the keyboard either with 61 keys (only 'solo' without automatism) or separating it into two sections ('accompaniment + solo') with the possibility of chord and bass automatic in the first section.

- The '61/24 + 37' (17 + 44) control chooses the keyboard operating mode, ie the whole keyboard dedicated to 'solo' or 24 (17) keys dedicated to 'accompaniment' and 37 (44) to 'solo'.
- The 'Man/Auto' control, which operates only in case of 'accompaniment and solo', chooses the manual or the automatic accompaniment.
- The 'Sust OFF/Sust ON' allows the storage of the 'solo' section and handles the whole keyboard or 37 (44) keys depending on the operating mode.
- The '$\overline{\text{Latch}}$/Latch' similarly allows the storage of the 'accompaniment' + solo' only.
- The '3rd+/3rd—' which operates only in case of 'accompaniment + solo' and 'automatic' changes the automatic chord generated from major to minor or vice versa.



V_{SS} IS THE LOWEST SUPPLY VOLTAGE
V_{DD} IS THE HIGHEST SUPPLY VOLTAGE

Fig. 2 Pin connections for the M108/M208.

MATRIX ORGANISATION (KEYBOARD AND CONTROLS)

M108/208 Matrix outputs	M108/208 Octave bar inputs					
	B1	B2	B3	B4	B5	B6
$\overline{F1}$	C_1	C_2	C_3	C_4	C_5	C_6
$\overline{F2}$	$C_1\#$	$C_2\#$	$C_3\#$	$C_4\#$	$C_5\#$	7th OFF/7th ON
$\overline{F3}$	D_1	D_2	D_3	D_4	D_5	3rd+/3rd—
$\overline{F4}$	$D_1\#$	$D_2\#$	$D_3\#$	$D_4\#$	$D_5\#$	Sust. OFF/Sust. ON
$\overline{F5}$	E_1	E_2	E_3	E_4	E_5	$\overline{\text{Latch}}$/Latch
$\overline{F6}$	F_1	F_2	F_3	F_4	F_5	Man/Auto
$\overline{F7}$	$F_1\#$	$F_2\#$	$F_3\#$	$F_4\#$	$F_5\#$	61/24 + 37 (17 + 44)
$\overline{F8}$	G_1	G_2	G_3	G_4	G_5	Antibounce ON/Antibounce OFF
$\overline{F9}$	$G_1\#$	$G_2\#$	$G_3\#$	$G_4\#$	$G_5\#$	ROM Low/ROM High
$\overline{F10}$	A_1	A_2	A_3	A_4	A_5	
$\overline{F11}$	$A_1\#$	$A_2\#$	$A_3\#$	$A_4\#$	$A_5\#$	
$\overline{F12}$	B_1	B_2	B_3	B_4	B_5	

C_1 is the first key on the left, C_6 is the last key on the right of the keyboard.

- The '7th OFF/7th ON' adds the seventh to the automatic chord generated.
- The 'Antibounce ON/Antibounce OFF' disables the antibounce circuit which is usually enabled.
- The 'ROM Low/ROM High' selects between ROMs with return to '1' (Low active) or with return to '0' (High active). Usually the chip is enabled for ROMs with return to '1' (Low active).

'Solo' Operation

In this case the chip recognizes the whole keyboard as 'solo' and does not read the controls which concern the 'accompaniment + solo' operation. The chip identifies all the keys pressed and transfers to the outputs of each section the analogue sum of corresponding pitches. The outputs are current generators with average value constant, therefore it is sufficient to connect the pins to one load and send the signals on to the filters.

In the case of 'Sustain OFF' each new key pressed or released is accepted or deleted in a time less than 576 microseconds. In the case of 'Sustain ON' the chip has a different operation according to whether the new key (keys) is pressed or released: each new key pressed is always accepted in a time less than 576 microseconds, whereas each key released is deleted with a delay of 73 milliseconds and only if there are still keys pressed. In fact, if after the 73 milliseconds there are no keys pressed, the last key (or keys) released remains stored until new keys are pressed. In this mode it is possible to have Sustain, with external envelope shaping, for the last keys (or key) released. The pitch envelope is controlled by a DC signal $\overline{\text{KPS}}$ (any key pressed), and there is also an AC signal $\overline{\text{TDS}}$ (trigger decay solo) which provides a pulse whenever a key is pressed. An appropriate antibounce circuit, inside the chip, solves the problems associated with the keyboard contacts.

'Solo + Accompaniment' Operation

In this case the chip identifies the 'accompaniment' on the first 24 (17) keys on the left, and the 'solo' on the remaining 37 (44) keys and reads all the controls which concern the 'accompaniment' section. The 'solo' function is identical to '61 keys' mode, but for the 'accompaniment' section there are two possibilities:

Manual

The chip identifies which keys are pressed in the 'accompaniment' section, and transfers to the 'accompaniment' outputs the analogue sum of the corresponding pitches. The 'accompaniment' section is fully independent of the 'solo' section and the signals (if there is no 'latch') remain at the output only while the keys are pressed even if there is 'sustain on'.

The 'bass' section gives at the bass output an alternating bass bet-

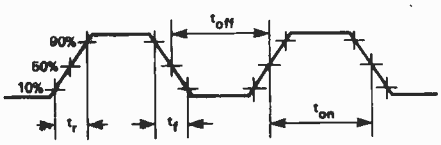


Fig. 3 The input clock waveform.

ween the first on the left and the first on the right of the keys pressed in the 'accompaniment' section; the pitch switching timing is dependent on an external ROM (three bits). The 'accompaniment' control stores the last keys released and the output signals, including the bass output, remain until new keys are pressed. The $\overline{TDB}$ (trigger decay bass) output gives a pulse corresponding to every output change; there are also two DC signals, $\overline{KPA}$ (any key pressed accompaniment) and $\overline{NPA}$ (pitches in output accompaniment) relative only to the 'accompaniment' section. The first of these signals (analogous to $\overline{KPS}$) concerns the keyboard and does not consider the 'latch' condition. The second on the contrary concerns the 'accompaniment' output and considers the 'latch' condition.

Automatic

The chip recognizes in the 'accompaniment' section only the first on the left of the keys pressed and, according to the setting of the following controls, produces a major or minor chord with or without seventh only the 4' footage but with separated outputs for root, third, fifth and eighth (or seventh if the chord is with seventh).

The bass section gives the bass arpeggio among root, third, fourth, fifth, sixth, seventh and eighth with pitch switching dependent on an external ROM (3 bits). In automatic mode the two octaves of the 'accompaniment' section inside the chip are connected in parallel both for the chord and for the bass; therefore by pressing any one of the two keys of the same note the chip generates the same chord.

The 'latch' control stores the major chord and the bass pitches (until new keys are pressed); the modification of the chord stored (from major to minor, addition of seventh) is always possible by operating the proper controls: by releasing these controls the chord becomes major again. It is possible to delete the stored pitches both in manual and in 'automatic' mode by a latch control signal.

Once again there are $\overline{KPA}$, $\overline{NPA}$, and $\overline{TDB}$ information; however the $\overline{TDB}$ pulse, which normally appears at each arrival of the ROM codes, does not appear if there are no pitches in the 'accompaniment' (and bass) outputs or, in the case of alternate bass (in manual mode) if the codes indicate conditions of indifference.

Parameter	Test conditions	Min.	Typ.	Max.	Unit
RECOMMENDED OPERATING CONDITIONS					
V_{DD} Highest supply voltage		11.4	12	12.6	V

STATIC ELECTRICAL CHARACTERISTICS (Positive logic, $V_{DD}=+10$ to $+14$ V, $V_{SS}=0$ V, $T_{amb}=0$ to 50°C unless otherwise specified)

Parameter	Test conditions	Min.	Typ.	Max.	Unit
INPUT SIGNALS					
V_{IH} Input high voltage	Note 1	$V_{DD}-1$		V_{DD}	V
	Note 2	4		18	V
	Note 3	$V_{DD}-2$		V_{DD}	V
V_{IL} Input low voltage	Note 1	V_{SS}		$V_{SS}+1$	V
	Note 2	V_{SS}		$V_{ss}+0.6$	V
	Note 3	V_{SS}		$V_{SS}+2$	V
I_{LI} Input leakage current	$V_I=14$ V $T_{amb}=25$°C			10	µA
LOGIC SIGNAL OUTPUTS					
R_{ON} Output resistance with respect to V_{SS}			300	500	ohms
R_{ON} Output resistance with respect to V_{DD}	$V_{OUT}=V_{DD}-1$ (driver off)		15	25	kilohms
V_{OH} Output high voltage		$V_{DD}-0.4$		V_{DD}	V
V_{OL} Output low voltage			$V_{SS}+0.2$	$V_{SS}+0.4$	V
POWER DISSIPATION					
I_{DD} Supply current	$T_{amb}=25$°C		30	45	mA
ANALOGUE SIGNAL OUTPUTS (the external load must be connected to $V_{DD}/2$)					
I_{OH} Output current with respect to $V_{DD}/2$	Outputs loaded with 1k0 resistor versus $V_{DD}/2$	35	50	70	µA
I_{OL} Output current with respect to V_{SS}	Outputs loaded with 1k0 resistor versus $V_{DD}/2$	−35	−50	−70	µA

Note 1: Refers only to the clock inputs
Note 2: Refers only to the inputs from the external memory
Note 3: Refers only to the reset input.

DYNAMIC ELECTRICAL CHARACTERISTICS

Parameter	Test conditions	Min.	Typ.	Max.	Unit
MASTER CLOCK INPUT					
f_i Input clock frequency			1000.12		kHz
t_r, t_f Input clock rise and fall time 10% to 90%	1000.12 kHz			40	nS
t_{on}, t_{off} Input clock ON and OFF times	1000 kHz		500		nS
TOP OCTAVE SYNTHESISER CLOCK INPUT					
f_i Input clock frequency		100	1000.12	2500	kHz
t_r, t_f Input clock rise and fall times 10% to 90%	1000.12 kHz			40	nS
t_{on}, t_{off} Input clock ON and OFF times	2000 kHz		250		nS
$\overline{TDS}$ and $\overline{TDB}$ OUTPUTS					
t_{on} Pulse duration	1000 kHz		9.216		mS
t_r, t_f Outputs rise and fall times 10% to 90%	1000 kHz		100		nS

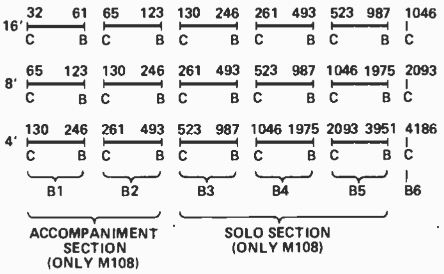


Fig. 4 The frequency range of each octave (16', 8', 4' footages).

ABSOLUTE MAXIMUM RATINGS

V_{DD}	Source supply voltage with respect to V_{ss} (GND) pin voltage	−0.3 to +20 V
V_i	Input voltage with respect to V_{ss}	−0.3 to +20 V
I_O	Output current at any pin	3 mA
T_{op}	Operating temperature	0 to 50°C

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other condition above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

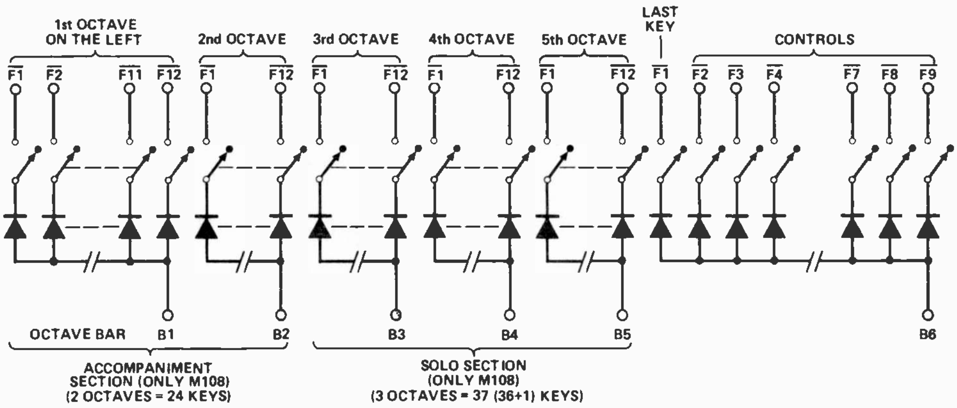


Fig. 5 Connection of the keyboard and control switches.

NOTE: THE SWITCH 'OPEN' CORRESPONDS TO 'KEY NOT PRESSED' OR 'CONTROL IN THE FIRST CONDITION' (SEE THE TABLE 'MATRIX ORGANISATION')

BASS TRUTH TABLES

Low Active (Change 1s to 0s and vice versa for high active)				
External Memory Code			Bass Arpeggio Output (Automatic mode)	Alternate Bass Output (Manual mode)
C	B	A		
1	1	1	No change	No change
1	1	0	Root	1st on the left
1	0	1	3rd	———
1	0	0	4th	———
0	1	1	5th	1st on the right
0	1	0	6th	———
0	0	1	7th	———
0	0	0	8th	———

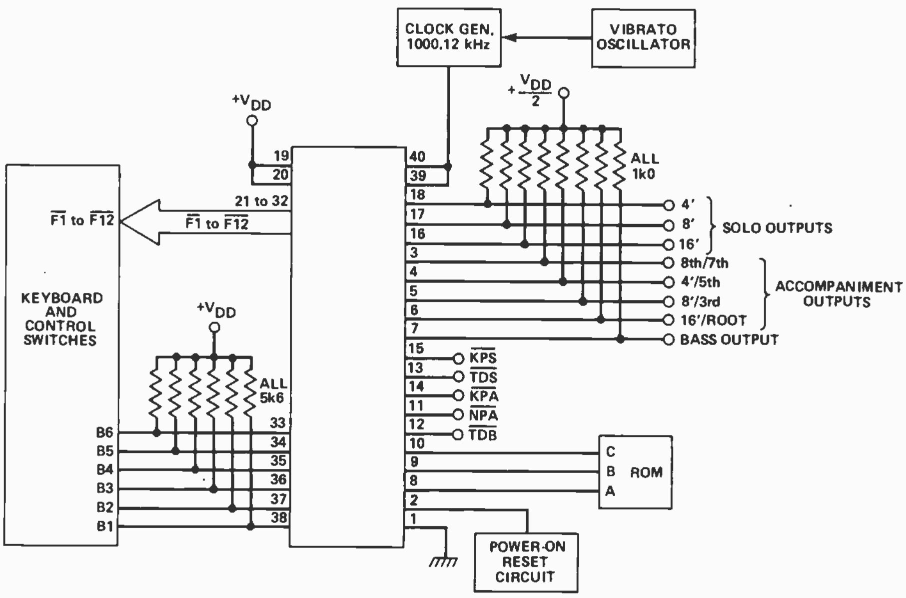


Fig. 6 A typical application.

Play the AMBIT numbers game ......

The long awaited implementation of on-line order processing is with us at last, and whilst this means that orders for in-stock items can now be processed more efficiently, it also means that orders should be submitted using stock codes for best results. Our current catalogue (75p) includes all order codes (watch out for the new expanded Spring edition), but here's an abstract from some of the more popular lines to use as a quick reference.

Remember that you can also access our catalogue via REWSHOP on REWTEL, which now includes on-line current price and delivery information. You need a 300 baud MODEM and RS232 terminal, (various suitable configurations based on popular micros have been published in recent past issues of Radio and Electronics World).

Prices shown here exclude VAT, and the P&P charge is currently 60p per order (unless otherwise indicated). Remember that our telesales service operates with human beings (not 'dumb' machines) from 8am to 7pm (and frequently later) Monday to Friday, and 9am to 6pm on Saturdays. REWSHOP operates 24 hours a day, 365 days a year with full price and delivery information.

ALWAYS USE STOCK NUMBERS WHEN ORDERING PLEASE.

4000 CMOS

Type	Stock No	Price
4000UB	22 04000	0.11
4001	23 04001	0.11
4002	23 04002	0.12
4007	23 04007	0.13
4008	23 04008	0.50
4009UB	22 04009	0.25
4011	23 04011	0.11
4011UB	23 04011	0.11
4012	23 04012	0.14
4013	23 04013	0.25
4015	23 04015	0.50
4016	23 04016	0.22
4017	23 04017	0.40
4020	23 04020	0.55
4021	23 04021	0.55
4022	23 04022	0.55
4023	23 04023	0.15
4024	23 04024	0.33
4025	23 04025	0.15
4027	23 04027	0.26
4028	23 04028	0.50
4029	23 04029	0.55
4035	23 04035	0.67
4040	23 04040	0.68
4042	23 04042	0.50
4043	23 04043	0.60
4044	23 04044	0.68
4046	23 04046	0.60
4049UB	22 04049	0.24
4050	23 04050	0.24
4051	23 04051	0.55
4052	23 04052	0.55
4053	23 04053	0.55
4060	23 04060	0.75
4066	23 04066	0.30
4068	23 04068	0.16
4069UB	22 04069	0.14
4070	23 04070	0.16
4071	23 04071	0.16
4072	23 04072	0.16
4073	23 04073	0.16
4075	23 04075	0.16
4076	23 04076	0.55
4077	23 04077	0.18
4078	23 04078	0.18
4081	23 04081	0.18
4082	23 04082	0.18
4093	23 04093	0.30
4099	23 04099	0.80
4175	23 04175	0.80
4502	23 04502	0.60
4503	23 04503	0.50
4506	23 04506	0.70
4507	23 04507	0.37
4508	23 04508	1.50
4510	23 04510	0.55
4511	23 04511	0.45
4512	23 04512	0.55
4514	23 04514	1.25
4515	23 04515	1.25
4516	23 04516	0.60
4518	23 04518	0.35
4520	23 04520	0.60
4521	23 04521	1.30
4522	23 04522	0.89
4526	23 04526	0.60
4527	23 04527	0.80
4528	23 04528	0.65
4529	23 04529	0.70
4531	23 04531	0.65
4532	23 04532	0.80
4534	23 04534	4.00
4536	23 04536	2.50
4538	23 04538	0.85
4539	23 04539	0.80
4543	23 04543	0.80
4549	23 04549	3.50
4553	23 04553	2.70
4554	23 04554	1.20
4555	23 04555	0.35
4556	23 04556	0.40
4557	23 04557	2.30
4558	23 04558	0.80
4559	23 04559	3.50
4560	23 04560	2.50
4561	23 04561	1.00
4562	23 04562	2.50
4566	23 04566	1.20
4568	23 04568	1.45
4569	23 04569	1.70
45672UB	23 04572	0.32
4580	23 04580	3.25
4581	23 04581	1.40
4582	23 04582	0.70
4583	23 04583	0.80
4584	23 04584	0.27
4585	23 04585	0.45
4702	23 04702	4.50
4703	23 04703	4.48
4704	23 04704	4.24
4705	23 04705	4.24
4706	23 04706	4.50
4720	23 04720	4.00
4723	23 04723	0.95
4724	23 04724	0.95
4725	23 04725	2.24
40014	23 40014	0.54
40085	23 40085	0.99
40098	23 40098	0.54
40106	23 40106	0.69
40160	23 40160	1.05
40161	23 40161	1.05
40162	23 40162	1.05
40163	23 40163	1.05
40174	23 40174	1.05
40175	23 40175	1.05
40192	23 40192	1.08
40193	23 40193	1.08
40195	23 40195	1.08

74LSXX

Type	Stock No.	Price
74LS00	31 07400	0.11
74LS01	31 07401	0.11
74LS02	31 07402	0.11
74LS03	31 07403	0.11
74LS04	31 07404	0.14
74LS05	31 07405	0.14
74LS08	31 07408	0.14
74LS09	31 07409	0.14
74LS10	31 07410	0.14
74LS11	31 07411	0.14
74LS12	31 07412	0.14
74LS13	31 07413	0.32
74LS14	31 07414	0.32
74LS15	31 07415	0.14
74LS20	31 07420	0.14
74LS21	31 07421	0.14
74LS22	31 07422	0.14
74LS26	31 07426	0.14
74LS27	31 07427	0.30
74LS28	31 07428	0.18
74LS30	31 07430	0.14
74LS32	31 07432	0.14
74LS33	31 07433	0.14
74LS37	31 07437	0.18
74LS38	31 07438	0.14
74LS40	31 07440	0.18
74LS42	31 07427	0.30
74LS47	31 07447	0.75
74LS48	31 07448	0.40
74LS49	31 07449	0.80
74LS51	31 07451	0.14
74LS54	31 07454	0.14
74LS55	31 07455	0.14
74LS74	31 07474	0.21
74LS75	31 07475	0.21
74LS76	31 07476	0.25
74LS78	31 07478	0.19
74LS83	31 07483	0.33
74LS85	31 07485	0.44
74LS86	31 07486	0.15
74LS90	31 07490	0.24
74LS91	31 07491	0.36
74LS92	31 07492	0.32
74LS93	31 07493	0.24
74LS95	31 07495	0.36
74LS107	31 74107	0.31
74LS109	31 74109	0.25
74LS112	31 74112	0.21
74LS113	31 74113	0.21
74LS114	31 74114	0.21
74LS122	31 74122	0.27
74LS123	31 74123	0.36
74LS125	31 74125	0.27
74LS126	31 74126	0.27
74LS132	31 74132	0.27
74LS133	31 74133	0.24
74LS136	31 74136	0.20
74LS138	31 74138	0.30
74LS139	31 74139	0.30
74LS151	31 74151	0.30
74LS153	31 74153	0.34
74LS155	31 74155	0.30
74LS156	31 74156	0.33
74LS157	31 74157	0.27
74LS158	31 74158	0.27
74LS160	31 74160	0.34
74LS161	31 74161	0.36
74LS162	31 74162	0.36
74LS163	31 74163	0.36
74LS164	31 74164	0.40
74LS165	31 74165	0.60
74LS166	31 74166	0.58
74LS168	31 74168	0.69
74LS170	31 74170	0.63
74LS173	31 74173	0.47
74LS174	31 74174	0.37
74LS175	31 74175	0.40
74LS181	31 74181	0.87
74LS183	31 74183	1.05
74LS190	31 74190	0.39
74LS191	31 74191	0.39
74LS192	31 74192	0.39
74LS193	31 74193	0.39
74LS194	31 74194	0.39
74LS195	31 74196	0.39
74LS196	31 74196	0.39
74LS197	31 74197	0.47
74LS221	31 74221	0.50
74LS240	31 74240	0.60
74LS241	31 74241	0.60
74LS242	31 74242	0.55
74LS243	31 74243	0.55
74LS244	31 74244	0.60
74LS245	31 74245	1.00
74LS251	31 74251	0.36
74LS253	31 74253	0.36
74LS257	31 74257	0.36
74LS258	31 74258	0.36
74LS259	31 74259	0.51
74LS260	31 74260	0.26
74LS266	31 74266	0.20
74LS273	31 74273	0.70
74LS279	31 74279	0.35
74LS283	31 74283	0.40
74LS290	31 74290	0.40
74LS293	31 74293	0.40
74LS298	31 74298	0.54
74LS365	31 74365	0.34
74LS366	31 74366	0.40
74LS367	31 74367	0.30
74LS368	31 74368	0.30
74LS373	31 74373	0.72
74LS374	31 74374	0.72
74LS375	31 74375	0.31
74LS377	31 74377	0.60
74LS378	31 74378	0.44
74LS379	31 74379	0.44
74LS385	31 74385	1.30
74LS386	31 74386	0.27
74LS390	31 74390	0.51
74LS393	31 74393	0.48
74LS398	31 74398	0.80
74LS399	31 74399	0.65
74LS490	31 74490	0.60
74LS670	31 74670	1.15

74CXX

Type	Stock No.	Price
74C00	29 07400	0.35
74C02	29 07402	0.35
74C04	4069C	
74C08	29 07408	0.35
74C10	29 07410	0.35
74C14	4584C	
74C20	29 07420	0.35
74C30	29 07430	0.35
74C32	29 07432	0.35
74C42	29 07442	1.05
74C48	29 07448	1.50
74C73	29 07473	0.75
74C74	29 07474	0.75
74C76	29 07476	0.60
74C83	29 07483	1.30
74C85	29 07485	1.30
74C86	29 07485	1.30
74C89	29 07489	3.60
74C90	29 07490	1.05
74C93	29 07493	1.05
74C95	29 07495	1.25
74C107	29 74107	0.60
74C151	29 74151	2.10
74C154	29 74154	3.05
74C157	29 74157	2.10
74C160	40160	
74C1610	40161CM	
74C1620	40162CM	
74C1630	40163CM	
74C164	29 74164	1.05
74C165	29 74165	1.10
74C173	4076C	
74C1740	40174CM	
74C1750	40175CM	
74C1920	40192CM	
74C1930	40193CM	
74C1950	40195CM	
74C200	29 74200	6.50
74C221	29 74221	1.55
74C901	29 74901	0.55
74C902	29 74902	0.55
74C903	29 74903	0.55
74C904	29 74904	0.55
74C905	29 74905	6.50
74C906	29 74906	0.55
74C907	29 74907	0.55
74C908	29 74908	1.10
74C909	29 74909	2.10
74C910	29 74910	5.00
74C914	29 74914	1.10
74C918	29 74918	1.30
74C925	29 74925	6.00
74C926	29 74926	6.00
74C927	29 74927	6.00

74HCXX

Type	Stock No.	Price
74HC00	30 07400	0.56
74HC02	30 07402	0.56
74HC04	30 07404	0.68
74HC10	30 07410	0.56
74HC20	30 07420	0.56
74HC86	30 07486	0.74
74HC132	30 74132	1.26
74HC266	30 74266	0.81
74HC4002	30 04002	0.58
74HC4075	30 04075	0.56
74HC242	30 74242	2.00
74HC243	30 74243	2.00
74HC74	30 07474	0.74
74HC109	30 74109	0.68
74HC175	30 74175	1.08
74HC373	30 74373	2.40
74HC374	30 74374	2.40
74HC533	30 74533	2.40
74HC534	30 74534	2.40
74HC165	30 74165	1.96
74HC173	30 74173	1.20
74HC160	30 74160	1.33
74HC161	30 74161	1.33
74HC162	30 74162	1.33
74HC163	30 74163	1.33
74HC4538	30 74538	2.10
74HC85	30 74280	2.95
74HC280	30 74280	2.95
74HC42	30 07442	1.00
74HC138	30 74138	1.08
74HC139	30 74139	1.08
74HC4514	30 04514	3.40
74HC4543	30 04543	2.75
74HC157	30 74157	0.92
74HC158	30 74158	0.90
74HC257	30 74257	0.90

LINEAR ICs

Type	Stock No.	Price
LM10CN	61 00010	3.88
MF10	61 00011	5.05
L149	61 00149	1.86
ZNA234	61 02340	8.50
U237B	61 00237	1.28
U247B	61 00247	1.28
U257B	61 00257	1.28
U267B	61 00267	1.28
LM301AH	61 03010	0.67
LM301AN	61 03011	0.27
LM308H	61 03080	0.70
LM308CN	61 03081	0.65
LM324	61 03240	0.45
LM339N	61 03390	0.66
LF347	61 00347	1.60
LM348	61 03480	0.90
LF351	61 03510	0.49
LF353	61 03530	0.76
LM380N	61 00380	1.00
LM381	61 00381	1.81
LM382	61 00382	1.81
ZN419CE	61 00419	1.98
ZNA423	61 04230	1.00
ZN425E/8	61 04250	3.50
ZN426E/8	61 04260	3.00
ZN427E/8	61 04270	6.28
ZN428E/8	61 04280	4.78
ZN429E/8	61 04290	2.10
ZN432CJ10	61 04320	28.09
ZN433CJ10	61 04330	22.59
ZN440J	61 04400	0.80
ZN450E	61 04500	7.61
NE542	61 05420	1.20
NE544	61 00544	1.80
NE555N	61 05550	0.20
NE556N	61 05560	0.50
SL560C	61 05600	1.98
NE562	61 00562	4.05
NE564	61 00564	4.29
NE565	61 00565	1.00
NE566	61 00566	1.30
NE567	61 00567	1.30
NE570N	61 00570	3.85
SL624	61 00624	3.28
uA709HC	61 07090	0.64
uA709PC	61 07091	0.36
uA710HC	61 07100	0.64
uA710PC	61 07101	0.59
uA711CN	61 07110	0.85
uA733CN	61 07330	0.89
uA741CH	61 07410	0.66
uA741CN	61 07411	0.20
uA747CN	61 07470	0.70
uA748CN	61 04780	0.30
uA758	61 00758	2.35
TBA820M	61 00820	0.78
TDA1028	61 01028	2.11
TDA1029	61 01029	2.11
ZNA1034	61 01034	2.10
LM1035	61 01034	2.10
TDA1054M	61 01054	1.45
TDA1062	61 01062	1.95
TDA1072	61 01072	2.69
TDA1074A	61 01074	5.04
TDA1083	61 01083	1.95
TDA1090	61 01090	3.05
HA1137	61 12411	1.20
HA1196	61 01196	2.00
HA1197	61 01197	1.00
TDA1220	61 01220	1.40
LM1303	61 01303	0.99
LM1307	61 01307	1.55
MC1310P	61 01310	1.90
MC1330	61 01330	1.20
MC1350	61 01350	1.20
HA1370	61 11370	1.90
HA1388	61 01388	2.75
LM1458N	61 14580	0.45
MC1496P	61 01496	1.25
SL1610	61 01610	1.92
SL1611	61 01611	1.60
SL1612	61 01612	1.60
SL1613	61 01613	2.06
SL1620	61 01620	2.50
SL1621	61 01621	2.50
SL1623	61 01623	2.44
SL1625	61 01625	2.50
SL1626	(SL6270)	
SL1630	61 01630	1.62
SL1640	61 01640	2.25
SL1641	61 01641	2.25
MC1648	61 01648	3.25
TDA2002	61 02002	1.25
ULN2240	61 02240	3.25
ULN2242	61 01090	3.05
ULN2283	61 02283	1.00
CA3080	61 03080	0.70
CA3089	61 03089	1.84
CA3123	61 03123	1.40
CA3130E	61 31300	0.80
CA3130T	61 31301	0.90
CA3140E	61 31400	0.46
CA3189E	61 03189	2.20
CA3240E	61 32400	1.27
MC3357	61 03357	2.85
MC3359 (see ULN3859)		
ULN3859	61 03859	2.95
KM3701	61 03701	85.53
KM3702	61 03702	74.84
LM3900	61 39000	0.60
LM3909N	61 39090	0.68
LM3914N	61 03914	2.80
LM3915N	61 03915	2.80
KB4400	61 04400	0.80
KB4412	61 04412	1.95
KB4413	61 04413	1.95
KB4417	61 04417	1.80
KB4420B	61 04420	1.09
TDA4420	61 14420	2.65
TDA4421	61 14421	2.65
KB4423	61 04423	2.30
KB4424	61 04424	1.65
KB4430	61 04430	2.30
KB4431	61 04431	1.95
KB4432	61 04432	1.95
KB4433	61 04433	1.52
KB4436	61 04436	2.53
KB4437	61 04437	1.75
KB4438	61 04438	2.22
KB4441	61 04441	1.35
KB4445	61 04445	1.29
KB4446	61 04446	2.75
KB4448	61 04448	1.65
NE5044	61 05044	2.26
MC5229	61 05229	9.60
NE5532	61 55320	1.85
KM5624	61 05624	4.35
SD6000	61 06000	3.75
SL6270	61 06270	2.03
SL6310	61 06310	2.45
SL6440	61 06440	3.38
SL6600	61 06600	3.75
SAS6610	61 06610	1.48
SL6640	61 06640	2.75
SL6690	61 06690	3.75
SL6700	61 06700	2.75
SAS6710	61 06710	1.48
LS7225	61 07225	3.65
ICM7555	61 75550	0.80
CL8038CC	61 08038	4.50
MSL9362	61 09362	1.75
MSL9363	61 09363	1.75
K10170	61 10170	1.87
TK10321	61 10321	2.75
HA11223	61 11223	2.15
HA11225	61 11225	1.45
HA12002	61 12002	1.22
HA12017	61 12017	0.80
HA12402	61 12402	1.95
HA12411	61 12411	1.20
HA12412	61 12412	1.55
LF13741	61 13741	0.33
MK50366	61 50366	3.35
MK50375	61 50375	3.85
MM53200	61 53200	3.90

PRESCALER

Type	Stock No.	Price
U264	61 02640	2.27
U265	61 02650	3.18
U266	61 02660	2.43
11C90DC	61 01190	12.95
MSL2312R	61 02312	3.94
MSL2318	61 02318	3.64
MSM5523	61 05523	11.30
MSM5524	61 05524	11.30
MSM5525	61 05525	7.85
MSM5526	61 05526	7.85
MSM55271	61 55271	9.75
ICM7106CP	61 07106	9.55
ICM7107CP	61 07107	9.55
LC7137	61 07137	7.50
ICM7216B	61 72161	19.50
ICM7216C	61 72162	19.95
ICM7217A	61 07217	9.50
SP8629	61 08629	3.85
SP8647	61 08647	6.00
SP8793	61 08793	7.70
95H90	61 09590	7.80
HD10551	61 10551	2.45
HA12009	61 12009	8.00
HD44015	61 44015	4.45
HD44752	61 44752	8.00
MC145151P	61 14151	8.00
MC145152P	61 14151	8.60
MC145156P	61 14156	4.60

SMALL SIGNAL AUDIO

Type	Stock No.	Price
BC182	58 00182	0.10
BC212	58 00212	0.10
BC237	58 00237	0.08
BC238	58 00238	0.08
BC239	58 00239	0.08
BC307	58 00307	0.08
BC308	58 00308	0.08
BC309	58 00309	0.08
BC327	58 00327	0.13
BC337	58 00337	0.13
BC413	58 00413	0.10
BC414	58 00414	0.11
BC415	58 00415	0.10
BC416	58 00416	0.11
BC546	58 00546	0.12
BC550	58 00550	0.12
BC556	58 00556	0.12
BC560	58 00560	0.12
BC639	58 00639	0.22
BC640	58 00640	0.22
MPSA13	58 04013	0.30
MPSA63	58 04063	0.30
ZTX108	58 01108	0.10
ZTX212	58 01212	0.10
ZTX653	58 01653	0.20
ZTX753	58 01753	0.20
2N2904	58 02904	0.25
2N2905	58 02905	0.25
2N3905	58 03905	0.10
2SB646A	58 03646	0.30
2SB648A	58 03648	0.40
2SD666A	58 03666	0.30
2SD668A	58 03668	0.40
2SA872A	58 02872	0.19
2SA1084E	58 01084	0.25
2SA1085E	58 01085	0.25
2SC1775A	58 01775	0.19
2SC2546E	58 02546	0.24
2SC2547E	58 02547	0.24

AUDIO POWER

Type	Stock No.	Price
BD139	58 15139	0.29
BD140	58 15140	0.31
BD165	58 15165	0.46
BD166	58 15166	0.48
BD179	58 15179	0.38
BD180	58 15180	0.41
TIP31A	58 15031	0.35
TIP32A	58 15032	0.35
MJ2955	58 12955	0.88
2N3055	58 13099	0.58
2SB720	58 15720	0.60
2SD760	58 17800	0.60
2SJ49	60 01049	3.10
2SJ50	60 01050	4.25
2SJ83	60 01083	3.55
2SK134	60 00134	3.10
2SK135	60 00135	4.25
2SK227	60 00227	3.55
2SD753	58 03753	2.34

SMALL SIGNAL RF

Type	Stock No.	Price
BFY50	58 06500	0.22
BF241	58 06241	0.18
BF273	58 06273	0.18
BF274	58 06274	0.20
BF362	58 06362	0.49
BF440	58 06440	0.21
BF441	58 06441	0.21
BF479	58 06479	0.88
BF6795	58 06679	0.55
BFR91	58 07091	1.33
BFT95	58 10095	0.99
BFW92	58 08092	0.80
BFY90	58 09090	0.90
NE21936	58 21936	5.00
ZTX323	58 06232	0.60
2N2369A	58 02369	0.38

RF POWER

Type	Stock No.	Price
BFW16A	58 08016	0.85
MRF237	58 14237	3.20
MRF238	58 14238	18.50
MRF245	58 14245	40.00
MRF449A	58 14449	16.50
MRF472	58 14472	1.25
MRF475	58 14475	4.80
MRF629	58 14629	4.99
PT8811	58 18811	9.50
TP2320	58 12320	10.24
VN66AF	60 02066	0.95
ZTX3866	58 03866	0.45
2N3866	58 13866	1.20

SMALL SIGNAL FET

Type	Stock No.	Price
BF256	59 00256	0.38
BF960	60 06960	0.99
BF961	60 06961	0.70
BF963	60 06963	0.99
J310	59 02310	0.69
J176	59 02176	0.65
2SK55	59 01055	0.32
2SK168	59 01168	0.37
3SK45	60 04045	0.49
3SK51	60 04051	0.54
3SK60	60 04060	0.58
3SK88	60 04088	0.99
40673 see 3SK51		
40822 see 3SK51		
40823	60 03823	0.65
3SK112	60 04112	4.80

DIODES

Type	Stock No.	Price
AA112	12 01126	0.25
BA244	12 02447	0.17
BA379	12 03797	0.35
ND4981 7E	12 49817	0.51
OA91	12 00916	0.07
OA47	12 00476	0.10
PW02	12 62006	0.75
S04	12 24006	0.45
W005	12 10506	0.28
1N4001	12 40016	0.08
1N4002	12 40026	0.07
1N4004	12 40046	0.07
1N4148	12 41486	0.05
1N5404	12 54046	0.16
1N6263	12 62637	0.62

VARICAPS

Type	Stock No.	Price
BA102	12 01025	0.30
BA121	12 01215	0.30
BB105B	12 01055	0.30
BB109B	12 01095	0.27
BB204B	12 02045	0.38
BB212	12 02125	1.95
ITT210	12 02105	0.30
MVAM115 see KV1236		
MVAM125 see KV1225		
KV1210	12 12105	2.45
KV1211 see XV1236		
KV1225	12 12255	2.75
KV1235	12 12355	2.75
KV1236	12 12365	2.55
KV1310	12 13105	0.40
KV1310	12 13205	0.40

ZENER DIODES

BZY88C 400mW. 5%.

Type	Stock No.	Price
2V7	12 00278	0.10
3V3	12 00338	0.10
3V9	12 00398	0.10
4V7	12 00478	0.10
5V1	12 00518	0.10
5V6	12 00568	0.10
6V8	12 00688	0.10
8V2	12 00828	0.10
9V1	12 00918	0.10
10	12 01008	0.10
11	12 01108	0.10
12	12 01208	0.10
15	12 01508	0.10
18	12 01808	0.10
22	12 02208	0.10
27	12 02708	0.10
33	12 03308	0.10

SCRS TRIACS

Type	Stock No.	Price
BRY55-100	52 55100	0.50
C10601	52 00106	0.70
C12201	52 00122	1.45
2N6403	52 06403	2.22
2N6073A	58 06073	0.98

BALANCED MIXERS

Type	Stock No.	Price
SBL1	12 00003	[illegible].68
SBL1-8	12 00013	5.00
SBL1-X	12 00023	6.33
SRA1	12 00033	10.80
SRA1-1	12 00043	12.77
SRA1H	12 00053	16.34
SRA3	12 00063	15.35

LEDs

3mm round types

Type	Stock No.	Price
CQX25 Red/Clr	15 20250	0.15
V178P Red	15 01780	0.15
CQX26 Gr/Clr	15 20260	0.16
V179P Green	15 01790	0.16
CQX27 Yel/Clr	15 20270	0.18
V180P Yellow	15 01800	0.18
CQX41A Or/Rd	15 20410	0.19

Standard 5mm DIA LEDs

Type	Stock No.	Price
CQY40L Red	15 10400	0.12
CQY72L Green	15 10720	0.15
CQY74L Yellow	15 10740	0.15
CQX38A Or/rd	15 20380	0.20
CQX39B Or/cl	15 20390	0.29

Rectangular 2.5 x 5mm LEDs

Type	Stock No.	Price
CQX10 Red	15 20100	0.17
CQX11 Green	15 20110	0.20
CQX12 Yellow	15 20150	0.20
CQX40 Or/Red	15 20400	0.24

Infra-Red LEDs

Type	Stock No.	Price
CQY99 Emit	15 10990	0.56
BPW41 Det	15 30410	1.51

I R Optocoupler

Type	Stock No.	Price
BNY37	15 40370	1.44

FLAT DIFFUSED

Type	Stock No.	Price
V320	15 03200	0.17
V321	15 03210	0.26
V322	15 03220	0.20
V323	15 03230	0.20
V330	15 03300	0.17
V331	15 03310	0.26
V332	15 03320	0.20
V333	15 03330	0.20
V340	15 03400	0.17
V341	15 03410	0.26
V342	15 03420	0.20
V343	15 03430	0.20
V510	15 05100	0.17
V511	15 05110	0.26
V512	15 05120	0.20
V513	15 05130	0.20
V520	15 05200	0.17
V521	15 05210	0.26
V522	15 05220	0.20
V523	15 05230	0.20
V530	15 05300	0.17
V531	15 05310	0.26
V532	15 05320	0.20
V533	15 05330	0.20
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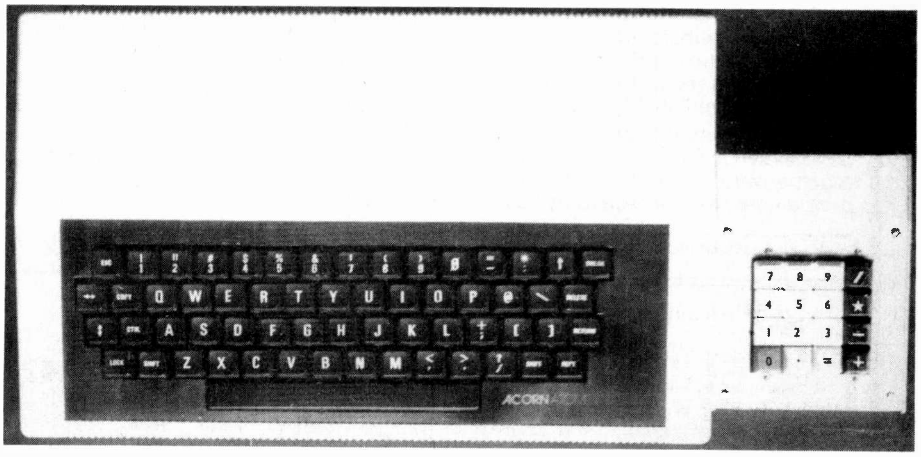
Software control allows the high resolution characters, once set up, to be saved on cassette then loaded and re-used at any time, and switching between either HRG user-graphics or the standard Sinclair character set is easy, under software control. Any single element of an 8x8-pixel character can be individually controlled, giving a screen resolution of 256x176, allowing fine detail graphics programming.

The ZX HRG Board is the first half of a Sinclair Graphics Package. The second project is a user-programmable joystick controller — the first of its kind! Unlike all others it can be instructed to operate with any commercially available games programme, and will appear in the August issue of Hobby Electronics. A slightly different version for the Sinclair Spectrum will also be out shortly.

Although these articles are being prepared for the next issue, circumstances may alter the final content.



ATOM CALCULATOR PAD

And now for some Atomic fusion. Nothing to do with nuclear reactors (that's still at the breadboarding stage): this is an add-on numeric keypad. Design by Patrick Squire.

The addition of a numeric pad to the standard QWERTY keyboard greatly increases the ease of use of a microcomputer, both for programs containing extensive numerical statements and for joystick operations, where the layout of the numeric keys corresponds directly to the direction of movement of an object being controlled on the VDU. Anyone accustomed to using machines both with and without numeric pads will appreciate the advantages of the extra keys. An additional drawback of the QWERTY keyboard is that the +, * and = operations are obtained by shifted keys. This can be very frustrating and lead to errors when entering programs.

For all these reasons it is desirable to be able to add a basic calculator pad, containing the numbers 0-9, the decimal point, equals sign and the four arithmetic operators, to machines not originally supplied with such a facility. Unfortunately such an accessory is not generally available for most micros. This article describes a calculator pad designed specifically for the Acorn Atom, although the general principles employed are capable of straightforward modification to other machines which use a similar system of scanning the key matrix. The whole unit can be constructed for under £20, but it does involve soldering to the masterboard of the Atom, so construction should not be undertaken by the fainthearted.

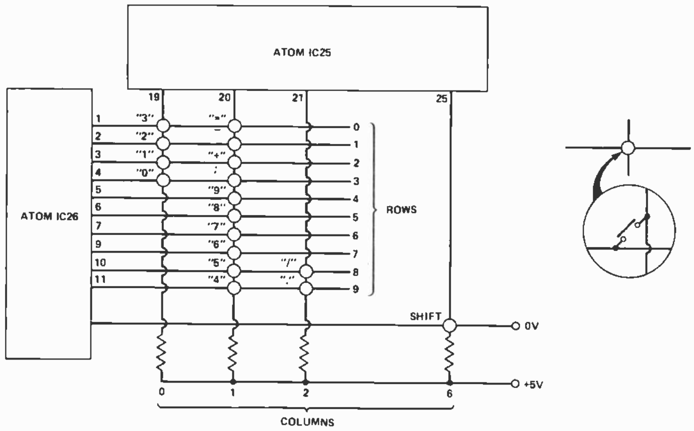


Fig. 1 Part of the Atom keyboard matrix. Each row is connected to one or more columns by a single keyboard switch. The rows are driven by the 3-to-10 decoder IC26. The columns are read by the PIA IC25.

Matrix Scanning

In order to understand the operation of the unit described here, or in order to modify it for other machines or to incorporate alternative functions, it is essential to understand how the Atom reads a depressed key. Figure 1 shows the appropriate section of the Atom circuit. It can be seen that each character key connects a particular row (numbered 0 to 9) with a particular column (numbered 0 to 6). For example, key '9' connects row 4 with column 1. The SHIFT key works in a slightly different way, so I will first describe the operation of reading an unshifted key.

The Atom operating system includes a machine code routine that scans the keyboard. Normally all the rows 0-9 are held at logic high. The columns are connected by pull-up resistors to the + 5 V rail, so they are also logic high. In this state the depression of a character key has no effect, since it merely connects two lines both in the same state. When the scan commences, each row is successively driven low by IC26. The routine then interrogates each column to see if it is low. Consider the state when row 4 has been set low. If no key has been pressed the columns will all be high. If key 9 is pressed, however, column 1 will be connected to row 4, which is low. Column 1 will thus be pulled low and the Atom will know from the

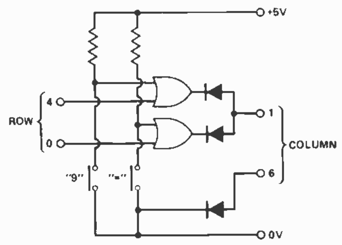


Fig. 2 The principle of the keyboard extension. The unshifted key '9' drives column 1 low when row 4 is also low. The shifted key '=' drives column 1 low when row 1 is low; it also pulls column 6 low to give the shift operation.

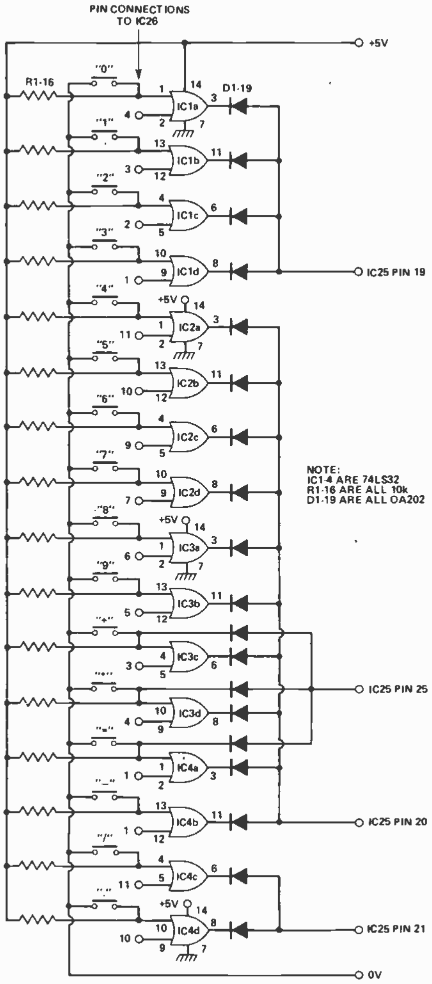


Fig. 3 The complete circuit of the keypad extension.

BUYLINES

Nothing at all unusual in this project and most suppliers should have the components in stock. One source for the case we used is BI-PAK Semiconductors, PO Box 6, 63a High Street, Ware, Herts SG12 9AG (telephone 0920 3182/3442): they also stock the semiconductors and resistors. The order number for the case is 148. The PCB can be ordered using our PCB Service order form on page 95.

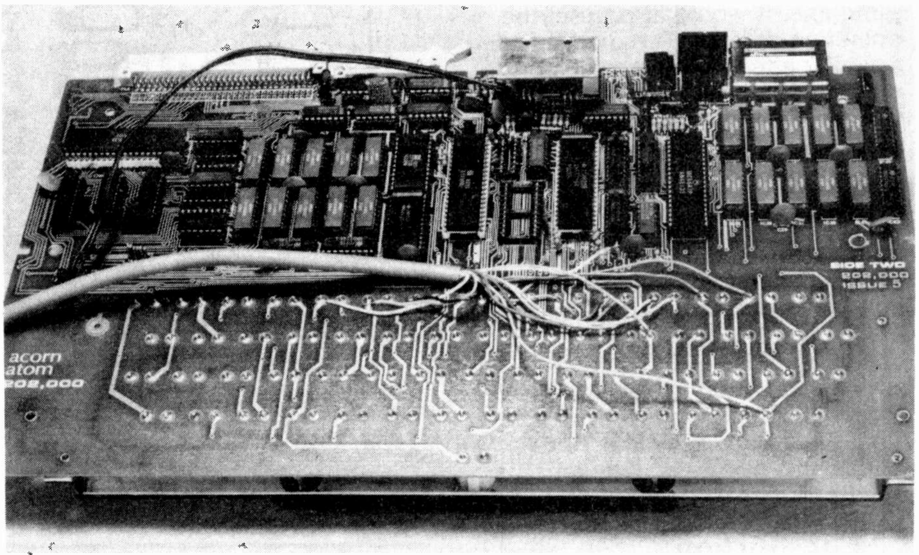
information stored in ROM that the combination 'row 4 low and column 1 low' means that key '9' has been pressed. A similar process works for all the unshifted keys.

For the shifted keys use is made of column 6. Figure 1 shows that this is normally high, but that if the SHIFT key is pressed it pulls the line low by direct connection to the 0 V line. The key scan routine therefore also interrogates column 6 and, according to its state, decides whether a dual-role key, such as '=/—' is to be interpreted as shifted or unshifted.

Circuit Principles

The direct way of extending the ATOM keyboard would be to parallel each keyboard switch by a corresponding key on the pad. However, this would involve having 16 unconnected switches and 32 connecting wires. This would be a very inefficient system and would not be able to cope with shifted characters as single-key operations. The system employed in this design employs an OR gate for each key, and is illustrated in Fig. 2 for two keys, one the unshifted '9', the other the shifted '='.

Consider first the unshifted '9' key. When the Atom drives pin 5 of IC26 low (this corresponds to row 4 — see Fig. 1) one input of the upper OR gate is driven low. So long as key '9' remains open, however, the other input of this gate remains high. The OR action then maintains the output high, so pin 20 of IC25 (column 1) remains high. If, on the other hand, key '9' is closed both



Wiring up to the Atom — the diagram below refers.

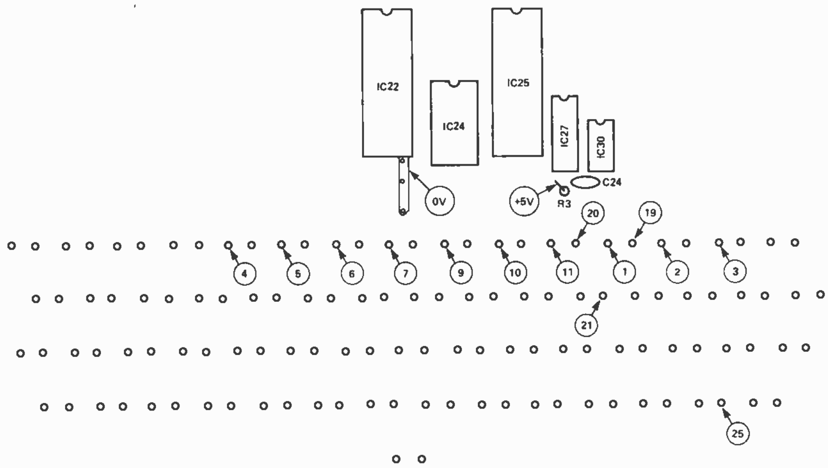


Fig. 4 A diagram of the Atom PCB (rearside of the keyboard) showing take-off points for the wiring. The numbers refer to the pins on IC25 and IC26 (as Fig. 1 shows, this numbering is unambiguous), and correspond to the numbers on the PCB.

PARTS LIST

Resistors (all ¼W, 5%)
R1-16 10k

Semiconductors
IC1-4 74LS32
D1-19 OA202

Miscellaneous
PCB (see Buylines); 16-switch keypad matrix (see text); ½ meter 15-core plus screen cable; case to suit.

inputs to the OR gate are low, and the output is low. The fourth possibility (pin 5 of IC26 high, '9' low) also results in a high output, so pressing '9' will not have any effect unless row 4 is also low, as required. The purpose of the diodes is to isolate the outputs of the various OR gates. In the absence of the diodes, when one gate tried to go low it would be pulled up by all the other gates connected to the same line. It would also upset the operation of IC26. The diodes have a similar effect to open-collector outputs. However, open-collector OR gates are not generally available.

Now consider the operation of the shifted '=' key. The logic of the lower OR gate is identical to that just described, but in addition a diode connection to pin 25 of IC25 pulls column 6 low, thus simulating the effect of the combined operation of the SHIFT and '=/—' keys on the Atom keyboard. The complete circuit is shown in Fig. 3. Note that for 16 keys, the 16 OR gates conveniently occupy four quad OR gate ICs (type 74LS32).

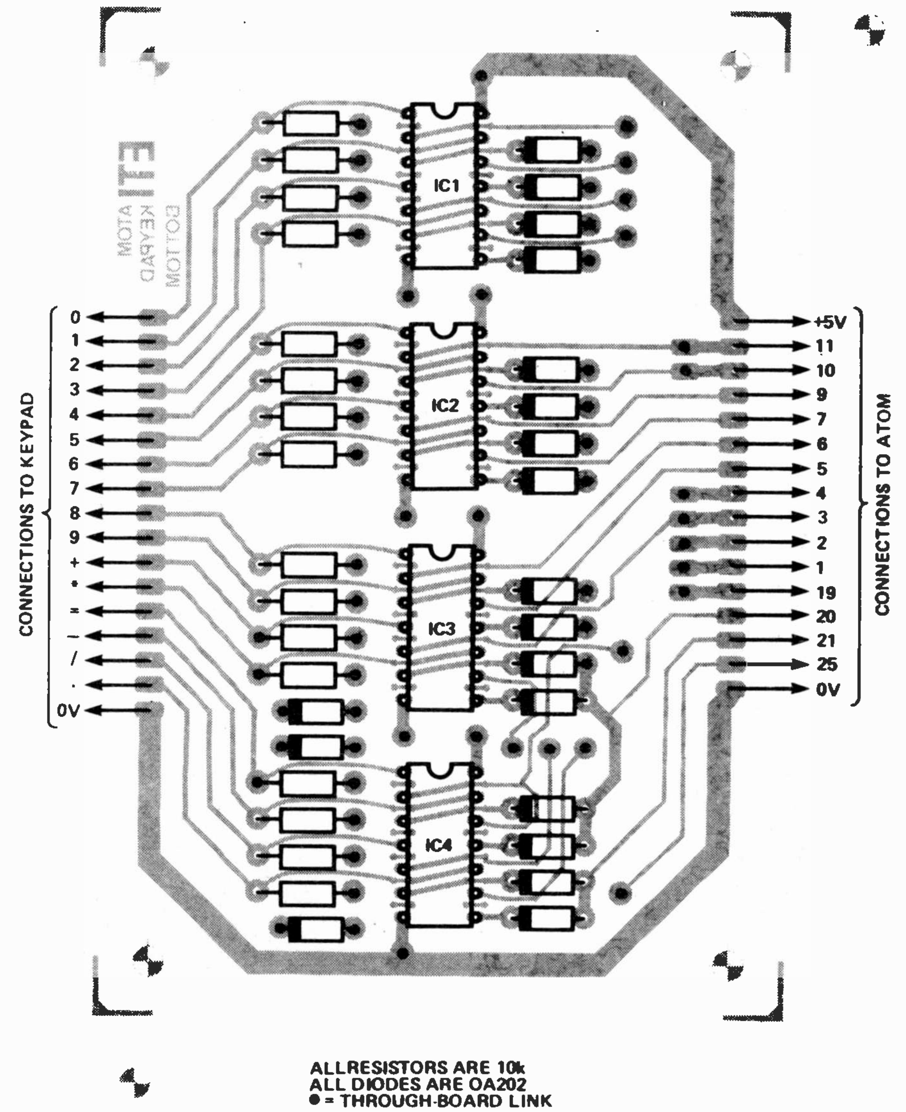


Fig. 5 Component overlay for the project. Remember to solder both sides of the board at each point indicated by a dot.

Construction

The most expensive item is the keyboard itself. It should contain 16 single-poll switches with one side commoned to the 0 V rail. The author used a very cheap but entirely satsifactory unit from Watford Electronics Ltd. Perusal of the advertising columns should reveal a source of a suitable alternative for less than £10. Avoid decoded types, which are connected in a matrix fashion unsuitable for this application. As a last resort you could make your own from the readily available keypad switches.

The circuit should be constructed on a printed circuit board. Veroboard can be used, but is much more difficult to wire up and looks messy with so many connections. We've designed a double-sided PCB for this project — with care this shouldn't cause grave difficulties to home constructors, and finished boards will be on sale through our PCB Service. To avoid the cost of plated-through holes, links between the two sides of the PCB are required: these are shown by dots on the overlay. If the position has a component lead, solder it on both sides of the board — otherwise fit a through-board link.

Now comes the tricky bit. The problem is to find suitable places on the Atom masterboard to pick up connections to the key matrix. After an hour or so of probing with a multimeter we came up with the connection diagram of Fig. 5. We don't need to distinguish between the sets of pins for IC25 and IC26, incidentally, as the two have no numbers in common.

All the keyboard matrix connections can be made to the pins of the existing keyboard switches. The supply connections are somewhat trickier. The 0 V is taken from a large area near IC22 (it will be necessary to scrape away the green varnish in order to solder the lead), while the +5 V is taken from the top end of R3. The photograph will hopefully make things clear.

The number of connections required between the Atom and the PCB is 16, including the 0 V and +5 V rails. These are conveniently provided by 15 core and earth cable, of which a length of half a meter is ample. You will have to make a hole in the Atom case to bring the cable through.

The pad is mounted in a sloping fronted Bim case, which conveniently matches the shape of the Atom case, and helps to give a uniform appearance to the finished product. **ETI**

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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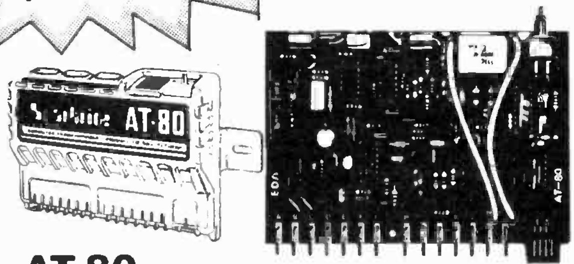

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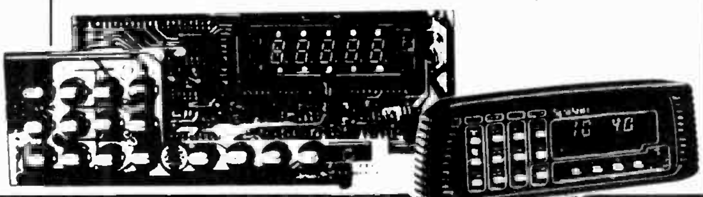

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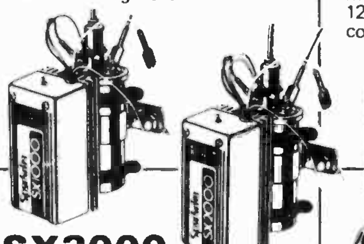

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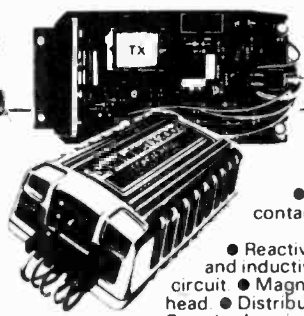

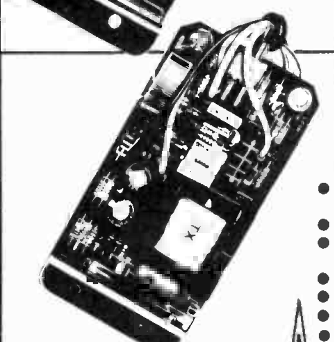

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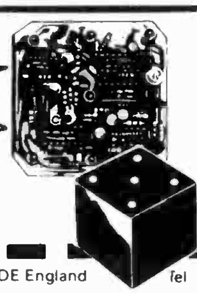

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TECH TIPS

Scope Bargraph Unit

Graeme Durant, Selby

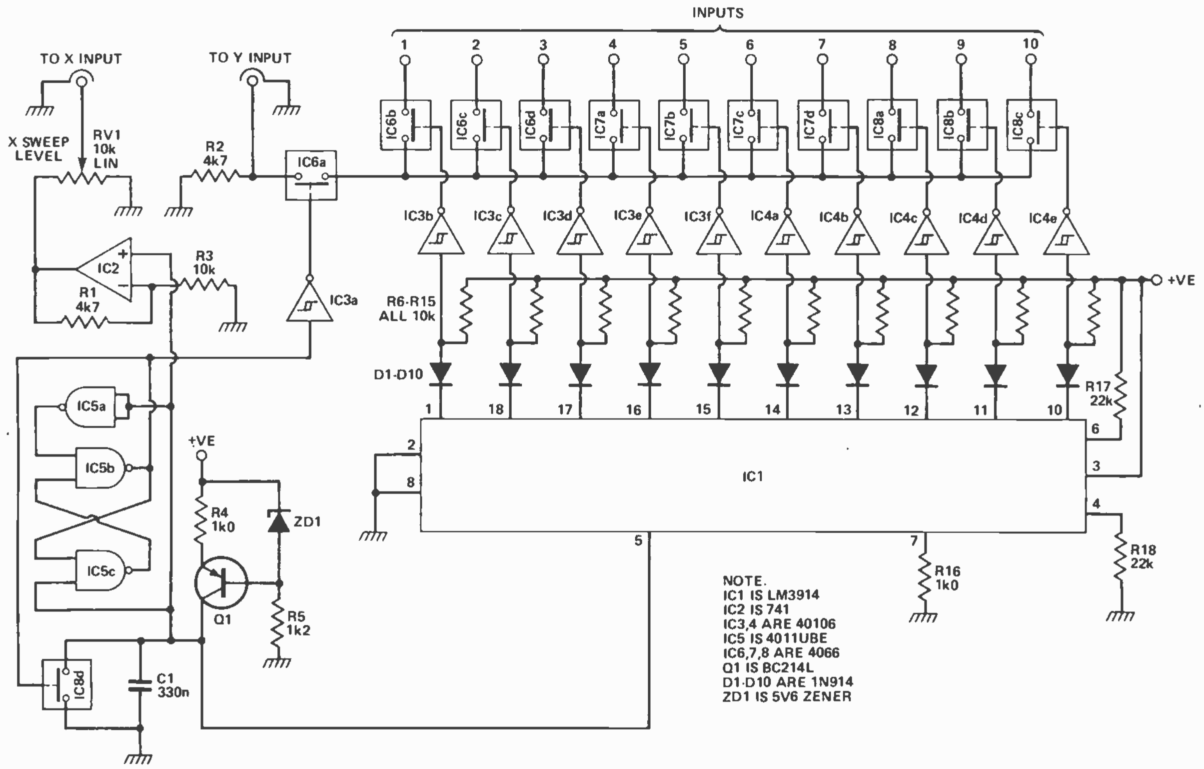
This circuit is designed to be used in conjunction with any ordinary oscilloscope which has an X-deflection input, and allows it to be used as a bargraph display. The screen has 10 useable columns, thus making it suitable for use with the ETI Spectrum Analyst published recently.

The heart of the circuit is IC1, an LM3914 bargraph driver. The input to this, pin 5, is connected to a sawtooth generator running at about 1 kHz, formed around Q1. Q1 is a constant current generator supplying 5 mA and charging a 330nF capacitor to create a linear sweep. As the voltage on this capacitor reaches the upper CMOS threshold, about two-thirds supply, a latch formed by IC5b and c is triggered by IC5a. This rapidly discharges the capacitor through IC8d. When the voltage has dropped to the lower CMOS level, about one-third supply, the latch is reset and the capacitor starts to charge up again. Thus a linear sawtooth waveform is produced.

This is buffered by IC2 and fed out to drive the X amplifier in the scope. However, as this sweep also drives a bargraph IC which has its upper and lower limits set to be similar to the two CMOS switching levels, the 10 outputs go low, one at a time, in sequence. These outputs are used to drive a multiplexing system: a set of 10 analogue switches (IC6b to IC8c). These are driven via inverting Schmitt triggers, diodes and pull-up resistors due to the limited drive capability of IC1 at logic 1.

The multiplexed output is sent to the scope's Y input via another analogue switch, which is normally on, but cut off while the sweep capacitor discharges so as to blank out the 'flyback'. Alternatively, the 'Z modulation' input of the scope could be used if one is available.

In use, the internal sweep generator in the scope is turned off and the circuit is connected. It is recommended that a regulated supply of 15 V is used so as to provide adequate X output drive. The X sweep level is adjusted until a suitable width of diplay is produced (this being a horizontal line at the present), which should be moved to the bottom of the screen. Now the inputs to the scope may be connected and the Y sensitivity of the scope adjusted to give a good display.



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Improving Crossover Performance (Zobel network)

J. P. Macauley, Crawley

When designing crossover networks, problems are encountered due to the reactive nature of the speakers. This problem can cause ringing, and more importantly the roll-offs will not occur at the frequency that the normal design calculations would indicate. It is pointless to design a crossover on the assumption that the impedance remains at a constant value throughout the operating range.

In fact a moving coil speaker looks like an inductance and a resistance in series. Because of the inductance the impedance of the speaker increases with frequency. It is not unusual to find that the impedance presented by a nominally 8 ohm speaker is nearer 15 ohms at 3 kHz.

This problem can be overcome by shunting the speakers in the proposed system with a series resistor-capacitor combination. If the values of these components are correctly chosen the speaker will look like a nearly pure resistive load to the crossover. Obviously this ensures that the latter rolls the response of the speakers on and off at the calculated frequencies without problems.

The circuit is shown in Fig. 1, and the component values are determined as follows. Feed the speakers with a sine wave at the desired crossover frequency via a 100R resistor (see Fig. 2). Measure the output voltage at the output of the generator (V_1) and the voltage across the speaker terminals (V_2). The impedance of the speaker Z can now be determined by the equation

$$Z = \frac{100 \times V_2}{V_1 - V_2}$$

The DC resistance is now measured across the speaker terminals and R is made equal to this. C can now be determined from the equation

$$C = \frac{Z - R}{2\pi f R^2}$$

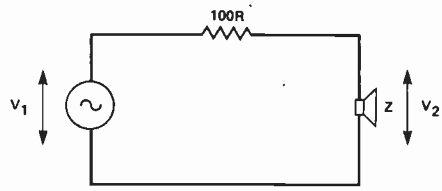


Fig. 1.

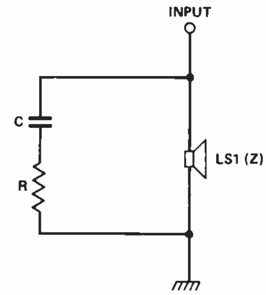


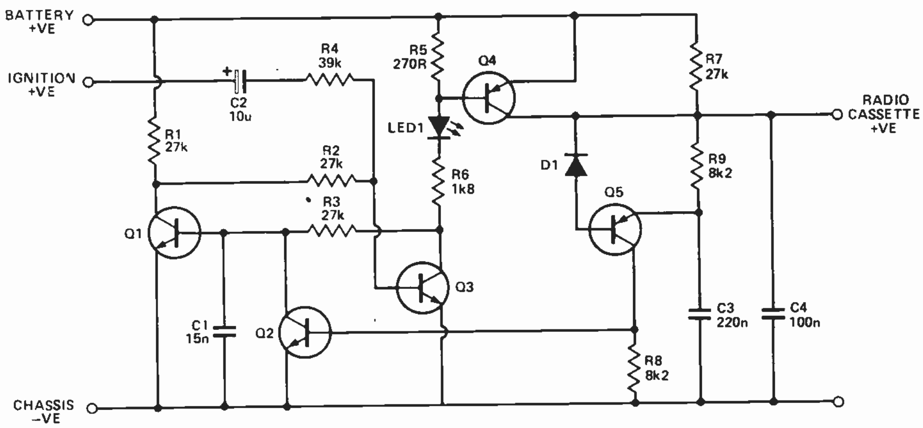
Fig. 2.

where f is the crossover frequency in Hertz and C is given in Farads. The speaker and network now present a resistive load equal to R and the crossover can safely be calculated on this assumption.

ETI

Car Radio Latch

A. Miller, Loughborough



When fitting a car radio or cassette player into a car, one problem is deciding which side of the ignition to connect the supply lead. If it's connected to the ignition side the keys must be in to use the radio, a potential hazard if children are left listening. On the other hand, if it's connected to the battery side you have to remember to turn off the radio every time you leave the car.

The answer is simple — you connect to both using the circuit shown here. Normally the radio is left switched on and it will go on and off with the ignition. But if the ignition is off, switching the radio off and then on again also turns the radio on.

The circuit consists of a latch using Q1 and Q3, which controls a driver stage Q4. The LED indicates the state of the latch and is optional, but it doesn't consume any extra power since without it, the power would only be dissipated in R6. C2 serves to trigger the latch on and off with the ignition, and R4 prevents false triggering during starting. If the radio goes off after starting R4 should be increased, and if the radio fails to go on and off with the ignition, R4 should be reduced.

When the latch is in the 'off' state, a small current passes through R7 to the radio. While the radio is on, C3 and C4 will remain discharged, but if the radio is off, C3 and C4 charge to the full battery voltage. If the radio is switched on, C4 rapidly discharges through the radio leaving C3 to discharge via Q5 and D1 and produce a current in R8. This turns on Q2, triggering the latch to supply power to the radio. C1 ensures reliable triggering.

Q1,2,3 and 5 are all general-purpose transistors, such as the BC108/BC158 types, and Q4 is a power Darlington with at least 2 A rated collector current. No heatsink should be necessary for Q4, as it is always either off or in saturation. D1 is a general-purpose diode such as the 1N4148. R4 is the only component with a critical value and may need adjusting as mentioned earlier. All the component values are those used in the prototype and any similar values should work. The quiescent power consumption is either 2 mA or 10 mA depending on the state of the latch, but if the vehicle is to be left standing for longer than a fortnight the unit (or the battery) should be disconnected.

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HYCONOMISER

Although not electronic, we believe that Vivian Capel's report on the Hyconomiser will interest ETI readers as it could affect something very near to their hearts — their wallets! After all, the more cash you save, the more you can spend on electronic goodies.

Petrol-saving gadgets have abounded over recent years, and even before that when the stuff was much cheaper. Savings were marginal with most, some made no difference and a few actually increased consumption! It was with great scepticism, then, that I greeted the announcement of yet another, especially as it cost the not insignificant sum of £47.50. Even today you can buy quite a few gallons of petrol for that.

The ad claimed savings of up to 20%. That phrase 'up to' of course is the let-out; 5% or even 2% could be said to qualify. However, I was impressed by the fact that all the listed suppliers and fitters were well-known main-agent garages that had reputations to lose. Fitting, incidentally, must be by a trained mechanic, and this is included in the price.

Still suspicious, I phoned all the garages and questioned the mechanics. All were enthusiastic except a Volkswagen dealer who was having troubles, which I believe have since been resolved.

So what actually is it and what does it do? Much of the wastage in a petrol engine is due to large drops of fuel which are too big to be fully burnt before they are ejected from the exhaust. Some, because of their size and mass do not move quickly enough to make it around the sharp bends of the inlet ducts, hit the walls and run down the cylinders to dilute the oil. This is aggravated at part-throttle settings by the throttle-plate, which diverts the flow toward the manifold walls. A further factor is the low-pressure region set up under the throttle-plate which tends to deflect the fuel toward the front cylinders, thus giving uneven distribution and power loss. And finally in the fuel saga, uneven atomisation produces regions of uneven mixture in the combustion chambers around the plug tips.

A formidable collection of ills, curable you might think only by completely redesigning the petrol engine! Not so, for the Hyconomiser claims to overcome them all. How? By sonic pulses.

Blowing In The Wind

It consists of a plastic cylinder containing three plastic balls. A controlled air flow passes through the cylinder making the balls resonate at three different frequencies from 850 Hz to 2.5 kHz. The pulsed air flow is injected through a tube into the intake manifold below the carburettor. There the highest frequency produces a cone of microturbulence that smashes the fuel droplets into a fine mist with particles smaller than 20 microns.

The mixture still has to be distributed evenly to all cylinders, and evenly within each cylinder. This is the job of the middle and lower frequencies which set up areas of turbulence throughout the fuel inlet system.

The results are less consumption, more power, smoother running and, of interest to the environmentalists, less exhaust pollution. Engine and plugs also run cleaner. Air/fuel ratio is maintained closely to the optimum 14.6:1 stoichiometric region.

Well, it sounds good but does it work? I decided to take a chance and had one fitted. Beforehand I made a careful check on my consumption in my elderly 1964 Wolseley 16/60, and for mixed town and country travel found it was 23 mpg. After fitting, I repeated the test with the same journeys. In view of the 'up to' phrase I would have been happy with 10% improvement: so I was very pleased to achieve 28 mpg, a 21% increase. Later, on a single long-distance run I did 34 mpg, but had no previous figure for this run to compare with.

I discussed this later with Hyco's managing director Tom Pearse. I learned that performances in excess of 20% were not at all uncommon, and I saw a report by one of the main-agent garages of before-and-after tests on various more recent model cars at several fixed speeds. Some were considerably higher, although this would not be a fair test of everyday motoring. Pressed for a minimum expected figure, Mr Pearse said he would be surprised if a normal production car did not attain 15% improvement.

As to cleaning the engine, I found it does this too. The makers stipulate that cars with old engines should be returned to the fitter after about 150 miles for re-tuning the device. It is in fact individually tuned for resonance with the particular engine it is fitted to. The turbulance breaks up the carbon deposits and thereby enlarges the combustion area, causing the device to de-tune. Once re-tuned the engine remains carbon-free and there is no further need of tuning.

The fitters did not inform me of this, and some thousand miles later my consumption had climbed and the device was completely off tune. Re-tuning restored optimum economy once more.

I can also confirm that the performance of my car is more sprightly although I have not pursued this too far, as my driving is definitely economy-orientated.

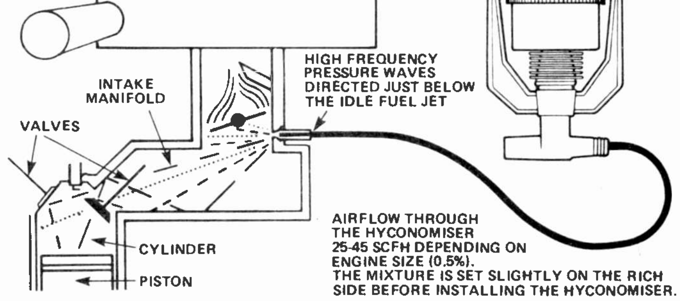

Fig. 1 Schematic diagram showing the operation of the Hyconomiser. By acoustically atomising the petrol, improved combustion and air/fuel ratio results.

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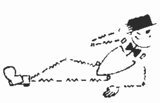

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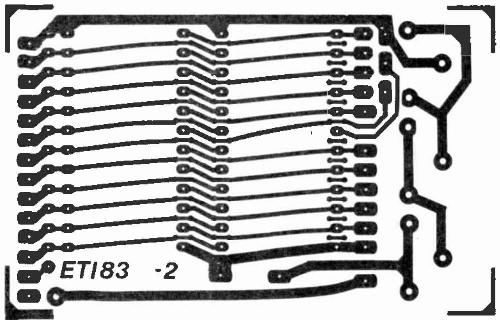

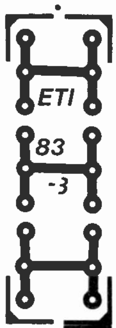

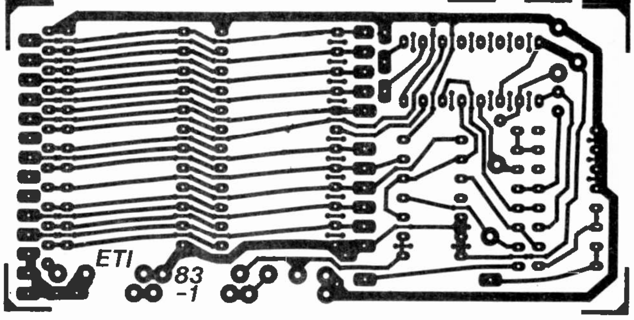

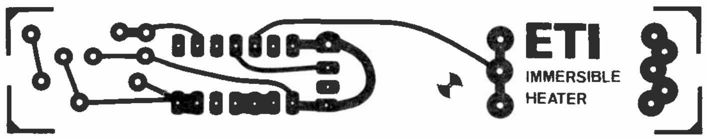

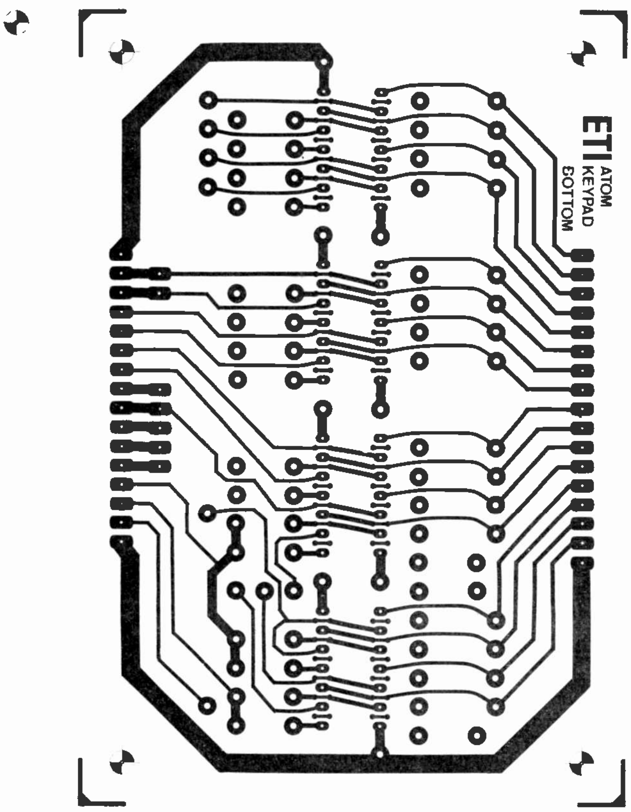

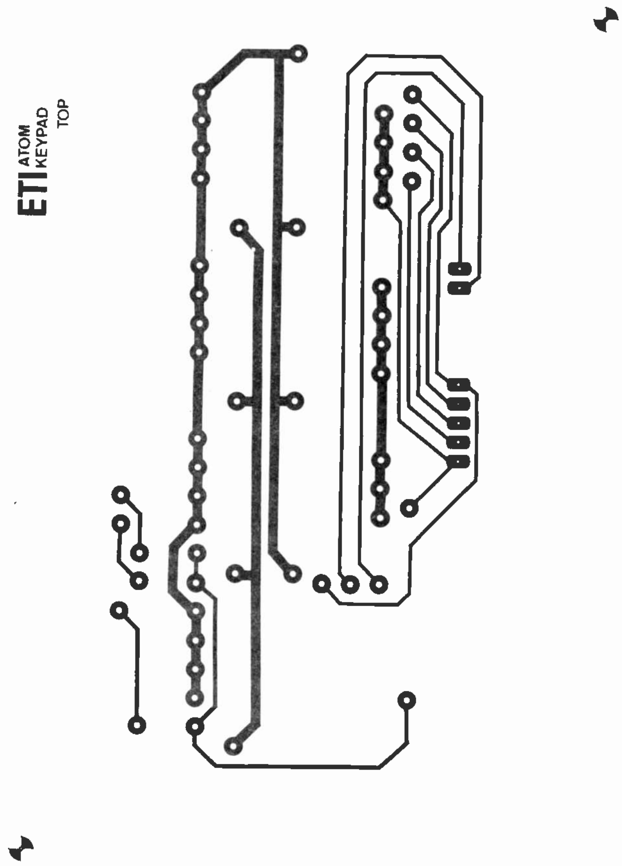

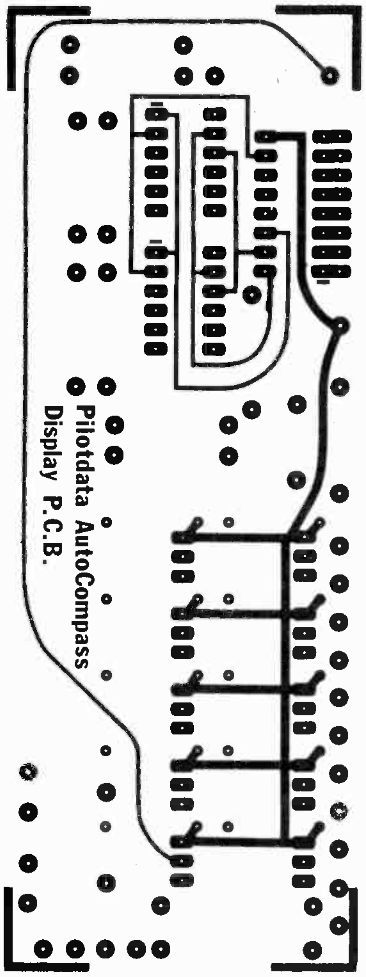
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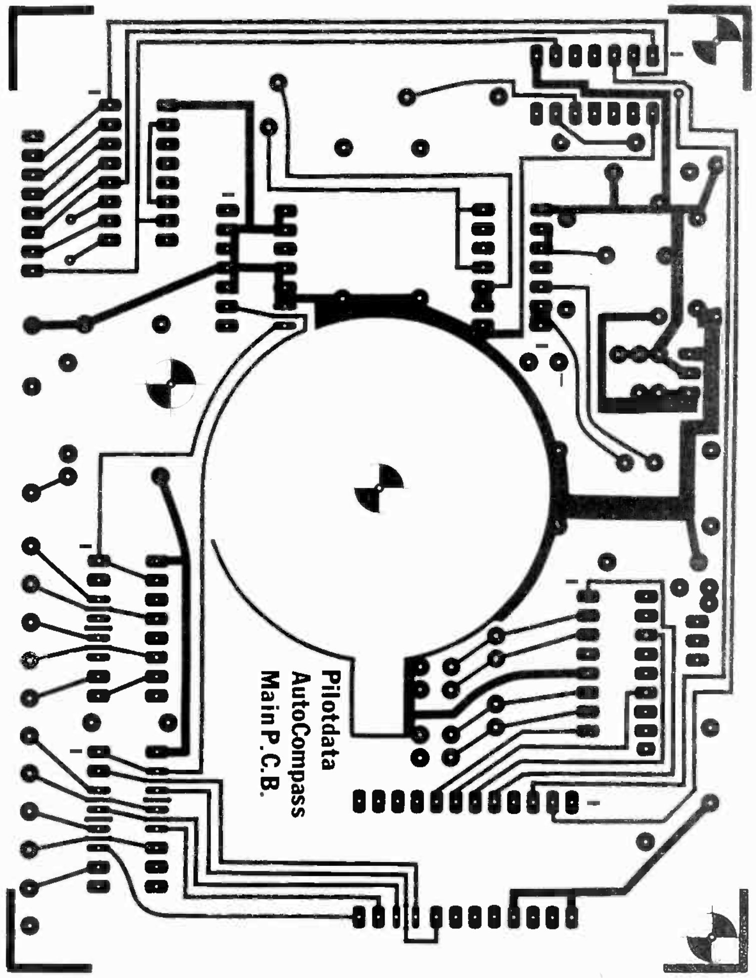
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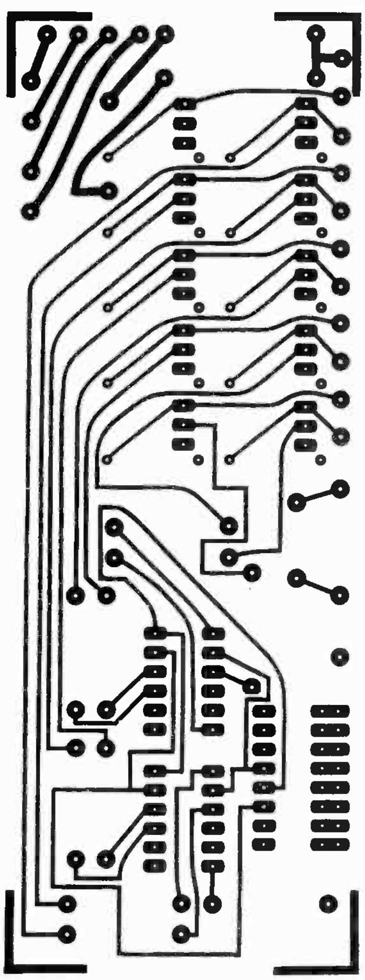

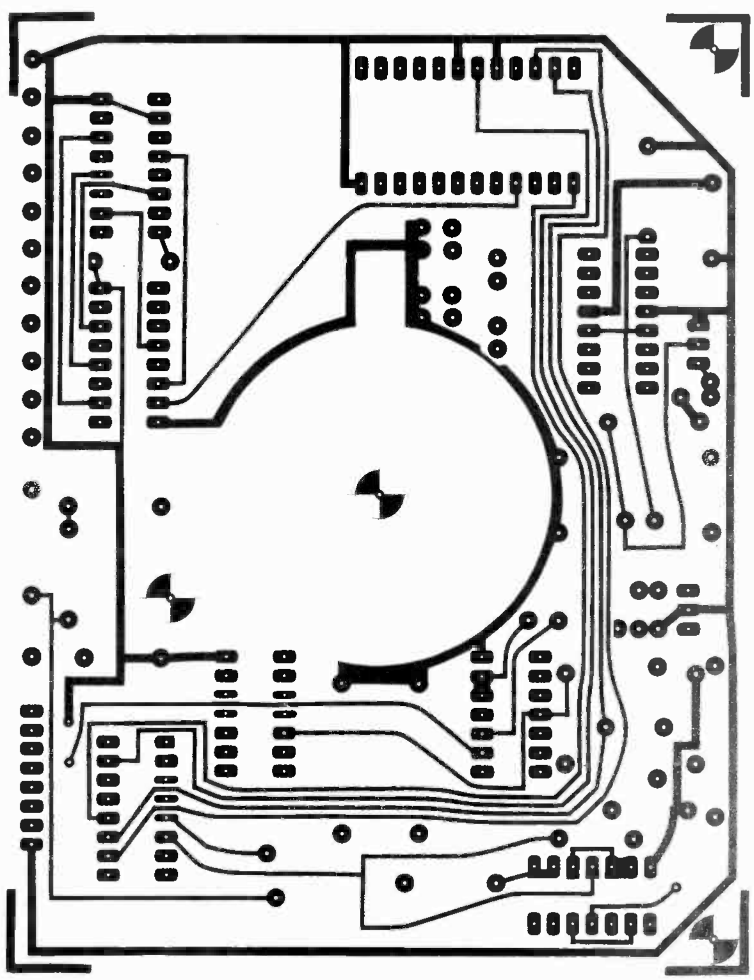

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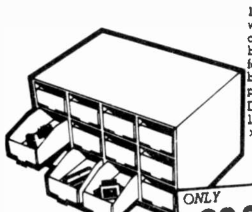

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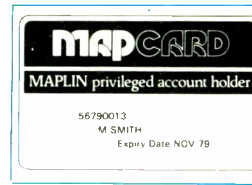

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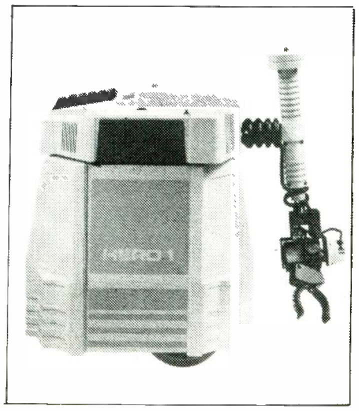

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