PRACTICAL
ELECTRONICS

Australia $1.50 New Zealand $1.75 Malaysia $4.95

MARCH 1984

90p

FREE INSIDE · LOGIC DESIGN CARD·1

PE LOGIC DESIGN CARD No.1

PRESENTED FREE WITH PRACTICAL ELECTRONICS MARCH '84

Spectrum AUTO-SAVE

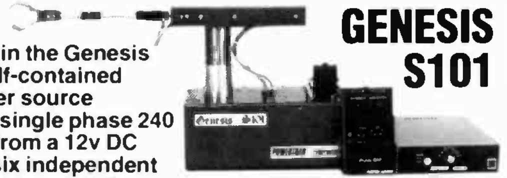
Also...

INMOS – THE BRITISH CHIP MANUFACTURER

Low-price robots from POWERTRAN

– hydraulically powered
– microprocessor controlled

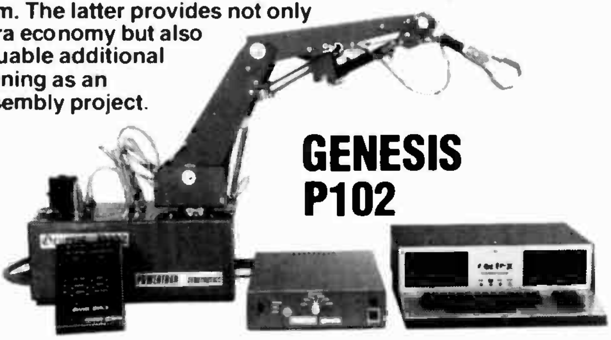
The UK-designed and manufactured range of Genesis general purpose robots provides a first-rate introduction to robotics for both education and industry. With prices from as low as £425, even the home enthusiast can aspire to his or her own robot.

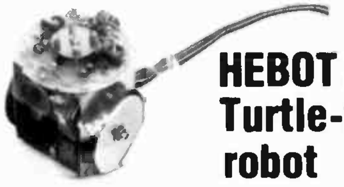


Each robot in the Genesis range has a self-contained hydraulic power source operated from single phase 240 or 120v AC or from a 12v DC supply. Up to six independent axes are capable of simultaneous operation and all except the grip axis have sensing devices fitted to provide positional control by a closed loop system based on a dedicated microprocessor. Movement sequences can be programmed by means of a hand-held controller or the systems can be interfaced with an external computer via a standard RS232C link.

The top-of-the-range P102 has dual speed control, enhanced memory and double acting cylinders for increased torque on the wrist and arm joints. There is position interrogation via the RS232C interface, increasing the versatility of computer control and inputs are provided for machine tool interfacing.

All Genesis robots are available either ready-built or in kit form. The latter provides not only extra economy but also valuable additional training as an assembly project.





HEBOT II Turtle-type robot

For under £100, Hebot II takes programming off the VDU and into the real world. Each wheel is independently controlled by a computer, enabling the robot to perform an almost infinite number of moves. It has blinking eyes, a two-tone bleep and a solenoid-operated pen to chart its moves. Touch sensors coupled to its shell return data about its environment to the computer enabling evasive or exploratory action to be calculated.

The robot connects directly to an I/O port or, via the interface board, to the expansion bus of a ZX81 or other microcomputer.

HEBOT II

Weight 1.8kg

complete kit with assembly instructions	**£85**
Interface board kit	**£10**

A real, programmable robot for under £200! Micrograsp has an articulated arm jointed at shoulder, elbow and wrist positions. The entire arm rotates about its base and there is a motor driven gripper. All five axes are motor driven and four of these are servo controlled giving positive positioning. The robot can be controlled by any microcomputer with an expansion bus – the Sinclair ZX81 being particularly suitable.

MICROGRASP

Weight 8.7kg, max. lifting capacity 100g

Robot kit with power supply	**£145.00**
Universal computer interface board kit	**£48.50**
23 way edge connector	**£2.50**
AX81 peripheral/RAM pack splitter board	**£3.00**

GENESIS S101

Weight 29kg, max. lifting capacity 1.5kg

4-axis model (kit form)	**£425**
5-axis model (kit form)	**£475**
5-axis complete system (kit form)	**£737**

GENESIS P101

Weight 34kg, max lifting capacity 1.8kg

6-axis model (kit form)	**£675**
6-axis complete system (kit form)	**£945**

GENESIS P102

Weight 36kg, max lifting capacity 2kg

6-axis system (kit form)	**£1175.00**
Powertran Cortex microcomputer self-assembly kit	**£295.00**

POWERTRAN
cybernetics ltd.

PORTWAY INDUSTRIAL ESTATE, ANDOVER, HANTS SP10 3PE. TEL (0264) 64455

ALL PRICES ARE EXCLUSIVE OF VAT – ALLOW 21 DAYS FOR DELIVERY.

PRACTICAL
ELECTRONICS

VOLUME 20 No. 3 MARCH 1984

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL SUPPLEMENT

OUR APRIL ISSUE WILL BE ON SALE FRIDAY, MARCH 2nd, 1984
(for details of contents see page 14/6 of Micro-file)

WATFORD ELECTRONICS

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VAT Export orders no VAT. U.K. customers please add 15% VAT to total cost incl. p&p. We stock thousands more items. It pays to visit us. We are situated behind Watford Football Ground. Open Monday to Saturday, 9.00am to 6.00pm. Ample FREE Car parking.

POLYESTER RADIAL LEAD CAPACITORS: 250V; 10n, 20n, 15n, 22n, 27n **6p**; 33n, 47n, 68n, 100n **8p**; 150n, 220n **10p**; 330n, 470n **15p**; 680n **19p**; 1μ **23p**; 1μ5 **40p**; 2μ2 **46p**.

ELECTROLYTIC CAPACITORS (Values in μF). **500V**: 10μF **52p**; 47 **78p**; **63V**: 0·47, 1·0, 1·5, 2·2, 3·3, **8p**; 4·7 **9p**; 10 **10p**; 15, 22 **12p**; 33 **15p**; 47 **12p**; 68 **16p**; 100 **19p**; 220 **26p**; 1000 **70p**; 2200 **99p**; **50V**: 68 **20p**; 100 **17p**; 220 **24p**; **40V**: 6·8 **15p**; 22 **9p**; 33 **12p**; 330, 470 **32p**; 1000 **46p**; 2200 **90p**; **25V**: 4·7, 10, 22, 47 **8p**; 100 **11p**; 150 **12p**; 220 **15p**; 330 **22p**; 470 **25p**; 680, 1000 **34p**; 1500 **42p**; 2200 **50p**; 3300 **76p**; 4700 **92p**; **16V**: 2·5, 40 **8p**; 47, 68, 100 **9p**; 125 **12p**; 220 **13p**; 330 **16p**; 470 **20p**; 680 **34p**; 1000 **27p**; 1500 **31p**; 2200 **36p**; 4700 **79p**.

TAG-END TYPE: 64V: 4700 **245p**; 3300 **198p**; 2200 **139p**; **50V**: 3300 **154p**; 2200 **110p**; **40V**: 4700 **160p**; **25V**: 4700 **98p**; 10,000 **320p**; 15,000 **345p**.

TANTALUM BEAD CAPACITORS:
35V: 0·1μ, 0·22, 0·33 **15p** 0·47, 0·68, 1·0, 1·5 **18p** 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 **36p** 33, 47 **50p** 100 **95p** 220 **100p** **10V**: 15, 22 **26p** 33, 47 **50p** 100 **75p**.

SILVER MICA (pf)
2, 3·3, 4·7, 6·8, 8·2, 10, 12, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180 **15p**.
220, 250, 270, 330, 360, 390, 470, 600, 800 & 820pF **21p**.
1000, 1200, 1800 **30p each**
3300, 4700 **60p each**

SIEMENS mulitlayer miniature capacitors.
250V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 8n2, 10n, 15n, 22n **7p**; 18n, 27n, 33n, 47n **8p**; 39n, 56n, 68n **9p**, 100nF **11p**.
100V: 100n, 120n, **10p**; 150n **11p**; 220n **13p**; 330n **18p**; 470n **23p**; 680n **30p**; 1μF **34p**; 2μ2 **50p**.

CERAMIC Capacitors: 50V
Range 1pF to 6800pF **4p**; 10nF, 15n, 33n, 47nF **5p**; 100nF/30V **7p**.

POLYSTYRENE Caps:

10pF to 1nF	8p
1n5 to 12nF	10p

POTENTIOMETERS: Carbon Track, 0·25W Log & Linear Values.

500Ω, 1K & 2K (LIN ONLY) Single	34p
5KΩ-2MΩ single gang	34p
5KΩ-2MΩ single gang D/P switch	80p
5KΩ-2MΩ dual gang stereo	90p

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm track

5KΩ-500KΩ Single gang	70p

PRESET POTENTIOMETERS

0·1W 50Ω-2·2M Mini Vert. & Horiz.	8p
0·25W 220Ω-4M7 Vert. & Horiz.	12p

RESISTORS Hi-stab, Miniature, 5% Carbon.

	RANGE	Val.	1-99	100+
0·25W	2Ω2-4M7	E24	3p	1p
0·5W	2Ω2-4M7	E12	3p	1p
1W	2Ω2-10M	E12	6p	4p
1% Metal Film	51Ω-1M	E24	8p	6p

RESISTORS S.I.L. Package: 7 Commoned, 100Ω, 680Ω, 1K, 2K2, 4K7, 10K, 47K, 100K **24p**.
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K, 100K **26p**

TRANSISTORS

AC127/8	35
AC176	28
AC187/8	32
AD142	120
AD149	79
AD161/2	42
AF118	95
AF139	40
AF239	58
BC107/8	12
BC107B	14
BC108B	12
BC108C	14
BC109	12
BC109B	14
BC109C	14
BC147/8	9
BC147B	10
BC148C	10
BC149	9
BC149C	12
BC157/8	10
BC159	11
BC167A	10
BC168C	10
BC169C	10
BC171/2	11
BC173	11
BC177/8	16
BC179/81	20
BC182/3	10
BC184	10
BC182L	10
BC183L	10
BC184L	10
BC186/7	26
BC212/3	10
BC212L	10
BC213L	10
BC214	10
BC214L	10
BC237/8	14
BC307B	14
BC308B	16
BC327/8	15
BC337/8	15
BC441	34
BC461	34
BC477/8	40
BC516/7	40
BC547/8	12
BC549C	14
BC556/7	15
BC558/9	15
BCY70	16
BCY71/2	20
BD131/2	48
BD133	60
BD135	45
BD136/7	40
BD138/9	40
BD140	40
BD245	45
BD695A	150
BD696A	150
BF194/5	12
BF198/9	18
BF200	30
BF224	25
BF244A	28
BF244B	29
BF256B	35
BF257/8	32
BF259	35
BF594/5	30
BFR39/40	23
BFR41/79	23
BFR80/81	25
BFR98	105
BFX29/84	28
BFX85/86	28
BFX87/88	28
BFY50/51	23
BFY52	23
BFY56	32
BFY90	80
BRY39	40
BSX20	20
BSX29	34
BU105	170
BU205	190
BU206	200
BU208	200
MJ2955	70
MJE340	54
MJE371	100
MJE2955	99
MJE3055	70
MPF102	40
MPF103/4	30
MPF105	30
MPSA05	25
MPSA06	25
MPSA12	32
MPSA55	30
MPSA56	30
MPSA70	30
MPSU02	58
MPSU05	55
MPSU06	55
MPSU52	65
MPSU55	60
MPSU56	60
OC23	170
OC28/36	220
OC41/42	75
OC70	40
OC76	50
OC81/82	50
OC83/84	40
TIP29A	32
TIP29C	38
TIP30A	35
TIP30C	37
TIP31A	38
TIP31C	37
TIP32A	38
TIP32C	42
TIP33A	65
TIP33C	78
TIP34A	74
TIP34C	88
TIP35A	110
TIP35C	128
TIP36A	130
TIP36C	140
TIP41A	50
TIP41B	52
TIP42A	55
TIP42B	58
TIP120	70
TIP121	73
TIP141	105
TIP142	105
TIP147	120
TIP2955	60
TIP3055	60
TIS43	32
TIS44	45
TIS88A	50
TIS90	30
TIS91/93	32
VK1010	99
VN10KM	70
VN46AF	95
VN66AF	110
VN88AF	120
VN89AF	120
ZTX107/8	11
ZTX109	12
ZTX212	28
ZTX300	13
ZTX301/2	16
ZTX303	25
ZTX304	17
ZTX320/26	30
ZTX500/1	14
ZTX502/3	18
ZTX504	25
ZTX531	25
ZTX550	25
2N696	30
2N697	23
2N698	40
2N699	48
2N706A	19
2N708	19
2N914/5	32
2N918	35
2N930	20
2N1131/2	24
2N1303/4/5	
2N1307/8	65
2N1613	30
2N1671B	160
2N2160	295
2N2219A/20A/21A/22A	25
2N2369A	16
2N2646	45
2N2846	80
2N2904A/05A/06A/07A	26
2N2926G	10
2N3053	25
2N3054	58
2N3055	40
2N3442	140
2N3615	199
2N3702/3	10
2N3704/5	10
2N3706/7	10
2N3708/9	10
2N3710	10
2N3771	179
2N3772	195
2N3773	210
2N3819	27
2N3820	38
2N3822/3	45
2N3866	90
2N3903/4	15
2N3906/5	15
2N4427	80
2N4859	78
2N5172	18
2N5180	45
2N5191	75
2N5194	80
2N5305	24
2N5457	30
2N5458/9	30
2N5485	36
2N5777	45
2N6027	32
2N6109	60
2N6290	70
2SA636	250
2SA671	250
2SA715	60
2SC495/6	70
2SC1061	250
2SC1096	85
2SC1162	30
2SC1172	125
2SC1173	125
2SC1306	100
2SC1307	150
2SC1449	85
2SC1679	190
2SC1678	140
2SC1923	50
2SC1945	225
2SC1953	90
2SC1957	90
2SC1969	140
2SC2028	85
2SC2029	200
2SC2078	170
2SC2091	85
2SC2166	165
2SC2314	85
2SC2465	125
2SC2547	30
2SD234	75
2SK45	90
2SK288	225
2SJ83	225
2SJ85	225
3N128	112
3N140	112
40251	150
40311	60
40313	130
40361/62	70
40408	76
40412	90
40467	130
40468	85
40594	105
40595	110
40603	110
40673	70
40871/2	90

JUST PHONE YOUR ORDER THROUGH, WE DO THE REST.
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LINEAR IC's

555 CMOS	85
702	75
709C 8 pin	35
710	48
741	14
747C 14 pin	65
748C 8 pin	36
753 8 pin	185
810	159
9400CJ	350
AY-1-1320	225
AY-1-5050	99
AY-1-5051	160
AY-1-6720	210
AY-3-1270	730
AY-3-8910	420
AY-3-8912	625
AY-5-1230	450
AY-5-1317A	630
CA3011	130
CA3012	175
CA3014	275
CA3018	86
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
CA3085	00
CA3086	48
CA3089E	200
CA3090AO	375
CA3123	165
CA3130	90
CA3140	40
CA3160	95
CA3161E	160
CA3189	200
CA3240	110
HA1366	175
HA1388	255
ICL7106	690
ICL7107	975
ICL7611	99
ICL7660	248
ICL8038CC	300
ICL8211	350
ICM7205	1150
ICM7207	475
ICM7215	1050
ICM7216A	£22
ICM7217A	750
ICM7224	785
ICM7240	300
ICM7555	85
ICM7556	150
LA3350	250
LA4031P	340
LA4032	295
LA4400	350
LA4422	320
LC7120	300
LC7130	340
LC7137	395
LF347	150
LF351	48
LF353	95
LF355	85
LF356	95
LF357	110
LF398	475
LM10	350
LM301A	30
LM307	45
LM308	95
LM311	55
LM318	150
LM319	195
LM324	35
LM334Z	90
LM335	128
LM337	00
LM339	47
LM348	60
LM349	115
LM358	60
LM377	175
LM379	475
LM380	75
LM381N	145
LM382	115
LM384	160
LM386	90
LM387	120
LM389	95
LM393	45
LM394CH	290
LM725CN	325
LM733	70
LM1871	325
LM1889	350
LM2907	00
LM2917	00
LM3900	50
LM3909	85
LM3911	125
LM3914	200
LM3915	200
LM3916	250
LS7220	280
M51513L	230
M51515L	320
M51516L	475
M706B1	00
MB3712	220
MB3756	440
MC1204	250
MC1303	98
MC1304P	260
MC1310P	150
MC1445	250
MC1455	50
MC1458	35
MC1469	300
MC1494	694
MC1495	350
MC1496L	70
MC1596	225
MC1648	290
MC3302	90
MC3401	65
MC3403	85
MC3405	150
MC3442	00
MC3423P	80
MC3487	00
MC4016	00
MF10	350
MFC6040	75
ML924	275
NE515	275
NE529	225
NE531	140
NE543	225
NE544	210
NE555	18
NE556DB	45
NE558	140
NE560	325
NE561	395
NE562B	410
NE564	420
NE565A	120
NE566	155
NE567	140
NE570	410
NE571	400
NE5532	145
NE5534	105
OM335	750
RC4136D	60
RC4558	45
S566B	225
SAB3209	425
SAB3210	325
SAB3271	485
SAB4209	595
SG3402	295
SL490	350
SL924	00
SL6270	150
SN76013N	350
SN76023N	350
SN76033	350
SN76488	480
SP8629	00
SP0256AL	850
TA7120	125
TA7130	125
TA7204	150
TA7205	175
TA7222	150
TA7310	00
TAA900	395
TAA621	296
TAA661	190
TAA700	275
TAD100	159
TBA120S	70
TBA540	275
TBA550Q	330
TBA641	290
TBA651	190
TBA800	80
TBA810S	95
TBA820	80
TBA920Q	200
TBA990	350
TCA270	350
TCA280A	220
TCA940	175
TCA950	00
TCA965	145
TDA1004	290
TDA1008	310
TDA1010	198
TDA1022	499
TDA1024	115
TDA1034	350
TDA1054	00
TDA1490	350
TDA2002	325
TDA2003	250
TDA2004	495
TDA2006	330
TDA2020	320
TDB0791	420
TL061CP	40
TL062CP	60
TL064CN	98
TL071CP	25
TL072CP	45
TL074CN	100
TL081CP	24
TL082CP	45
TL083CP	75
TL084CP	90
TL091CP	55
TL170	50
TL430C	90
TL507	110
TL509	110
UA2240	120
UA78540	230
UAA170	180
UAA180	180
ULN2003	75
ULN2004	75
ULN2283	100
UPC556	00
UPC575	275
UPC1025H	375
UPC1156H	270
UPC1181	00
UPC1182	320
UPC1366	195
XR2206	300
XR2207	375
XR2211	575
XR2216	675
XR2266	360
ZN414	80
ZN419CE	180
ZN423E	130
ZN424E	130
ZN425E-8	345
ZN426E-8	300
ZN427E-8	590
ZN428E	410
ZN429E-8	210
ZN459	325
ZN1034E	200
ZN1040E	665
ZNA234E	850

COMPUTER IC's

2102L	100
2114L-200n	150
2147-3	425
2532-3	300
25L32	450
2564	700
27L08	450
2716-5V	270
2732	320
2764-250	495
26501	75
27128/250n	£18
3242	590
4027	95
4116-150	100
4164-200	425
4416-2	475
4532-3	290
4816-100ns	300
5101	220
5514	250
6116-150ns	495
6116L-120ns	525
6117-100n	490
6167-6	795
6264L-15	£26
6402	350
6502 CPU	325
6502A	450
6503	650
6504	600
6505	650
6520	100
6522 VIA	295
6530 RRIOT	£11
6532 RIOT	570
6545 CRTC	899
6551 ACIA	650
6592	00
6800	220
6802	250
6803	850
6805	670
6808	520
6809	630
6810	115
68B21	220
6821	100
6840	375
6843	00
6845	750
6846	625
6847	650
6850	110
6852	250
6854	599
68B54	760
6875	500
68000	£50
8035	600
8080A	250
8085A	350
8088	£18
81LS95/96	120
81LS97/98	120
8123	125
8131	275
8154	£9
8155	350
8156	350
8202	£25
8212	150
8214	425
8216	100
8224	150
8226	250
8228	220
8236	00
8243	270
8250	950
8251A	250
8253	400
8255	225
8256A	£35
8257A	400
8259	395
8271	£39
8272	£17
8279	385
8282	450
8283	450
8284	350
8288	00
8T26A	99
8T27	150
8T28A	120
8T31	350
8T95N	90
8T97N	90
9364AP	550
9602	220
AM26LS31C	125
AM26LS32	100
AM26LS32A	125
AM26LS33	150
AY-3-1015	300
AY-5-1013	300
AY-5-1350	388
AY-5-2376	600
AY-5-3600	750
COM8017	275
COM8116	700
DM8131	275
DP8303	00
DP8304BN	250
DS3647	00
DS3691N	320
DS8820	110
DS8830	110
DS8831	125
DS8832	250
DS88LS120	275
E9364	00
E9365	£38
FD1691	£15
FD1771	£15
FD1791	£22
FD1793	£23
FD1795	£28
FD1797	£28
HD26501	75
IM6402	350
INS8060N	1050
MC1488	55
MC1489	55
MC14411	675
MC14412	725
MC3242	590
MC3446	250
MC3447P	315
MC3486	175
MC3487	175
MK3886-2M	£7
MM5280D	695
MM5303	635
MM5307	1275
MM5387A	475
MM58174	700
RO-3-2513L	550
RO-3-2513U	650
SFF96364E	800
SP0256AL2	850
TMS2716-3	725
TMS4047	100
TMS4164-15	395
TMS4416-2	475
TMS4500	£14
TMS4532-3	350
TMS5100	600
TMS6011	500
TMS9927	£14
TMS9928	£20
TMS9929	£16
TMS9980	£20
TMS9995	£12
ULN2003	75
UPD7002	425
WD1691	£14
Z80CPU 2·5	299
Z80ACPU4M	300
Z80ACTC	260
Z80B	875
Z80DART	495
Z80ADART	550
Z80ADMA	895
Z80DMA	695
Z80P10	260
Z80AP10	275
Z80S10-1	850
Z80AS10	900
Z80AS10-2	00
Z8002CPU	00
74S365	250
74S373	400
74S374	365
74S412	380
74S470	325
74S471	620
74S472	1150
74S473	00
74S474	400
74S475	800
74S571	620
74S573	950

74S

74S00	30
74S02	30
74S03	35
74S04	40
74S05	60
74S08	60
74S09	00
74S10	40
74S11	50
74S15	00
74S20	40
74S22	50
74S30	40
74S32	70
74S37	60
74S38	00
74S40	00
74S51	00
74S64	00
74S65	00
74S74	75
74S85	295
74S86	70
74S112	90
74S113	90
74S114	80
74S124	300
74S132	110
74S133	80
74S134	00
74S135	00
74S138	100
74S139	115
74S140	60
74S151	180
74S153	182
74S157	250
74S158	195
74S162	00
74S163	300
74S168	00
74S169	00
74S174	250
74S175	320
74S181	00
74S182	00
74S188	140
74S189	140
74S194	295
74S195	275
74S196	00
74S197	400
74S201	350
74S225	500
74S226	00
74S240	300
74S241	300
74S244	290
74S251	225
74S257	225
74S258	250
74S260	70
74S262	850
74S274	00
74S275	00
74S280	00
74S281	00
74S283	00
74S287	225
74S288	210
74S289	200
74S299	540
74S301	350

75

75107/8/9	95
75110	90
75114	00
75121	00
75122	00
75150	125
75151	00
75154	195
75158	00
75159	125
75182/3	99
75188/9	55
75322	140
75324	00
75325	00
75353	00
75361	00
75365	00
75376	00
75450	86
75451/2	52
75454	70
75491/2	65

TTL 74

7400	18
7401	18
7402	18
7403	18
7404	20
74L04	00
7405	20
7406	90
7407	90
7408	20
7409	20
7410	20
7411	20
7412	20
7413	35
7414	45
7416	35
7417	35
7420	20
7421	20
7422	30
7423	30
7425	30
7426	45
7427	30
7428	30
7430	25
7432	25
7433	25
7437	30
7438	50
7440	25
7441	55
7442	40
7443	70
7444	65
7445	75
7446	55
7447	55
7448	60
7450	25
7451	25
7453	25
7454	25
7460	28
7470	35
7472	35
7473	35
7474	30
7475	60
7476	35
7480	50
7481	140
7482	80
7483	50
7484	90
7485	110
7486	35
7489	175
7490	30
7491	48
7492	30
7493	30
7494	60
7495	35
7496	50
7497	120
74100	90
74104	50
74105	50
74107	35
74109	40
74110	35
74111	60
74112	170
74116	80
74118	75
74119	85
74120	80
74121	32
74122	40
74123	55
74125	35
74126	40
74128	45
74132	40
74136	35
74141	60
74142	175
74143	190
74144	190
74145	60
74147	85
74148	70
74150	85
74151	40
74153	40
74154	85
74155	40
74156	40
74157	40
74159	100
74160	50
74161	50
74162	50
74163	55
74164	55
74165	50
74166	55
74167	200
74170	150
74172	280
74173	60
74174	100
74175	70
74176	50
74177	45
74178	80
74179	90
74180	50
74181	140
74182	55
74184	100
74185	100
74186	70
74188	75
74190	70
74191	75
74192	75
74193	60
74194	60
74195	50
74196	60
74197	50
74198	100
74199	100
74221	80
74246	100
74247	100
74248	130
74249	120
74251	60
74259	150
74265	75
74273	175
74276	135
74278	130
74279	45
74283	70
74284	200
74285	210
74290	85
74293	85
74297	900
74298	70
74351	120
74365	80
74366	60
74367	60
74368	60
74376	00
74390	80
74393	100
74490	110

74C

C244	195
C245	195
C373	240
C374	245
C922	420
C923	500
C925	400

74LS

LS00	18
LS01	18
LS02	18
LS03	18
LS04	18
LS05	18
LS08	18
LS09	18
LS10	20
LS11	18
LS12	20
LS13	26
LS14	46
LS15	20
LS19	00
LS20	18
LS21	20
LS22	18
LS24	46
LS26	22
LS27	18
LS28	20
LS30	18
LS32	18
LS33	20
LS37	20
LS38	20
LS40	20
LS42	38
LS47	50
LS48	50
LS49	50
LS51	20
LS52	20
LS54	20
LS55	20
LS63	55
LS73	25
LS74	25
LS75	38
LS76	25
LS78	40
LS83	40
LS85	55
LS86	34
LS90	30
LS91	55
LS92	35
LS93	35
LS95	45
LS96	75
LS107	45
LS109	45
LS112	45
LS113	33
LS114	30
LS122	62
LS123	75
LS124	150
LS125	39
LS126	39
LS132	40
LS133	32
LS135	28
LS136	29
LS138	45
LS139	45
LS145	60
LS147	122
LS148	100
LS151	45
LS153	45
LS154	150
LS155	35
LS156	35
LS157	35
LS158	35
LS160	45
LS161	45
LS162	40
LS163	40
LS164	45
LS165	55
LS166	95
LS168	140
LS169	90
LS170	99
LS173	75
LS174	75
LS175	90
LS181	100
LS183	100
LS190	55
LS191	60
LS192	55
LS193	50
LS194	45
LS195	50
LS196	55
LS197	50
LS221	80
LS240	65
LS241	65
LS242	68
LS243	68
LS244	110
LS245	220
LS247	60
LS248	60
LS249	60
LS251	40
LS253	40
LS257	40
LS258	40
LS259	80
LS260	30
LS261	30
LS266	24
LS273	150
LS275	165
LS279	40
LS280	170
LS283	45
LS290	40
LS292	900
LS293	40
LS294	999
LS295	70
LS298	70
LS299	135
LS320	160
LS323	175
LS324	150
LS325	150
LS326	290
LS327	290
LS347	65
LS348	125
LS352	60
LS353	80
LS356	180
LS363	180
LS365	45
LS366	45
LS367	45
LS368	45
LS373	80
LS374	70
LS375	40
LS377	75
LS378	85
LS379	99
LS384	475
LS385	185
LS386	50
LS390	60
LS393	60
LS395	85
LS396	220
LS398	80
LS399	80
LS445	125
LS447	50
LS465	120
LS467	120
LS490	80
LS540	90
LS541	90
LS624	00
LS640	200
LS641	200
LS645	245
LS668	70
LS669	70
LS670	120
LS673	950
LS674	950

CMOS

4000	14
4001	14
4002	14
4006	50
4007	15
4008	32
4009	24
4010	24
4011	15
4012	16
4013	20
4014	46
4015	40
4016	20
4017	32
4018	45
4019	25
4020	42
4021	40
4022	40
4023	15
4024	32
4025	16
4026	90
4027	22
4028	45
4029	47
4030	20
4031	125
4032	80
4033	125
4034	140
4035	45
4036	275
4037	115
4038	110
4039	280
4040	40
4041	40
4042	40
4043	40
4044	40
4045	105
4046	46
4047	40
4048	40
4049	30
4050	30
4051	45
4052	60
4053	50
4054	85
4055	85
4056	85
4057	£10
4059	435
4060	45
4061	1195
4062	995
4063	85
4066	27
4067	245
4068	20
4069	20
4070	20
4071	22
4072	20
4073	22
4075	20
4076	55
4077	20
4078	20
4081	20
4082	20
4085	55
4086	60
4089	125
4093	20
4094	70
4095	95
4096	70
4097	275
4098	75
4099	75
4160	95
4161	99
4162	99
4163	99
4174	99
4175	105
4194	105
4408	790
4409	790
4410	725
4411	675
4412	790
4415	480
4419	260
4422	770
4433	770
4435	850
4440	999
4450	350
4490	350
4500	675
4501	28
4502	60
4503	40
4504	75
4505	185
4506	35
4507	35
4508	130
4510	46
4511	46
4512	45
4513	199
4514	115
4515	125
4516	65
4517	275
4518	40
4519	30
4520	50
4521	90
4522	125
4526	60
4527	65
4528	50
4529	150
4530	90
4531	130
4532	50
4534	400
4536	275
4538	80
4539	90
4541	140
4543	70
4544	150
4549	375
4553	245
4554	160
4555	35
4556	35
4557	320
4558	120
4559	395
4560	160
4561	104
4562	495
4566	165
4568	250
4569	175
4572	36
4580	480
4581	250
4582	99
4583	90
4584	48
4585	70
4599	290
40097	45
40098	42
40100	215
40101	130
40102	140
40103	175
40104	95
40105	105
40106	35
40107	60
40108	198
40109	100
40110	300
40114	240
40161	194
40163	50
40174	45
40175	50
40181	220
40192	75
40193	95
40194	90
40195	80
40244	195
40245	195
40257	198
40373	240
40374	245

SPEAKERS

8Ω, 0·3W, 2"; 2·25", 2·5", 3" **80p**

0·3W, 2·5" 40Ω; 64Ω or 80Ω **80p**

DIODES	
AA119	15
AA129	20
AAY30	15
BA100	15
BAX13	20
BY100	24
BY126	12
BY127	14
CRO33	250
OA9	40
OA47	12
OA70	12
OA79	15
OA81	20
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	15
1N5404	16
1N5406	17
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

BRIDGE RECTIFIERS (plastic case)	
1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	396
BY164	56
VM18	50

ZENERS

Range: 2V7 to 39V 400mW **8p each**

Range: 3V3 to 33V. 1·3W **15p each**

VARICAPS	
MVAM2	165
BA102	30
BB105B	40
BB106	40

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

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

SOLDERCON PINS	
100	75p
500	370p

DIAC	
ST2	25

OPTO

LEDS price includes Clips

TIL209 Red 3mm	10
TIL211 Green 3mm	14
TIL212 Yellow	14
TIL220 ·2" Red	12
0·2" Yel, Grn, Amber	14
Rectangular LEDs with two part clip. R, G & Y	45
Rectangl. Stackable LEDS	16
Triangular LEDs R&G	18
0·2" Flashing LED Red	56
0·2" Bi colour LEDs Red/Green	65
Green/Yellow	80
0·2" Tri colour LEDs Red/Green/Yellow	85
0·2" Red High Bright	59
High Bright Green or Yellow	65
LD271 Infra Red (emit)	46
TIL32 Infra Red (emit)	52
SFH205 (detector)	118
TIL78 (detector)	55
TIL38	50
TIL81 **82**; TIL100	90

7 Segment Displays	
TIL321 ·5" C.An	120
TIL322 ·5" C.th	120
DL704 ·3" C.Cth	125
DL707 ·3" C.Anod	125
FND357 or 500	130
·3" Green C.A.	140
±1 ·3" Red or Green	150
Bargraph 10 seg. Red	250
Bargraph NSM3914	500

FERRIC CHLORIDE

Crystals 1lb

195p + 50p p&p

DALO ETCH RESIST

Pen plus spare tip **100p**

0·5" LIQUID CRYSTAL DISPLAYS	
3½ digit	495
4 digit	530
6 digit	625

BPX25	250
BPW21	320
BPX65	320
IL74	65
ILD74	115
ILQ74	220
ILCT6 Darlington Isolator	135
TIL111	70
OCP71	120
ORP12	78
2N5777	50
4N33	135
Pin diode	720
Schmitt Receiver	715

OPTO SWITCH

Reflective	
TIL139	225
Slotted similar to RS	186

ALUM.BOXES	
4×2¼×2"	100
4×2¾×2¼"	103
4×4×2¼"	120
5×4×2"	105
5×2¾×1½"	90
5×2¾×2½"	130
5×4×1½"	99
5×4×2½"	120
6×4×2"	120
6×4×3"	150
7×5×3"	180
8×6×3"	210
10×4½×3"	240
10×7×3"	275
12×5×3"	260
12×8×3"	295

COPPER CLAD BOARDS

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

VEROBOARDS 0·1"

	Clad	Plain		
2½×3¾"	85-95	—	'VQ' Board	180
2½×5"	100-110	—	'DIP' Board	395
3¾×3¾"	100-110	—	Vero Strip	144
3¾×5"	115-125	95p	**PROTO-DECs**	
3¾×17"	390-420	275p	Veroblock	405
4¾×18"	495p	—	S-Dec	395
Pkt. of 100 pins		55p	Eurobreadboard	590
Spot Face Cutter		150p	Bimboard 1	695
Pin Insertion Tool		185p	Superstrip SS2	£13

VERO WIRING PEN and Spool **350p**

Spare Wire (Spool) **75p**; Combs **6p** ea.

Wire Wrapping Stakes 100 **250p**

VOLTAGE REGULATORS

1A	T0220 Plastic Casing			
	+ve		−ve	
5V	7805	40p	7905	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p		
100mA	T092 Plastic Casing			
5V	78L05	30p	79L05	50p
6V	78L62	30p		—
8V	78L82	30p		—
12V	78L12	30p	79L12	50p
15V	78L15	30p	79L15	50p

ICL7660	248	LM317K	250
78H05 5V/5A	550	LM317P	99
78H12 12V/5A	640	LM323K	500
78HG +5 to +24V 5A	599	LM337T	175
		LM723	30
79HG −2.25V to −24V 5A	685	TBA625B	75
		RC4194	375
LM309K	120	RC4195	160

SWITCHES

SLIDE 250V	
1A DPDT	14
1A DPDT C/OFF	15
½A DP on/on/on	40

PUSH BUTTON

Spring loaded

Latching or Momentary 6A	
SPDT c/over	110
DPDT c/over	160

MINIATURE

Non Locking

Push to make	15p
Push break	25p

TOGGLE 2A 250V	
SPST	35
DPDT	48
4 pole on off	54

SUB-MIN TOGGLE 2 amp	
SP changeover	60
SPST on off	54
SPDT c/off	85
SPDT Biased	105
DPDT 6 tags	75
DPDT C/OFF	88
DPDT on/on/on	185
DPDT Biased	145
3 pole c/over	205

ROTARY: (Adjustable Stop Type)

1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way **48p**

ROTARY: Mains 250V AC, 4 Amp **64p**

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

AMPHENOL PLUG

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

ASTEC UHF MODULATORS

6MHz Standard	325p
8MHz Wideband	450p

Telephone orders by Access. Simply phone your order through 0923-50234 & we do the rest.

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

ZIF DIL SOCKET	
24 way	565p
28 way	750p
40 way	799p

DIL PLUGS (Headers)

Pins	Solder	IDC
14	38p	95p
16	42p	100p
24	88p	138p
28	185p	290p
40	195p	218p

RIBBON CABLE (price per foot)

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

'D' CONNECTORS:

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

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

SIL Sockets 0.1"

20 way **65p**

32 way **95p**

EDGE CONNECTORS ·1"

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

BEEBFONT ROM

This is a character FONT ROM that gives you 5 16×16 predefined FONT. The ROM is ideal for high quality demonstration on screen and when used in conjunction with EPSON printer, allows printing of letters etc. in mixed type faces. The package is complete, including an Editor to design your own Fonts and several spare Fonts which could not be fitted in the ROM can still be run from RAM. Supplied complete with ROM, software on DISC/tape and Manual. **Price £45**

IDC CONNECTORS (Speed block type)

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

EURO CONNECTORS Gold flashed contacts	FEMALE SOCKETS Strt.	Angle	MALE PLUGS Strt.	Angle
DIN 41612 2×32 way	275p	320p	220p	285p
DIN 41612 2-3×32 way	295p	340p	240p	300p
DIN 41612 3×32 way	360p	385p	260p	395p

TRANSFORMERS (mains Prim. 220-240V)

3-0-3V, 6-0-6V 100mA; 9-0-9V 75mA; 12-0-12V 75mA; 15-0-15V 75mA **98p**

6VA: 2x6V-·5A; 2x9V-·4A; 2x12V-0·3A; 2x15V-·25A **250p**

12VA: 2x4V5-1·3A; 2x6V-1·2A; 2x12V-·5A; 2x15V-·4A **345p** (35p p&p)

24VA: 6V-1·5A 6V-1·5A; 9V-1·2A 9V-1·2A; 12V-1A 12V-1A; 15-·8A 15-·8A; 20V-·6A 20V-·6A **385p** (60p p&p)

50VA: 2×6V-4A; 2×9V-2·5A; 2×12V-2A; 2×15V-1·5A; 2×20V-1·2A; 2×25V-2A; 2×30V-0·8A **520p** (60p p&p)

100VA: 2×12V-4A; 2×15V-3A; 2×20V-2·5A; 2×30V-1·5A; 2×40V-1·25A; 2×50V-1A **965p** (60p p&p)

JUMPER LEADS Ribbon Cable Assembly

DIL Plug (Headers)

Single Ended Lead, 24" long

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

IDC FEMALE RECEPTACLE Jumper Leads 36"

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

COMPUTER CORNER

- **SEIKOSHA GP100A** – Unihammer Printer, normal & double width characters, dot resolution graphics 10" Tractor feed, parallel interface standard. **FREE 500 Sheets** **£155**
- **SEIKOSHA GP 250X** Printer **£199**
- **EPSON FX80 PRINTER** 160 CPS, 11×9 matrix, proportional spacing, superscript, subscript, dot addressable graphics, Normal, Italic & Elite characters. Up to 256 user definable characters. Down loadable character set. Condensed and double width printing. 4 user define margin positions. Tractor and Friction feed. 10" maximum width, Bi-directional, logic seeking. Centronix Interface standard. **£349**
- **EPSON RX80 PRINTER** **£235**
- **EPSON RX80 FT PRINTER** **£259**
- **KAGA – RGB** 12 inch medium resolution colour monitors **£215**
  Connecting lead for KAGA monitors **£5**
- **ZENITH 12" Hi-RES**, Green Monitor 40/80 column select switch, value for money. **£75**
- **MICROVITEC 14"** colour monitor. RGB input. Lead incl. **£205**
- **MICROVITEC 1451** Hi-res 14" Monitor incl. Lead **£319**
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- **Spare** 'UV lamp bulbs **£9**
- **POWER SUPPLY** Regulated, Variable from +5V to +15V, 4A. Fully Cased **£39**
- **MULTIRAIL PSU KIT**. Output: +5V/5A; +12V; +25V; −5V; −12V @ 1A. **£40**
- **4 × 4 matrix keypad** (reed switch assembly) **£4**
- **C12 COMPUTER Grade BASF Cassettes** in Library Cases **40p**
- **8½" or 9½" Fan fold paper** (1000 sheets) **(150p)** **£7**
- **Teleprinter Roll** (no VAT) **£3.50**

MANY MORE PRINTERS, MONITORS, INTERFACES, AVAILABLE. CALL IN AT OUR SHOP FOR DEMONSTRATION OR WRITE IN FOR OUR DESCRIPTIVE LEAFLET.

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

BROTHER HR-15 DAISEY-WHEEL PRINTER/

An exceptionally high quality Daisy Wheel printer at the price of a Dot matrix printer. 18CPS; Bi-directional, has 3K of Buffer; has clear buffer facility, Carriage skip movement, Proportional spacing; underlining; Bold print and Shadow print. Prints in two colours; Super and subscript facility. Impact control facility to vary pressure on paper for making carbon copies. Has Centronics parallel or RS-232 interface. Connects directly to BBC Micro. A ribbon cassette plus a separate red ribbon. Optional extras: Single Sheet Feeder takes up to 150 A4 sheets; & Keyboard that transforms HR15 into a sophisticated electronics typewriter. Attractively finished in Beige. Special Introductory Offer:

Only £375 (Carr. £7)

NEW LAUNCH
Z80A 2nd PROCESSOR BOARD for BBC
With CP/M and Double Density Disc Interface for BBC MICRO

Yes it's here. Z80A 4 MHz 2nd processor Board with 64K memory, 4K Monitor EPROM, Parallel printer interface, CP/M handling, double density board will handle, 3½", 5¼" & 8" Floppy Disk Drives and many more facilities. All neatly housed in a twin slimline disc drive case.

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C15W	510	Spare bits	85
G517W	510	Elements	230
G18W	525	Iron stand	175
XS25W	530	Heat Shunt	30

CRYSTALS

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

BBC MICROCOMPUTER

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

DISC DRIVES FOR BBC MICRO

- **CS100 – TEAC** Cased with own Power Supply, S/S, 40 track, 5¼", 100K **£135**
- **CD200 – TEAC** Twin Cased with own PSU, S/S, 40 track, 5¼", 200K **£350**
- **CS200 – TEAC** Single Cased with own PSU, S/S, 80 track, 5¼", 200K **£250**
- **CD400 – TEAC** Twin Cased with own PSU, S/S, 80 track, 5¼", 400K **£475**
- **SINGLE MITSUBISHI** Slim line – Cased with own PSU, DS/DD, 1 Megabytes (400K with BBC) **£275**
- **TWIN MITSUBISHI** Slim line – Cased with own PSU, DS/DD, 2 Megabytes (800K with BBC) **£535**
- Single Drive Cable for BBC Micro **£8**
- Twin Drive Cable for BBC Micro **£12**

(5 year warranty)

- 10 Verbatim or 3M Diskettes, S/S **£18**
- 10 Verbatim or 3M Diskettes, D/S **£28**

(2 year warranty on WABASH Diskettes)

- 10 WABASH Diskettes, 5¼", S/S **£15**
- 10 WABASH Diskettes, 5¼", D/S **£25**

Many more types available.

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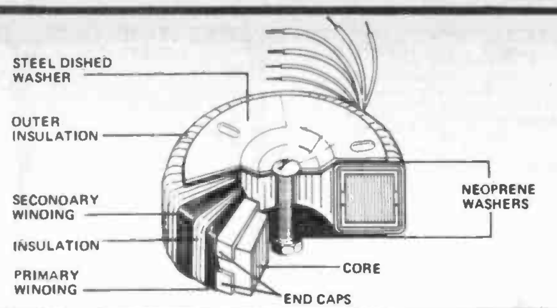
Our large standard range is complemented by our SPECIAL DESIGN section which can offer a prototype service within 7 DAYS together with a short lead time on quantity orders which can be programmed to your requirements with no price penalty.



15 VA
62 x 34mm 0.35Kg
Regulation 19%

SERIES No	SECONDARY Volts	RMS Current
0x010	6+6	1 25
0x011	9+9	0 83
0x012	12+12	0 63
0x013	15+15	0 50
0x014	18+18	0 42
0x015	22+22	0 34
0x016	25+25	0 30
0x017	30+30	0 25

(encased in ABS plastic)

30 VA
70 x 30mm 0.45Kg
Regulation 18%

1x010	6+6	2 50
1x011	9+9	1.66
1x012	12+12	1.25
1x013	15+15	1 00
1x014	18+18	0 83
1x015	22+22	0.68
1x016	25+25	0 60
1x017	30+30	0 50

50 VA
80 x 35mm 0.9Kg
Regulation 13%

2x010	6+6	4 16
2x011	9+9	2.77
2x012	12+12	2.08
2x013	15+15	1.66
2x014	18+18	1.38
2x015	22+22	1.13
2x016	25+25	1.00
2x017	30+30	0.83
2x028	110	0.45
2x029	220	0 22
2x030	240	0 20

80 VA
90 x 30mm 1Kg
Regulation 12%

3x010	6+6	6 64
3x011	9+9	4 44
3x012	12+12	3.33
3x013	15+15	2.66
3x014	18+18	2 22
3x015	22+22	1 81
3x016	25+25	1 60
3x017	30+30	1 33
3x028	110	0.72
3x029	220	0 36
3x030	240	0 33

120 VA
90 x 40mm 1.2Kg
Regulation 11%

4x010	6+6	10.00
4x011	9+9	6 66
4x012	12+12	5 00
4x013	15+15	4.00
4x014	18+18	3.33
4x015	22+22	2.72
4x016	25+25	2.40
4x017	30+30	2.00
4x018	35+35	1.71
4x028	110	1.09
4x029	220	0.54
4x030	240	0.50

160 VA
110 x 40mm 1.8Kg
Regulation 8%

5x011	9+9	8.89
5x012	12+12	6.66
5x013	15+15	5.33
5x014	18+18	4.44
5x015	22+22	3 63
5x016	25+25	3.20
5x017	30+30	2.66
5x018	35+35	2.28
5x026	40+40	2.00
5x028	110	1 45
5x029	220	0.72
5x030	240	0.66

225 VA
110 x 45mm 2.2Kg
Regulation 7%

6x012	12+12	9.38
6x013	15+15	7 50
6x014	18+18	6.25
6x015	22+22	5.11
6x016	25+25	4.50
6x017	30+30	3.75
6x018	35+35	3.21
6x026	40+40	2.81
6x025	45+45	2 50
6x033	50+50	2 25
6x028	110	2 04
6x029	220	1.02
6x030	240	0 93

300 VA
110 x 50mm 2.6Kg
Regulation 6%

7x013	15+15	10.00
7x014	18+18	8.33
7x015	22+22	6 82
7x016	25+25	6 00
7x017	30+30	5.00
7x018	35+35	4 28
7x026	40+40	3 75
7x025	45+45	3 33
7x033	50+50	3 00
7x028	110	2 72
7x029	220	1.36
7x030	240	1.25

500 VA
140 x 60mm 4Kg
Regulation 4%

8x016	25+25	10.00
8x017	30+30	8.33
8x018	35+35	7 14
8x026	40+40	6 25
8x025	45+45	5.55
8x033	50+50	5.00
8x042	55+55	4.54
8x028	110	4 54
8x029	220	2.27
8x030	240	2.08

625 VA
140 x 75mm 5Kg
Regulation 4%

9x017	30+30	10 41
9x018	35+35	8.92
9x026	40+40	7.81
9x025	45+45	6 94
9x033	50+50	6 25
9x042	55+55	5.68
9x028	110	5 68
9x029	220	2.84
9x030	240	2.60

Why a Toroid?

- Smaller size & weight to meet modern 'slimline' requirements.
- Low electrically induced noise demanded by compact equipment.
- High efficiency enabling conservative rating whilst maintaining size advantages.
- Lower operating temperature.

Why ILP?

- Ex-stock delivery for small quantities.
- Gold service available. 21 days manufacture for urgent deliveries.
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- Realistic delivery for volume orders.
- No price penalty for call off orders.

Prices including P&P and VAT

VA	Size	£	VA	Size	£
15	0	7.43	160	5	12.90
30	1	8.08	225	6	16.30
50	2	10.10	300	7	18.55
80	3	10.81	500	8	25.73
120	4	11.73	625	9	31.63

For 110V primary insert "O" in place of "X" in type number.
For 220V primary (Europe) insert "1" in place of "X" in type number.
For 240V primary (UK) insert "2" in place of "X" in type number.
IMPORTANT: Regulation - All voltages quoted are FULL LOAD.
Please add regulation figure to secondary voltage to obtain off load voltage.

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GET READY FOR THE SPRING EDITION

We must apologise to our readers for missing out with our Winter edition — but we've been preparing something a little special to tempt you out of your Winter hibernation and back to the soldering iron........

Book now by sending **80p**

or watch your newsagent's shelf around the end of January 1984

Order as Stock No. **02-00009**

PRICE ON THE PAGE as usual, **3 x £1 discount vouchers** as usual, and the components you need for

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★ **COMPUTING**
★ **AUDIO**

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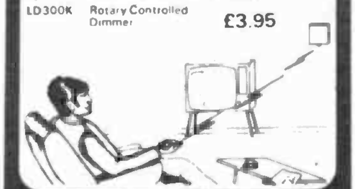
HOME LIGHTING KITS

These kits contain all necessary components and full instructions & are designed to replace a standard wall switch and control up to 300w. of lighting.

TDR300K	Remote Control Dimmer	£14.95
MK6	Transmitter for above	£4.50
TD300K	Touchdimmer	£7.75
TS300K	Touchswitch	£7.75
TDE/K	Extension kit for 2-way switching for TD300K	£2.50
LD300K	Rotary Controlled Dimmer	£3.95



DVM/ULTRA SENSITIVE THERMOMETER KIT

This new design is based on the ICL 7126 (a lower power version of the ICL 7106 chip) and a 3½ digit liquid crystal display. This kit will form the basis of a digital multimeter (only a few additional resistors and switches are required – details supplied), or a sensitive digital thermometer (– 50°C to + 150°C) reading to 0.1°C. The basic kit has a sensitivity of 200mV for a full-scale reading, automatic polarity indication and an ultra low power requirement – giving a 2 year typical battery life from a standard 9V PP3 when used 8 hours a day, 7 days a week. **Price £15.50**

XK113 MW RADIO KIT

Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5.5 × 2.7 × 2cms. Requires PP3 9V battery. IDEAL FOR BEGINNERS. £5.50

MINI KITS

MK1 ELECTRONIC THERMOSTAT
Uses LM3911 IC to sense temperature (80°C max) and triac to switch heater (1KW). Mains powered. £4.60

MK2 SOLID STATE RELAY
Switches 240V ac motors, lights, heaters from logic/computer circuits. Zero voltage switching, opto isolated. Supplied without triac £2.60

MK4 PROPORTIONAL TEMPERATURE CONTROLLER
Uses "burst fire" technique to maintain temperature to within 0.5°C. Ideal for photography, incubators, wine making, etc. Max. load 3KW (240V ac). Temp. range up to 90°C. £6.50

MK5 MAINS TIMER
Mains powered timer enabling a load up to 1KW at 240V ac to be switched on (or off) for a variable time from 20 mins. to 35 hrs. Longer or shorter periods possible with minor component changes. £4.50

MK15 DUAL LATCHED SOLID STATE RELAY
Comprises two MK2s with latch circuit enabling the MK12 kit to control two mains loads independently. Two output triacs not supplied. (See remote control kits.) £4.50

NEW! MK19 DC CONTROLLED AUDIO AMPLIFIER
May be used with virtually any stereo audio amplifier to control bass, volume, treble and balance remotely either using a wire link or the MK11 infra red receiver. A 1 of 10 decoder with LEDS is also included for remote input selection/display. (See remote control kits.) £10.70

MICROPROCESSOR CONTROLLED MULTI-PURPOSE TIMER

Now you can run your central heating, lighting, hi-fi system and lots more with just one programmable timer. At your selection it is designed to control four mains outputs independently, switching on and off at pre-set times over a 7 day cycle, e.g. to control your central heating (including different switching times for weekends), just connect it to your system programme and set it and forget it – the clock will do the rest.

- * 7mm LED 12 hour display
- * Day of week, am/pm and output status indicators
- * 4 open collector outputs for driving relays, triacs, etc.
- * 50/60Hz mains operation
- * Battery backup saves stored programmes and continues time-keeping during power failures. (Battery not supplied).
- * Display blanking during power failure to conserve battery power
- * 18 programme time sets
- * Powerful 'Everyday' function enabling output to switch every day but use only one time set
- * Useful 'sleep' function – turns on output for one hour
- * Direct switch control enabling output to be turned on immediately or after a specified time interval
- * 20 function keypad for programme entry

NOW ONLY £39.00

- * Programme verification at the touch of a button
- * Plastic box with attractive screen printed front panel 15 × 10 × 5.5cm

(Kit includes all components, PCB, box, assembly and programming instructions)
Order as CT6000

XK114 OPTIONAL RELAY KIT
Kit includes one relay, PCB to accommodate up to 4 relays, terminal blocks, etc., to fit inside CT6000 box. Provides up to 4 3amp 240V AC changeover contacts £3.90

Additional relays £1.65 each

DISCO LIGHTING KITS

DL 1000K
This value for money kit features a bi-directional sequence, speed of sequence and frequency of direction change being variable by means of potentiometers and incorporates a master dimming control. £15.95

DLZ 1000K
A lower cost version of the above, featuring unidirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum. £8.95

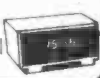
Optional opto input DLA1
Allowing audio ("beat") – light response 60p

DL3000K
This 3 channel sound to light kit features zero voltage switching, automatic level control and built-in mic. No connections to speaker or amp required. No knobs to adjust – simply connect to mains supply and lamps (1Kw channel) Only £12.95

24 HOUR CLOCK/ APPLIANCE TIMER KIT

Switches any appliance up to 1kW on and off at preset times once per day. Kit contains: AY-5-1230 IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triacs, PCBs and full instructions.

CT1000K Basic Kit	£14.90
CT1000K with white box (56 131 × 71mm)	£17.40
(Ready Built)	£22.50



3-NOTE DOOR CHIME

Based on the SAB0600 IC the kit is supplied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 × 71 × 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete. AN IDEAL PROJECT FOR BEGINNERS. Order as XK 102. £5.50

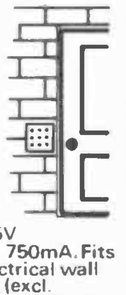
COMPONENT PACKS

PACK 1	650 Resistors 47 ohm to 10 Mohm – 10 per value £4.00
PACK 2	40 × 16V Electrolytic Capacitors 10μF to 1000μF – 5 per value £3.25
PACK 3	60 Polyester Capacitors 0.01 to 1μF 250V 5 per value £5.55
PACK 4	45 Sub miniature Presets 100 ohm to 1 Mohm – 5 per value £2.90
PACK 5	30 Low Profile IC Sockets 8, 14 and 16 pin – 10 of each £2.40
PACK 6	25 Red LEDs (5mm dia.) £1.50

LCD 3½ DIGIT MULTIMETER

16 ranges including DC voltage (200 mv-1000 v) and AC voltage, DC current (200 mA-10A) and resistance (0-2 M) + NPN & PNP transistor gain and diode check. Input impedance 10M. Size 155 × 31mm. Requires PP3 9v battery. Test leads included. **ONLY £29.00**

ELECTRONIC LOCK KIT



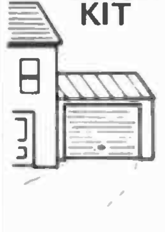
With hundreds of uses in doors, garages, car anti-theft devices, electronic equipment etc. Only the correct easily changed four digit code will open it! Requires a 5 to 15V dc supply. Output 750mA. Fits into standard electrical wall box. Complete kit (excl. front panel) XK101 £11.50

Electronic lock mechanism for use with the above kit. 70 150 £14.95

WE ALSO STOCK A WIDE RANGE OF ELECTRONIC COMPONENTS

SEE CATALOGUE FOR DETAILS

INFRA RED GARAGE CONTROLLER KIT

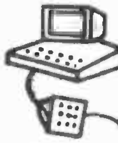


For opening and closing motorised garage doors plus switching garage and drive lights on and off up to a range of 40ft and numerous other applications like controlling lights and TV's etc. in the home. Ideal for aged or disabled persons, this coded kit comprises of a mains powered infra red remote control receiver with a normally open relay output plus two latched transistor outputs; battery-powered four button transmitter and an opto isolated solid state mains switch. As with all our kits, full instructions are supplied.

XK103 £25

Extra transmitters
XK105 £10.00

HOME CONTROL CENTRE



This kit enables you to control up to 16 different appliances by means of coded pulses in the mains wiring which may be decoded by special receivers anywhere in the house. The transmitter may be controlled manually or by the computer interface enabling your favourite micro to make your coffee in the morning, switch lights anywhere in the house, or your electric blanket in your bedroom. Just think of the possibilities – and no wiring!

The Kit comprises a transmitter with predrilled box and two receiver.

XK112 £42.00
ADDITIONAL RECEIVERS
XK111 £10.00

REMOTE CONTROL KITS

FOR A DETAILED BOOKLET ON REMOTE CONTROL – send 30p + 8" × 9" S.A.E

These kits have been designed to enable infra red remote control to be incorporated into virtually any application from switching car locks or alarms to controlling Hi-Fi or TV. The exact application will determine the interface circuitry (not supplied) between the receiver and the device to be controlled. In many cases this could by a relay or triac. General instructions and applications are supplied with the kits. The kits are coded and provide a high degree of noise immunity and security.

MK18 Transmitter Kit. For use with MK11/MK12 Receivers and MK 9 10 13 keyboards. Requires PP3 battery. Size 8 × 2 × 13 cms. Range approximately 60ft £6.80

MK11 Receiver Kit. Mains powered. Provides 10 latched plus 3 analogue outputs. Ideal for controlling audio amplifiers, TV or lighting circuits where control of lamp brightness is required £13.50

MK13 Transmitter Keyboard £4.35

MK19 DC Controlled Stereo Amplifier Kit. If control of stereo amplifier is required the MK19 may be used providing for remote control of base, treble and volume (or balance). This kit also includes a one of 10 decoder with LEDs for remote selection of programme or channel. May be connected between the pre amp and power amp sections of almost any audio amplifier £10.70

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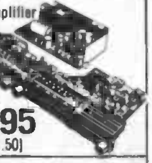

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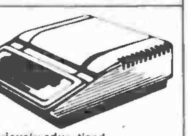

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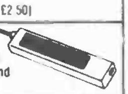

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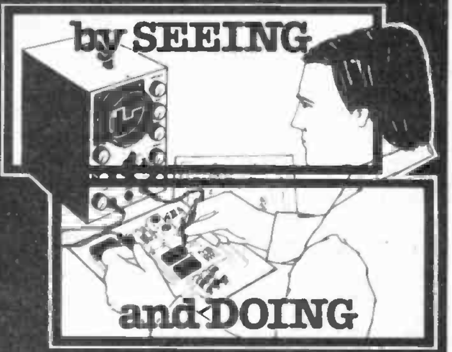

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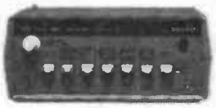

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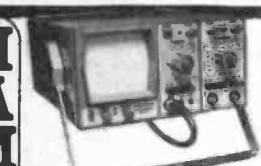
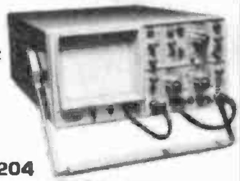
JF 77 £95 DC accuracy 0.3% Touch hold function Multi purpose holster

HAMEG



◄ Hameg HM 103 10MHz Oscilloscope £158 Single trace, suitable for field service or home constructor. Two year warranty applies to this and all Hameg instruments.

Hameg HM ► 203-4 20MHz Oscilloscope £264 Dual trace for general purpose applications in industry and education. X-Y operation, TV triggering, add/invert and component tester.



◄ Hameg HM 204 20MHz Oscilloscope £365 High performance instrument with sweep delay. Versatile triggering to 50MHz, variable hold off control, Z modulation and internal illuminated graticule.

ICE

I.C.E. Microtest 80 Multimeter £19 Compact meter in robust case. 40 ranges of measurement with high sensitivity and accuracy. Large range of inexpensive accessories.

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Z902 Probably the most popular electronic game on the market – based on the old fashioned pencil and paper battleship game, this computerized version has brought it bang up to date! We supply a ready built PCB containing **76477** sound effect chip, TMS1000 micro-processor chip, R's, C's etc. Offered for its component value only (board may be cracked or chipped, **it's** only **£1.95**. Instructions and circuit, **30p**.

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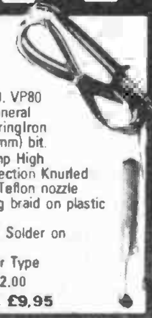

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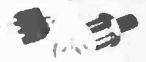

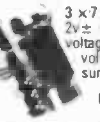

DIGITAL VOLT METER MODULE

3 × 7 segment displays Basic Circuit 0-2v ± instructions provided to extend voltage & current ranges Operating voltage 9/12v. Typ. Power Consumption 50mA

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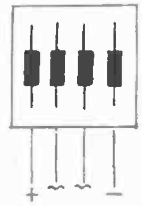
FB4	2	14 × 4"	110	£2.00

SILICON BRIDGE RECTIFIERS



Comprising 4 × 1½ Amp rectifers mounted on PCB.
VRM – 150 vlts
IFM – 1.5 Amps

Size: 1 inch square
10 off £1.00
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100 off £7.50

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A selection of large and small sized LED's in various shapes, sizes & colours, together with 7 Segment Displays both anode & cathode plus photo transistors emitters and detectors. Cadmium Cell ORP12 and Germ. photo transistor OCP71 included. In all a total of 25 Opto pieces valued over £12 Normal Price

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OPTO 7–Segment Displays

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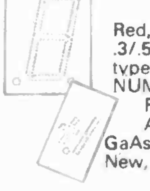

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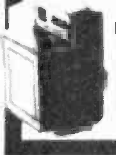

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Power supply fits directly into 13 amp socket Fused for safety. Polarity reversing socket. Voltage switch. Lead with multi plug Input – 240V AC 50HZ. Output – 3, 4, 5, 6, 7.5, 9 & 12V DC Rating – 300 ma MW88.

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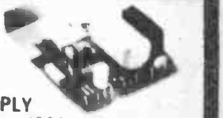

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12v DC

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Install your own system and save using built and tested modules

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Requires no installation. Easily assembled using our professionally built and tested modules.

- ● Adjustable range up to 25ft.
- ● Built-in entrance & exit delay
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- ● Uses US 5063, PSL 1865, Key Switch 3901, 3" Speaker 3515

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Now you can assemble a really effective intruder alarm at this low price using tried and tested Riscomp modules. Supplied with full instructions, the kit contains everything necessary to provide an effective warning system for your house or flat. With a built-in LED indicator and test position the unit is easily set-up requiring no installation. It may simply be placed on a cupboard or desk. Movement within its range will then cause the built-in siren to produce a penetrating 90dbs of sound, or even 110db's with an additional speaker. All parts included and supplied with full instructions for ease of assembly.
Size 200 × 180 × 70mm Order as CK 5063

DIGITAL ULTRASONIC DETECTOR
US 5063

only £13.95 + V.A.T.

NEW

- ● 3 levels of discrimination against false alarms
- ● Crystal control for greater stability
- ● Adjustable range up to 25ft.
- ● Built-in delays
- ● 12V operation

This advanced new module uses digital signal processing to provide the highest level of sensitivity whilst discriminating against potential false alarm conditions. The module has a built-in exit delay and timed alarm period, together with a selectable entrance delay, plus many more outstanding features.

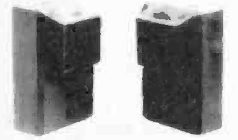
ULTRASONIC MODULE
US 4012

£10.95 +V.A.T.

- ● Adjustable range from 5-25ft.

This popular low cost ultrasonic detector is already used in a wider range of applications from intruder detectors to automatic light switches and door opening equipment, featuring 2 LED indicators for ease of setting up.

INFRA-RED SYSTEM
IR 1470 only £25.61 +V.A.T.



Consisting of separate transmitter and receiver both of which are housed in attractive moulded cases, the system provides an invisible modulated beam over distances of up to 50ft, operating a relay when the beam is broken. Intended for use in security systems, but also ideal for photographic and measurement applications. Size 80 by 50 by 35mm.

POWER SUPPLY & RELAY UNIT
PS 4012

Provides stabilised 12V output at 85mA and contains a relay with 3 amp contacts. The unit is designed to operate with up to 2 ultrasonic units or 1 infra-red unit IR 1470. **Price £4.25 + V.A.T.**

SIREN MODULE SL 157

Produces a loud penetrating sliding tone which, when coupled to a suitable horn speaker, produces S.P.L.'s of 110dbs at 2 metres. Operating from 9-15V. **Price £2.95 + V.A.T.**

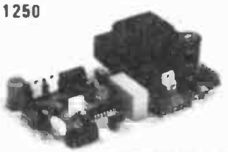
5½" HORN SPEAKER HS 588

This weather-proof horn speaker provides extremely high sound pressure levels (110dbs at 2 metres) when used with the CA 1250, PS 1865 or SL 157. **Price £4.95 + V.A.T.**

3-POS. KEY SWITCH 3901

Single pole, 3-pos. key switch intended for use with the CA 1250. **Price £3.43 + V.A.T.**

ALARM CONTROL UNIT
CA 1250



Price £19.95 + V.A.T.

The heart of any alarm system is the control unit. The CA 1250 offers every possible feature that is likely to be required when constructing a system whether a highly sophisticated installation or simply controlling a single magnetic switch on the front door.

- ● Built-in electronic siren drives 2 loud speakers
- ● Provides exit and entrance delays together with fixed alarm time
- ● Battery back-up with trickle charging facility
- ● Operates with magnetic switches, pressure pads, ultrasonic or I.R. units
- ● Anti-tamper and panic facility
- ● Stabilised output voltage
- ● 2 operating modes - full alarm/anti-tamper and panic facility
- ● Screw connections for ease of installation
- ● Separate relay contacts for external loads
- ● Test loop facility

SIREN & POWER SUPPLY MOOULE
PSL 1865

only
£9.95
+ V.A.T.

NEW

A complete siren and power supply module which is capable of providing sound levels of 110dbs at 2 metres when used with a horn speaker. In addition, the unit provides a stabilised 12V output up to 100mA. A switching relay is also included so that the unit may be used in conjunction with the US 5063 to form a complete alarm.

HAROWARE KIT
HW 1250

only
£9.50
+ V.A.T.

NEW

This attractive case is designed to house the control unit CA 1250, together with the appropriate LED Indicators and key switch. Supplied with the necessary mounting pillars and punched front panel, the unit is given a professional appearance by an adhesive silk screened label. Size 200 by 180 by 70mm

ULTRASONIC MODULE ENCLOSURE

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NEW

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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.
This TV SOUND TUNER offers full UHF coverage with 5 pre-selected tuning controls. It can also be used in conjunction with your video recorder. Dimensions: 10½"x 7½"x 2½".

PRACTICAL ELECTRONICS STEREO CASSETTE RECORDER KIT

COMPLETE WITH CASE

ONLY £31.00 plus £2.75 p&p.

• NOISE REDUCTION SYSTEM. • AUTO STOP. • TAPE COUNTER. • SWITCHABLE E.Q. • INDEPENDENT LEVEL CONTROLS. • TWIN V.U. METER. • WOW & FLUTTER 0.1%. • RECORD/PLAYBACK I.C. WITH ELECTRONIC SWITCHING. • FULLY VARIABLE RECORDING BIAS FOR ACCURATE MATCHING OF ALL TYPES.

Kit includes tape transport mechanism, ready punched and back printed quality circuit board and all electronic parts, i.e. semiconductors, resistors, capacitors, hardware, top cover, printed scale and mains transformer.
You only supply solder & hook-up wire. Featured in April P.E. reprint 50p. Free with kit.

STEREO TUNER KIT

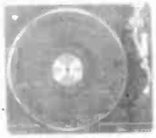
SPECIAL OFFER! £13.95 +£2.50 p&p.

This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with P.E. (July '81). For ease of construction and alignment it incorporates three Mullard modules and an I.C. IF System.
FEATURES: VHF, MW, LW Bands, interstation muting and AFC on VHF. Tuning meter. Two back printed PCB's. Ready made chassis and scale. Aerial: AM-ferrite rod, FM-75 or 300 ohms. Stabilised power supply with 'C' core mains transformer. All components supplied are to P.E. strict specification. Front scale size 10½"x 2½" approx. Complete with diagram and instructions.

BSR RECORD DECKS

3 speed, manual, auto, setdown; with auto return.
Fitted with viscous damped cue, tubular aluminium counter-weighted arm, fitted with stereo ceramic head. Ideally suited for home or disco use:

£17.50 +£1.75 p&p.

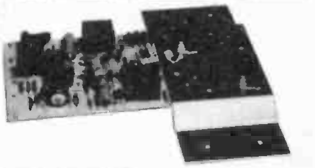


Auto Changer model — takes up to six records with manual override. Also supplied with stereo ceramic cartridge.

£12.95 +£1.75 p&p.

PLINTH to suit BSR Record Player Deck (with cover). Size 16½"x 14¾"x 2¾". Cover size: £14½"x 13½"x 3½". Due to fragile nature, Buyer collect only. Price: £8.95.

125W HIGH POWER AMP MODULES



The power amp kit is a module for high power applications - disco units, guitar amplifiers, public address systems and even high power domestic systems. The unit is protected against short circuiting of the load and is safe in an open circuit condition. A large safety margin exists by use of generously rated components, result, a high powered rugged unit. The PC board is back printed, etched and ready to drill for ease of construction and the aluminium chassis is preformed and ready to use. Supplied with all parts, circuit diagrams and instructions.

SPECIFICATIONS:
Max. output power (RMS): 125 W. Operating voltage (DC): 50 - 80 max. Loads: 4 - 16 ohm. Frequency response measured @ 100 watts: 25Hz - 20KHz. Sensitivity for 100w: 400mV @ 47K. Typical T.H.D. @ 50 watts, 4 ohms: 0.1%. Dimensions: 205x90 and 190x36mm.

ACCESSORIES: Stereo/mono mains power supply kit with transformer: £10.50 plus £2.00 p&p.

KIT £10.50 +£1.15 p&p.

BUILT £14.25 +£1.15 p&p.

HI-FI SPEAKER BARGAINS

AUDAX 8" SPEAKER £5.95 + £2.20 p&p.
High quality 40 watts RMS bass/mid. Ideal for either HIFI or Disco use this speaker features an aluminium voice coil and a heavy 70mm dia. magnet. Freq. Res.: 20Hz to 7kHz. Imp.: 8 ohms.

AUDAX 40W FERRO-FLUID HI-FI TWEETER Freq. res.: 5KHz - 22KHz. Imp.: 8 ohms. 60mm sq. £5.50 + 60p p&p.

GOODMANS TWEETERS 8 ohm soft dome radiator tweeter (3¾"sq) for use in systems up to 40W.
£3.95 ea + £1 p&p. £6.95 pr + £1.50.

MONO MIXER AMP

Ideal for halls and clubs.

£45.00
+ £2 p&p.

50 Watt, six individually mixed inputs for 2 pickups (Cer. or mag), 2 moving coil microphones and 2 auxiliary for tape tuner, organs etc. Eight slider controls — 6 for level and 2 for master bass and treble, 4 extra treble controls for mic. and aux. Inputs. Size: 13¼"x 6½"x 3¾" app. Power output 50 W RMS (cont.) for use with 4 to 8 ohm speakers. Attractive black vinyl case with matching fascia and knobs. Ready to use.

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RTVC

PE VOLUME 20 No. 3 MARCH 1984

BRITAIN'S FUTURE

DOES Britain have an independent future in high technology? Has £50m of public money assured the UK of its own chip maker? Will the Transputer put the UK ahead of the world in electronics?

There are no single word answers to these questions but the answers could be vital to the future UK economy. Just recently the name of Inmos has been hitting the headlines again for a number of reasons not the least being their need to find more finance and the resulting talks with GEC and other companies—names like Philips, SGS, Fujitsu and Western Electric have also been reported. Inmos was the subject of much press comment back in '79 and '80 when the 'new' Government hesitated about providing its second £25m.

In the October 1980 issue of PE Nexus wrote the following words "As I write there is still no decision on Inmos an ominous sign reflecting lack of enthusiasm for, if not imminent abandonment of, Government (i.e. taxpayers) support". Within a week or two of that being written the Government (i.e. taxpayers) did cough up and Inmos was away, albeit after losing a valuable six months waiting for a decision. Over the last three years Inmos has quietly built a reputation in the industry for technical excellence and has proved its ability to process high volume chips at Newport; surely it would be madness to let it slip into foreign ownership now.

Sir Clive Sinclair recently predicted that a "wall of secrecy" will soon be built around high tech. research and he went on to add "Either we get ourselves back into the hardware business or we're out of the game".

Sir Clive suggested that hardware and software would be so closely related that to ensure our ability to stay in the field, and not be reliant on foreign manufacturers, we must develop both. He stressed the "very serious implications" if Inmos was allowed to be bought by a non-UK company.

With this background PE has commissioned Tom Ivall to look at Inmos and its first five years. The article does not provide straightforward answers to the above questions but it gives clear indications of where the UK chip maker is now, how it got there and where it might go in the near future.

TRANSPUTER

The future of Inmos is closely tied up with the Transputer so in order to round off the scene we also commissioned Ray Coles (who writes Micro-File) to take an in depth look at this exciting device. The Transputer article will be published next month in place of Micro-File.

These two articles should interest anyone involved in electronics at any level, because of the implications outlined above, make sure you read them.

Incidentally Sir Clive is not slow in developing new products—see *News and Market Place* for details of his new computer.

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SINCLAIR'S QUANTUM LEAP

You are probably going to see the computer shown here a great deal over the next few years. It's Sinclair's new QL (Quantum Leap, would you believe) the name is perhaps OTT but then so is the computer. Based on the Motorola 68 008 32 bit chip the QL has 128K of usable RAM (up to 32K can be required from a screen bit map) extendable up to 640K, and 32K of ROM extendable up to 64K containing a new "Sinclair Super BASIC" and Sinclair QDOS operating system.

The unit has a full size "proper" keyboard, two 100K microdrives built-in and sockets for microdrive extension (up to six extra drives), local area network, RGB monitor port, u.h.f. tv port, two standard RS-232-C sockets, two joysticks sockets, ROM cartridges slot and expansion slot for extra memory or peripherals.

Planned enhancements under development are: PASCAL compiler, 68000 assembler, terminal emulator, 0·5mb memory expansion, A to D converter, Winchester interface, modem, parallel printer interface and IEEE-488 interface.

Super BASIC is said to be a radical enhancement of Spectrum BASIC, and QDOS is a new Sinclair development which allows single-user multiple tasking, time sliced priority job scheduler, display handling for multiple screen windows and device-independent I/O.

The QL comes complete with an extensive manual in an A4 ring binder, a 1·8A power supply, a suite of four software programs on microdrive cartridges and four blank cartridges. The software supplied has been developed by Psion and is claimed to "completely out perform existing software for micros" it comprises QL Abacus for spreadsheet analysis, Archive or database management, Easel for graphics and Quill for word processing. All are said to be immediately usable and very advanced, so much so that it is claimed "you probably won't refer to the manual"!

All this is provided for £399 including VAT; by mail order only at present. Other things that may be of interest are: The 68008 runs at 7·5MHz and a second processor (Intel 8049) controls keyboard, sound, RS-232-C receive and real time clock functions.

RT-VC CHANGE

One of PE's oldest advertisers have just reopened their original Acton premises as an Electronics Discount Centre. RT-VC have used the premises as a mail order operation for many years with shop sales from their Edgware Road address.

The Edgware Road shop remains unaltered while 21 High Street, Acton, is now open for trading and carries a wide range of consumer electronics including telephones, watches, calculators, speakers and record decks plus the well known RT-VC kits and modules. The latter include the PE Stereo Cassette Recorder and a VHF Stereo Tuner that were published in PE in conjunction with RT-VC.

RT-VC have always been known for their low price products and these are now readily available in Acton High St. They are of course continuing their mail order operation from the same address.

FOOD FOR THOUGHT

It is unlikely that Ocean Software have bitten off more than they can chew with 'Mr Wimpey', a new game for the 48K Spectrum, indeed it looks like a recipe for success.

The game involves a culinary concoction of ingredient pinching nasties who constantly hamper the player's attempts to assemble hamburgers. The program also incorporates the company logo and jingle.

Even if this first UK company commissioned program does not go down well the business principle behind it certainly will. In the USA company sponsored programs are already big business, the advantages are obvious if the games climb high in the popularity charts. This will certainly be the first of many such attempts by companies to cash in on the infinite commercial possibilities within the home computer market. Interesting variations spring to mind, who knows what Andrex could come up with.

'Mr Wimpey' is written in 100% machine code and has hi-res graphics and sound. It can be snapped up from leading stores for around £5·90 and will shortly be available for the Commodore 64K.

MULTI-FUNCTION KEYBOARD

The Concept keyboard is a new approach to educational computing, allowing easier pupil-computer integration.

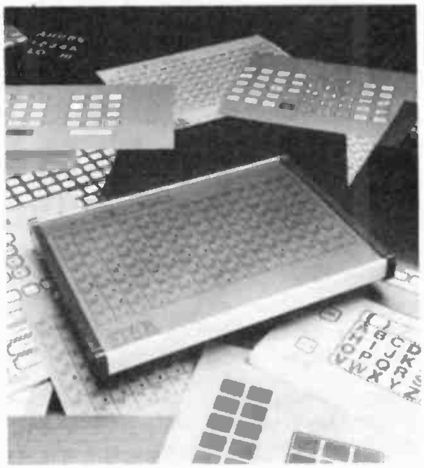
The Concept keyboard takes interchangeable A4-size overlays which define the number, shape, size, colour, position and legending of the keys. Each program can use a separate overlay, with keys appropriate to the application. The ability to respond directly to programmed questions, via keys labelled 'Yes', 'No', 'True', 'False' for example, greatly improves pupils' interaction with the computer.

The keys can be made large enough to allow operation by visually or physically handicapped pupils.

The flat pressure-sensitive keyboard also gives great flexibility in designing teaching programs. A program to teach shopping skills, for example, could use a model trolley and an overlay showing the floor-plan of a supermarket with the various aisles and counters.

The Concept keyboard can be used with any microcomputer. It is of value in any educational application and special education where the normal QWERTY keyboard presents operating difficulties.

The keyboard has an 8×16 matrix of touch-sensitive areas, each producing a unique 7-bit ASCII code which the programmer defines as required. A bleeper with on/off control, and two additional user-dedicated touch pads, are also provided.



The price of the Concept keyboard (£91·00 ex VAT) includes full documentation and, for educational applications, a connecting lead for the majority of micros and a set of demonstration software.

Star Microterminals Limitd, 22 Hyde Street, Winchester, Hampshire, SO23 7DR. (0962) 51422.

MARKET PLACE

PICO-POWER

Probably the smallest power supply of its type available is the Picopac range from Rastra Electronics; these 1W mains packages would certainly fit into the proverbial matchbox.

The supplies feature small physical size (43·2 × 25·4 × 21·5mm) coupled with high reliability. Modules are available with inputs at 115/220V a.c. 50/60/400Hz and with single or dual outputs. Single outputs range from 5V to 24V d.c. the dual output type being ±15V d.c. Since the units feature series regulation, the residual ripple is well under 1mV.

Despite the tiny size of these units the manufacturers claim an impressive 2kV a.c. isolation for 1 minute between primary and secondary. The Picopac is encapsulated and is intended for p.c.b. mounting. Prices however are not quite so small at £26 for the single and £42 for the dual output version, exc VAT. Details from Rastra Electronics Ltd, 275-281 King Street, Hammersmith, London W6 9NF (01-748 3143/2960).

Silicon News Corner

Zilog (Exxon) ◆ introduces 12MHz version of entire Z8 micro family. Zilog (UK) Ltd., Zilog House, Moorbridge Rd., Maidenhead, Berks SL6 8PL.

Omron ◆ Flat mini-sized relay uses "see-saw" system which is free from contact bounce and highly shock resistant. IMO Precision Controls, 1000 North Circular Rd., Staples Corner, London NW2.

◆ IMS1400M high performance 16K static RAM. 70ns CE access, 165mW standby power (660mW active). Single supply (5V). I/O is TTL compatible. Inmos, Whitefriars, Lewins Meads, Bristol BS1 2NP.

◆ CTS101AGB is a high performance, general purpose op. amp. High gain, s/c protected, excellent temp. stability and simplified compensation.

◆ CTS0002GB buffer amp., high speed, high impedance follower.

◆ CTS00081B hybrid, high voltage, high current driver, TTL/DTL to 3A (pulsed) drive.

Inmos ◆ IMS2600 high performance 64K ×1 dynamic RAM. 100ns access, 22mW standby power (303W active). Single supply (5V) with on-chip refresh. I/O is TTL compatible. Bit & nibble mode capability.

Briefly...

An electronic potato has been developed by the Scottish Institute of Agricultural Engineering in an attempt to reduce damage during mechanical processing.

The potato—a direct descendant of a similarly pseudo raspberry from the same stable uses an Entran accelerometer to gather information about the forces acting upon it during its automated journey. A v.h.f. transmitter sends out data from the foam potato to remote recording equipment.

It is hoped that the present day loss of over 10 per cent of the nation's maincrop will be reduced using data gleaned from this unlikely 'spudnik'.

Got any bright ideas? Unemployed? Live in London? The GLC are spending £40 million on a scheme to make University and Polytechnic equipment and know-how available to the public. Ideas can be brought to the prototype stage using the scheme which already has a list of new ideas including medical systems and a robot arm. It is hoped that jobs may ultimately be created to fill up some of the 33 million square feet of idle factory space in the capital.

● ● ● ●

Sixty of the world's top CMOS experts agree that Ultra Large Scale Integration will, within five years, allow chips with one billion transistors on them, to go into production. How this will be achieved is shrouded in some mystery, but Alan Aitken, of Mitel, has stated that ULSI is already possible, the only thing holding up production he said is the investment required to adapt existing equipment.

Countdown . . .

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to Mike Abbott.

Barclays Techmart Feb. 21–25. NEC, B/ham. J4
Electrex Feb. 27–March 2. NEC, B/ham. L3
Hybrid Microtech Feb. 28. Cunard Int. Hotel, London. R2
Scotest March 6–8. Anderson Exhibition Cntr., Glasgow. T
Scottish Sensors March 6–8. Anderson Ex. Cntr., Glasgow. T
Home Appliances International March 12–15. NEC, B/ham. M
Computer Trade Show March 13–15. Wemb. Conf. Cntr. Z1
Business Telecom March 13–15. Barbican Cntr., London. O
Visit to Firefly Electric Vehicles (Milton Keynes). March 17. R1
Electro-Optics/Laser Int. March 20–22. Metropole, Brighton. T1
Information Technology (Conf. & Ex.) March 20–22. London. ☎ 01-828 2333
Scottish Computer Show March '84. Holiday Inn, Glasgow. T1
Fibre Optics May 1–3. Porter Tun Room, Whitbread Brewery. E
All Electronics /ECIF May 1–3. Barbican, London. E
Biotech Europe May 15–17. Wembley Conf. Cntr., London. O
Micro City May 15–17. Exhibition Complex, Bristol. F3
Scotelex June 5–7. Royal Highland Exhibition Halls, Ingliston, Edinburgh. O5
IBM System User Show June 12–14. Wembley Conf. Cntr., London. O
Qualex June 19–21. Corn Exchange, Brighton. D4
Surface Treatment & Finishing Show June 25–29. Birmingham. M
Networks July 3–5. Wembley Conf. Cntr., London. O
Cable July 10–12. Wembley Conf. Cntr., London. O
Testmex Sept. 11–13. Grosvenor Ho. Pk. Lane, London. E
Building & Home Improvement Sept. 25–30. Earls Court, London. M

D4	Network ☎ 0280 815226
E	Evan Steadman ☎ 0799 26699
F3	Tomorrow's World ☎ 0272 292156
J4	NEC ☎ 021 780 4141
L3	Electrex Ltd. ☎ 0483 222888
M	Montbuild ☎ 01-486 1951
O5	Institute of Electronics ☎ 0706 43661
R1	Battery Vehicle Association. ☎ Brian Hampton, 0908 316991
R2	☎ 08956 32476
T	Trident ☎ 0822 4671
T1	Cahners ☎ 0483 38085
Z1	IPC ☎ 01-643 8040

Spectrum AUTO-SAVE

R.A.Penfold

THE popular Sinclair ZX Spectrum computer has a quite fast and efficient cassette interface, but it can be a little awkward to use. One reason for this is that problems can arise if the "Ear" and "Mic" sockets of the computer are both connected to their respective sockets on the cassette recorder, and for satisfactory results it is usually necessary to only connect the lead that is actually being used. Another problem is the lack of any automatic control of the cassette motor when loading and saving. This is not really too important when loading since the computer will continue to search until the program is found, giving the user unlimited time to load the cassette into the recorder and run it through to the beginning of the appropriate program. On the other hand, when saving a program it is very much easier if the cassette and recorder can be set up ready to record, and the computer will then automatically start the recorder, record the program, and switch the recorder off again.

SIMPLE AUTO SWITCH

The problem of having to unplug one lead and plug in the other, every time a change is made from loading to saving (or vice versa), is easily overcome by using a switch to disconnect whichever of the leads is not required. A simple way of providing an auto-save facility would be to have a switch which would activate the cassette motor when an output from the "Mic" socket of the recorder was detected. There would obviously be some slight delay between the start of an output from the computer and the recorder beginning to record properly, but the Spectrum precedes all data with a tone leader (to operate the auto recording level of the recorder), and in practice this system gives no loss of data.

This auto-save unit uses what is basically the system outlined above, as can be seen from the block diagram of the unit which is shown in Fig. 1.

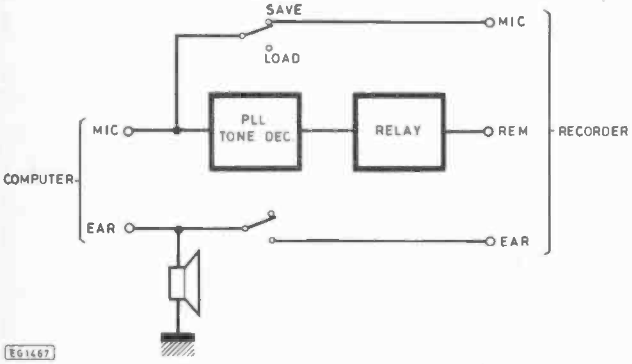


Fig. 1. Block diagram of the Auto-Save

A two pole switch is used to connect either the "Mic" lead or the "Ear" lead, depending on the mode of operation selected. A set of relay contacts control the cassette motor via the "Rem" (remote) socket of the recorder, and a third pole on the save/load switch is used to place a short circuit on the "Rem" output when the unit is in the "load" mode and the auto switching is inoperative. This also enables the recorder to be used in the fast forward and rewind modes without having to unplug the remote lead.

Although it might, on the face of it, appear that using a simple amplifier, rectifier, smoothing circuit, and relay driver would give satisfactory results and activate the relay in the presence of an output signal, in practice things are slightly less straightforward. The problem stems from the fact that signals other than the "save" signal are fed to the "Mic" socket. These come from the computer's sound generator, and apart from the signal produced by BEEP commands there is also the signal generated each time a key is operated.

The problem is largely overcome by using a phase locked loop tone decoder to drive the relay. This does not respond to the short bursts of keyboard tone even if a number of them follow in rapid succession. It will respond to any signals within its narrow lock range that are caused by BEEP

instructions, but this can be overcome by avoiding this small range of frequencies, and in practice the tape recorder would normally be switched off anyway when a program is running. It would therefore be irrelevant even if a spurious operation of the unit did occur.

It can be very helpful to monitor the output of the recorder when loading programs as it is then immediately obvious if a program is being fed into the computer but is failing to load, or if some other loading problem occurs. A loudspeaker is therefore used to monitor the signal being fed into the computer.

THE CIRCUIT

It will be apparent from the circuit diagram of Fig. 2 that the unit uses few components and has a very simple circuit.

IC1 is an NE567 PLL tone decoder, and as this requires an input signal of only about 20 millivolts r.m.s. no pre-amplification is required. However, as there is normally a very low input impedance at the microphone input of a cassette recorder, R1 is added in series with the output to the recorder to prevent loading from reducing the signal to an inadequate level. Of course, losses through R1 substantially reduce the signal level reaching the "Mic" input of the recorder, but in practice the signal level still seems to be far higher than the minimum acceptable level.

The timing components for the oscillator in the PLL are VR1, R2 and C2. The Spectrum has a nominal tone leader frequency of 800 hertz, and VR1 is adjusted for an 800 hertz centre frequency.

A switching action is used to detect whether or not the oscillator has locked on to the same frequency as that of the incoming signal. Basically, all that happens is the oscillator operates an electronic switch and the input signal is fed through this switch. If the two signals are at the same frequency the switch cuts off negative half cycles but allows positive ones to pass. This rectified signal is smoothed and used to drive an internal npn switching transistor. C4 is the smoothing capacitor and the collector of the switching transistor connects to pin 8 of the NE567. C3 is the capacitor in the lowpass filter of the PLL, incidentally.

If the input signal and the oscillator are at different frequencies the two signals will have a constantly changing phase relationship so that the electronic switch passes a mixture of positive and negative signals. This gives zero average voltage across C4 and the output transistor is not switched on.

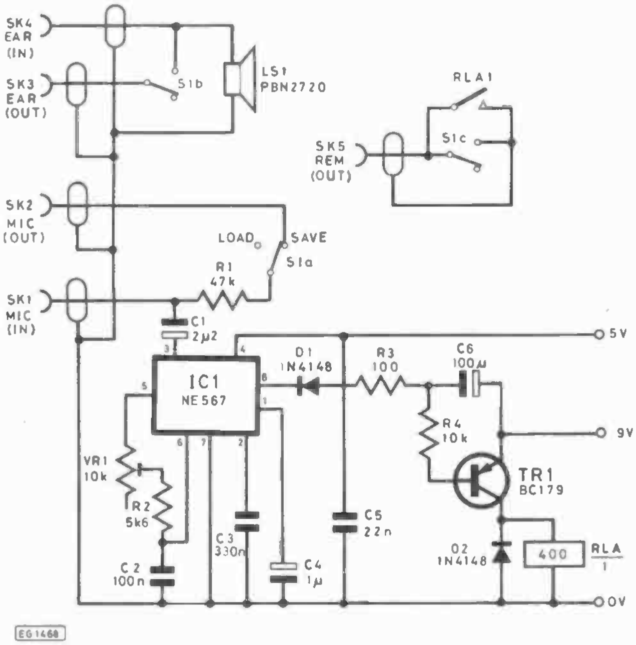


Fig. 2. Circuit diagram of the Auto-Save

The output transistor is activated continuously when the 800 hertz tone leader is present, but when data is being saved the output tone is modulated and the output transistor is pulsed on intermittently. The output of IC1 is therefore used to drive a smoothing circuit which has a fast attack and a long decay of about 4 seconds, and this drives discrete switching transistor TR1 which in turn drives the relay. This system prevents the relay from cutting out while a program is being saved and gives good reliability. A relay is better than some form of electronic switching in this application since the relay contacts are totally isolated from the rest of the circuit. With some tape recorders neither side of the REM socket is at earth potential. Also, using a relay there is no significant voltage drop through the switch.

LS1 is the loudspeaker which monitors the signal entering the computer during load operations. This is actually a ceramic resonator rather than a normal loudspeaker, and although it only provides limited volume, it is adequate in this respect. In fact, higher volume would be unnecessary and undesirable in this application.

S1 is the switch which connects the "Ear" or "Mic" lead, as appropriate, and places a short circuit across the "Rem" socket when the unit is set in the "load" mode. Power for the circuit is obtained from the 0V, 5V and 9V rails of the Spectrum edge connector.

COMPONENTS . . .

Resistors

R1	47k
R2	5k6
R3	100
R4	10k

All resistors ¼W 5% carbon film

Potentiometer

VR1	10k 0·1W horizontal preset

Capacitors

C1	2µ2 63V radial electrolytic
C2	100n polyester
C3	330n polyester
C4	1µ 63V radial electrolytic
C5	22n ceramic plate
C6	100µ 10V radial electrolytic

Semiconductors

D1, D2	1N4148 (2 off)
TR1	BC179
IC1	NE567

Miscellaneous

S1	4 way 3 pole rotary (with end stop)
LS1	PBN2720 ceramic resonator
SK1, 2, 3, 4	3·5mm jack sockets (4 off)
SK5	2·5mm jack socket
RLA	12 volt 400 coil, s.p.s.t. contacts, min PCM (Maplin)
	Printed circuit board 3·1 x 1·6in.
	Metal box 133 x 70 x 38mm
	28 way Spectrum edge connector (Watford or Technomatic)
	Control knob
	Wire, fixings, etc.

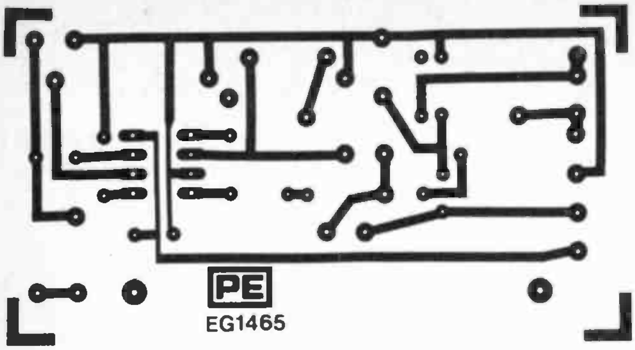


Fig. 3. P.c.b. design

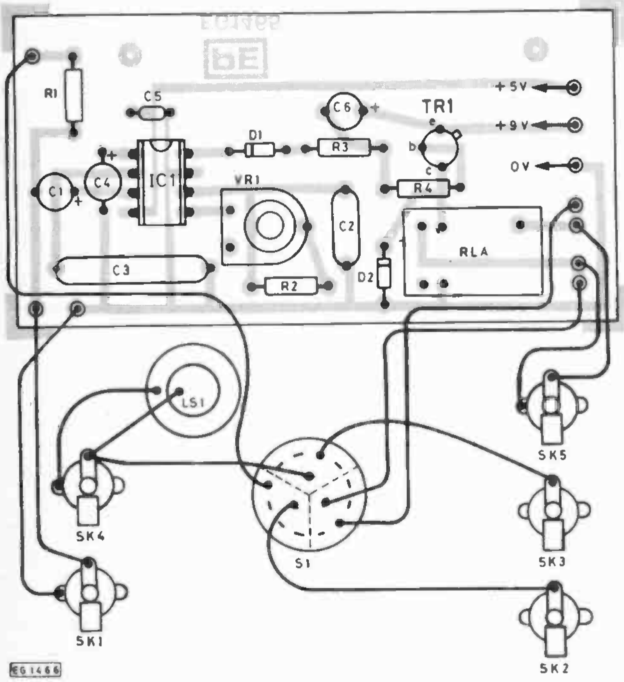


Fig. 4. Component layout and wiring diagram

CONSTRUCTION

The printed circuit board design is shown in Fig. 3, with the component layout and wiring diagram shown in Fig. 4. If a different form of construction is used, note that supply decoupling capacitor C5 should be fitted close to IC1 or instability is almost certain to occur. S1 is a 4 way 3 pole rotary type having an adjustable end-stop which is set for 2 way operation.

Provided the specified relay is used it can be mounted on the printed circuit board, but if an alternative is used it will be necessary to modify the p.c.b. or mount the relay off-board. Any relay having at least one set of make contacts (or a set of changeover contacts), a coil resistance of about 300 ohms or more, and capable of operating from a 9 volt supply can be used in the unit.

The plain side of ceramic resonator LS1 is glued to the inside of the case at any convenient place using a good quality general purpose adhesive. This component does not have any tags or ready-connected leads, and soldered connections are made direct to the inner disc and outer ring. The connection to the inner disc should be completed fairly rapidly, to avoid damaging the component due to overheating.

As mentioned earlier, the "Rem" socket of the recorder may have neither terminal at earth potential, and if a metal case is used SK5 should be an insulated socket, or it should be insulated from the case. Alternatively, a plastic case could be used, but a wire to connect the earth tags of the other four sockets would then be needed.

The connection to the Spectrum edge connector is made via a 3 way cable, and an exit hole is drilled for this in one side of the case. The edge connector is a 2 x 28 way type, and should preferably be a type having the Spectrum polarising "key". Refer to page 160 of the Spectrum manual for connection details of the edge connector.

VR1 must be given the correct setting before the finished unit will function properly, and a suitable setting is found by empirical means. ★

BAZAAR

PET 2001 8K RAM (expandable) with integral monitor and cassette deck £200 o.n.o. Tel: Lytham (0253) 737397. D. R. Worley, 14 Mythop Ave., Lytham, Lancs.

CASIO FX31 scientific cal. Book-wallet-price £6·00. Holdway, Flat 20, Studland Close, Millbrook, Southampton.

OLIVETTI PR 1350 DOT Matrix printer with reference and service manuals. £130 o.n.o. Swop twin beam — scope. D. Bevan, 17 Beaufort Rd, Kingswood, Bristol. Tel: (0272) 616936.

WANTED any service information on G.E.C. TERMINET 300 Printer. Will pay. Tel: 01-651 4885. A. G. Seagrave, 175 Sorrel Bank, Linton Glade, Forestdale, Croydon CR0 9LZ.

CCTV Camera B/W early Crofton kit model complete and working full manuals v.g.c. £70 with lens. D. Russell, 9 South Beach Road, Ardrossan, Ayrshire, KA22 8AX. Tel: (0294) 64144.

WANTED Smart 2-update Nov. 1980—assembly instructions, especially page 7—system layout—one sheet copy only. Claessens Guido, Oversneslaan 51-2610 Wilryk, Belgium. Tel: 03-828 2314.

VOCODER, best of ETIs—Elektors, sensible offers, or exchange for colour computer plus accessories (value £200). J. Logsdon, Top Flat, 13 Bowmans Road, Dartford, Kent DA1 3QP.

PE 'Orion' amp, new Sanyo speakers, McDonald 610 turntable, small tuner, v.g. stereo sound £15 o.n.o. Mr. A. L. G. Senior, 22 Robinia Walk, Whitchurch, Bristol BS14 0SH. Tel: (0272) 830213.

WANTED manual for Tektronix scope type 545B. Will buy or borrow to copy, willing to pay. T. Measor, 5 Midlothian Road, Hartlepool, Cleveland TS25 3RH.

TELEQUIPMENT D61a dual trace oscilloscope with X10 probe and manual wanted. E. M. Jackson, Coombe Farm, Gidleigh, Chagford, Newton Abbot, Devon TQ13 8HP.

CLEF Microsynth. Fully built and housed. £125 o.n.o. Tel: (0272) 516304. B. Wiltshire, 7 South Hayes, Eastville, Bristol.

BREAKING UK101 Cegmon Word Processor new basics 1, 3 & 4 assembler editor chips available. Tel: (0642) 484122. D. Doyle, 21 Skelton Drive, Marske-by-the-Sea, Redcar, Cleveland TS11 THN.

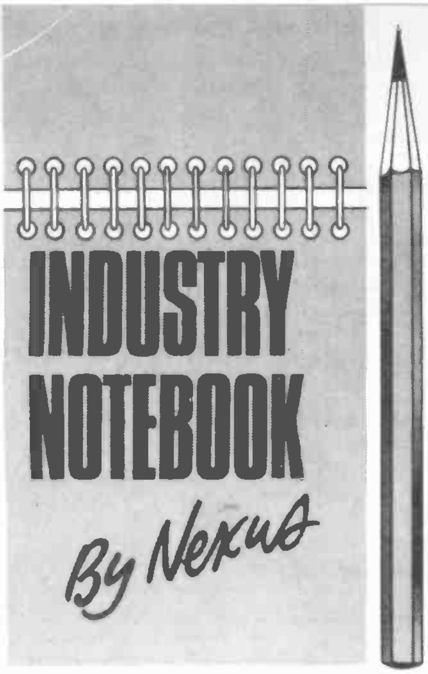
VALVES wanted, must be new and boxed. Also valve sockets and plugs, transformers, capacitors, tuners, amplifiers. N. Covington, 25 Ridge Road, Letchworth, Herts SG6 1PT. Tel: (04626) 79681.

MENTA, Z80 Microcomputer for control applications, including manual £75, five interface modules designed for Menta, s.a.e. Mr. D. H. Slater, rear of 25 New Market Street, Colne, Lancs BB8 9BJ.

WANTED circuit diagram or service manual for ferograph series Seven Model 71SH. Bob Allen, 69 Callcott Road, Kilburn, London NW6

RS232 interface module with instruction booklet for Microline 80 printer. Unused. £25. Tel: Oxford (0865) 779855.

HELP! Tandy 603043 Radio controlled Lamborghini—TX/RX Circuit and service info required. Chris Finn, 11 Alexandra Drive, Beverley, E. Yorks. Tel: (0482) 868899.



INDUSTRY NOTEBOOK

By Nexus

One World

We learn something new every day. For example that the greatest civil engineer of his time, Isambard Kingdom Brunel, was not as British as I had believed, his father having been French and the young Brunel educated in Paris. I learnt this from an IBM advertisement designed to convince us all that this huge multinational corporation, though not British in parentage, is at least as British as Brunel ever was because it practises its skills in Britain just as Brunel did in his time.

So what? The electrical and electronic sciences have always been international in character and, in fact, origin. Our own fundamental units of measurement, the Volt, Amp and Ohm are derived from the names of early Italian, French and German pioneers, the Farad from an Englishman.

The developments that led to radio are attributed to Maxwell, Hertz, Popoff and Marconi, respectively British, German, Russian and Italian. In television the inventor of the first camera tube, the iconoscope, was Zworykin who emigrated to the United States after the Russian revolution. Zworykin was building on earlier work such as the discovery of cathode rays by Crookes (British) and the invention of the cathode ray oscilloscope by Braun (German).

The scientific community has always believed in open publication of findings for the benefit of all. Not so the business community who guard their secrets, prudently patenting their products before disclosure.

But while protecting their products individually the electronics industry has always been a big sharer of ideas and even designs through cross licensing both within and across national boundaries whenever it is to mutual advantage. This sharing has accelerated in the age of solid state when it soon became apparent that second-sourcing was not giving a product away to a competitor but greatly expanding a market. Joint ventures are also common, a recent example being CMOS gate arrays designed in Britain by Smiths Industries' subsidiary Micro Circuit Engineering to be processed by ITT in establishments in the United States and Belgium.

One American company, Advanced Micro Devices, is trying to go beyond cross-licensing into co-operative R & D. AMD's president, Jerry Sanders, is clearly worried over his own company's 100 million dollar spend on R & D in a single year. He recently stated that he and other like-minded semiconductor manufacturers together with equipment manufacturers were contemplating joint formation of R & D organisations and then sharing the research results.

This idea has its parallel in government-sponsored schemes for advancing technology. Whether a private enterprise R & D co-operative would be more effective or even workable is an open question. The most likely cash benefit is in the potential for reducing duplication in R & D activities among participating companies. On the other hand it can be argued that the intense competition in private enterprise to introduce exciting new products is the prime mover of technological advance.

The proof is clearly visible in a comparison of the competitive system of the West with the non-competitive Soviet Union. There is no reason to suppose Russian engineers to be dimmer or less numerous than those in the West and yet they continue to lag behind in almost every field with the possible exceptions of space exploration and armaments.

Let's get back to IBM and Brunel! I may be wrong but I have it as a dim memory that the founder of IBM was himself British, or of British parentage. But who cares in any serious way? My colour TV bears the label of a famous British company whose parent organisation is in the Netherlands where it was most probably designed. The receiver was assembled in Singapore from components manufactured in several other countries.

IBM's long awaited personal computer will proudly bear the IBM label. But its 'works', the p.c.bs, will be made by a British company unheard of by those not in the trade. I refer to AB Electronics whose shares gained over £1 on announcement of the IBM contract which, through IBM Greenock, will serve the computer markets in Europe, the Middle East and Africa. Electronics is truly international, one world, and I'm glad it's so. But I suspect that all of us still enjoy a patriotic glow on achievements by and in our own country.

Piracy

Joint ventures, cross-licensing and other mutually advantageous deals have proved their worth over many years through legal or even gentlemen's agreements arranged in a civilised way. In October 1983 I drew attention to look-alike personal computers flooding the market from the Far East and, in particular, the possibility of pirated software becoming an even greater menace.

My fears seem to have been fully justified with software houses claiming collective losses of tens of millions of pounds. Pirating goes right across the board from schoolboy amateurs to skilled computer crooks who can make a good living by selling pirated programs of the more expensive business types at about one tenth of the list price. Protective devices have so far proved ineffective and the copyright laws, as far as the UK is concerned, cover only literature, music and artistic content. New legislation is contemplated.

Lady Harrison

One of the least publicised activities of the Racal Group is services for oil exploration. These were inherited through Decca's earlier involvement in navigation and precise positioning systems and, since the acquisition of Decca by Racal, have been greatly expanded through the formation of Racal Energy Resources Ltd.

Last November Lady Harrison, wife of Racal chairman Sir Ernest Harrison, launched a new geophysical survey ship, the m.v. 'Lady Harrison'. The vessel was launched from the Bergen, Norway, shipyard where she was built. She entered service in January and will operate wherever required in the world and almost certainly in offshore China where Racal already operates joint venture companies with the China National Offshore Oil Corporation for positioning and survey work.

Needless to say the ship is stuffed full of electronics and her complement of 34 crew and scientists are all accommodated in single-berth air-conditioned cabins.

Cablesat

Whatever the merits of privatisation (the controversy is still very much alive) the mere prospect continues to galvanise British Telecom. On March 1st BT starts routeing, via Intelsat V, entertainment TV programmes to local cable networks.

The programmes come from United Cable Programmes, a consortium of British companies. They will be transmitted to London Telecom Tower and then on to the London Earth Station at North Woolwich where they will be transmitted to Intelsat V. The participating cable operators will each have their own small satellite dish aerials at their cable head-ends for reception and feed-in to their cable systems. The signals will travel 44,600 miles in space before arriving at their destination. It may sound a long way round but is clearly a more economical method than relaying the signals individually to cable companies whose networks are geographically widely spaced.

Another advanced project for BT is the first transatlantic fibre-optic cable. This has been talked about for a year or two but has now been firmed up as TAT-8 costing in all £225 million shared between British Telecom, AT & T Communications (US) and Submarcom (France).

A new innovation apart from the fibre-optic cable itself is the world's first underwater junction box where the main link divides with one branch to the UK landing point at Widemouth Bay, Cornwall, the other to Penmarche on the coast of Brittany.

SEMICONDUCTOR CIRCUITS

TOM GASKELL B.A.(Hons)

TACHOMETERS (LM 2917N–8 AND LM 2917N)

ALTHOUGH the measurement of frequencies and speeds often involves digital techniques, it is preferable in some cases to obtain a purely analogue representation of these parameters. Analogue displays can have advantages in resolution, readability under rapidly changing conditions, and simplicity. The LM 2917N–8 is an 8 pin 'tachometer', or frequency-to-voltage converter i.c. which is specifically designed for this type of application. The i.c. incorporates not only tachometer circuitry, but also extra general purpose facilities such as internal voltage regulation, a driver transistor for external loads, and an op-amp with an uncommitted inverting input. This allows for considerable flexibility in use, and makes the device ideal for incorporation into many frequency or speed sensing and measuring systems. The LM 2917N is also available; this is a 14 pin version, with extra connections available to parts of the internal circuitry. It does not have input protection for negative voltages, unlike the LM 2917N–8, so be careful not to confuse the two! All diagrams will refer to the '–8' version, unless otherwise stated, although '–8' circuits are generally able to use the 14 pin i.c., with the necessary *extra* connections, bearing in mind that all-important input protection.

The pinout and specifications are given in Fig. 1, with block diagrams given in Fig. 2 and Fig. 3. A current limiting resistor must be provided for the internal 7·5V Zener diode, to limit the current to a maximum of 25mA. The minimum current should be 6mA (the maximum internal quiescent current). If this Zener diode is unacceptable, the LM 2907N–8 and LM 2907N are equivalent devices without it.

METHOD OF OPERATION

The input to the i.c. is a differential amplifier with hysteresis. (Hysteresis is the effect whereby the input passes through a threshold voltage in the positive going direction, then has to drop to a somewhat lower, or more negative, voltage in the negative going direction before the output will turn off. It helps to prevent spurious oscillations at the exact point of changeover). In the '–8' device, the input is protected to ±28V, since the input must swing about 0V, inferring an a.c. coupled input in most cases. Since it is possible to bias both inputs to the 14 pin i.c., this has no such protection, hence the earlier warning. Because of the very high gain of the input amplifier, and the absence of any negative feedback, the output is a square wave, the frequency of which is identical to the input signal.

The square wave signal causes the 'charge pump' circuit to charge, or discharge (as appropriate) the timing capacitor C_T between two internal voltage references which are half the Zener supply voltage apart. As a result, the average of the current pulses pumping into C_T is given by:
average current = $V_z \times f_I \times C_T$
where V_z = Zener voltage and f_I = input frequency.

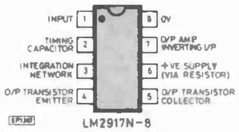


Fig. 1. Pin out and specification

Characteristic	Notes	Min.	Typically	Max.	Units
Supply voltage	All spec's measured at +12V		+12	+28	V
Quiescent current			3·8	6	mA
Temperature range		−40		+85	°C
ZENER VOLTAGE REGULATOR					
Zener voltage	Measured at pin 6		7·56		V
Effective internal series resistance			10·5	15	Ω
Max. supply current	Fed into pin 6			25	mA
OP-AMP AND O/P TRANSISTOR					
Input offset voltage	Input voltage = 6V		3	10	mV
Input bias current	Input voltage = 6V		50	500	nA
Voltage gain			200		V/mV
Input common-mode voltage range		0		(Zener voltage −1·5)	V
Output sink current	V_{ce} (sat) = 1·0V	40	50		mA
Output source current	V_{ce} (sat) = 2·0V		10		mA
Saturation voltage	5mA collector current		0·1	0·5	V
Op-amp i/p voltage	(Also, collector voltage)	0		+28	V
I/P AMPLIFIER AND CHARGE PUMP					
I/p voltage				±28*	V
I/p thresholds	I/p = 1kHz, 250mV p/p	±10	±15	±40	mV
Hysteresis			±30		mV
Input offset voltage			5	15	mV
Input bias current	I/p voltage = ±50mV d.c.		0·1	1	μA
Linearity (Variation in correct o/p voltage, with respect to 5kHz voltage)	I/p = 1kHz to 10kHz	−1·0	0·3	+1·0	%

* 0–28V for the LM 2917N

The output of the charge pump 'mirrors' an exactly equivalent current into the integration network C_I and R_I. The resistor acts as a load for the current mirror, and the capacitor smooths the pulsed waveform to provide a d.c. voltage at pin 3 (for LM 2917N–8) given by:
voltage at pin 3 = $V_z \times f_I \times C_T \times R_I$
In practice, due to i.c. tolerances, the d.c. voltage can vary from 0·9 to 1·1 times this value. This 'gain constant' error varies from one i.c. to the next, but stays constant within each i.c.

PRACTICAL CONSIDERATIONS

The larger the value of C_I, the less ripple will be produced, but the slower the circuit will be to respond to changes in frequency. The values of C_T and R_I will also affect response speed; C_I should be kept larger than 100p to avoid voltage errors. The value of ripple on the output is given by:

$$\text{ripple voltage p/p} = \frac{V_z \times C_T}{(2 \times C_I)} \times \left(1 - \frac{V_z \times f_I \times C_T}{I_o}\right)$$

I_o is the available output current from pin 2 or pin 3. This can vary from 140–240μA; typically it is 180μA. Finally, the maximum input frequency for the system is:

$$f_{max} = \frac{I_o}{V_z \times C_T}$$

BASIC CIRCUITS

The most effective way to illustrate the use

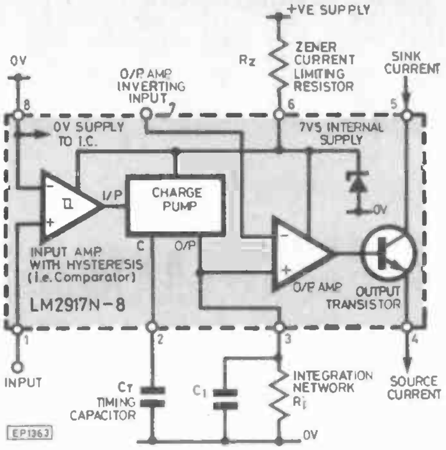


Fig. 2. Block diagram of LM 2917-8

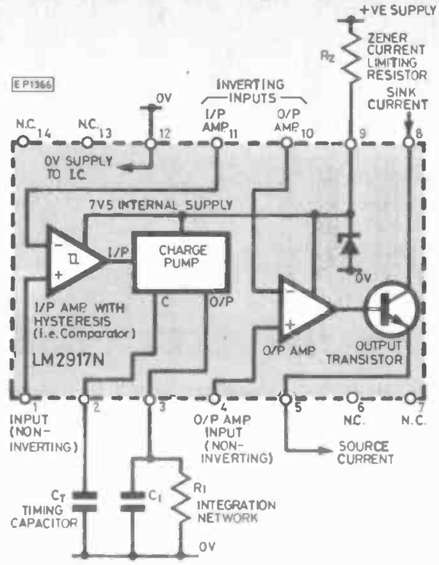


Fig. 3. Block diagram of LM 2917N

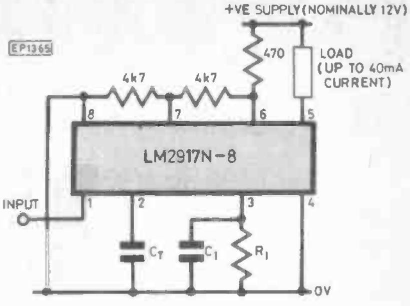


Fig. 5. Simple speed activated switch

of the output op-amp and transistor is to consider two typical examples of basic circuits. Fig. 4 shows a simple tachometer, with the transistor connected as an emitter follower. The connection to pin 7 therefore provides negative feedback to the op-amp, which acts as a unity gain voltage follower. R_L is a load resistor, which can be replaced with a 5V (full scale) meter movement, or can feed into a l.e.d. bargraph circuit if required. Remember to a.c. couple the input (and tie down pin 1 to 0V with a high value resistor) for most applications, or in the case of the LM 2917N, bias the inputs up to around half rail voltage.

Fig. 5 shows a speed activated switch, with the op-amp acting as a comparator. When the voltage at pin 3 exceeds the voltage at pin 7 (set up by the two 4k7 resistors), the output transistor turns on, sinking up to 40mA from the load. This occurs at the frequency given by:

$$f_{switch} = \frac{1}{(2 \times R_1 \times C_T)}$$

APPLICATION

Fig. 6 shows the circuit diagram of a more sophisticated 'speed switch', with Fig. 7 showing the Veroboard layout required for this. R2, R3, and R4 set the threshold at which the output amplifier switches. When this happens, the i.c.'s output transistor turns on, causing D2 to light up and TR1 to turn on, effectively connecting R14 in parallel with C6, which results in the voltage on C6 gradually dropping. This dropping occurs until the output op-amp turns off again, turning off the output transistor and TR1 in turn; the voltage across C6 starts to rise again when this happens, which in turn causes the output op-amp to turn on, etc. The connection from the resistor chain R2, R3, and R4 to pin 7 of IC1 provides extra hysteresis in the system, ensuring that the system does not oscillate at high frequencies around the turn on/turn off point of the output op-amp. There will, of course, be the low frequency oscillation as described above, the frequency of which will be determined by the rate at which IC1 pin 3 can charge up C6, which in turn is determined by the input frequency.

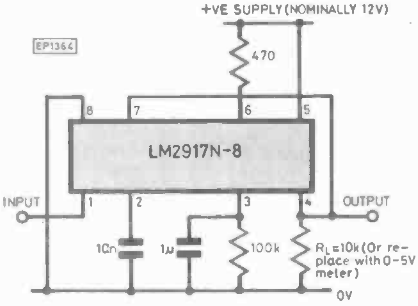


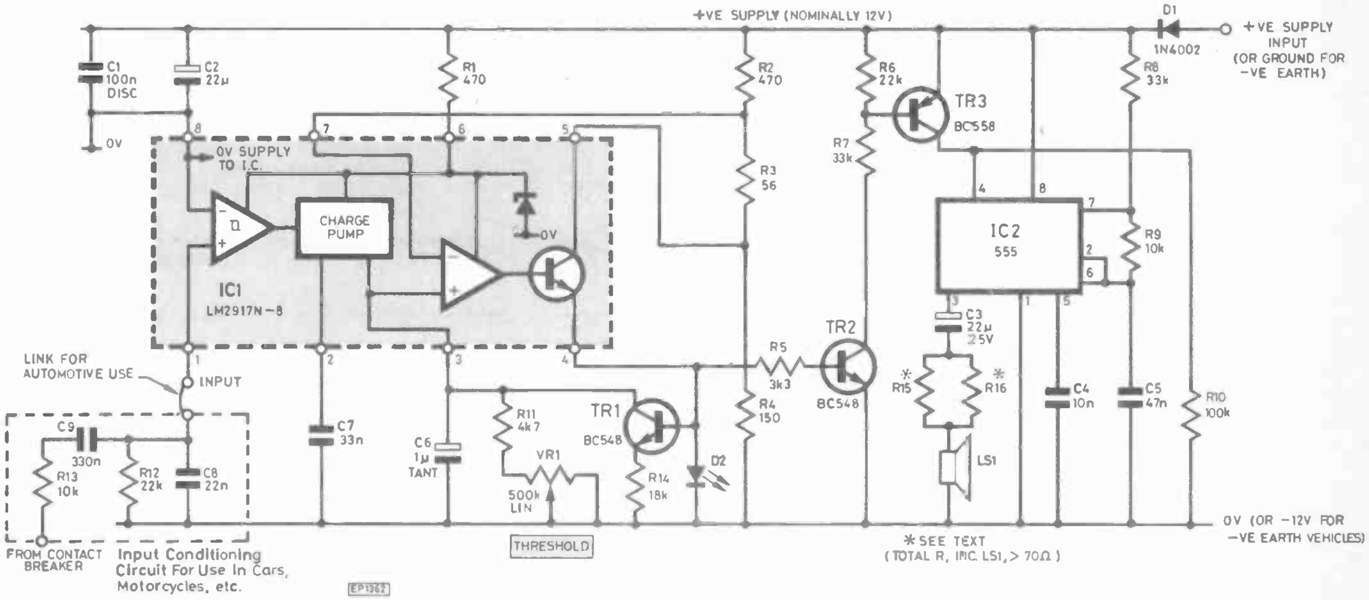
Fig. 4. Simple tachometer

The circuit will have no effect until a certain frequency is exceeded, at which point D2 will start to flash on and off slowly. If the input frequency increases, the l.e.d. will flash at a faster and faster rate, until it remains illuminated continuously. The threshold frequency at which the l.e.d. first lights up can be set via VR1.

AUDIBLE WARNING

IC2 is a 555 timer i.c. connected as an audio frequency oscillator. TR2 and TR3 turn the enable pin (pin 4) of the i.c. on whenever D2 is illuminated, providing an audible warning. The transducer used for this can be a piezo-sounder, in which case no series resistor is likely to be needed, or a loudspeaker, in which case the impedance of the loudspeaker, in series with dropper resistors, should ideally be approximately 70 ohms or more. The series dropper resistors shown asterisked in Fig. 6 should total 1W for low impedance loudspeakers. Use a pair of 0·5W 150 ohm resistors in parallel for a 4 to 16 ohm loudspeaker.

Fig. 6 (Below). Circuit diagram of overspeed alarm or 'speed switch'



D1 protects against incorrect connection to the supply, and, together with decoupling capacitors C1 and C2, provides a measure of isolation if used in 'noisy' automotive electrical systems. The circuit can be used to monitor car or motorbike engine revs if the input conditioning circuit shown in Fig. 6 is used. This circuit provides decoupling, filtering, and attenuation of the contact breaker voltage spikes, and is suitable for both positive and negative earth systems. Don't forget to include a fuse in the positive supply feed to the circuit, though, for safety (or negative supply for positive earth vehicles). If the LM 2917N is being used, a Zener diode should be fitted between pin 1 and 0V (with its anode connected to 0V) to protect against reverse voltages. The value is not critical, but 12V should be adequate in most cases (other changes to the circuit of Fig. 6 are also necessary, of course).

SOME ADVICE

Although this circuit works well, it would not be advisable to rely on it for keeping to speed limits, since it monitors engine revs, not road speed!

The LM 2917N–8, and LM 2917N, are useful devices for many frequency-to-voltage conversion applications. They are readily available from **Cricklewood Electronics Ltd., 40 Cricklewood Broadway, London NW2 3ET.**

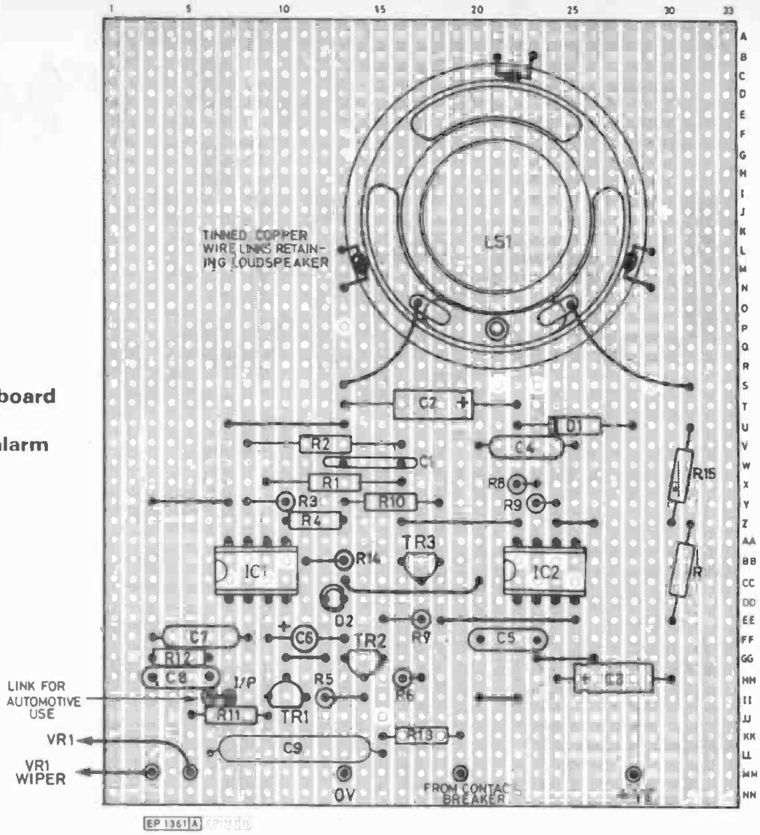


Fig. 7. Veroboard layout for overspeed alarm

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ELECTRONIC cruise control as fitted Rolls Royce. Fit any car, value £120. Bargain £60. Tel: Havant 486748. K. J. Chessell, 11 Castle Avenue, Warblington, Havant PO9 2RY.

WANTED, CT7001 Digital clock I.C. Good price paid. E. J. Steele, 382 Linnet Drive, Chelmsford, Essex CM2 8AL. Tel: Chelmsford 265217.

SCOPE Tektronix, large, £60. Frequency counter, £50, d.v.m. £50. AVO8, £60. Tel: 01-594 4126.

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ACULAB Floppy tape drive with 42 tapes, XBASIC etc., for video Genie. £100·00, tapes £50·00. W.H.Y. L. Dray, 53 Cambridge Road, Sandy, Beds. Tel: (0767) 80253, evenings.

SEEKING a friend having interests in electronics or collecting something in exchange of PE, EE, etc. Mustafizur Rahman, Research Assistant, Teachers' Training College, Rajshahi, Bangladesh.

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UK101, 8K, assembler and disassembler, cased. Eight C90 cassettes full of software. Perfect condition. £75 o.n.o. T. West, 354 Wolverhampton Road, Cannock, Staffs. Tel: Cannock 4963.

POWERTRAN Chromatherme light controller, perfect except strobe. Fitted with Bulgin 8-pin sockets, £50. Tel: Orpington 73879, Paul. P. Straker, 16 Orchard Grove, Orpington, Kent.

FOR sale, Cossor 1049 MKIII D/beam oscillograph with trolley and manual, £45 o.n.o., or W.H.Y. Buyer collects. Mr. S. Rose, 207 Bishopsfield, Harlow, Essex CM18 6UU. Tel: (0279) 30134.

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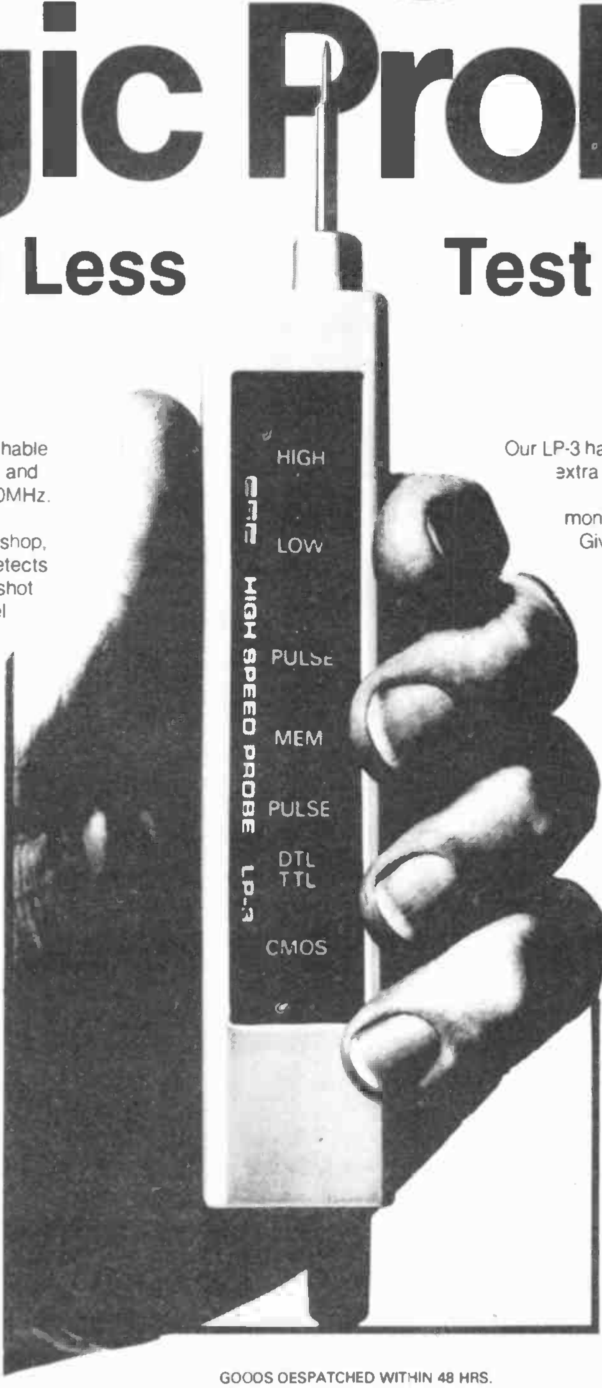

LP-1 Logic Probe

The LP-1 has a minimum detachable pulse width of 50 nanoseconds and maximum input frequency of 10MHz. This 100 K ohm probe is an inexpensive workhorse for any shop, lab or field service tool kit. It detects high-speed pulse trains or one-shot events and stores pulse or level transistions, replacing separate level detectors, pulse detectors, pulse stretchers and pulse memory devices. All for less than the price of a DVM

£34.50*

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LP-2 Logic Probe

The LP-2 performs the same basic functions as the LP-1, but, for slower-speed circuits and without pulse memory capability. Handling a minimum pulse width of 300 nanoseconds, this 300 K ohm probe is the economical way to test circuits up to 1.5 MHz. It detects pulse trains or single-shot events in TTL, DTL, HTL and CMOS circuits, replacing separate pulse detectors, pulse stretchers and mode state analysers.
(Available in kit form LPK-1 £14.50)

£21.00*

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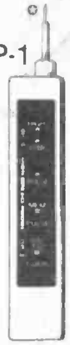

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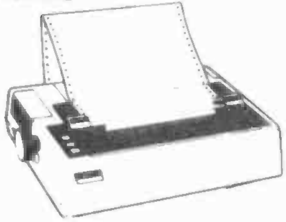

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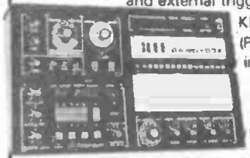

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I could tell immediately that he was an engineer of the old school. A dead giveaway was the slide rule poking out of his top pocket. Remember the slide rule? I rated him classical junction transistor vintage. He sighed and shook his head sadly.

"You know," he said. "I sometimes think this high-technology electronics business is getting a bit too clever for comfort. Sophistication, as they call it, is becoming an end in itself. Complexity is chic and it's jolly hard on the old hands like myself. Most mind-boggling of all is this computer-age language. I just can't get the hang of it.

"Words and phrases we learned at mother's knee have been deprived of their original meanings by the chip brigade. For instance, before the microprocessor processed itself into our lives, a bus driver was a chap who swore at cabbies and didn't always stop at one's request. A byte (see, they can't even spell anymore) was a munch on a cheese and pickle sandwich or something you got from a playful wasp while rolling in the long grass. And a RAM was a character much sought after by broody ewes."

I could have gone on with the usual gaff about the forward march of science and the need to keep up with the rest of the world. But he didn't seem in the right frame of mind to take it. So the best comfort I could offer was an invitation to join me on a visit to the HQ of the Sutton (Surrey) Talking Newspaper for the Blind. For him it would be a trip down the memory lane of basic electronics—which, when all is said and done, continues to serve humanity without benefit of the sophistication he finds so difficult to cope with. There's nothing particularly new about talking newspapers. They had their origin in Sweden and first reached our shores in the early 1960s. The STN was mooted in neighbouring Carshalton in 1974 and came out with its first issue three months later.

Lesley Page, a one-time employee of the Bank of England and a socially-active lady with a rare gift for organisation, is the STN's secretary. She told me: "In the initial stages we were financed by interest-free loans from the local Rotary Club. But thanks to our own fund-raising activities we were able to redeem them within a year. The local library lent us their recording equipment and we worked from the flat of the late John Bradley, the much-missed president of the British Amateur Tape Recording Society.

"Then came a splendid stroke of luck. The Wallington & Carshalton Round Table offered to buy us our own equipment if we could find ourselves permanent premises. Sutton Council helped generously here by giving us a suite of rooms in the building which we share with the Registrar of Births, Deaths & Marriages and the Rent Officer. Distinguished company indeed."

It was Thursday—'Press day'—when my morose friend and I called on STN. In one room a trio of ladies were busy unpacking and sorting the returned C60 cassettes carrying the previous week's issue (five mailbags of them in all). In another room a team of editors were scanning the local newspapers, supplied free by the publishers, for the 'hard news' side of the tape. Contary to what you might expect, there is no bias in selection towards only pleasant or neutral news. "The blind dislike the idea of being protected from unpleasant things," said Lesley. "They want to hear about both the good and the bad so that they can discuss current events with their sighted friends. Anything goes, from muggings to garden fetes." The second side of the tape accommodates the 'magazine' section. In this the blind themselves have a large slice of the action. They provide articles, seek out interviews with local officials and prominent personalities. There are items about holidays and leisure pursuits. One blind man has even contributed an account of his experiences as a mountaineer!

"You're out of date, dad. Your mind is pre-microchip"

In the control room I spoke with Doug Cook, formerly an engineer with the Post Office. He was in the process of making the master tape of the magazine section. "With our duplicating machines," he said, "we can turn out 13 copies in three minutes. We edit them so that halfway through there's a break for music which gives our 'readers', as we call the listeners, a chance to put the kettle on." By now all was ready for recording the news. The team consisted of one presenter and four readers, all of whom identified themselves by name. Their professionalism was remarkable, though, says Lesley: "We don't really need professionals—just people with enthusiasm and clarity."

The clock stood at 8.30 p.m. All the tapes were completed and checked. A standard procedure, by the way, is to include a reminder to turn off the recorder and to turn over the reversible label on the postal pouch for return of the tape to STN headquarters. And in case you're wondering how blind persons differentiate between the two sides of the tape, there's a tactile strip on the face of the cassette.

The rest was sheer humping. First, the registration of each pouch before it went into the mailbag. Then a trip to the back door of the main Post Office. The mailings—handled free of charge in both directions—would be dealt with overnight and the majority of tapes would reach their destinations by first post Friday. As Lesley said: "Sometimes we even beat the newspapers."

Some 300 blind people (out of a registered total of about 500) in the Sutton area regularly receive the STN. Applications come mostly through social workers. Most of the 'readers' are elderly, but there is a fair sprinkling of younger ones too. Many people have their own tape recorders, but those who do not borrow them from the STN free of charge. Between 200 and 300 public-spirited citizens, all unpaid and totally dedicated, working on a well-organised rota system, help to produce the newspaper every week. They come from all walks of life and many of them have blind relatives. "At the moment we have no shortage of volunteers," says Lesley.

The STN, which is a registered charity, costs between £1500 and £2000 a year to run. But rather than simply exist from year-to-year, a move has been made to set up an investment fund of around £20,000 to provide an assured income. This is being achieved by gala concerts, street collections, the sale of ballpoint pens and other novelties. Some schools have adopted STN as their pet charity for a specified period. There are regular carol-singing forays at Christmas. Even the local police force has contributed by making over some of the proceeds from the sale of unclaimed stolen property.

Backing the STN and similar organisations throughout Britain, is the Talking Newspaper Association of the UK. It deals with such matters as copyright, is the principal contact with official bodies and provides many other kinds of ideas and help. Here again, all concerned are unpaid volunteers.

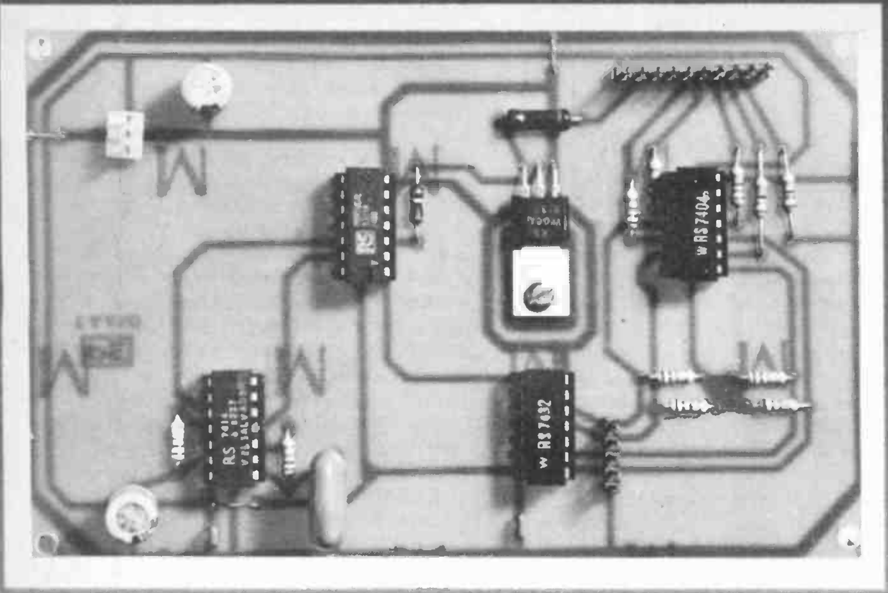
For those who have been reared on modern technology and all its wonders, the STN and others like it may seem an age away from the sophistication of the present. OK, so basic electronics may be old hat for the whiz-kids of the 1980s. But those same basics are helping to bring a fuller life and a broader involvement with society to a lot of people who wouldn't know, and couldn't care less about, the difference between a random access memory and a plate of fish and chips. My old engineer liked that sentiment.

★ ★ ★

I see that Football League clubs are likely to be offered some sort of microprocessor gubbins that will bring knife-toting, chain-carrying and otherwise mayhem-oriented louts to a standstill at the turnstiles. Anyone purporting to be a genuine supporter would be issued with a plastic card to establish his identity. This would then be screened for authenticity before he was allowed on to the ground. But would this really completely deter those who seem hell-bent on bovver and have little or no interest in the game?

★ ★ ★

I loved that piece by Ray Connolly in the London evening newspaper, The Standard. Failing to follow the interpretation by an 11-year-old of a War Games movie, he was told: "You're out of date, Dad. Your mind is pre-microchip. You need re-programming." Hard cheese, Ray. Maybe you'd better link up with my old mate with the slide rule. You seem to have a lot in common.



anti theft alarm...

MICHAEL TOOLEY BA   DAVID WHITFIELD MA MSc CEng MIEE

IN this month's issue we begin a new series which provides some practical examples of digital techniques. These projects, which have been carefully selected to complement the series entitled 'Introduction to Digital Electronics', also make excellent constructional projects in their own right, finding numerous applications in the home, school and workplace. Each project uses low-cost, readily available components and single-sided p.c.b.s are used throughout.

We start, this month, with a simple Anti-Theft Alarm which is designed to provide an audible and visual warning that property or goods are being tampered with. This project illustrates the use of some of the basic logic gates, demonstrates techniques for driving l.e.d.s, and shows how simple square wave oscillators can be constructed using Schmitt logic gates. A separate power supply module is also described. This module provides a regulated 5V supply of up to 500mA and is suitable for use with both the Anti-Theft Alarm and any of the subsequent projects.

CIRCUIT DESCRIPTION

The complete circuit of the Anti-Theft Alarm is shown in Fig. 1. The alarm is provided with four input loops which link points A, B, C, and D respectively to the common 0V rail. Whenever one, or more, of the loops is broken the respective pull-up resistor, R1 to R4, will generate a logic 1 input at IC1 which is arranged to form a four-input OR gate. The normal state of the output of IC1c, when all of the loops are closed, will be a logic 0. If, however, any of the loops is broken, the output from IC1c will become logic 1.

In order to provide a visual indication of which one of the loops is broken, IC4 is arranged as an l.e.d. driver, inverting the logical input to IC1 so that the respective l.e.d. becomes illuminated whenever an output goes low. A fifth l.e.d. is included merely to indicate that the supply is connected and that the alarm is active.

IC2a uses a Schmitt inverter to form a simple oscillator which produces a square wave output at approximately 3kHz. A similar stage, IC2f, operates at the much lower frequency of 3Hz. An inverting buffer follows each oscillator and then both square wave signals are applied to a two-input AND gate, IC3d. The resulting output from IC3d consists of 200ms bursts of 3kHz signal which is then fed to a further two-input AND gate, IC3a.

The gated square wave signal from IC3d only appears at the output of IC3a when a logic 1 appears at the output of IC1c (i.e. when any one, or more, of the loops is broken). In order to provide an audible output at ample volume, a VMOS f.e.t., TR1, follows IC3a. This device has a near infinite input impedance and is capable of driving the low impedance load presented by the loudspeaker. A series resistor, R13, is included in order to both reduce the volume of the output signal and reduce the peak drain current flowing in TR1 to an acceptable value.

The circuit diagram of the Power Supply Module is shown in Fig. 2. This uses a conventional i.c. regulator and an l.e.d. is incorporated in order to provide a visual indication of the d.c. output. Little further comment is necessary other than that the nominal 6V a.c. input is derived from a fully encapsulated mains transformer of similar type to that used with the Logic Tutor.

CONSTRUCTION

The Anti-Theft Alarm is built on a single sided p.c.b. measuring approximately 140x90mm, the copper foil layout of which is shown in Fig. 3. The corresponding component layout on the top surface of the p.c.b. is given in Fig. 4. Interconnections from the p.c.b. to the four input loops, l.e.d. indicators, loudspeaker and power supply are all made via 0·1" matrix p.c.b. connectors, the wiring for which is shown in Fig. 5.

Components should be assembled on the p.c.b. in the following sequence: d.i.l. sockets, p.c.b. connectors, resistors, capacitors, f.e.t. Once assembly has been completed the underside of the p.c.b. should be carefully

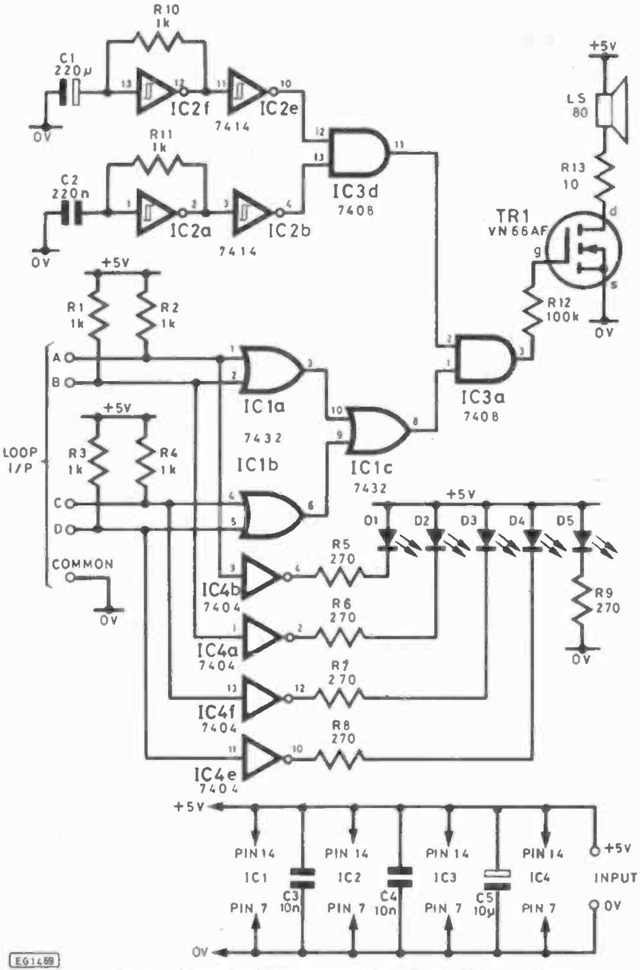


Fig. 1. Circuit diagram of the Anti-Theft Alarm

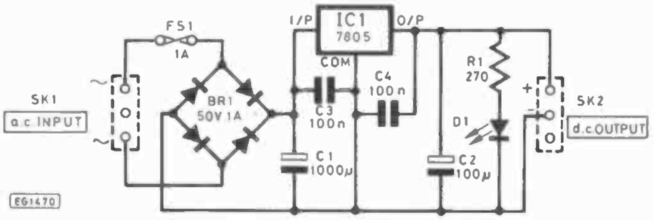


Fig. 2. Power supply circuit

COMPONENTS . . .

ANTI-THEFT ALARM

Resistors

R1, R2, R3, R4, R10, R11	1k (6 off)
R5, R6, R7, R8, R9	270 (5 off)
R12	100k
R13	10

Capacitors

C1	220µ 16V p.c. elect.
C2	220n polystyrene
C3, C4	10n ceramic disc (2 off)
C5	10µ 16V p.c. elect.

Semiconductors

D1, D2, D3, D4	Red l.e.d. (4 off)
D5	Green l.e.d.
TR1	VN66AF
IC1	7432
IC2	7414
IC3	7408
IC4	7404

Miscellaneous

P.c.b.
14-pin d.i.l. sockets (4 off)
3-way 0·1″ p.c.b. plug and socket
5-way 0·1″ p.c.b. plug and socket
10-way 0·1″ p.c.b. plug and socket
80 ohm loudspeaker

POWER SUPPLY MODULE

Resistors

R1	270

Capacitors

C1	1000µ 16V p.c. elect.
C2	100µ 16V p.c. elect.
C3, C4	100n polyester (2 off)

Semiconductors

D1	Red l.e.d.
BR1	50V 1A bridge rectifier
IC1	7805

Miscellaneous

P.c.b.
3-way 0·1″ p.c.b. plug and socket (2 off)
1A 20mm fuse and p.c. fuse clips

checked for solder splashes, bridges between adjacent tracks, and dry joints. Finally, the i.c.s may be inserted in their respective holders, taking care to ensure the correct orientation of each device. Constructional details of the enclosure and off-board wiring have not been given since this will undoubtedly be a matter of preference for the individual constructor.

The p.c.b. layout for the Power Supply Module and corresponding component layout are shown in Figs. 6 and 7. Assembly is very straightforward; however, care should be taken to ensure that the bridge rectifier is correctly orientated. The i.c. regulator should not require a heatsink for this project; however, if one is available rated at around 17·5° C/W, it may be fitted to meet the supply current demands of more ambitious projects. Once complete, and before the a.c. input is applied, the Power Supply Module should be carefully checked for soldering faults. The mains transformer is rated at 6V 3VA and should be housed in a fully insulated plastic encapsulation integral with the mains lead and plug.

TESTING

Testing the Anti-Theft Alarm is simply a matter of checking that the 5V supply is present and, if this is the case, D5 should be illuminated. Each of the input loops should then be open-circuited in turn. The alarm should be activated whenever any one of the loops is broken and the corresponding l.e.d., D1 to D4, should become illuminated. The input loops will normally consist of lengths of stranded insulated wire running through the goods to be protected.

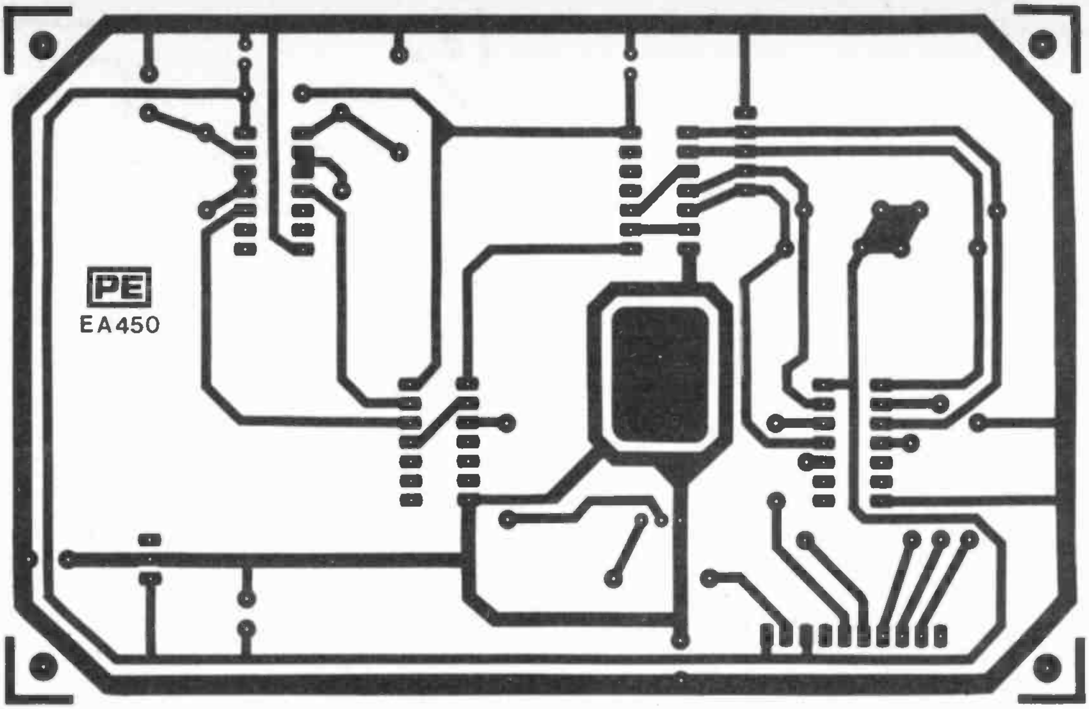


Fig. 3. Main p.c.b. design

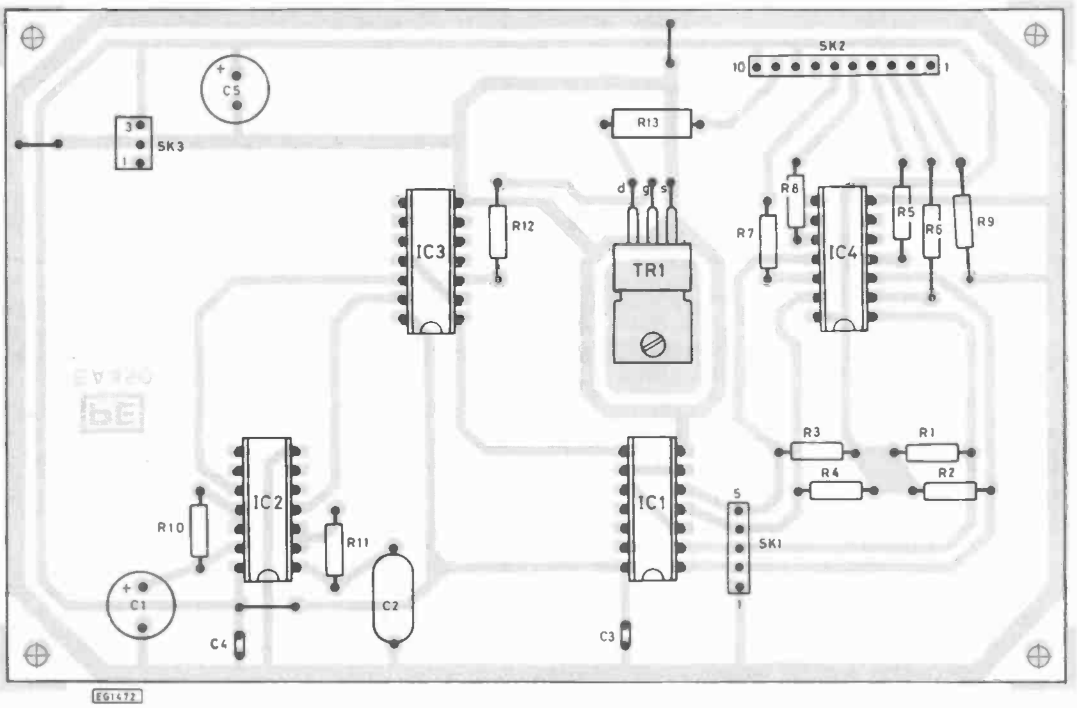


Fig. 4. Component layout

They may also consist of thin strips of foil fastened to windows and glass doors by means of a suitable adhesive. Indiscriminate breaking of the glass will cause the foil strip to break and the alarm to be set off.

MODIFICATIONS

The sound level of the output may be adjusted by varying R13 which should be reduced in value if more output is required or increased in value if less output is required. If R13 is reduced to less than 5·6 ohms a small heatsink will be required for TR1.

The frequency (pitch) of the audible warning signal may be changed by altering the value of C2. A larger value (say 470nF) will decrease the frequency, whilst a smaller value (say 100nF) will increase the frequency. If it is necessary to alter the rate at which the audible output is pulsed on and

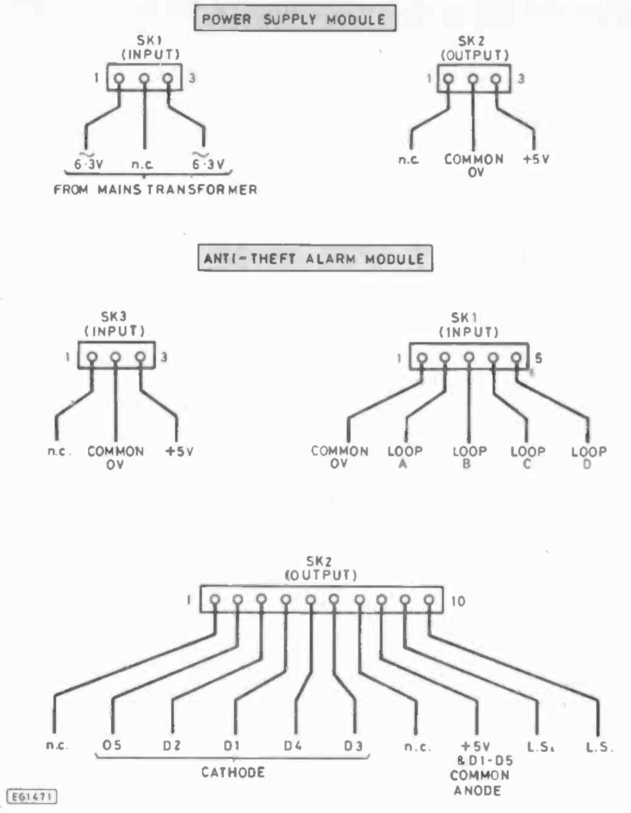


Fig. 5. Inter board wiring

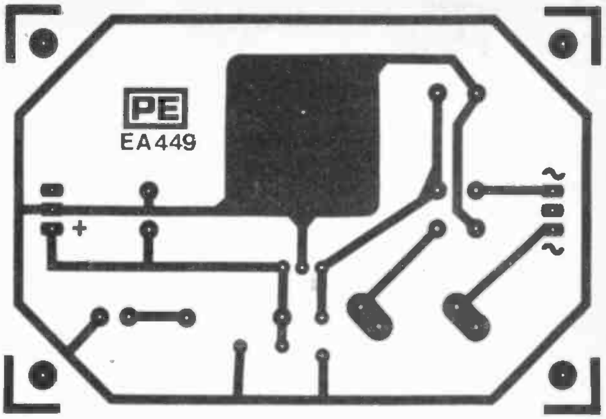


Fig. 6. P.s.u. board design

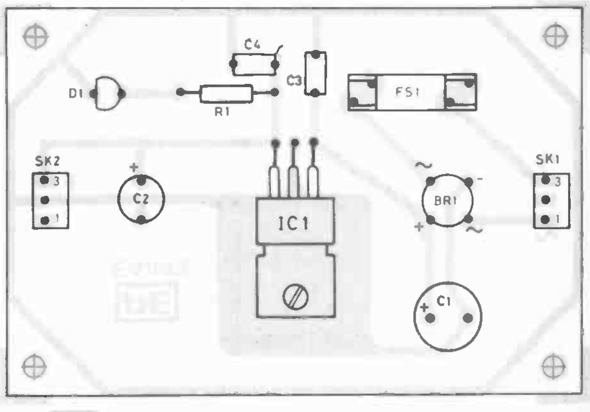


Fig. 7. Component layout

off, C1 may be similarly varied. Appropriate values lie in the range 100µF to 680µF.

To drive several loudspeakers, the circuit around R12, TR1, and R13 should be duplicated. Each loudspeaker then has its own driver circuit. The signal input for all of the driver circuits is derived from pin 3 of IC3a. The loudspeakers should be placed at various strategic points. These may, for example, include passageways, doorways, counter and checkout areas. ★

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★ NI-CAD BATTERY CHARGER ★
Enables ni-cad cells to be recharged from standard 12V car battery charger. Caters for PP3, HD7, HP11, and HP2 in banks of up to 12 cells (of same type).

★ REVERSING BLEEPER ★
Emits loud bleeping sound to warn pedestrians when driver moves gear into "reverse".

★ LOW-POWER STEREO AMPLIFIER ★
Modest budget project, ideal for the beginner. Output 2·5 watts per channel. Three inputs: for ceramic cartridge pickup, tape recorder and auxiliary. Bass and treble tone controls. 8 ohm outputs.

★ MULTIMETER ADD-ON FOR BBC MICRO ★
Connects to the User and Analogue Ports to produce an accurate digital multimeter with screen readout. Voltage, Resistance, Capacitance measurements, in ranges up to 100V, 10MΩ and 10µF respectively.

MARCH ISSUE
ON SALE FEBRUARY 17

COMPUTER TERMINAL

PART TWO

RAY STUART

IN THIS, the concluding part, details of the p.c.b. assembly and case construction are given. The project is a remote VDU/Keyboard terminal capable of RS232 serial communication with any home computer with an RS232 port.

P.C.B. ASSEMBLY

The p.c.b. foil pattern and component layout are shown in Figs. 2.1 and 2.2.

The components should be installed on the p.c.b. in the following order:

a) Links, terminal pins and regulator leads.
b) I.c. sockets.
c) Capacitors and resistors.
d) Modulator, buzzer and crystals.
e) Connectors.

It is strongly recommended that i.c. sockets are used, as it is difficult to change faulty or incorrectly installed devices if they are soldered to the p.c.b. Before proceeding any further it is wise to check for incorrect component locations and solder bridges. These are most likely to be found in the RAM area of the p.c.b.

CASE

There is a wide range of commercially available cases that the reader may choose from to house the system. However, the author found none suitable for his requirements and so constructed the case shown in the photographs. The side plates are made of solid mahogany, with the chassis, back and cover plates made from aluminium sheet, spray painted. The wooden side plates are cut to size and the support battens screwed to them as shown in Fig. 2.3, and the aluminium panels cut and drilled to the dimensions shown in that Fig. The back panel carries the UHF and monitor output sockets, mains input socket, the full/half duplex switch, the 25-way D-series connector for the RS232 link, and is also used as a heat sink by the three voltage regulators which should be fitted using insulating mica washers. The back plate is connected to the chassis by a length of 13mm aluminium angle as shown. Two identical covers should be constructed, one of these being cut to accept the chosen keyboard. All the aluminium panels should be rubbed down with wire wool before being sprayed. The keyboard is then secured to its cover, the various components fitted to the back plate which can be bolted to the chassis. The p.c.b., mounted on insulating spacers, and the transformer are then fitted to the chassis. The various parts should next be wired together as shown in Fig. 2.4. Finally, No. 5 x $\frac{1}{2}$ inch countersunk screws are used to mount the aluminium panels to the side plate battens, with the exception of the top cover plate which should be fitted after the Computer Terminal has been tested.

TESTING

Before inserting any i.c.s the power supplies should be checked to establish that the correct voltages are being produced. Check that the correct voltages are present on the various i.c. power pins. If all is well the unit should be switched off and the i.c.s inserted, taking care to insert IC12 and IC15 the correct way round. The normal precautions should be employed when handling the i.c.s, *especially the RAMs*. The full/half duplex switch should be set to the half duplex position, the monitor or television connected and switched on.

The terminal can now be switched on. If a television is being used, it should be tuned to channel 36 (that used by video recorders). The screen will be filled with random characters. It may be necessary to adjust VR1 and VR2 for best results. The reader will notice a flashing cursor somewhere on the screen: characters entered on the keyboard will be displayed at the cursor position. The cursor itself may be moved around the screen, or the screen cleared by entering the ASCII control characters listed in Part 1.

COMPONENTS . . .

Resistors

R1–9, R11, R17	10k (11 off)
R10	10M
R12	100R
R13	2k
R14, R18	1k (2 off)
R15	4k7
R16	82R ($\frac{1}{2}$W)

All resistors $\frac{1}{8}$W 5% unless otherwise stated

Potentiometers

VR1	470R
VR2	100R

Capacitors

C1	100p
C2	22μ/10V
C3,4	2200μ/25V (2 off)
C5–30	100n (26 off)

Semiconductors

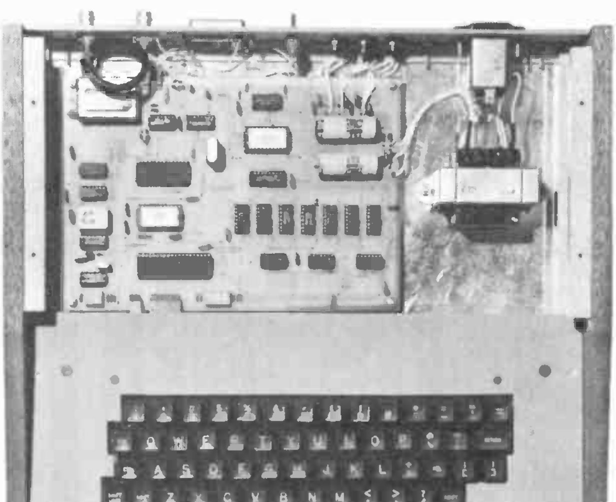
IC1–7	2102 (7 off)
IC8	74LS374
IC9	SFF96364
IC10	2716 EPROM
IC11	6402 or AY-5-1013 (see text)
IC12	2716 EPROM
IC13	74LS163
IC14	74121
IC15	74LS165
IC16	COM8126
IC17	74LS08
IC18	74LS00
IC19	74LS08
IC20	74LS132
IC21	1488
IC22	1489
IC23	7805
IC24	7812
IC25	7912
TR1,2	BC109, BC547 etc (2 off)
D1–4	1N4001 (4 off)

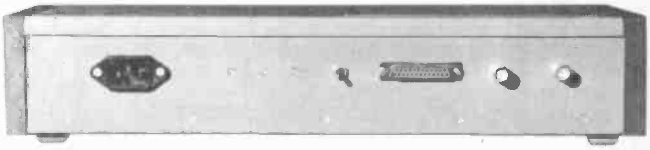
Miscellaneous

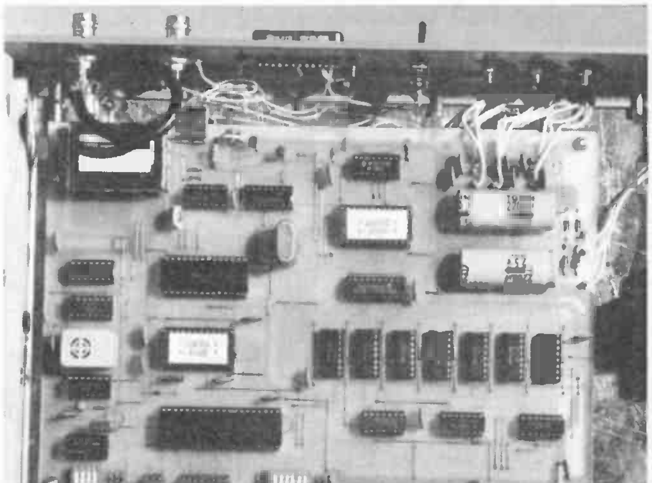
X1	1MHz crystal
X2	5·0688MHz crystal
UHF modulator	Astec 1233 (8MHz)
S1–4	4-way p.c.b.
S5–10	6-way p.c.b.
S11	S.p.d.t.
SK1	25-way D-Series
SK2,3	BNC Chassis Mounting
SK4	IEC Mains Connector
SK5	5-way p.c.b. Connector
SK6	3-way p.c.b. Connector
SK7	8-way p.c.b. Connector
Buzzer	Verospeed 41–22515K
T1	12–0–12 25VA transformer
Keyboard	
Case (see text)	
Double Eurocard single-sided p.c.b.	
I.c. sockets	

Constructors' Note

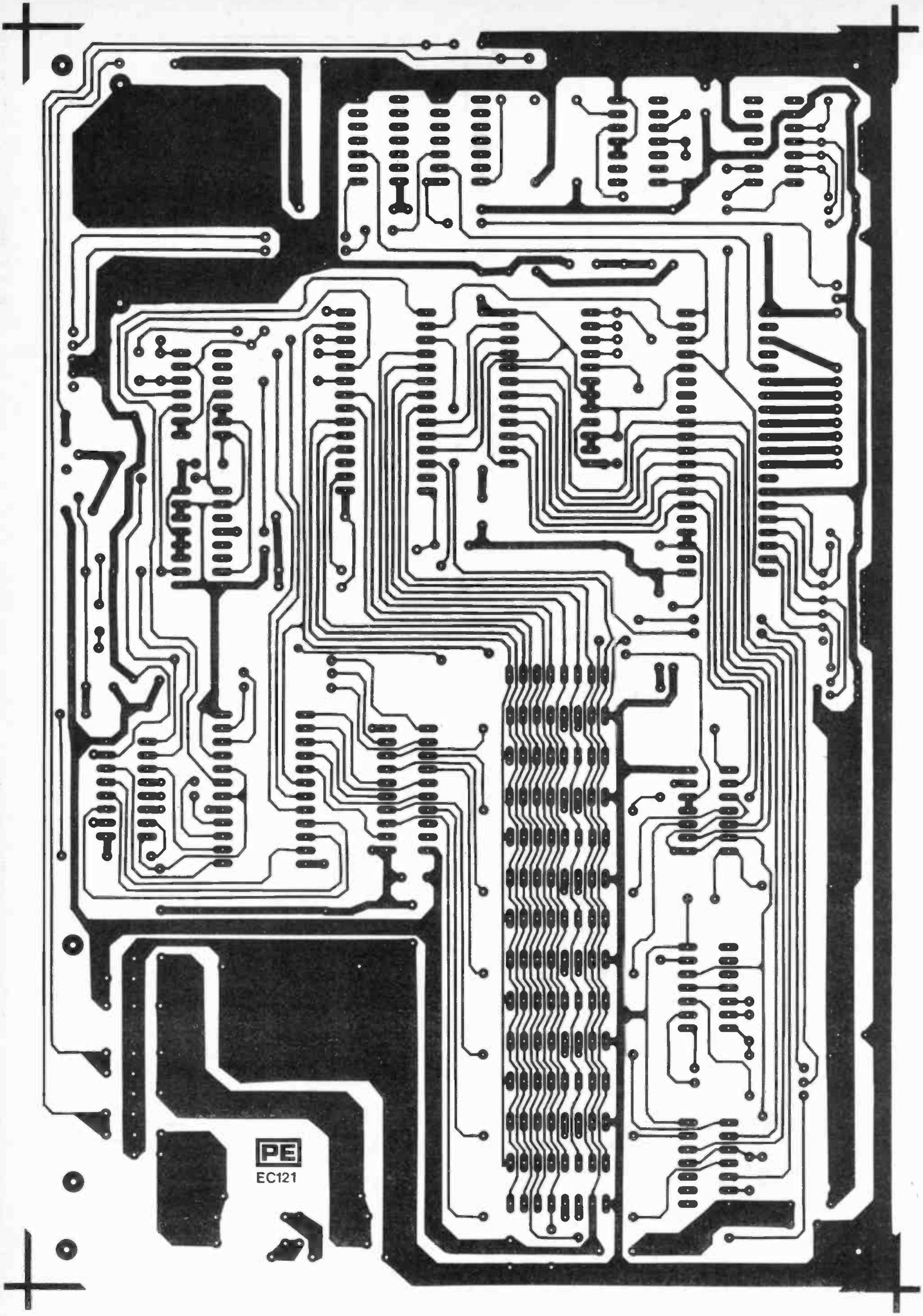
A Hex dump of the EPROM contents is available from P.E. (Poole office); please send 230 x 150mm SAE. Pre-programmed EPROMs and COM8126s are available from: "Peripheral Projects," 25 Braycourt Avenue, Walton-on-Thames, Surrey KT12 2AZ. Printed circuit boards, if not found available from P.E.'s usual suppliers (see advertisers), will in any case be available from this supplier.







Internal views of the Computer Terminal


PE
EC121

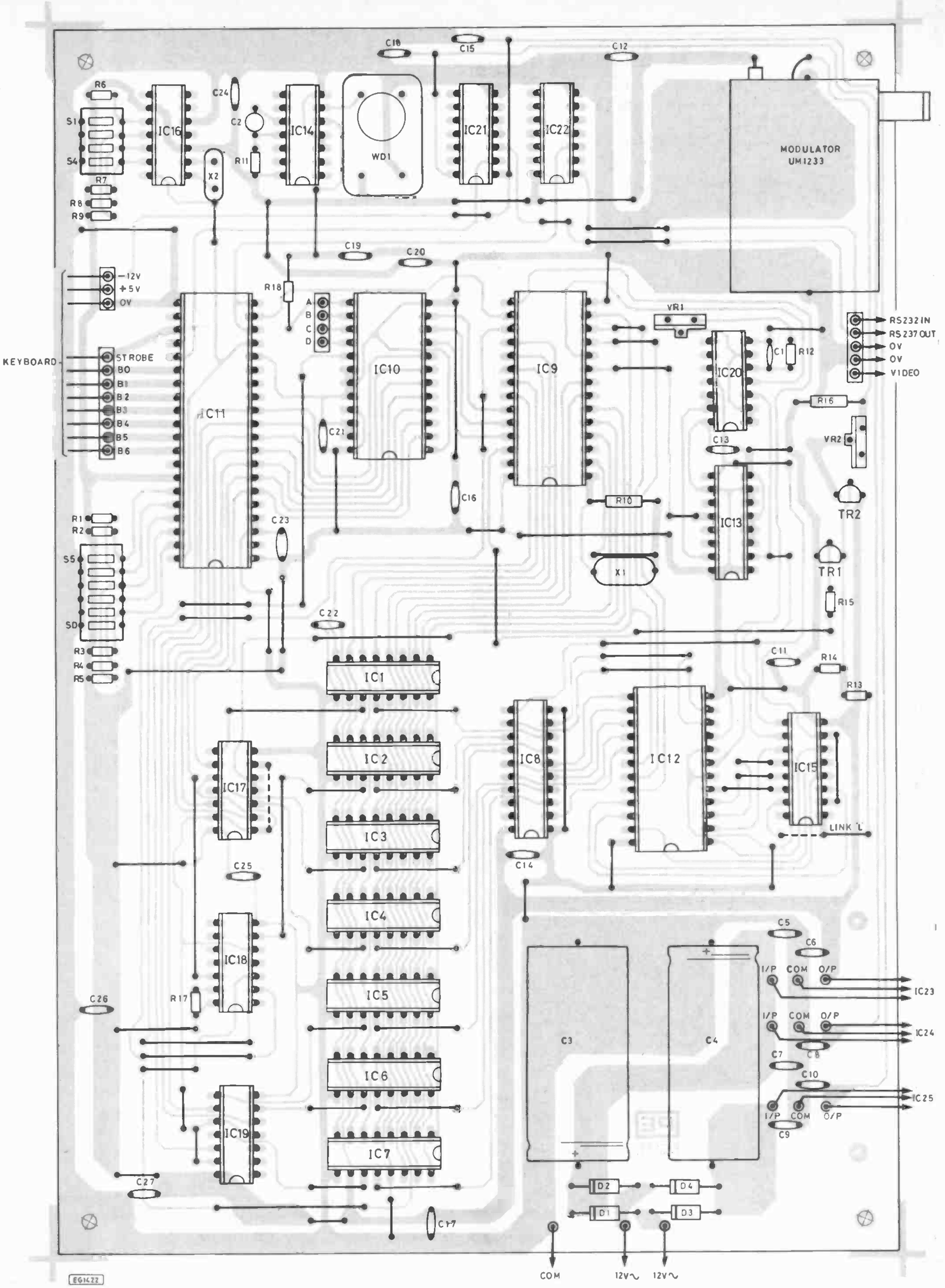
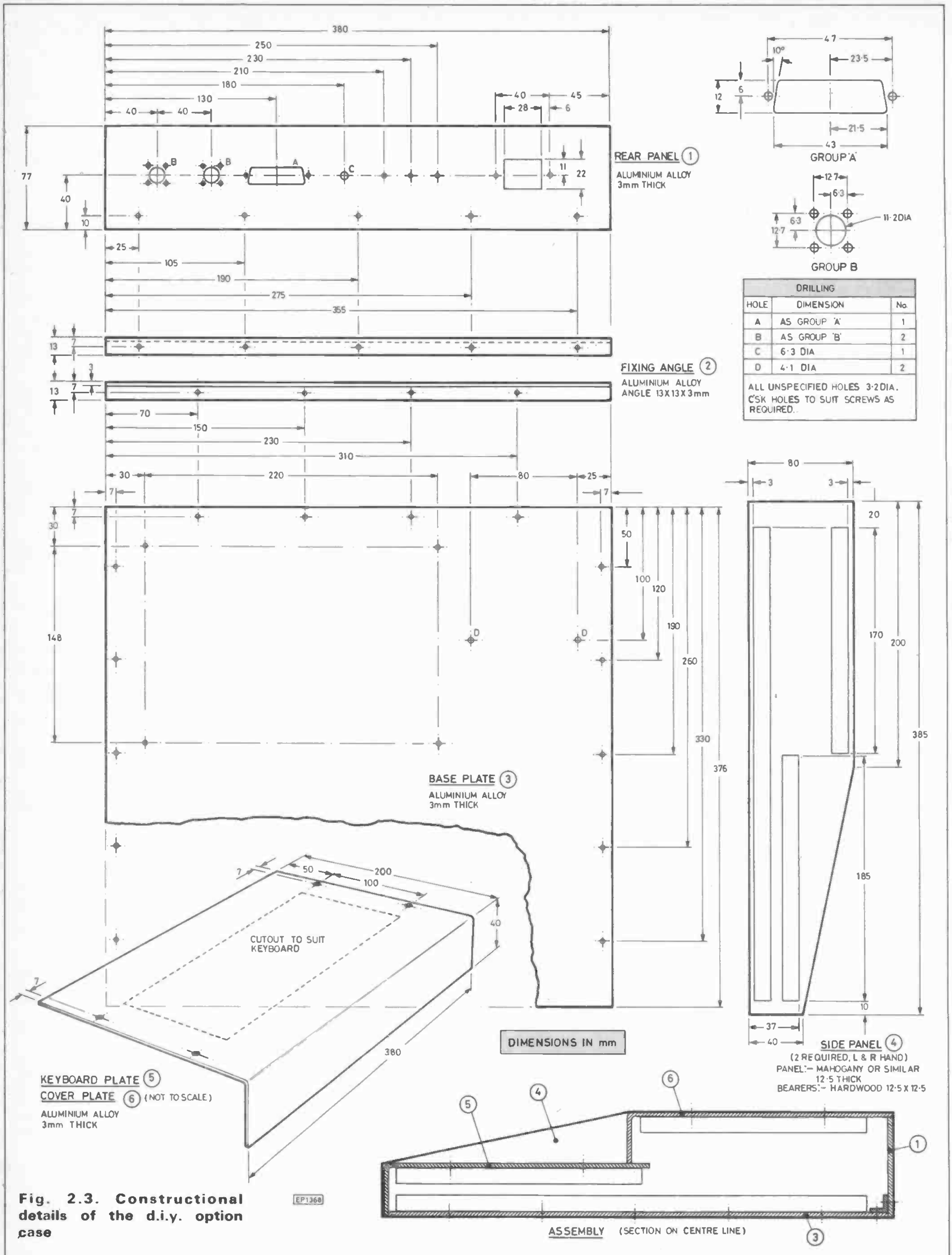


Fig. 2.2 (above). Component layout

Fig. 2.1 (facing page). P.c.b. layout of the Computer Terminal (actual size)



DRILLING		
HOLE	DIMENSION	No.
A	AS GROUP 'A'	1
B	AS GROUP 'B'	2
C	6·3 DIA	1
D	4·1 DIA	2

ALL UNSPECIFIED HOLES 3·2DIA.
CSK HOLES TO SUIT SCREWS AS REQUIRED.

Fig. 2.3. Constructional details of the d.i.y. option case

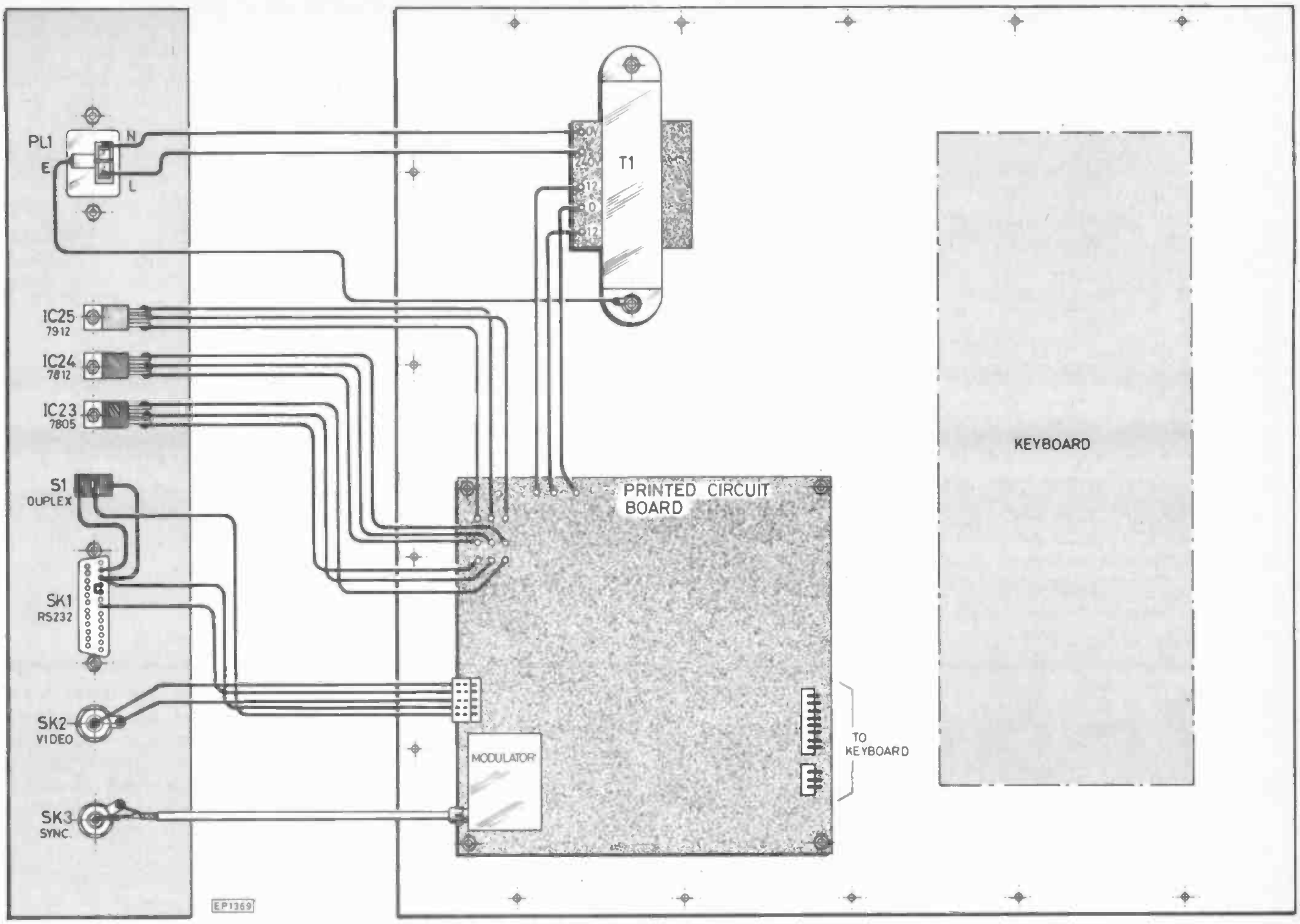


Fig. 2.4. Wiring diagram of the Computer Terminal

The BEL function can be checked by pushing the CTL and G keys together, whereupon a buzzing sound should be heard. Note that the UART latches its receiver outputs to the last character detected. As the buzzer's monostable is edge triggered it will only respond to the *first* CTL/G when several are sent consecutively. Normally CTL/G would be followed by a different character.

Switch to full duplex, the screen will remain unchanged, but characters entered on the keyboard will not appear on the screen. Connect the terminal to the host system via an RS232 cable. The host system's output should now be displayed on the screen. Similarly the host system should respond to characters entered on the keyboard.

ADDITIONAL FEATURES

As previously described, the control EPROM is programmed so that four of its outputs respond to the ASCII control characters as shown below:

03 — CTL/G (BEL) — p.c.b. pin A
04 — CTL/Q (DC1) — p.c.b. pin B
05 — CTL/R (DC2) — p.c.b. pin C
06 — CTL/S (DC3) — p.c.b. pin D

A p.c.b. plug is provided so that these signals may be used to drive additional circuitry.

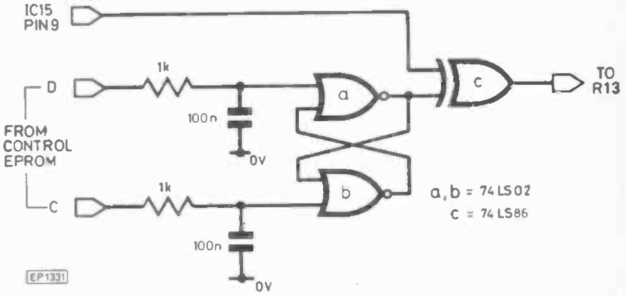


Fig. 2.5. Reversed video using ASCII characters DC2 and DC3

The circuit in Fig. 2.5 shows how normal or reversed video could be selected using the ASCII control characters DC2 and DC3. Gates 1A and 1B form a bistable flip-flop, set by DC2 and reset by DC3. The flip-flop's output is exclusive ORed with the normal video signal to produce normal or reversed video which is fed to the transistor mixer TR1. Issuing a DC2 character will cause all following characters to be reversed until a DC3 character is issued to revert back to normal video. The reader can therefore select various parts of the screen to display reversed video at will. If this circuit is used link "L" must be removed from the p.c.b.

A similar circuit (see Fig. 2.6) could be used to control a relay which could drive, for example, a cassette recorder's motor. DC3 would turn it on and DC2 turn it off. These two examples serve to indicate the types of additional facilities that may be included in the system and is by no means an exhaustive list.

INTERFACING WITH THE BBC COMPUTER

As stated at the beginning of this article, the Computer Terminal can be used as a second terminal for a BBC computer. The following notes describe how this can be achieved. With this terminal, or "glass teletype", connected to the BBC's RS432 socket, the command *FX2,1 allows the BBC computer to get characters from the "glass teletype", whilst *FX3,7 allows data to be sent from the BBC computer to the "glass teletype". Note that in this mode the BBC computer's keyboard and screen are disabled. The BBC computer's Baud rate is set to the same value as that of the PE terminal (say 2400 Baud) by using the commands *FX7,5 and *FX8,5 for receive and transmit rates respectively. Reference should be made to the BBC computer's "user guide" for further information on the use of the RS423 port.

CONCLUSION

Although reference has been made to the BBC computer, it is by no means the only system to which the terminal may be interfaced. The Computer Terminal can be used with any system fitted with a RS232 or RS423 interface. Examples of such systems are: Microprocessor development systems, Modems, EPROM programmers, Printers, as a terminal for a RTTY radio receiver, or on its own in half duplex as a practice typewriter. ★

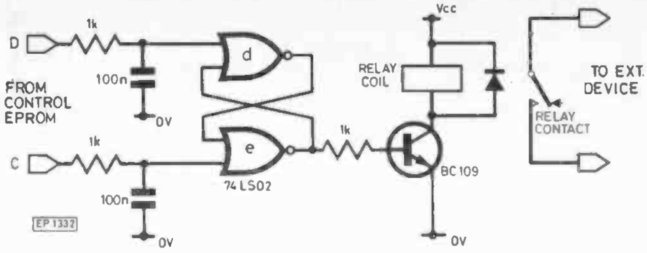


Fig. 2.6. A relay control circuit suitable for a cassette recorder

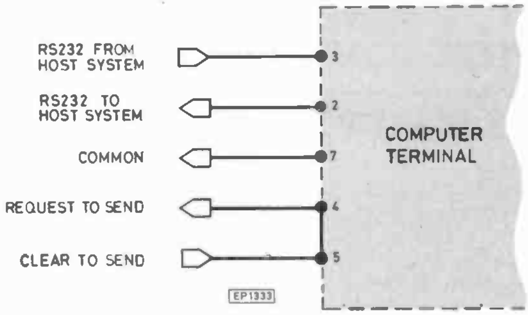


Fig. 2.7. RS232 connections

Readout...

Gas Saver

Sir—The boiler referred to in this article is obsolete, production finishing in 1970; although later series continued the basic design through to 1980.

The heating interests of Ideal-Standard Ltd. were incorporated into the Stelrad Group Ltd. in 1976 and it is with Stelrad that I am employed as Senior Controls Engineer within Group R&D department. In this capacity I must point out the problems associated with "add-on" modifications to approved gas appliances.

Interference with the working parts (in particular the electrical controls) of an approved gas boiler could invalidate the approval and warranty/service agreements as well as infringing the Gas Safety Regulations and, more to the point, could seriously impair the safe working of the appliance.

Any modification must give due regard as to the consequences—in particular taking full responsibility for the modifications carried out.

Obviously appreciable running cost savings can be made and manufacturers are currently investigating many possibilities for future incorporation into manufactured appliances.

The article also seems to suggest that only electronics can give the savings indicated. However, with the inclusion of a clamp-on cylinder thermostat and some simple wiring modifications the indicated savings could be achieved for less initial outlay, without invalidating the above comments.

It would appear that there is little appreciation for heating, as the article seems to concentrate on controlled hot water and controlled boiler temperature rather than total comfort and cost effectiveness. As regards to controlling the gas valves via triacs and the associated gates and comparators, this is at present not accepted by the Industry for primary output because of its possible failure mode resulting in an unsafe condition, among other factors. It is true though that the article does suggest the thermostats provided with the boiler should be connected in series with the "Gas Saver" but this is not shown on the diagram and is not highlighted sufficiently within the article.

As you state in the article ". . . Safety is all important in any equipment . . . using gas and electricity simultaneously, particularly, when running continuously without supervision." Hence we would suggest this should be left to experts as a little knowledge can be, so often, dangerous.

The subject is too large to handle in a few lines but it is hoped that the foregoing will be seen as constructive and helpful as we all endeavour to further the interest of electronics to the benefit of the Industry and our customers.

M. J. Blissett,
Senior Controls Engineer,
Stelrad Group Ltd.

We have received a couple of similar letters, and it seems I must first plead guilty to perpetuating the misconception that the copper tube in the typical boiler thermostat conducts heat directly. In fact, it contains a fluid which expands when heated, and the capillary action is used to operate electrical contacts via a "bellows" mechanism. Although not as rapid as electronics, the action is not as slow as the article suggested.

To respond to the particular points raised by Mr. Blissett: First, I believe most consumers cannot afford to replace their C.H. system (or any other appliance) each time it is declared obsolete. Gas Saver was intended to allow the older, or cheaper, system to become more economical, given its inherent limitations.

An older system will not be covered by a manufacturer's warranty, but of course, Mr. Blissett is right to point out that a consumer should not carry out d.i.y. modifications that will invalidate a service agreement, and is indeed personally responsible for any such alterations. Beyond this, it is difficult to see how Gas Saver could impair reliability when connected, as suggested, in series with the existing thermostat. However, if I did not "highlight" this precaution sufficiently in the article, let me stress it now. A number of hobbyists experiment with electronics C.H. control, and look upon published material as further input, which is why I emphasised safety in general.

We accept the fact that "mechanical" equivalents to circuits published in Practical Electronics often do exist; as in "timers" for example. The clamp-on cylinder thermostat will not be as cheap if a professional is called in to install it—which I presume is advocated. The electronics enthusiast will argue that his approach paves the way to more flexible programming, making it possible to consider a timer that not only turns the C.H. system on and off, but which permits a programme of differing temperatures etc.

Failure modes should obviously be taken into account, and the article did underline this, hopefully to benefit also the hobbyist with his own ideas. But whether or not magazines should publish projects with which someone could have an accident, is a broader issue. I am sure the d.i.y. brand of hobbyist generally knows his own limitations and has the sense to avoid activities about which he has doubts.

M.A.

PE micro-file

R.W.Coles

FILESHEET 14 8073

IT would appear that about the only thing the various single-chip microprocessor families have in common is that they are all different! This month we are going to take a look at the gospel according to National Semiconductor as expounded by their 8070 family, and as usual there are a few surprises in the approach they have taken.

At first sight National appear to have been an also-ran in the great microprocessor race, because although they have produced a number of original chip designs, they have never become a serious challenge to the Intel-Motorola-Zilog "Big three", and have probably made more money from second-sourcing Intel designs such as the 4040, 8080, and 8048 than they have from the chips from their own stable. Whether this somewhat mediocre performance is a reflection on the quality of their designs or whether it is due to shortcomings in their marketing policy I cannot say, but it will be interesting to see how their latest offering, the very powerful 16 bit NS16032 fares in the coming months.

The first National microprocessor to achieve popular prominence was the 8 bit SC/MP, which pioneers in the microprocessor hobby field may remember as one of the first devices to become available in hobby kit form. I certainly remember reviewing for P.E. one of the first evaluation kits in the country, and I remember being impressed by its "generous" provision of 512 bytes of ROM based monitor software and its 256 byte RAM area for user programs. All of that squeezed onto just *one* single Eurocard! Of course, that was in the antediluvian days of 1976 or 1977 and things have changed a lot since then. The PMOS SC/MP caught on quite well, especially in Europe, and was soon followed by a 5 volt NMOS version, the SC/MP 8060, but in the end its limited processor performance and restrictive 12 bit direct addressing range caused it to lose ground to the competing Intel and Motorola processors.

National did not abandon the basic architecture of the 8060 however, and in 1980 they introduced the 8070 family which features extended performance and the capability to use an on-chip ROM and RAM array, a logical move since the original 8060 had proved most successful in the low cost controller applications most suited to single chip processors.

One of the most successful features of the 8060 family was its suitability for use in multi-processor systems thanks to an extensive set of control inputs and outputs, and it was decided to retain this feature on the 8070. A decision was also made to have separate non-multiplexed data and address busses, using 24 pins in all, and this, combined with the extensive control facilities, left only five pins available for I/O use.

This lack of the usual complement of parallel I/O ports puts the 8070 family on the fringes of the single chip processor scene, and makes the use of external I/O chips a necessity in most applications, but despite this apparent disadvantage there are certainly plenty of jobs in which the particular characteristics of the 8070 family make it the most suitable choice.

There are currently three devices in the family, the 8070 itself which has 64 bytes of on-chip RAM but no ROM, the 8072 which has 2·5K bytes of masked ROM for high volume applications, and the 8073 which is an 8072 with the ROM preprogrammed with a monitor and a Tiny BASIC interpreter, in the style of the Zilog Z8671 discussed last month. All three chips have the same basic internal architecture, instruction set, and pin connections, and all feature an 8 bit data bus, a 16 bit address bus and a 16 × 16 bit hardware multiplier/divider.

The 8070 and 8073 are both usable for hobby applications, but there seems to be little to recommend the multichip 8070 solution over competitive devices unless a potential user suffers from 8060 nostalgia! Since there is no EPROM version I have chosen to feature the 8073 which is one of the two devices available which feature on-chip BASIC (the other being the Z8671).

Even when programming in BASIC, it is desirable to know something about the internal architecture of the chip itself, and so these details, common to the whole family are given as usual. Details of the BASIC interpreter which is of course specific to the 8073, are given in the Software section.

As you may have expected, the launch of the on-chip BASIC 8073 caused quite a surge of interest and more requests for data sheets than had ever been received for any previous National product. This must have generated mixed feelings at National, because data mailings are expensive and they must have realised that most recipients were either just plain curious, or were serious potential customers who would ultimately buy only one or two devices, since a device programmed in BASIC is not a cost effective solution for high volume applications.

Still, their loss is our gain, since a single-chip processor programmable in BASIC is an excellent choice for many one-off hobby applications!

REGISTERS

The original 8060 register set is carried through into the 8070 family with little change, although some names have been changed to reflect improvements in register usage and flexibility. The new family uses a single 8 bit accumulator register which acts as the implied source or destination for many instructions in typical first generation style, but this has been extended by means of an additional 8 bit register called the Extension register (E) which can be used either by itself as a temporary data store, or together with the accumulator to form the 16 bit EA accumulator for 16 bit operations.

There are five 16 bit registers, two of which are the Program Counter (PC) and the Stack Pointer which are quite conventional. There are two pointer registers (P2 and P3), which would be called index registers in most other processors, and finally something a little different, the Temporary (T) register which is needed for the 16 bit multiplier or divisor in multiplication or division operations, and can also be used as a general purpose 16 bit data store.

The only other user accessible register is the Status register (S), and this contains the eight flag bits as shown on the file sheet. Five of the flag bits are used for the two input lines, SA and SB, and the three output lines F1, F2 and F3, which are the closest the 8070 family comes to having any parallel I/O capability on-chip.

The only other flags available are the conventional Carry (CY), Overflow (OU), and Interrupt Enabled (IE), which means that there are no zero, sign, or auxiliary carry flags. No doubt the zero and sign functions can be simulated easily enough, but the lack of an auxiliary carry flag has the potentially serious implication that no direct BCD arithmetic is possible. Fortunately however, there is no requirement for BCD arithmetic when using the 8073's Tiny BASIC, and so there is no need to worry too much about this feature unless the use of an 8070 is being considered.

Apart from the above mentioned flag limitations, the 8070 family has quite a useful complement of registers.

INSTRUCTION SET

Although the 8070 family instruction set has obvious links with the earlier SC/MP 8060 set, there are some deletions and several useful additions.

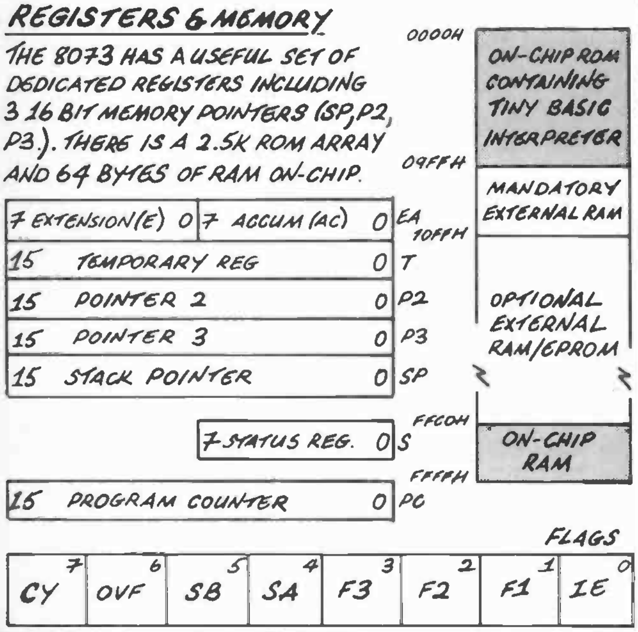
8073 REFERENCE FILE SHEET

GENERAL

The 8073 is a member of the National Semiconductor range of 8 bit NMOS processors which has been developed from the earlier SC/MP 8060 family. The 8073 has the outstanding feature of an on-chip Tiny BASIC interpreter stored in 2.5K bytes of ROM and is designed for low cost controller applications which do not require the high speed of machine code. Unlike most other single chip microprocessors the 8073 has very few on-chip I/O lines, but it does have extensive control features to allow multiprocessing.

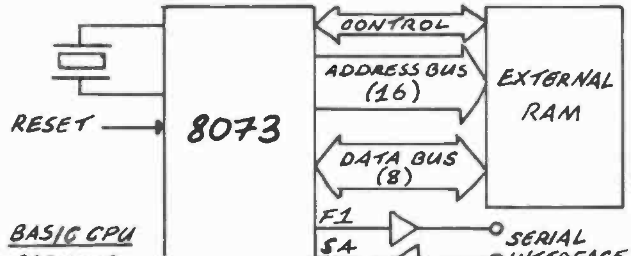
REGISTERS & MEMORY

THE 8073 HAS A USEFUL SET OF DEDICATED REGISTERS INCLUDING 3 16 BIT MEMORY POINTERS (SP, P2, P3). THERE IS A 2.5K ROM ARRAY AND 64 BYTES OF RAM ON-CHIP.



INSTRUCTION SET AND SOFTWARE

The machine code instruction set of the 8073 is identical to that of the other chips in the family and contains some very useful features such as signed 16 bit multiply and divide instructions. The Tiny BASIC is based on National's earlier NIBL interpreter, offers 16 bit integer arithmetic, a useful set of control orientated BASIC statements and functions, and allows the use of embedded machine code routines if required.



BASIC CPU CIRCUIT

PERFORMANCE DATA 8073

MEMORY ADDRESS RANGE: 64KB

I/O ADDRESS RANGE : MEMORY MAPPED

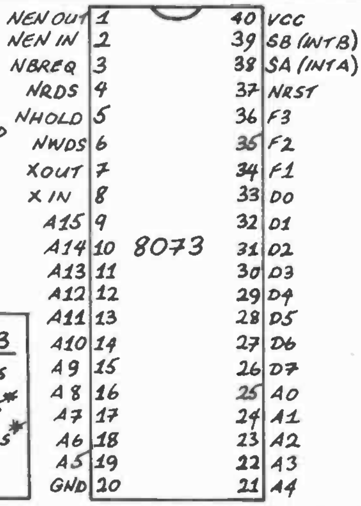
CLOCK FREQUENCY : 4MHz

POWER SUPPLIES : 5V

INTERRUPTS : INTA, INTB

BENCHMARKS	8073
ADD REGISTER TO ACCUM.	4μs
O/P ACCUM TO PORT	7μs*
MOVE FROM MEMORY TO MEMORY	14μs*

* DIRECT (8BIT) MODE



OTHER FAMILY MEMBERS

8060	(SC/MP) this device was the predecessor of the 8070 family but had limited addressing and no on-chip memory
8070	Basic family member with 64 bytes of RAM but no ROM.
8072	Like 8073 with 2.5K of on-chip ROM but without Tiny BASIC. For mass production applications.

MANUFACTURERS

ORIGINATOR : NATIONAL SEMICONDUCTOR

2ND. SOURCE : AMD

SUPPORT CHIPS

UNLIKE THE 8748, 68701 AND Z8 THE 8073 DOES NOT HAVE MUCH ON-CHIP PARALLEL I/O CAPABILITY BUT CAN INTERFACE TO THE 8080 PERIPHERAL CHIP FAMILY EXTERNALLY. ALTHOUGH THERE ARE 64 BYTES OF RAM ON-CHIP, THE 8073 NEEDS AT LEAST 256 BYTES OF EXTERNAL RAM.

INSTRUCTION SET SUMMARY

INSTRUCTION	MNE-MONIC	FIRST OPERAND	SECOND OPERAND	OPERATION PERFORMED
LOAD	LD	A		(A)←(addr)
		EA		(EA)←(addr + 1, addr)
		T		(T)←(addr + 1, addr)
		SP		(SP)←(PC + 2, PC + 1)
		P2		(P2)←(PC + 2, PC + 1)
		P3		(P3)←(PC + 2, PC + 1)
		A	E	(A)←(E)
		E	A	(E)←(A)
		A	S	(A)←(S)
		S	A	(S)←(A)
		EA	PC	(EA)←(PC)
		EA	SP	(EA)←(SP)
		EA	P2	(EA)←(P2)
		EA	P3	(EA)←(P3)
		SP	EA	(SP)←(EA)
		P2	EA	(P2)←(EA)
		P3	EA	(P3)←(EA)
		T	EA	(T)←(EA)
		EA	T	(EA)←(T)
STORE	ST	A		(A)→(addr)
		EA		(AE)→(addr + 1, addr)
ADD	ADD	A		(A)←(A) + (addr)
		A	E	(A)←(A) + (E)
		EA		(EA)←(EA) + (addr + 1, addr)
SUBTRACT	SUB	A		(A)←(A) - (addr)
		A	E	(A)←(A) - (E)
		EA		(EA)←(EA) - (addr + 1, addr)
MULTIPLY	MPY	EA	T	(EA)←[(EA) *(T)] 31:16, (T)←[(EA) * (T)] 15:0
DIVIDE	DIV	EA	T	Quotient: (EA)←[(EA / (T)] 15.0 Remainder: (T)←[(EA) / (T)]
AND	AND	A		(A)←(A) ∧ (addr)
		A	E	(A)←(A) ∧ (E)
		S		(S)←(S) ∧ data
OR	OR	A		(A)←(A) ∨ (addr)
		A	E	(A)←(A) ∨ (E)
		S		(S)←(S) ∨ data
EXCLUSIVE-OR	XOR	A		(A)←(A) ⊻ (addr)
		A	E	(A)←(A) ⊻ (E)

INSTRUCTION	MNE-MONIC	FIRST OPERAND	SECOND OPERAND	OPERATION PERFORMED
EXCHANGE REGISTERS	XCH	A	E	(A)←→(E)
		EA	SP	(EA)←→(SP)
		EA	P2	(EA)←→(P2)
		EA	P3	(EA)←→(P3)
SHIFT RIGHT	SR	A		(Ai)→(Ai-1), i = 7, 1, 0→A7
		EA		(EAi)→(EAi-1) i = 15, 1; 0→EA15
SHIFT RIGHT WITH LINK	SRL	A		(Ai)→(Ai-1), i = 7, 1, CY→A7
ROTATE RIGHT	RR	A		(Ai)→(Ai-1); i = 7, 1, A0→A7
ROTATE RIGHT WITH LINK	RRL	A		(Ai)→(Ai-1), i = 7, 1, A0→CY→A7
SHIFT LEFT	SL	A		(Ai+1)←(Ai), i = 6, 0, 0→A0
		EA		(EAi+1)←(EAi), i = 14, 0, 0→EA0
SEARCH AND SKIP IF CHARACTER MATCHED	SSM			See Text
BRANCH IF NOT DIGIT	BND			If (A) ≠ ASCII (PC)← addr If not digit, 7 or 9, If digit 7
PUSH	PUSH	A		(SP)←(SP) - 1, ((SP))←(A)
		EA		((SP)) - 1←(E), ((SP)) - 2←(A); (SP)←(SP) - 2
		PC		((SP)) - 1←(PCH); ((SP)) - 2←(PCL), (SP)←(SP) -2
		P2		((SP)) - 1←(P2H), ((SP)) - 2←(P2L), (SP)←(SP) - 2
		P3		((SP)) - 1←(P3H); ((SP)) - 2←(P3L), (SP)←(SP) - 2
PUSH AND LOAD IMMEDIATE	PLI	P2		((SP)) - 1←(P2H); ((SP)) - 2←(P2L), (SP)←(SP) - 2, (P2H)←byte 3, (P2L)←byte 2
		P3		((SP)) - 1←(P3H), ((SP)) - 2←(P3L), (SP)←(SP) - 2, (P3H)←byte 3, (P3L)←byte 2
POP	POP	A		(A)←((SP)), (SP)←(SP) + 1
		EA		(A)←((SP)), (E)←((SP)) + 1, (SP)←(SP) + 2
		P2		(P2L)←((SP)), (P2H)←((SP)) + 1, (SP)←(SP) + 2
		P3		(P3L)←((SP)), (P3H)←((SP)) + 1 (SP)←(SP) + 2
BRANCH UNCONDITIONAL	BRA			(PC)←(PC) + disp
BRANCH POSITIVE	BP			If (A) > 0 (PC)←(PC) + disp
BRANCH ZERO	BZ			If (A) = 0 (PC)←(PC) + disp
BRANCH NOT ZERO	BNZ			If (A) ≠ 0, (PC)←(PC) + disp
JUMP UNCONDITIONAL	JMP			(PCH)←byte 3, (PCL)←byte 2
JUMP TO SUBROUTINE	JSR			((SP)) - 1←(PCH)←byte 3 ((SP)) - 2←(PCL)← byte 2, (SP)←(SP) - 2
CALL	CALL	0 - 15		((SP)) - 1←(PCH)←(021 + 2*N), ((SP)) - 2←(PCL)←(020 + 2*N), (SP)←(SP) - 2
RETURN	RET			(PCL)←((SP)), (PCH)←((SP)) + 1, (SP)←(SP) + 2
LOAD PC	LD	PC	EA	(PC)←(EA)
EXCHANGE PC	XCH	PC	EA	(PC)←→(EA)
INCREMENT AND LOAD	ILD	A		(A), (addr)←(addr) + 1
DECREMENT AND LOAD	DLD	A		(A), (addr)←(addr) - 1
NO OPERATION	NOP			(PC)←(PC) + 1

Gone are the flag manipulations (Carry Set and Clear, Interrupt Enable and Disable) and these functions now have to be performed by means of logic instructions operating on the status register. Also missing are the unique SC/MP Delay instruction, which now has to be simulated with a counter loop, and the decimal arithmetic operators which represent a more serious loss.

Improvements include the inclusion of a true Jump to Subroutine Instruction, Push and Pop stack instruction, and a new one byte Call instruction which operates like JSR but uses up to 16 fixed vectors as indirect jump addresses, just like the 8080 style Restart. The new signed 16 bit Multiply and Divide instructions are particularly useful for high level language operation of course, and the unique "Search and Skip if character Matched" (SSM) and "Branch if Not DIgit" (BND) appear to have been included with the needs of the 8073 BASIC interpreter very much in mind.

The SSM instruction searches through a 256 byte memory block for a character that matches the accumulator contents using the P2 or P3 register as a pointer. When a match is found the following two program bytes are skipped and the chosen pointer register indicates the address of the matching byte, very useful for interpretive programming.

The BND instruction tests the ASCII character in the accumulator to see if it corresponds to one of the ASCII decimal digit codes (30H to 39H). If it does not then a PC relative branch is executed, but if it does the ASCII character is converted into its binary equivalent (00H to 09H) thus saving several program steps. A useful feature for keyboard orientated applications.

There are 192 instruction types in the 8070 set, supplemented by a useful set of 9 addressing modes including Implied, Immediate, Direct Absolute, Indirect, Indexed, Auto Indexed, Program Counter Relative, and Pointer Relative. All in all, quite a useful instruction set with some nice features.

SOFTWARE

The 8070 family is intended mainly for controller applications and does not aspire to the dizzy heights of a common user software base or a disc operating system, so this section will be devoted to a description of the 8073 Tiny BASIC interpreter.

Tiny BASIC is not intended for general purpose data processing applications of course, because it has only integer arithmetic, no array capability and only limited string handling. It is mainly useful for the rapid creation and testing of controller type programs as an alternative to assembly language, and is a boon wherever the fatal flaw of slow operation can be tolerated (tens of milliseconds rather than the hundreds of microseconds possible with an assembly language version).

The 8073 contains the complete Tiny BASIC interpreter and system monitor code within its 2·5K bytes of on-chip ROM, and needs only some external RAM and an RS232 interface to a terminal to function as a complete system. The external RAM must total at least 256 bytes, plus any additional amount required to hold the user program (a bytewide 2K x 8 RAM such as the Mostek 4802 would be ideal). No external UART is required because the system monitor contains routines which emulate a UART, making F1 the serial output, F2 a "ready" flag, and SA the serial input. Baud rates of between 110 and 4800 are handled by the monitor and can be selected by programming the D1 and D2 bits of memory or I/O location FD00H appropriately. If bit D7 of the same location is set to zero, the monitor I/O routines are not used, but instead a branch is made to user supplied routines located at addresses stored in FD01H/FD02H for character output, and FD03H/FD04H for character input. This useful facility allows the connection of other types of character I/O device (such as a parallel ASCII keyboard and LED display) if required. Note however, that the user subroutines have to be in machine code, not BASIC!

When the 8073 is powered up or reset the Tiny BASIC automatically performs a memory search to find the address range of any external RAM which is connected as a contiguous block above 1000H. After locating the RAM area and extent, Tiny BASIC then tests location 8000H to see if it is RAM. If it is, COMMAND mode is entered and user inputs via the terminal are awaited. If it is not, the interpreter will assume that an EPROM based BASIC program resides there and execution will be attempted. If there is not an EPROM program resident, the execution attempt will be aborted and COMMAND mode will be entered.

This feature makes possible the creation of stand-alone, BASIC programmed control systems, which need not use a terminal (for example a central heating controller). Programs can be developed using RAM and a terminal, then blown into EPROM for continued automatic use.

In program development (or RAM) mode, the user is required to initialise the system by entering two commands as follows:—

NEW (ADDRESS)
NEW Carriage Return.

These commands establish the start and end addresses for the new program which can then be entered, with line numbers, in the normal way.

In addition to NEW, the RUN, CONT (Continue), and LIST commands are available.

A useful range of BASIC statements is catered for, as follows:

REM anything: Remark (no operation).

CLEAR: Initializes all variables to 0, disables interrupts, and resets all stacks (GOSUB FOR-NEXT DO-UNTIL).

(LET) var = expr: Assigns expression value to variable.

(LET) STAT = expr: Sets the STATUS word equal to the least significant byte of "expr." When the STATUS word is used to enable interrupts at the hardware level, interrupt processing will be deferred for one statement.

(LET) @ factor = expr: Sets the memory location pointed to by 'factor' equal to the least significant byte of 'expr.'

(LET) $ factor = "string": Assigns a string in RAM starting at the address 'factor.' Strings are terminated by a carriage return.

(LET) $ factor = $ factor: Memory to memory assignment (copy).

PRINT expr: Prints the value of 'expr.'

PRINT "string": Prints the string.

PRINT $ factor: Prints the string starting at the memory address 'factor.'

IF expr (THEN) statements: Remainder of the program line is executed if 'expr' is true (non-zero).

FOR var = expr TO expr (STEP expr): FOR loop initiation. Loops may be nested to four levels.

NEXT var: For loop termination.

DO: DO loop initiation. DO loops may be nested to eight levels.

UNTIL expr: DO loop termination.

GO TO expr: Transfer control to statement number 'expr.'

GO SUB expr: Call subroutine at satement number 'expr'. Subroutines may be nested to eight levels.

RETURN: Return from subroutine.

INPUT var: Read value from console into variable.

INPUT $ factor: Read string from console into memory beginning at address 'factor.'

LINK expr: Links to an assembly language subroutine which begins at address 'expr.' A "RET" instruction in this routine will cause continuation of the NSC Tiny BASIC program.
hprogram.

¾expr: Interrupt processing definition. When interrupt number 1 or 2 occurs, NSC Tiny BASIC will execute a GOSUB beginning at line number 'expr.' If 'expr' is zero, the corresponding interrupt is disabled at the software level.

DELAY expr: Delay for 'expr' time units (nominally milliseconds. 1–1040). DELAY 0 gives the maximum delay of 1040 milliseconds.

STOP: Terminate program execution. A message is printed and the Microinterpreter returns to COMMAND mode.

Note the useful machine code LINK statement, ON 1 or 2 interrupt handler, and the DELAY capability, each of which make the 8073 BASIC ideal for control applications.

All arithmetic is performed in 16 bit signed integer format (−32768 to +32767) and the following operators and functions are provided:—

Arithmetic operators: addition, subtraction, multiplication, division

Relational operators: less than, greater than, equal to, not equal to, less than or equal to, greater than or equal to

Logical operators: logical AND, logical OR, logical NOT

FUNCTION SUMMARY

@ factor: The memory/peripheral address for memory–I/O read/write operations.
STAT: STATUS register.
TOP: Top-Of-Program address (first available memory address after end-of-program byte).
INC (x), DEC (x): Increment or Decrement a memory location (non-interruptable for multiprocessing).
MOD(x,y): Modulus function (remainder of x/y).
RND(x,y): Random number generator (in interval x,y).

There can be little doubt that the 8073 represents an excellent way into do-it-yourself microprocessor applications.

INTERFACING

The 8070 family all run from a single 5 volt supply and have on-chip clock oscillators to keep external components to a minimum.

A full set of control lines are provided to allow the design of multi-processor systems sharing a common memory and I/O bus, as follows:—

NWDS	tri-state output similar to the $\overline{WR}$ line of 8080 style processors.
NRDS	tri-state output similar to the $\overline{RD}$ line of 8080 style processors.
NENIN	when this input is low, the 8070 is allowed access to the bus. When set high by another device such as a second 8070 or a DMA chip the 8070 is denied bus access.
NENOUT	This active low bus enable output provides a "bus-grant" to other devices which require bus access.
NBREQ	A bi-directional input/output which accepts bus requests from other devices as an input when set high, and generates an own-request when set low.

When required, for example in DMA or multiprocessor systems, the extensive set of internal 8070 bus control logic can save a considerable number of external gate packages.

Two interrupt inputs are available on the 8070 family of processors by utilising the two sense lines SA and SB, called INTA and INTB when used for this purpose. Both interrupt lines are disabled when the IE flag in the status register is set to zero, and the SA SB flag bits can be used as program readable inputs.

When used as interrupts (IE = 1) INTA has higher priority than INTB, but both inputs are edge triggered to remove the need for external interrupt acknowledge logic. A high to low transition on either input causes the program counter contents to be pushed onto the stack, the program counter to be set to 0004H (INTA) or 0007H (INTB), and the IE bit set to zero. The programmer is responsible for storing appropriate BRANCH or JUMP instructions in locations 0004H and 0007H, so that access to interrupt routines stored anywhere in memory can be achieved. (In the case of the 8073, this is handled automatically by the Tiny BASIC interpreter of course.)

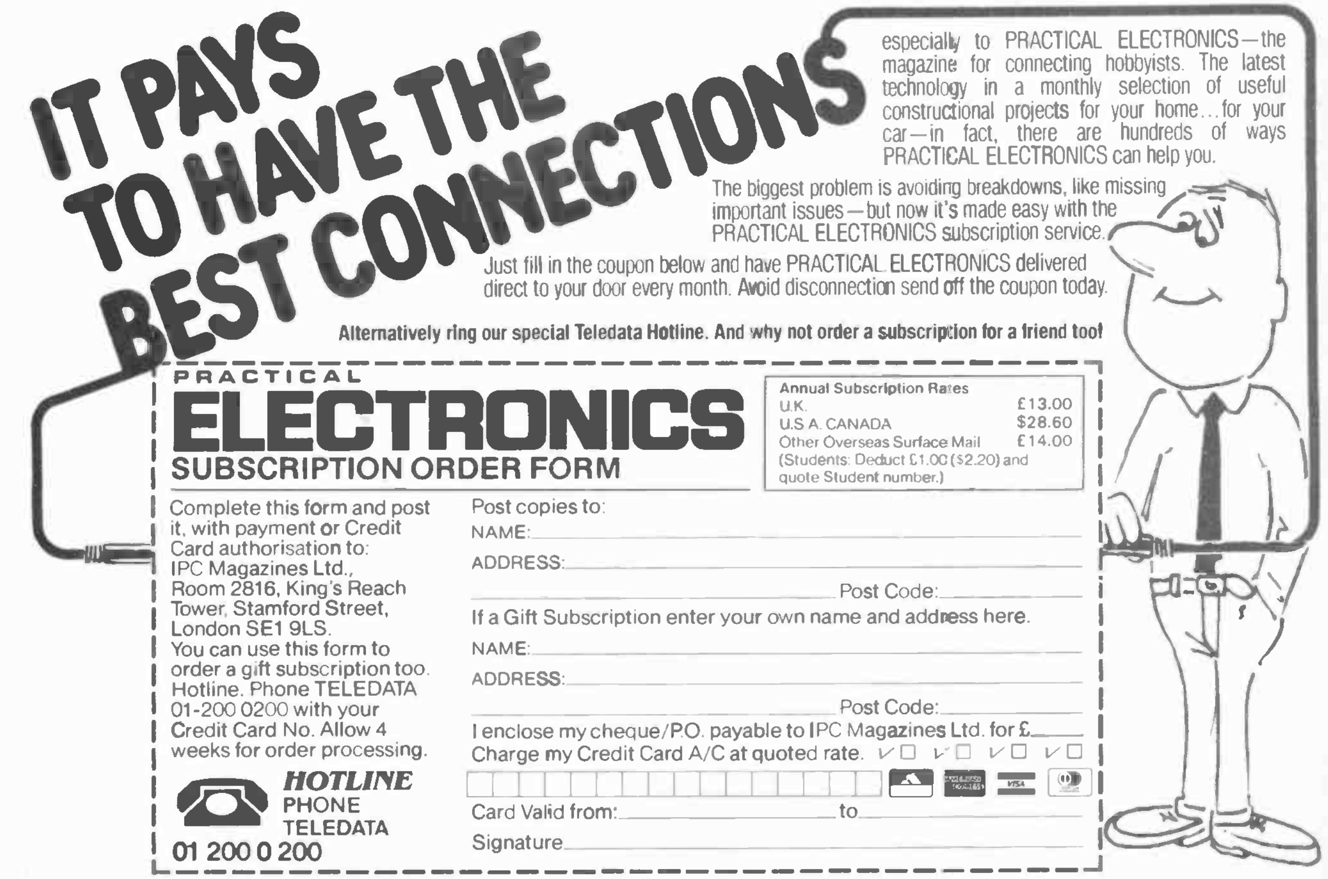
There are no special peripheral chips designed especially for the 8070 (or even the earlier 8060) family, but this is not a major drawback because most Intel 8080 peripherals can easily be used. Unlike the 8080 however, the 8070 family has no separate I/O address space and so the peripherals must be memory-mapped.

For serial I/O an external UART could be used, but a cheaper way is to implement a software UART using the sense and flag lines like that provided in the 8073 interpreter.

APPLICATIONS

The 8070 provides a useful compromise between the 8048/Z8 style "everything-on-board" single chip processors and the 6800/8080 style multi-chip solutions. It is probably not as good as the 68701 which can also provide this compromise, but it is, after all, a good deal less expensive!

I personally would not use the basic no-ROM 8070, because it has few advantages over other multi-chip processors like the 6802, but the 8073 with its on-chip BASIC interpreter is an excellent choice for hobby projects and can be recommended to everyone who wants to get into system design with the minimum financial outlay and risk. The design of a homebrew 8073 development system is quite straightforward, but for those who want to get started quickly there are a number of 8073 single board systems now available, such as the one designed by Essex University.



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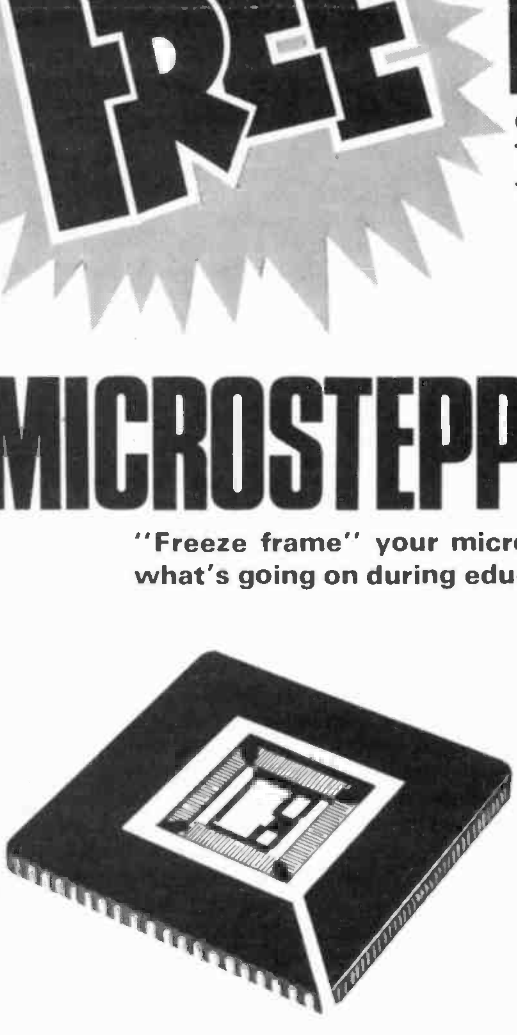


TRANSPUTER

Inmos claim the Transputer array processor will set new standards in ease of programming, provide maximum performance to the user, exploit future developments in VLSI within a compatible family and be able to form fifth generation systems with large numbers of concurrent computing elements. Next month we take a close look at the device.

PRACTICAL
ELECTRONICS

APRIL ISSUE ON SALE FRIDAY, MARCH 2, 1984

Space Watch...

EUROPEAN SPACE AGENCY PROJECT

It is proposed that the ESA should submit designs for a space station for a joint enterprise with the United States. It is expected that it will require funding of some ten million pounds. ESA would retain the option of going it alone if the United States decided not to participate. It is, however, apparent that the radical re-designing necessary for use with a single shot launcher suggests that it is better to spend the money on launching by shuttle and concentrate on space stations. The experience with Ariane may also have influenced the decision. Greater-attention is now being paid to finance when dealing with these very large projects. Of course, it is also true that new techniques are more reliable and that hardware can be built to a high standard. The source of money has realised that risks are reduced by the methods in use, it must also be remembered that failures are less likely now so that insurance rates have fallen. It is true that precise anticipation of costs is dealt with in a more efficient way, since the guesswork of the past is almost gone. There is everything to gain as far as the ESA is concerned, since cooperation has proved successful in the past and the rapid advances in know-how are available for every country.

This new venture could well be the beginning of a successful co-operative. A significant part of this study is the long, hard look approach. In principle there are three parts, the modules, the platform units and the orbital manoeuvring units.

Modules—These are pressurised segments and would be used for experiments and logistics. They could be adapted for crew living quarters, though it is possible that the USA might keep this within their own confines.

Platform units—This study will look at unpressurised components and in the main this will refer to free-flying unmanned units that could be used for materials processing and the like.

Orbital manoeuvring units—Studies of unmanned orbit transfer and space station service vehicles will be included. This valuation will be set at about £250,000 and will be carried out by the Messerschmitt-Boelkow-Blohm consortium and Erno, with the help of AEG, Aeritalia, British Aerospace, Dornier, Fokker, Matra, Sebra, Sener and Aerospatiale. West Germany and Italy have already done work to this end (Columbia programme).

COLUMBIA PROGRAMME

The study carried out by Germany and Italy was called Columbus. This was undertaken as a special study and centres on a pressurised module, capable of being docked with a station, for long duration missions. Thus it could be used as a building brick for space stations. The module could contain a docking facility, complete with pressurised docking-berthing port, and one experimental air-lock. This module would be compatible with the shuttle space orbiter's payload bay, since it will be of the standard size. A service module using a portion of the Columbus module could be developed as a support/link vehicle to the space station. It would be equipped with a Solar array that could provide power when going to and from the station. There would be a small manoeuvring system. Crew transfer would be by a manned space vehicle.

Unmanned platforms would be derived from Eureka or the German SPAS to operate from the station as free-flying carriers of scientific experiments. It is evident that commercially viable processes may be achieved effectively, as the shuttle has proved, it is already attracting finance. This is clear with the fall in insurance rates and movement to get places in the launch queue. It would be wise, for the sake of the vital experiments that science needs to continuously carry out, that the two sides get together. One way of doing itself a commercial service would be for commerce to finance science in a more extensive manner. It is true that some of the large organisations do this, but what of the smaller commercial concerns whose work is essential in the new world to come? It is essential in the long run that cooperation is the operative word, and by cooperation that it means all the nations of the world would participate.

FUEL CELLS

In the Orbiter Columbia, each fuel cell has been tested to a peak power of 16kW. Hitherto this has been at the lower level of 14/15kW, the reason for this being that the power was much more in demand for the 54 workdays of the mission of Columbia 9.

The fuel cell power and water generation system contained one-third more than previously allotted. There are three stacks of 32 cells each in the vehicle. Earlier units flew with two stacks of 32 cells each. Each cell contains hydrogen and oxygen electrodes and an electrolyte of potassium hydroxide and water. The fuel cell normally will supply 2·12kW. At 2kW per cell, each stack can supply 32·5V and 61·5A of direct current. At 12kW it can supply 27·5V at a current of 43·6A. Water is recovered from the system which is used for drinking and cooling. The designers, United Technologies Power Systems, claim that the system can be developed to supply a 24kW output and a 5,000 hour operating lifetime.

HEARING AND SPACE

Spacelab has proved an old theory of hearing originally proposed in 1914. This was related to the semi-circular canals of the inner ear. It was found that if air at different temperatures was blown into the ear, then the sensation of turning was induced, even if the person was not moving. It was believed that the cause was the different density of the air and the fluid in the semi-circular canal. Spacelab have now confirmed this theory. The investigators used the eye movements of the astronauts to assess the temperatures. Another test, which was designed to determine the adaptation of the body to weightlessness, caused motion sickness for specialist crew member Byron K. Lichtenberg, requiring the termination of a life-sciences experiment.

A further test designed by an English psychology scientist, and mentioned in a recent *Spacewatch*, was designed for estimating different densities of pairs of balls which were visually of the same size.

A partially completed experiment was undertaken by Owen Garriott and Byron Lichtenberg; it was completed by Owen Garriott only because it caused Lichtenberg pain. The object was to discover the effect of weightlessness on reflexes and posture. The method was to drag the astronaut towards the floor and slightly shock him behind the knees during his descent. In order to minimise motion sickness the crew slowed all their movements during the mission. It is believed by Garriott that the movement of the head plays an important part in solving the problem. It certainly seems that some re-thinking needs to be done on these matters. Another experiment consisted of observing a field of dots which is rotating, followed by 35mm photographs of eye movements of the reaction of the subjects. This could not be completed owing to the failure of the photoflash. There will be a report published later and this will appear in a future issue of *Spacewatch*.

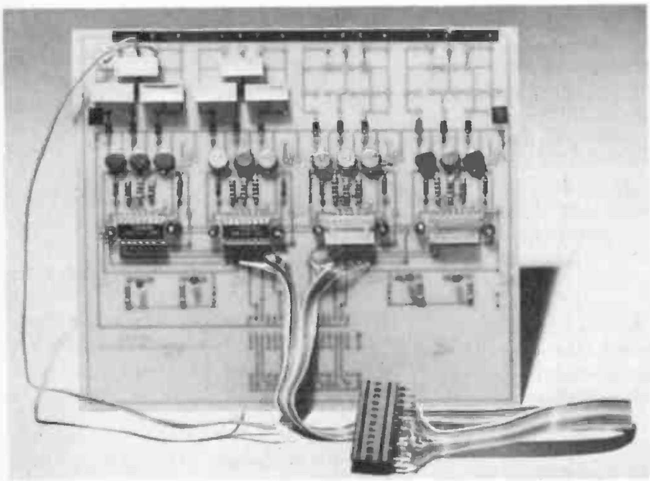
VENUS OBSERVED

There have been some reports of the Russian Space Explorer which are quite informative in that they confirm the finding of earlier space and ground-based instruments. The information is interesting for the planet has been the subject of two probes, Venera 15 and 16, which have been orbiting Venus since October. They have radar for investigating in close-up mode. It is claimed that resolution of one to two kilometres has been achieved. It needs a resolution of as good as at least one kilometre to assess the mountain elevations. If the resolution on these vehicles is less than one kilometre then we will have to wait for the publication of the results. The USA will not be ready to map at this level before 1988 or thereabouts. There are some pictures of the Soviet work around Venus. These are clear and show the general terrain, both craters and elevated land. There are large craters and considerable signs of volcanic activity. Near the pole it was noticeable that there is a large volcanic dome rising from an undulating terrain. One picture shows distinct lava flows, another shows a crater some 32 x 43 miles in size. Such pictures are only available after penetration of the cloud cover. The Soviet orbiters are able to overcome this.

EXPANDING THE VIC 20

PART FIVE SAM WITHEY

STEPPER MOTOR CONTROL . . .



FOR AROUND £29

THIS month, we first catch up on the input and output routines held over from Part 4, and then go on to look at two stepper motor control boards ideal for the robotics experimenter

Fig. 5.1. OUTPUT ROUTINE for displaying the state of ports in Binary

The following programs are not the most sophisticated, but it is hoped that they will help realise the potential of this series of interfaces.

```
05 PRINT“Shift/ClrHome”:REM Clear screen
10 POKE 37138,255:REM Set DDR to required state
15 PRINT“DDR SETTING”
18 PRINT PEEK(37138):REM Display DDR setting
19 PRINT:PRINT:REM Spaces
20 PRINT“SET I/O REGISTER”
30 INPUT X:REM To put a decimal value in I/O Register
35 IF X<0 OR X>255 GOTO 20:REM Must be 0 to 255 inclusive
40 POKE 37136,X:REM Enter value
50 PRINT“I/O REGISTER”
55 PRINT PEEK(37136):REM Display it:PRINT:PRINT
60 PRINT“STATE OF PORTS”
70 PRINT“P7 P6 P5 P4 P3 P2 P1 P0”
80 GOSUB 100:REM Go to Decimal to Binary conversion routine
90 GOTO 20:REM To reset I/O Registers
100 P0=X–INT(X/2)*2:REM Decimal to Binary conversion
105 X=INT(X/2)
110 P1=X–INT(X/2)*2
115 X=INT(X/2)
120 P2=X–INT(X/2)*2
125 X=INT(X/2)
130 P3=X–INT(X/2)*2
135 X=INT(X/2)
140 P4=X–INT(X/2)*2
145 X=INT(X/2)
150 P5=X–INT(X/2)*2
155 X=INT(X/2)
160 P6=X–INT(X/2)*2
165 X=INT(X/2)
170 P7=X–INT(X/2)*2
175 X=INT(X/2)
200 PRINT P7;P6;P5;P4;P3;P2;P1;P0
205 PRINT:PRINT
210 RETURN:Return to line 80 in program
```

The conversion program is an integer arithmetic process and should therefore be possible on even the simplest machines. The principle is to divide the decimal figure by 2 and place the remainder in the least significant bit.

e.g. 255 Decimal becomes 1 1 1 1 1 1 1 1 Binary

		P7	P6	P5	P4	P3	P2	P1	P0
255/2	Rem	0	0	0	0	0	0	0	1
127/2	„	0	0	0	0	0	0	1	0
63/2	„	0	0	0	0	0	1	0	0
31/2	„	0	0	0	0	1	0	0	0
15/2	„	0	0	0	1	0	0	0	0
7/2	„	0	0	1	0	0	0	0	0
3/2	„	0	1	0	0	0	0	0	0
1/2	„	1	0	0	0	0	0	0	0
		1	1	1	1	1	1	1	1

Similarly, 131 Decimal becomes 1 0 0 0 0 0 1 1

		P7	P6	P5	P4	P3	P2	P1	P0
131/2	Rem	0	0	0	0	0	0	0	1
65/2	„	0	0	0	0	0	0	1	0
32/2	„	0	0	0	0	0	0	0	0
16/2	„	0	0	0	0	0	0	0	0
8/2	„	0	0	0	0	0	0	0	0
2/2	„	0	0	0	0	0	0	0	0
1/2	„	1	0	0	0	0	0	0	0
		1	0	0	0	0	0	1	1

Fig. 5.2. This program makes further use of changing outputs during the running of a program

```
 05 PRINT“Shift/ClrHome”:REM Clear screen
 10 POKE 37138,255:REM Set DDR to required state
 15 PRINT“DDR SETTING”
 18 PRINT PEEK(37138):REM Display DDR setting
 19 PRINT:PRINT:REM Spaces
 20 PRINT“SET I/O REGISTER”
 30 INPUT X:REM To put a decimal value in I/O Register
 35 IF X<0 OR X>255 GOTO 20:REM (0 to 255)
 40 POKE 37136,X:REM Enter decimal value
 42 PRINT:PRINT
 45 PRINT“INITIAL STATE OF PORT”
 50 Z=X:REM Put value of X into Z
 55 GOSUB 200:REM To dec/bin conversion routine
 60 PRINT“CHANGE OUTPUT?”
 65 INPUT Y:REM Enter decimal value
 70 IF Y <0 OR Y>255 GOTO 60
 72 Z=Y:REM Put value of Y into Z
 75 GOSUB 200
 80 INPUT“YES OR NO”;A$:REM Examine output
 82 IF A$=“YES” GOTO 90:REM pattern before accepting
 85 IF A$=“NO” GOTO 60
 90 POKE 37136,Y:REM Satisfactory, so enter
 95 PRINT:PRINT:PRINT:PRINT
100 PRINT“I/O REGISTER”
105 PRINT PEEK(37136):REM Display it:PRINT:PRINT
110 PRINT“STATE OF PORTS”
120 PRINT“P7 P6 P5 P4 P3 P2 P1 P0”
130 GOSUB 200:REM To dec/bin conversion routine
140 GOTO 60:REM To reset I/O Registers
200 P0=Z-INT(Z/2)*2:REM Decimal to Binary conversion
205 Z=INT(Z/2)
210 P1=Z-INT(Z/2)*2
215 Z=INT(Z/2)
220 P2=Z-INT(Z/2)*2
225 Z=INT(Z/2)
230 P3=Z-INT(Z/2)*2
235 Z=INT(Z/2)
240 P4=Z-INT(Z/2)*2
245 Z=INT(Z/2)
250 P5=Z-INT(Z/2)*2
255 Z=INT(Z/2)
260 P6=Z-INT(Z/2)*2
265 Z=INT(Z/2)
270 P7=Z-INT(Z/2)*2
275 Z=INT(Z/2)
200 PRINT P7;P6;P5;P4;P3;P2;P1;P0:REM Display ports
205 PRINT:PRINT
210 RETURN:REM Return to line 140 in program
```

Fig. 5.3. INPUT ROUTINE for changing the DDR register and displaying the state of ports in Binary

```
 05 PRINT“Shift/Clr Home”:REM Clear screen
 10 PRINT“INITIAL DDR SETTING”
 15 PRINT PEEK(37138):REM Display it
 20 PRINT:PRINT
 30 PRINT“KEY THIS IN”
 35 INPUT D
 40 Z=D:REM Put value of D into Z
 45 GOSUB 200:REM Go to Decimal to Binary converter
    routine
 50 PRINT:PRINT
 60 PRINT“CHANGE DDR SETTING?”
 70 INPUT“Y OR N”;A$
 80 PRINT:PRINT
 90 IF A$=“Y” GOTO 300:REM To bin/dec
 95 IF A$=“N” GOTO 100:REM Carry on
100 PRINT“I/O REGISTER”
105 PRINT PEEK(37136): REM Display it:PRINT:PRINT
110 PRINT“KEY THIS IN”:PRINT:PRINT
115 INPUT Y
120 PRINT“STATE OF PORTS”
125 PRINT“P7 P6 P5 P4 P3 P2 P1 P0”
130 Z=Y:REM Put value of Y into Z
132 REM Note here that Vic 20 requires logic ‘0’ for Input and
133 REM holds lines without inputs at logic ‘1’ on simulator
135 GOSUB 200:REM To dec/bin conversion routine
140 GOTO 100:REM To reset display of I/O Registers
200 P0=Z-INT(Z/2)*2:REM Decimal to Binary conversion
205 Z=INT(Z/2)
210 P1=Z-INT(Z/2)*2
215 Z=INT(Z/2)
220 P2=Z-INT(Z/2)*2
225 Z=INT(Z/2)
230 P3=Z-INT(Z/2)*2
235 Z=INT(Z/2)
240 P4=Z-INT(Z/2)*2
245 Z=INT(Z/2)
250 P5=Z-INT(Z/2)*2
255 Z=INT(Z/2)
260 P6=Z-INT(Z/2)*2
265 Z=INT(Z/2)
270 P7=Z-INT(Z/2)*2
275 Z=INT(Z/2)
200 PRINT P7;P6;P5;P4;P3;P2;P1;P0:REM Display ports
205 PRINT:PRINT
210 RETURN:REM Return to line 140 in program
300 INPUT“ENTER BIT PATTERN :”;B$:REM Binary to
    Decimal converter
310 IF LEN(B$) <> 8 THEN PRINT“8 BITS PLEASE”
315 GOTO 300:REM Do again if wrong
320 M=0:N=0
330 FOR P=8 TO 1 STEP-1:N=N+1
340 M=M+VAL(MID$(B$,N,1))*2 (P-1)
350 NEXT P
360 PRINT B$;“=”;M
365 PRINT“KEY THIS IN”
370 INPUT M:POKE 37138,M
380 PRINT“STATE OF DDR”
390 Z=M:GOTO 45:REM Return to program
```

STEPPER MOTOR INTERFACES

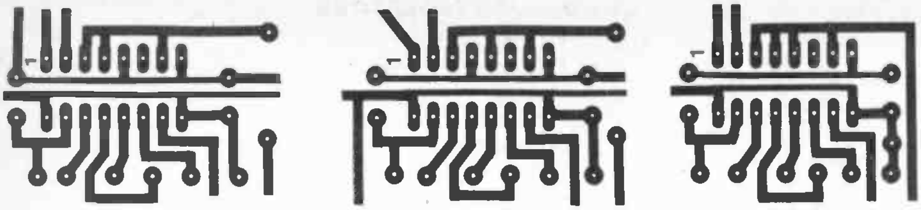
The next stage in this series concerns interfacing the computer with stepper motors, and their application in practical experiments. Two stepper motor controllers are described, with designs for two p.c.b.s which will each accommodate four controllers. This enables experimentation with XY movement involving two axes, or simple robotics having four axes, as opposed to the usual five or six axes normally found on commercial controllers, but of course, at a fraction of the cost of the latter.

The SDB520 i.c. is chosen for its versatility and power handling capabilities, whilst the SAA1027, though more limited in its application, has been a popular device in schools and colleges for several years.

The prime consideration in interfacing is always the safety of the host computer. The SDB520 and SAA1027, because of their different inherent characteristics, are treated differently where the method of electrical isolation from the computer is concerned. This is explained within the text covering the individual devices.

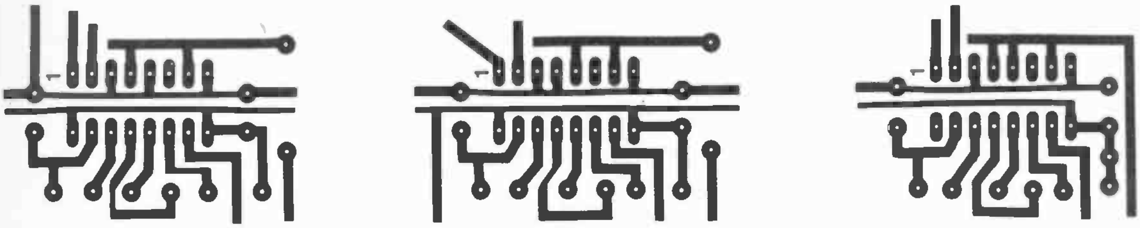
Stepper motors are available, suitable for such a wide variety of applications that it is impossible to report on them to any great extent in the space available here. A useful

Fig. 5.7. P.c.b. configurations (IC1–4) for stepper motor control 1



Single-phase excitation Dual-phase excitation Single/dual-phase excitation

4-PHASE MOTOR LINKS



Single-phase excitation Dual-phase excitation Single/dual-phase excitation

3-PHASE MOTOR LINKS

source of very cheap, yet top quality low and medium power motors is ex-equipment. This source often provides much of the hardwear required for constructing a functional machine. A visit to an Amateur Radio rally is well worth the entrance fee, as many of the advertisers in *Practical Electronics* and *Practical Wireless* attend with such bargain packages. More important, in general, these people are not just salesmen, but practical constructors who have tried the equipment out for themselves, and are free with advice on wiring and serviceability. Some general comments are therefore included which are applicable to the article.

Some programming hints are included, suggesting methods of "stepping" the motors clockwise, counterclockwise, and for angular movement where more than one motor is being operated.

Those who have constructed the l.e.d.s and switches board can use it for development of their programs as with any other output program.

THE SDB520 DRIVER BOARD

The first p.c.b. described uses the versatile SDB520 Stepper Motor Driver i.c., which can be used with 3-phase or 4-phase motors. In addition to this, the chip enables the use of either type of motor in single, dual, or single/dual phase excitation.

In order to accommodate all these functions, connections from pins 3, 4 and 5 have been left open. In all modes, pins 7 and 10 are connected via a 2k2 resistor to the +5V d.c. supply, whilst pins 3, 4 and 5 are either individually coupled with these, or taken to ground. Provision has also been made to mount capacitors between motor coils 1 and 2, 2 and 3, 1 and 3 for 3-phase motors and 1 and 3, 2 and 4 for 4-phase motors.

Opto isolated output from the computer is provided, a feature that the author normally recommends. However, in the case of the SDB520, it is well protected internally against short circuit, making opto isolation at low motor voltages and current, less necessary. It is provided for the less experienced constructor, and those who may have larger motors available.

The SDB520 uses the +5V d.c. supply from the computer, provision for external supply being made for use with computers other than the Vic 20. The outputs from the driver turn on their associated transistors sequentially, allowing current to flow through the relevant motor coil. The transistors used on the board are BFY51, 2N3053 or similar 0.7W NPN transistors that can handle up to 1A of current.

COMPONENTS . . .

STEPPER MOTOR CONTROL 1

Resistors

R1,2,6,7,11,12,17,18	2k2 (8 off)
R3,4,5,8,9,10,13–16, 19–22	100 (14 off)
R23	See note

All resistors ¼W 5%. R23 (if necessary) depends upon motors/supply voltage, and is not mounted on the board.

Capacitors

C1,6,11,15	2µ2 (4 off)
C2,7,12,16	10µ (4 off)
C3,4,5,8,9,10,13,14,17,18	1µF poly (10 off)

Transistors & Diodes

D1–14	1N4001 (14 off)
TR1–14	2N3053 or similar (14 off)

Integrated Circuits

IC1–4	SDB520 (4 off)

COMPONENTS . . .

STEPPER MOTOR CONTROL 1
Opto-coupling option (shown in comp. layout)

Resistors

R23–26,31–34	470 (8 off)
R27–30,35–37	12k (8 off)

Diodes

D15	1N4001

Integrated Circuits

IC5,6	ILQ74

Should there be a need for greater current handling, 2N3055 transistors can be mounted externally on heatsinks. Motor voltages are typically 12 to 24V d.c. and might require a small value 50W wirewound resistor at the common positive motor supply to correct L/R ratio. This information should be available with the motor.

The p.c.b. is single-sided fibre-glass, approximately 165 x 148mm, and requires short links on the upper surface. As mentioned earlier, in order to increase the versatility of the board, connections have to be made between pins 3, 4 and 5 and ground, or commoned with pins 7 and 10. A solder blob is all that is required, and this can be carried out neatly by using a single strand from multi-strand cable to bridge the gap and allowing solder to flow over it from side to side.

Pulses are supplied to two inputs, CD Counter clockwise, at pin 1 and CU Clockwise, at pin 2. A change from Low to High and back to Low will trigger the i.c. The inputs are designed with high noise margin, and comprise a Schmitt trigger circuit.

0C at pin 3 selects 3 phase, Low, or 4 phase, High, operation. EA and EB on pins 4 and 5, comprise the mode switching terminal.

EB	EA	Mode
0	0	Line drive facility
0	1	Single phase excitation
1	0	Dual phase excitation
1	1	Single/dual phase excitation

Mo at pin 6, provides a sequence monitor, low, when counter content is 000.

OFF 01·3 on pin 7 and OFF 02·4 on pin 10 provide excitation OFF or line drive input terminal, when terminals become Low without relation of sequence content, when output terminals are = 0. At pin 8 is the 0V supply terminal. Vcc2 at pin 9, the output driver power supply.

Output driver terminals are at pin 11, 4, pin 12, 2, pin 13, 3, and pin 14, 1. A clamping diode is inserted in the output.

R at pin 15 is the Reset input terminal, tied to Vcc via a 2k2 resistor. Vcc1 at pin 16 is the power supply for the logic circuit.

COMPONENTS . . .

STEPPER MOTOR CONTROL 2

Resistors

R1–4	470 (4 off)
R5,6,11,12,21,22,27,28	12k (8 off)
R7,8,13,14,23,24,29,30	4k7 (8 off)
R9,15,25,31	100 (4 off)
R10,16,26,32	150 ½W (4 off)

All resistors ¼W 5% unless otherwise stated.

Capacitors

C1–4	100n (4 off)

Diodes

D1	1N4001

Integrated Circuits

IC1,4	ILQ74 (2 off)
IC2,3,5,6	SAA1027 (4 off)

USE OF OPTO ISOLATORS

Those who have followed this series will note that the l.e.d.s in the opto isolators are turned on by making the cathode low relative to the power supply. This means, without the inclusion of inverters, that the logic is incorrect for an output on the Vic 20. For the purists this is overcome by complementing the binary pattern required at the output port and placing this value in the I/O Register.

Output required	10101010	Decimal 170
Complement	01010101	Decimal 85
Total	11111111	255

The easiest way, of course, is to treat the outputs required as inputs.

SDB520 DRIVER EXCITATION SEQUENCE

3-Phase motor excitation

Single phase

	Q1	Q2	Q3	Q4	CCW
0	1	0	0	0	↑
1	0	1	0	0	↓
2	0	0	1	0	CW

Dual phase

	Q1	Q2	Q3	Q4	CCW
0	1	1	0	0	↑
1	0	1	1	0	↓
2	1	0	1	0	CW

Single/dual phase

	Q1	Q2	Q3	Q4	CCW
0	1	0	0	0	↑
1	1	1	0	0	
2	0	1	0	0	
3	0	1	1	0	
4	0	0	1	0	↓
5	1	0	1	0	CW

4-Phase motor excitation

Single phase

	Q1	Q2	Q3	Q4	CCW
0	1	0	0	0	↑
1	0	1	0	0	
2	0	0	1	0	↓
3	0	0	0	1	CW

Dual phase

	Q1	Q2	Q3	Q4	CCW
0	1	1	0	0	↑
1	0	1	1	0	
2	0	0	1	1	↓
3	1	0	0	1	CW

Single/dual phase

	Q1	Q2	Q3	Q4	CCW
0	1	0	0	0	↑
1	1	1	0	0	
2	0	1	0	0	
3	0	1	1	0	
4	0	0	1	0	
5	0	0	1	1	
6	0	0	0	1	↓
7	1	0	0	1	CW

Sequence monitor (pin 6) is logic 0 at sequence stage 0 and logic 1 at other stages of sequence.

Pads are provided on the p.c.b. should it be wished to monitor the outputs whilst developing programs and setting up motors.

The monitor is active low, therefore when it becomes active at the beginning of each sequence, the cathode of the monitor l.e.d. is pulled down relative to the 5Vd.c. supply and comes on.

THE SAA1027 DRIVER BOARD

The SAA1027 is intended for pulse to step control of four-phase two stator motors. It is capable of driving a motor winding load of 350mA per phase and is encased in a 16 pin dual in line plastic package.

Pulses are supplied to a single input, whilst the direction of rotation is controlled by a voltage level applied to a gate input. A further input sets the four output stages. Supply voltages can be between 9·5 and 18Vd.c., but a single 12Vd.c. power supply is normally used to operate the driver

Fig. 5.4(a). Circuit diagram of SDB520 driver (3-coil motor type) annotated as in the p.c.b. layout shown below (channels A and B)

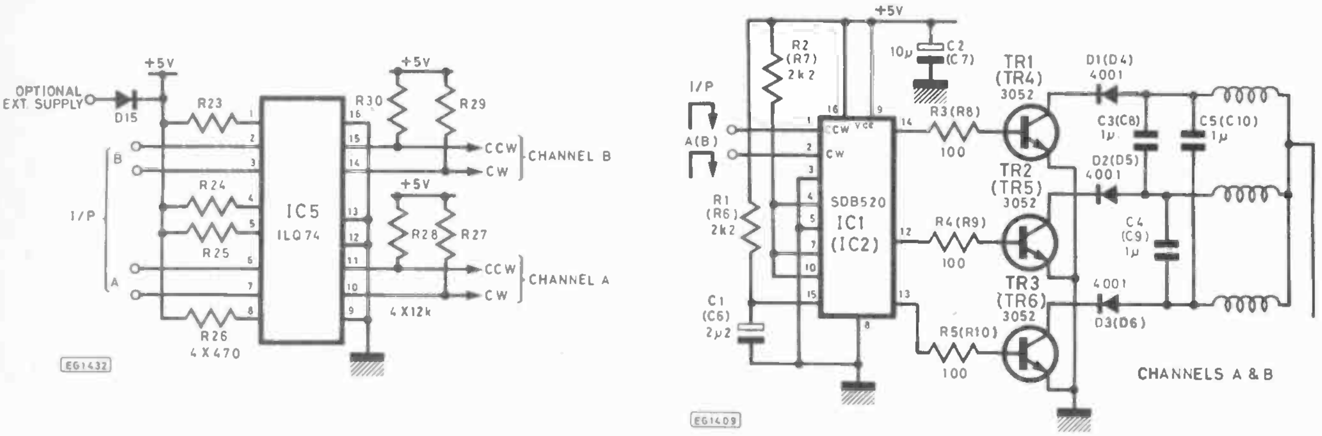


Fig. 5.5. P.c.b. layout of stepper motor control board 1. SDB520 type (actual size). This is a versatile board, designed to accommodate various component configurations. For example, the ILQ74s (IC5 & IC6) opto-isolators are optional

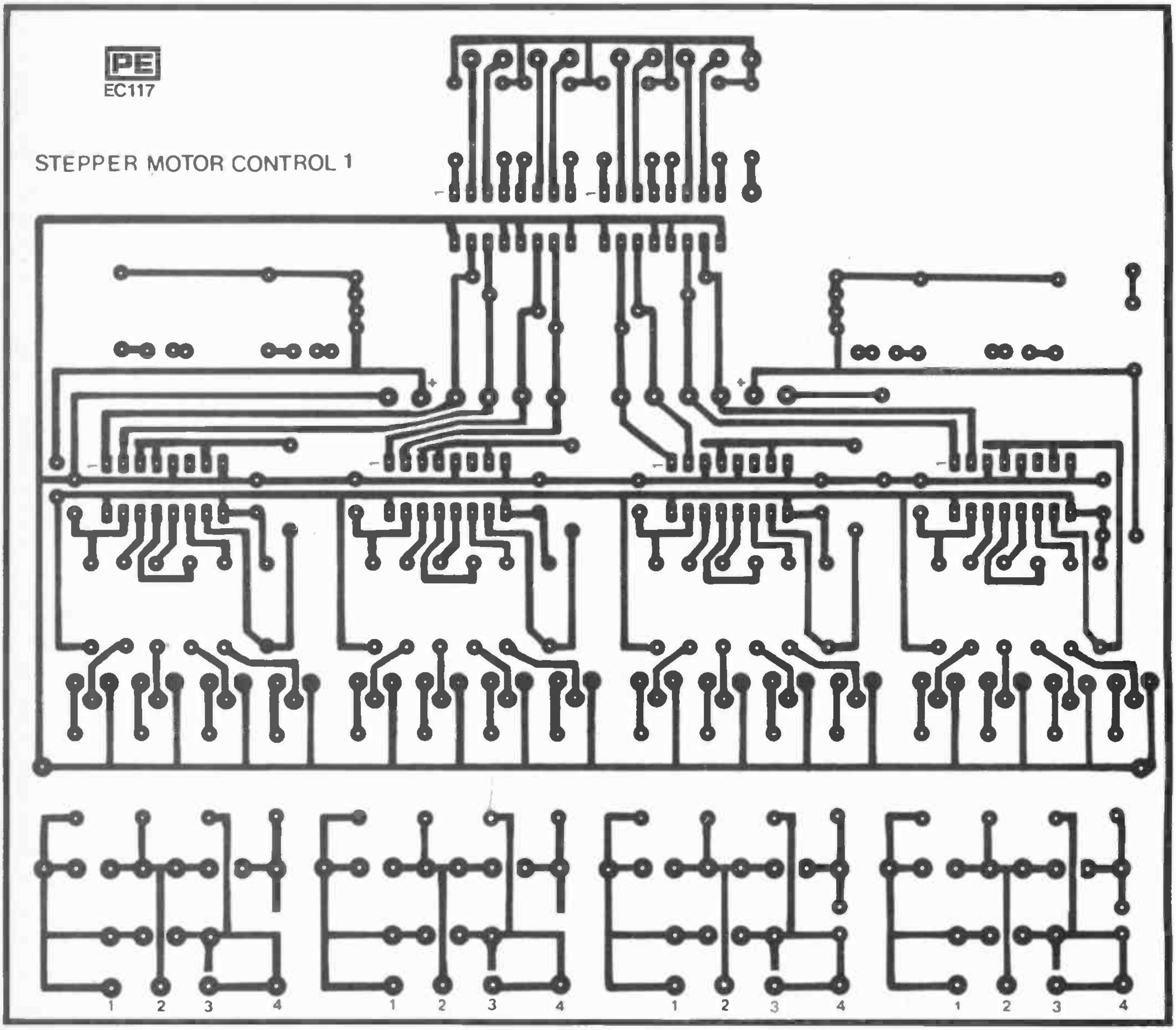


Fig. 5.4(b). Circuit diagram of SDB520 driver (4-coil motor type) annotated as in the p.c.b. layout shown below (channels C and D)

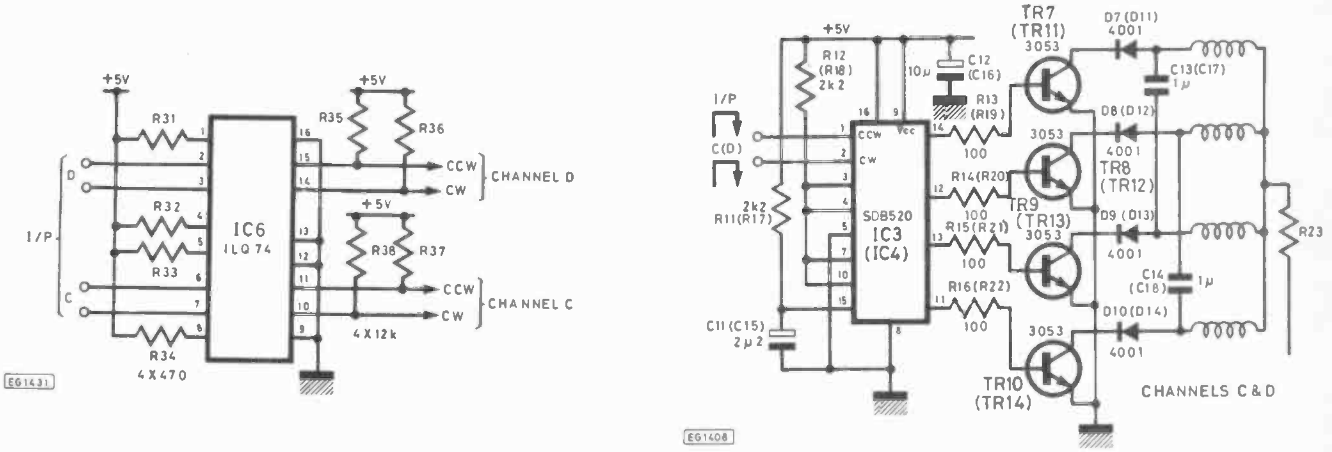
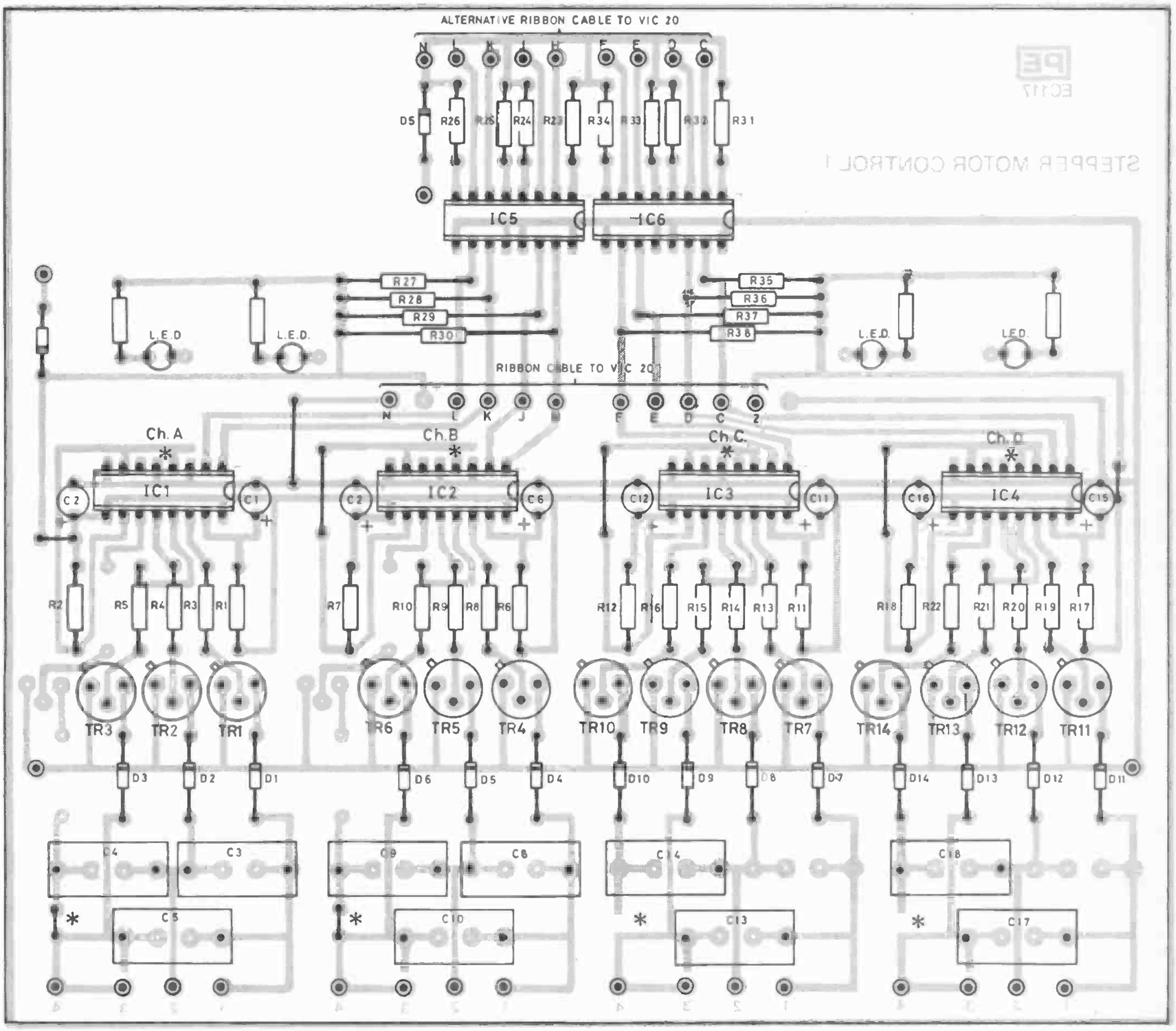


Fig. 5.6. Stepper motor control board 1 component layout, shown with channels A & B dedicated to the 3-coil configuration, and channels C & D dedicated to the 4-coil configuration. Asterisks draw attention to the link areas that allow reconfiguration. The l.e.d.s allow optional data signal monitoring



i.c. and the motor. The output drivers (pins 6,8,9,11) are open collector. The breakdown voltage is 18Vd.c. and this must not be exceeded.

Pin connections

(1) no connection
(2) Set input S
(3) Direction input (CW/CCW) R
(4) Bias resistor B (positive supply)
(5) Ground (negative supply)
(6) Q1 (output)
(7) no connection
(8) Q2 (output)
(9) Q3 (output)
(10) no connection
(11) Q4 (output)
(12) Ground (negative supply)
(13) VD (positive supply)
(14) VP (positive supply)
(15) Trigger input T
(16) no connection

INPUTS

The three inputs are controlled by applying high or low voltage levels to the terminals. The high level voltage can be between 7·5 and 18Vd.c. (12Vd.c. typical) and is normally equal to, but not greater than, the voltage on pin 14. Input current is high, typically 1µA. The low level voltage can be between 0 and 4·5Vd.c. maximum. Low level current is typically −30µA per input.

TRIGGER INPUT

The voltage on T, pin 15 is normally high when not being pulsed and is held at Vs via a 4k7 resistor. A change from high to low and back to high will trigger the i.c. The motor is connected to the output stages on the positive edge, low to high of the pulse.

SET INPUT

Pin 2, S is tied to Vs, enabling all outputs.

DIRECTION INPUT

Applying a high level to pin 3 causes the motor to be stepped CCW, whilst a low level to pin 3 causes the motor to step CW. The input is tied high via 4k7 resistor for maximum noise immunity.

BIAS RESISTOR

RB can be calculated, first from supply voltage and motor coil resistance to arrive at IQ. Then, by reference to graph, IB and VS permits calculation of RB.

When motors with current of 350mA (max) per winding are used, the bias current to pin 4 should be 80mA (max).

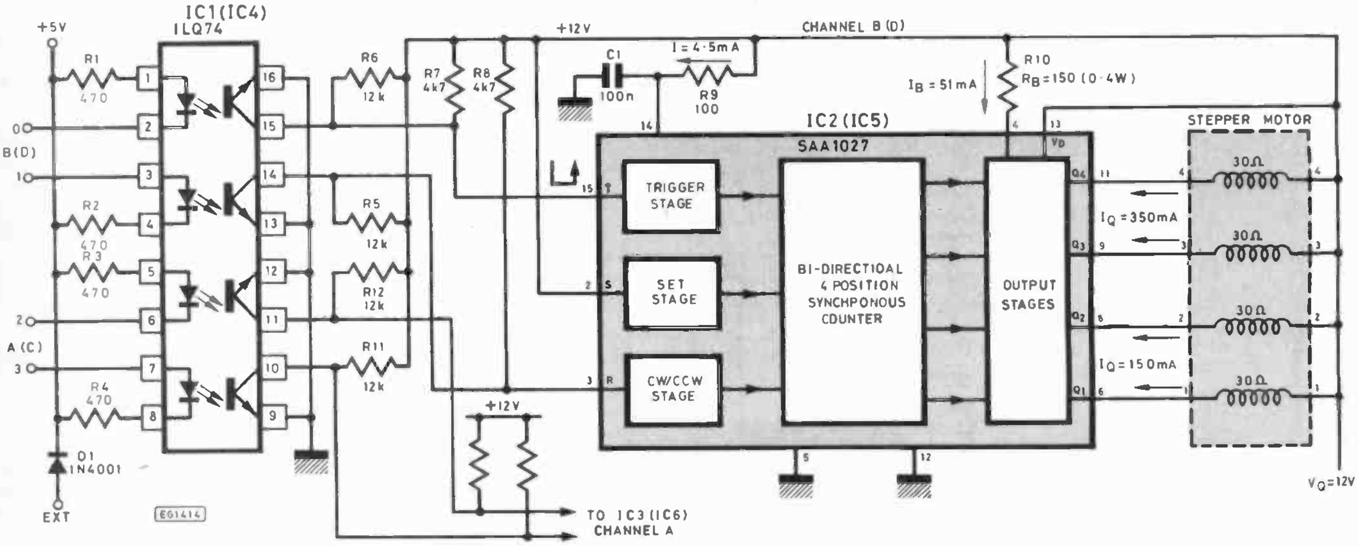
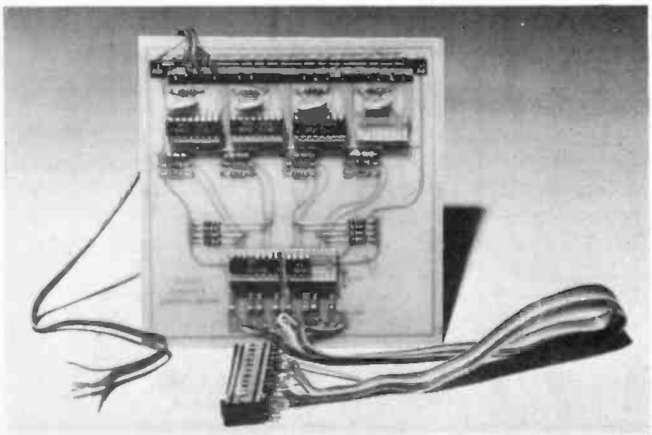


Fig. 5.8. Circuit diagram of the SAA1027 type driver board. There are four identical channels. Channel B is shown here



CHANNEL

A	B	C	D
–	R1	–	R17
–	R2	–	R18
R3	–	R19	–
R4	–	R20	–
R11	R5	R27	R21
R12	R6	R28	R22
R13	R7	R29	R23
R14	R8	R30	R24
R15	R9	R31	R25
R16	R10	R32	R26
C1	C2	C3	C4
IC3	IC2	IC5	IC6
IC1		IC4	

There are four channels. The circuit diagram shows a single channel, and this table indicates the equivalent components for the other channels.

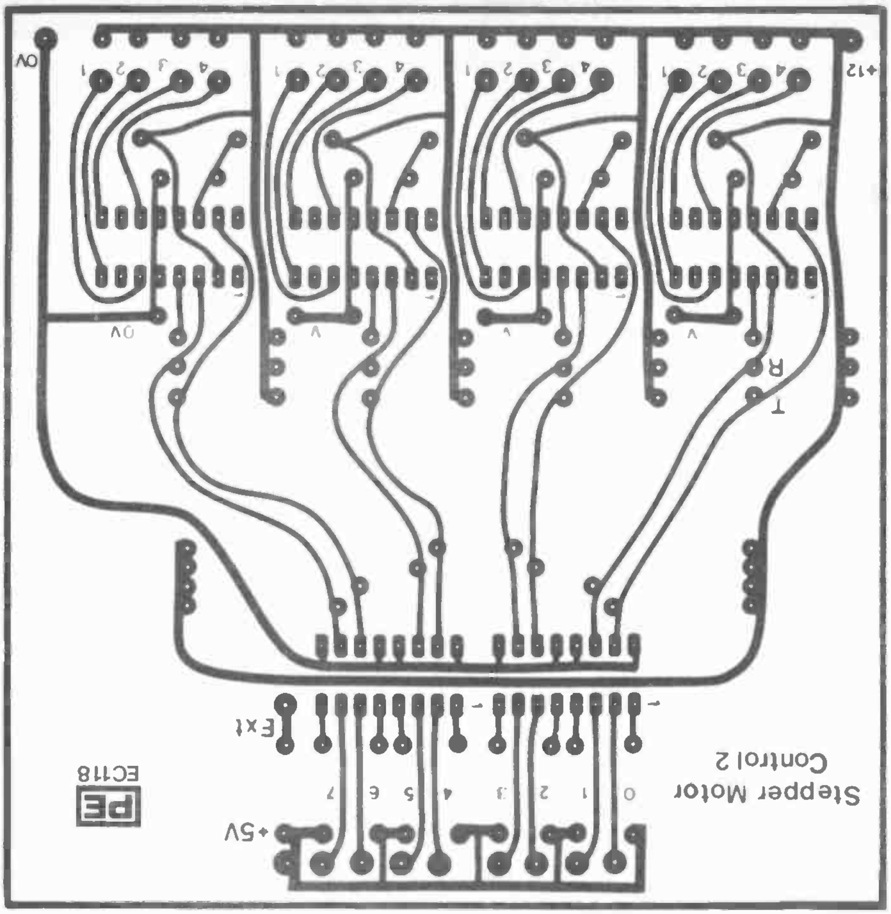
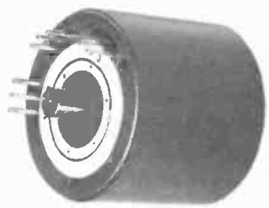
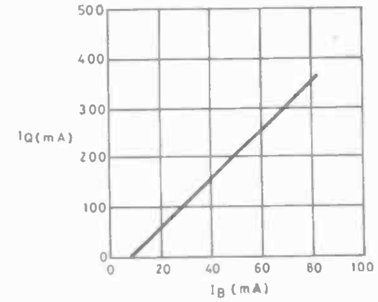


Fig. 5.9. P.c.b. layout of stepper motor control 2. SAA1027 type (actual size)

A typical surplus/ex-equipment stepper motor





Bias current and output current relationship of SAA1027 output stage

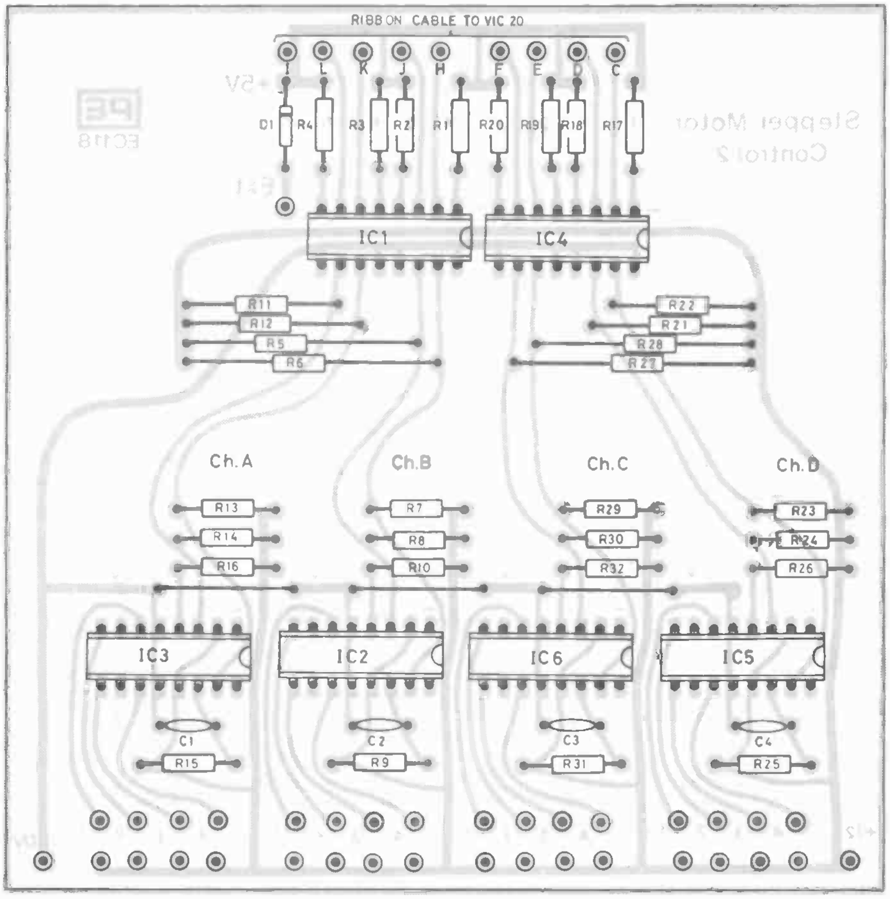
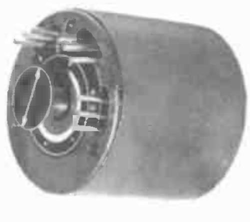


Fig. 5.10. Component layout of stepper motor control 2



Likewise, when the output current is 50mA, bias current should be 20mA. A linear graph plotted between these values is shown on page 43.

The R/C network at pin 14 stretches the pulse from trigger input, pin 15, to a length detectable by the trigger stage.

OUTPUTS

The switching sequence of the four phases is controlled by the logic part of the circuit and the four output stages, Q1 at pin 6, Q2 at pin 8, Q3 at pin 9 and Q4 at pin 11 are protected against transient spikes by integrated diodes.

OPTO ISOLATION

It is usual to use TTL Buffers between the computer and the SAA1027, but due to the danger of the maximum 18Vd.c. being exceeded, and added susceptibility of the i.c. to overheating and breakdown, it was decided to use opto isolation.

The collector of the transistor in the opto isolator is held high, at logic "1" via the 270k resistor connecting it to the power supply. When a logic "0" at the output port sinks the l.e.d. and turns it "on", the transistor is turned on also, causing the collector to go low. When the output changes back to logic "0" the l.e.d. turns off. The transistor also turns off, bringing the collector once again to high, causing excitation and creating a pulse.

Should overheating be experienced, clip-on d.i.l. heatsinks are available from most advertisers.

This board is much smaller than the SDB520 board because the driver is complete in itself and requires no external components beyond the capacitor and resistors mentioned. It is made on a 120mm square of single sided fibreglass p.c.b. Short links are required on the component side to connect the ground rails. Provision is made for an external 5Vd.c. power supply if used on a computer other than the Vic 20.

STEPPER MOTORS

A summary of various descriptions of a stepper motor would be "a direct digital motion control device that converts electrical pulses into discrete mechanical rotational movements. It possesses the ability to rotate in either direction, as well as start and stop at various mechanical, rotational positions. Its shaft moves in precise angular increments for each input excitation or step. The stepper motor allows control of position, velocity, distance and direction".

STEPPING

Due to the nature of its construction, unlike a normal free running motor, a stepper motor moves through a precisely defined arc of a complete revolution for each pulse and is held in that position until the next pulse, which moves the rotor through the same angle of rotation. Small motors usually come in 3 or 4 phase types and the number of steps to a complete revolution varies greatly, typically from 4 to 90, or angular movements varying from 90 degrees to 4 degrees.

SEQUENCE

Each phase is excited sequentially, the rotor moving in precise steps, in the same direction, for each excitation. Reversing the stepping sequence of the phases reverses the direction of movement of the rotor by the same precise angle. These processes are controlled by the internal logic of the stepper motor driver i.c.

ACCURACY

Unlike a normal motor, which keeps running after removal of power until stopped by friction, the stepper motor stops at a predictable position. Any errors of angular position are restricted to each single movement and are non-accumulative. An error of 1 degree in each and every step, no matter how many steps are performed, will be an error of just 1 degree at the end of a cycle. Accuracy varies from 0·01 degree for small steps to 5 degrees for large steps. Obviously, for precise positioning, the greater the number of steps the greater the accuracy.

In dual-excitation mode, two coils are excited simultaneously. This stops the motor in a position half-way between normal stopping positions, but because of increased holding torque gives consistent accuracy.

HOLDING TORQUE

At standstill, the torque required to deflect the motor a full step is called the Holding Torque. This is normally higher than the running torque and acts as a strong brake in holding the load. The higher the holding torque the more accurate the position of the rotor. Most stepper motors will operate at much lower voltages than that recommended by the manufacturer, but with decreased holding torque and therefore decreased accuracy. A similar situation can arise with increased step frequency due to the fact that the rise time of the coil limits the percentage of power actually delivered to the motor. The result can be incorrect starting or loss of steps. This effect is sometimes compensated for by increasing the supply voltage and including a series resistor to correct the L/R ratio of the circuit as depicted in the SDB520 4-phase schematic.

Next Month: Applications and control of stepper motor boards. Also, DAC and ADC boards.

BAZAAR

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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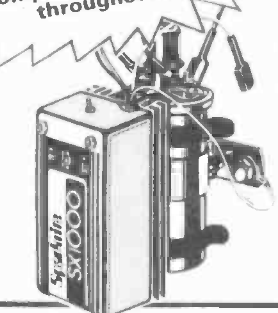


SX 1000 Electronic Ignition

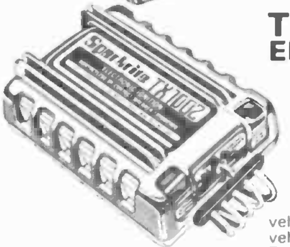
● Inductive Discharge ● Extended dwell circuit stores greater energy in coil ● Three position changeover switch ● Patented clip-to-coil fitting ● Easy to assemble, easy to fit ● Contact breaker triggered – includes bounce suppression circuit.

SUPER SAVE

SX 2000 Electronic Ignition

● Reactive Discharge ● Combines inductive & capacitive energy storage ● Gives highest possible spark energy ● Patented clip-to-coil fitting ● Easy assembly sequence ● Contact breaker triggered – includes bounce suppression circuit.

SUPER SAVE

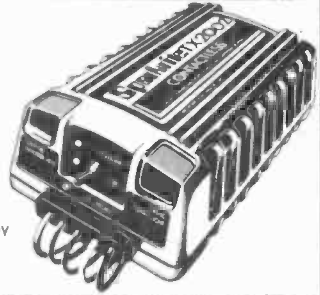


TX 1002 Electronic Ignition

● Inductive discharge ● Extended dwell circuit stores greater energy in coil ● Three position changeover switch ● Contactless or contact breaker triggered ● Clip-to-coil or remote mounting ● Rugged die-cast case ● Contactless adaptors included for majority of 4 & 6 cylinder vehicles ● Easy to build ● For details of vehicles fitted by contactless trigger, ring Technical Service Dept on (0922) 611338-9.

TX2002 Electronic Ignition

● Two separate systems in one unit! ● Reactive Discharge OR Inductive Discharge, with three position changeover switch ● Gives highest possible spark energy ● Clip-to-coil or remote mounting ● Rugged die-cast case ● Contactless or contact breaker triggered ● Contactless adaptors included for majority of 4 & 6 cylinder vehicles ● For details of vehicles fitted by contactless trigger, ring Technical Service Dept on (0922) 611338-9.



AT-40 Electronic Car Alarm

● Guards doors, boot, bonnet from unauthorised entry ● Armed/disarmed using concealed switch ● 30 second delay-to-arm: 7 second entry delay ● Can alternatively be wired to exterior key switch ● Flashes headlights & sounds horn intermittently for 60 seconds when activated ● Security loop protects accessories ● Low consumption C-MOS circuitry.

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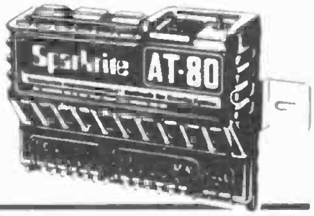

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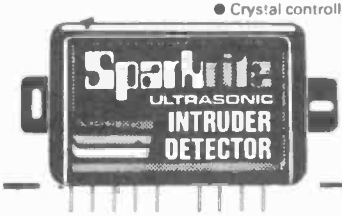

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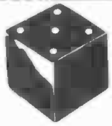

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MONOCHROME MONITOR

REVIEWED IN THIS ISSUE

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MONITORS... for Home Computers

MICHAEL TOOLEY BA **DAVID WHITFIELD** MA MSc CEng MIEE

PART TWO

THIS month we complete our brief look at monitors for home computers by reviewing two current models. The two units tested are representative of the most popular types of monitor for home computing: a high resolution monochrome monitor, and a medium resolution RGB monitor. The monitors have been reviewed primarily from a user's viewpoint, and the usual technical tests have been largely replaced by an extended practical evaluation with a BBC Micro.

NOVEX MONOCHROME MONITOR

First Impressions The Novex 12/800 is a transistorised custom-designed monochrome monitor from Taiwan. It comes well packed, and is supplied complete with a manual and a phono-to-phono lead. The manual, although rather quaintly worded in places, is well illustrated and provides all of the necessary information.

The unit has a 12-inch green (P31) phosphor display tube, and is attractively packaged in a two-tone beige and brown steel case measuring approximately 30x29x30cm. The colour scheme and styling are pleasing to the eye, and are a good match for Apple or BBC computers. The tube has a moulded surround which includes an illuminated mains switch and a door concealing a number of controls. The monitor weighs approximately 8kg, and is mounted on rubber feet. The video connectors, mains lead and two slide switches are located on the rear panel.

Front Panel The screen surround includes the illuminated mains switch, and a button to release the door concealing the preset adjustments and controls. The two screwdriver preset adjustments are for picture height and width. These are factory adjusted for optimum setting, and should therefore need little or no attention. The remaining controls are intended for user adjustment and allow setting of brightness, contrast, horizontal hold, and vertical hold. All of the presets and controls are clearly labelled.

The four controls all have a useful range of adjustment. Correct setting of the two hold controls is well described in the manual. The adjustment of contrast and brightness is not quite so well covered in the manual. The best way to perform the adjustment was easily found to be as follows. Both controls should be turned fully clockwise for the brightest possible picture; the raster should then be clearly visible. Next the brightness is reduced until the raster just disappears. Finally the contrast should be adjusted to produce an acceptable picture; the actual setting here is a matter of personal preference. Once set, little adjustment to any of the controls is necessary, and then usually only to take account of different ambient lighting conditions.

Rear Panel The mains power lead enters through a securing grommet on the monitor's rear panel. The length of this lead is a rather miserly 1·5 metres (in common, it must be said, with much other equipment); no plug is provided. Also on the rear panel are two miniature slide switches and two phono sockets, all clearly labelled. The reviewers' first reaction to the use of phono sockets was to look around for a spare pair of BNC sockets to fit in their place, but this again is a matter of personal preference.

The video input signal is connected to one of the phono sockets, and the second socket is internally connected to the input socket. This provides a video output signal which is useful for loop-through connection to more than one monitor. In order to be able to obtain the maximum video bandwidth, the video signal should be terminated (by 75 ohms) at the last monitor in the chain. A switch is provided to allow the signal to be left unterminated (high impedance for an intermediate unit), or terminated in 75 ohms (for the last or only monitor). In practice, the two phono sockets are interchangeable, and are labelled merely for convenience.

The second slide switch on the rear panel is labelled 'GRAPHICS' and 'DATA'. This allows the monitor's performance to be separately optimised for high resolution graphics and 80-column text.

Inside The Case On the rear of the case is a removable panel bearing warnings of electrical shock risk, and advising of no user servicable components. The internal construction is based on a large single-sided p.c.b. which is securely mounted on the base plate. This contains the majority of the components, and is screen printed for ease of component identification. Mounted on the base of the tube is a much smaller p.c.b. which carries the video amplifier. This is a common practice to minimise stray capacitance, and hence allow the the maximum video bandwidth to be retained.

The internal construction is very compact, and represents a utilitarian appearance in interesting contrast to the external styling. The unit is clearly a custom designed monitor, rather than a modified television chassis. The power supply incorporates a mains transformer, and has no provision for operation from an external 12 volt d.c. supply.

Looking inside the case from the rear, there are three

preset controls mounted on the edge of the main circuit board. These turn out to be (left to right): picture height, focus and black level adjustments. These are factory presets which are not intended for user adjustment.

Picture Quality In order to evaluate the picture quality, the monitor was connected to the video output of a BBC Micro. Tests were conducted using 20, 40 and 80-column text, and high resolution coloured graphics displays. The video signal was terminated by 75 ohms.

After using a black and white television, the first thing that strikes the user is the clarity of the display. The difference between the display on a monochrome television, and the display on the monitor, has to be seen to be believed. In fact going back to the television display after a number of hours of use with the monitor can cause acute frustration. The temptation is to keep trying to adjust the televison tuning to regain the 'lost' definition; a substantially fruitless exercise. It is on 80-column displays, however, that the difference is most apparent. The test is easily readable on the monitor, whereas on a television display, prolonged viewing is tiring.

The other factor which is quite noticeable is that the green phosphor has a significantly longer persistence than the white phosphor. This is quite typical of the P31 phosphor, and probably contributes to the strain-free display which can happily be viewed for many hours.

In 80-column mode the use of the 'graphics/data' switch eventually becomes clear. When switching from 'graphics' to 'data', very close observation of the screen shows that the leading edges of all characters become very slightly emphasised. This does not have any noticeable effect except on a very narrow vertical line (e.g. the centre upright of 'W'), which then becomes more clearly visible. Such lines represent very high video frequencies, and often result in a slightly fainter display, although remaining quite visible. The 'data' position appears to compensate for this effect by altering the time constant of the video amplifier to induce slight ringing. The end result is to allow the display of 80-column text to be outstandingly clear, but without compromising very high resolution graphics displays.

The overall display shows good linearity in both horizontal and vertical directions. There is no evidence of power supply problems with the display brightness, and the unit runs cool even after many hours of use. The picture focus is generally excellent, with only slight defocussing evident in the top right corner of the display. This would normally go unnoticed in everyday use. The display resolution is quoted at 1000 lines in the screen centre, and 800 lines in the corner. This is more than adequate for 80-column text, and in practice individual pixels can be distinguished (the BBC Micro uses 640 pixels per line in 80-column text mode).

The BBC Micro produces displays in up to eight colours, although black is not really a colour as such. When displayed on the Novex monitor, these colours appear as shades of green, but they are still distinguishable by virtue of their different brightness levels. In order of decreasing brightness, the colours appear as:—

WHITE	(Brightest)
YELLOW	
CYAN	
GREEN	
MAGENTA	
RED	
BLUE	
(BLACK)	(Darkest)

As delivered, the review unit was unable to display blue at all, and had some difficulty with red. However, after adjustment of the black level internal preset (not a user adjustment), all of the colours were visible and distinguishable.

VERDICT The overall impression after prolonged use (including preparing this review!) is excellent. The monitor is neat, compact, pleasant to use and fuss-free. It is ideal for word processing and any high resolution applications, and would make a very welcome addition to any home computer system.

CABEL RGB MONITOR

First Impressions The Cabel 370A is an RGB colour monitor which is supplied complete with a BBC Micro compatible RGB video lead. The unit as delivered has its colour settings optimised for the BBC Micro, and is extremely well packed in a double box. A single A4 instruction sheet is supplied which gives basic operating information, but this appears to have been rather hastily prepared, and contains a number of typographical errors. Hopefully this is an interim measure, pending production of a more substantial manual.

The monitor has a 14-inch Mullard colour tube with a dot pitch of 0·65mm, and is packaged in a strong moulded case with an integral combined carrying handle and ventilation slot. The colour scheme is beige (case body) and black (front panel). It must be said, however, that the overall styling is spoilt by poor design of the front panel. This is a great shame because the effect could have been so much better with only a little more effort and attention to matters of styling and ergonomics. As it is the two front panel controls (round knobs) are too close together, and in sharp contrast to the (square) mains switch. The mains indicator is a small (round) l.e.d. in the middle of a large blanking plug filling the hole occupied on previous models by the video connector. This said, we should remember that the prime function of the unit is to produce colour displays.

The overall dimensions of the monitor are probably the smallest possible for a unit using a 14-inch tube, and are approximately 39x36x41cm. The case itself tapers from front to back, and also inclines the screen usefully backwards to assist viewing. The height of the screen above the bench would allow it to stand behind many micros, in the (unlikely) event that sufficient bench space is available. The best alternative viewing position involves placing the monitor beside the computer. The unit weighs approximately 13kg, and is mounted on four rubber feet. All controls are on the front panel, and all leads connect at the rear.

Front Panel The front panel contains the mains switch and power indicator. The indicator provides a useful indication of whether the automatic power supply shut-down

circuitry has operated. Two controls allow adjustment of brightness and 'interlaceing'. The latter control seems wrongly labelled (and spelt!), and behaves as a contrast control; it certainly has no effect on picture scan interlacing. Both controls work well and have a useful range of adjustment.

Rear Panel The mains power lead enters the unit through a grommet on the rear panel. This lead is approximately 2 metres long (still a little on the short side, but a useful length), and has a fitted 13A plug. The video input is via a 6-pin DIN socket, wired to be compatible with the BBC Micro. The RGB input is terminated in 75 ohms, and automatically switches to accept inputs with positive or negative sync. The rear of the case contains ventilation slots, which are numerous enough to provide a good flow of air, yet narrow enough to prevent the intrusion of foreign objects.

Inside The Case At the rear of the case is a label which warns of electrical shock hazard if the cover is removed, and indicates that there are no user serviceable parts inside. Access is provided to ten preset adjustments through small holes in the base and rear of the case, obviating the need to remove the cover. The adjustments provided are for: red/green/blue input sensitivity, horizontal/vertical shift, field sync/linearity/amplitude, line width and linearity, and focus. The unit is provided fully aligned, and no adjustments were found to be necessary to the review sample.

The case itself is of substantial construction, and is removed by unscrewing the four feet. The internal construction of the monitor is extremely impressive, and is based around a standard Mullard colour monitor chassis, to which the case is attached. The chassis is built around the cradle which supports the colour tube. The tube itself is a standard television style 90-degree tube. The main circuit board is mounted in the base of the cradle, and is neatly laid out for automatic component insertion. The three (red, green, blue) video amplifiers, and the focus control, are mounted on a smaller second board mounted on the tube base. Signal connections between the sub-assemblies are by means of multi-way cables/connectors. All in all, a very well constructed unit incorporating the very latest technology.

Picture Quality The picture quality of the Cabel monitor was evaluated by driving it from the RGB output of a BBC Micro. The tests involved 20,40 and 80-column text, and high resolution coloured graphics.

When set against a standard, well-adjusted domestic colour television, the picture quality from the monitor can only be described as excellent. The difference has to be seen to be believed. The saturated, stable colours which are obtained are a delight to observe, and it is possible (using only the front panel controls) to obtain a colour display to suit all tastes. The usual problem is that no two people can ever agree on the subjectively 'correct' settings for any colour display; the reviewers certainly disagreed! The important point, however, is that the range of adjustment available on the monitor is more than enough to cater for all tastes. Whatever your preference, the final picture quality is excellent.

When used for text displays, the CE370A produces perfectly acceptable and stable displays for 20 and 40-column text. However, the 10MHz bandwidth causes a few problems with 80-column text. The actual horizontal resolution quoted for the display is 430 pixels per line, and the BBC Micro uses 640 pixels per line for 80-column text. The resulting text is still quite readable, but not pleasantly so for prolonged periods. A viewing distance of approximately 1·2 metres (eye-to-screen) was found to be the optimum for 80-column text. If contemplating frequent and prolonged use with 80-column text, the higher resolution CAT370 (22MHz, 0·65mm dot pitch, 430 pixel) or HR370 (22MHz, 0·3mm dot pitch, 640 pixel) models should be considered as possible alternatives.

The ideal, and the recommended, position for the monitor is behind the computer console. This has the advantage of increasing the separation between the eye of the user and the screen. The bottom of the screen is then 9cm above the bench level, and this means that it is not obscured by most micros. The screen size should be considered when deciding where to position any monitor; a large screen too close can be as bad as a small screen too far away. Both situations can lead to fatigue with prolonged use. In use the monitor normally runs warm, but the ventilation is quite adequate, and no hot spots are evident.

VERDICT The overall impression gained from prolonged use (including preparing last month's article) is of a unit which offers good performance for price. The styling is a matter of personal taste, but the colour quality of the display is unreservedly excellent. It would be unreasonable to expect too much from a medium resolution RGB monitor when it comes to displaying 80-column text. The performance achieved is as good as could be expected, and in general it is necessary to spend around twice as much to obtain a monitor to match (say) the Novex in this respect.

FINAL THOUGHTS

The selection of a monitor for your particular application, and to suit your budget, will always be a matter of personal choice. The two units reviewed are both worthy of serious consideration. The reviews also indicate some points which might be considered when making a selection. Wherever possible, try and see your final choice of monitor in action before you take delivery; both review samples arrived damaged after carriage by road and rail, despite having been very well packed. Prices for monitors appear to have substantially stabilised, so there is unlikely to be any significant price reductions in the near future.

The Novex 12/800 is priced at £75.62 excluding VAT and p&p and is available from Display Distribution Limited, 35 Grosvenor Road, Twickenham, Middlesex (01-891 1923).

The Cabel 370A is priced as £199.50 excluding VAT and p&p and is available from Cabel Electronics, 19 High Street, Tewkesbury, Glos. (0684 298840). ★

inmos

The British Chip Manufacturer

SOON after Britain's state-owned microelectronics company passed its fifth anniversary it sent out advance information on its latest development, a single-chip microcomputer called a Transputer. The fact that the device did not at that moment exist as a real component illustrates both the confidence of Inmos and the commercial conditions in which the company has to operate.

With fierce competition from the mighty American and Japanese semiconductor industries and prices of integrated circuits falling all the time, the only way to survive commercially is to keep on developing new products that will leapfrog their rivals in facilities, performance or price. In such conditions you have to announce and describe your latest development well ahead of its actual existence as a component on the market.

The idea, of course, is to stake a claim as soon as possible with the potential customers—the electronic equipment manufacturers—who are always waiting to pounce on devices using the latest and most advantageous technology to give their own products a competitive edge. To make such claims ahead of actuality you have to be very confident.

GENESIS

So what has Inmos actually achieved in its first five years in this dangerously competitive world? Inmos International PLC, as it is now known, was founded in August 1978 specifically to develop, manufacture and sell very large scale integrated circuits (VLSI) as standard devices in volume production. This means ICs with 100,000 or more transistors on a single chip.

The Labour government of that time had become convinced that the UK should have a stake in this high-technology business. Apart from the international trading advantages of being in such a field of manufacture, they felt it would create more jobs and would also help the UK electronics industry to be less dependent on imported devices, or the products of foreign-owned companies, and therefore less vulnerable to technical/commercial decisions made in other parts of the world.

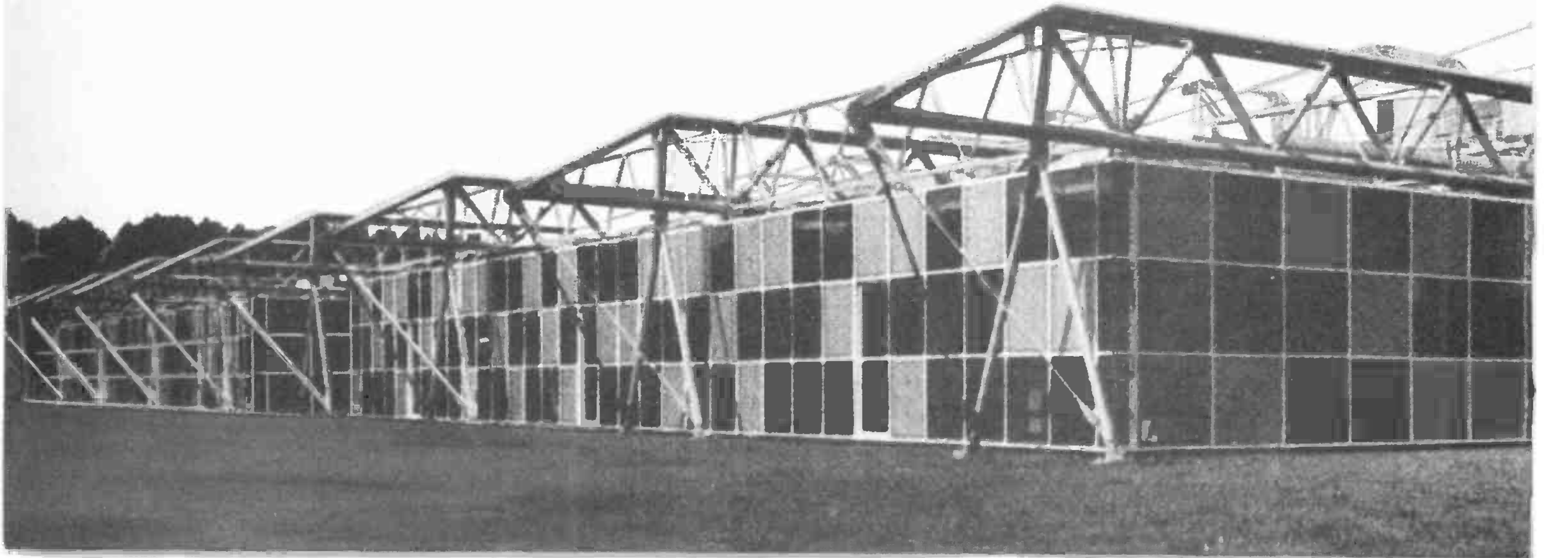
As British private capital had not produced any such VLSI company it was decided to invest £50M of public money in the venture, £25M immediately (1978) and a further £25M at a later date. This was arranged through the National Enterprise Board (NEB), a state run agency already existing to launch or support industrial companies felt to be important to the economy.

The NEB is now part of the British Technology Group. Recently it has been given the new role of assisting technology transfer and will be divesting itself of its holdings in the share capital of various companies.

It so happened that the government's aim had coincided with the ambitions of two very able technologists, who were then looking for an opportunity to exploit their ideas of producing large information processing systems on small silicon chips. Iann Barron, an English systems research specialist, then aged 42, had formed the first UK minicomputer company, Computer Technology Ltd, in 1965 and later had been a consultant in computers and information technology. The second party was Dr Richard Petritz, an American physicist, then 55, who had directed Texas Instruments' semiconductor research for ten years from 1958 and later had formed a company in Dallas for launching new electronics firms—one of which was Mostek.

Legend has it that these two discussed and formulated their common aims at Chicago Airport after a technical conference in 1977. Iann Barron was already aware of UK government intentions through his consulting work for the Department of Industry (now DTI), and it was only a matter of months before an agreement was signed to set up the new British VLSI company with these two individuals as founders.

A third founder was another American physicist, Dr Paul Schroeder, then 38, who had worked for Bell Telephone Laboratories on memory design and in 1967 had become director of memory design engineering at Mostek. (Dr Schroeder, an expert on MOS dynamic memory devices, resigned from Inmos in 1982.)



The essence of the setting-up agreement was that Inmos would be a subsidiary of the NEB. In return for the £50M of public funds, the NEB was to hold 72½ per cent of the equity in the company. A further 15 per cent of the shareholding was to be divided among the three founders and the remaining 12½ per cent between key employees of the company. Richard Petritz was appointed managing director.

The overall plan was to start by developing, manufacturing and selling random access memories (RAMs) because there was already a large and growing market for these devices. This activity would provide a manufacturing and commercial base from which other VLSI devices would be launched. Process technology and initial manufacturing would be based in the USA because that country had a large pool of people already skilled in VLSI technology. Then, after the products had been launched there, they would be transferred to the UK for volume production. Memories would be marketed and sold from the USA because North America provided a very big demand for these products.

THE EARLY YEARS

Less than a year after the founding of Inmos, and before the NEB had produced the second £25M of the investment capital, the 1979 General Election brought in a Conservative government—a government opposed to the principle of state-owned industries, committed to keeping down public expenditure and unwilling to use public funds to support loss-making private sector companies. The affairs of Inmos then moved into the political arena.

The new government hesitated for about a year and clearly would have liked the second £25M to be found from private sources of capital. There was dissension within the Department of Industry and lengthy deliberations on where the UK factory was to be sited. But Sir Keith Joseph, the then industry minister, was in favour of the original method of funding and in the end the remaining £25M of public money was provided, by a new NEB, in August 1980.

Meanwhile the Inmos plans for an American plant had gone ahead on schedule. Colorado Springs had been chosen as a good area for potential employees and by September 1979 the company had started building a plant there. By March 1980 an experimental establishment at Harrison Park had developed an NMOS process for making RAMs with 2–3μm active area widths in the silicon. And by May 1980 the first samples of 16K static RAMs made by this process were available. The Colorado Springs plant started operations in March 1981 and by December of that year had produced the first samples of dynamic RAMS.

The abbreviation MOS stands for the three kinds of material, metal—oxide—semiconductor, used to construct the integrated field-effect transistors in these devices. The N in NMOS indicates that the conducting channel of these integrated f.e.t.s is silicon containing inpurity atoms giving it a greater density of conduction electrons, making them the majority carriers, than of mobile holes—in other words the silicon is an n-type semiconductor. In the RAMs referred to the f.e.t. structures within the silicon are 2–3μm wide.

Static RAMs are constructed on the principle of using an integrated flip-flop or bistable circuit to store each binary digit, 1 or 0. They are faster than dynamic RAMs but dissipate power continuously to hold the information, have a lower packing density and are usually more expensive.

Dynamic RAMs are constructed on the principle of using a MOS capacitor, in conjunction with a MOS field-effect transistor, to store each 1 or 0 binary digit as an electric charge. Consequently, to hold information the charge in the capacitor has to be constantly maintained, or 'refreshed', by other circuitry. Dynamic RAMs use power only when reading and writing is taking place and their standby power dissipation is very low.

UK FACTORY SITE

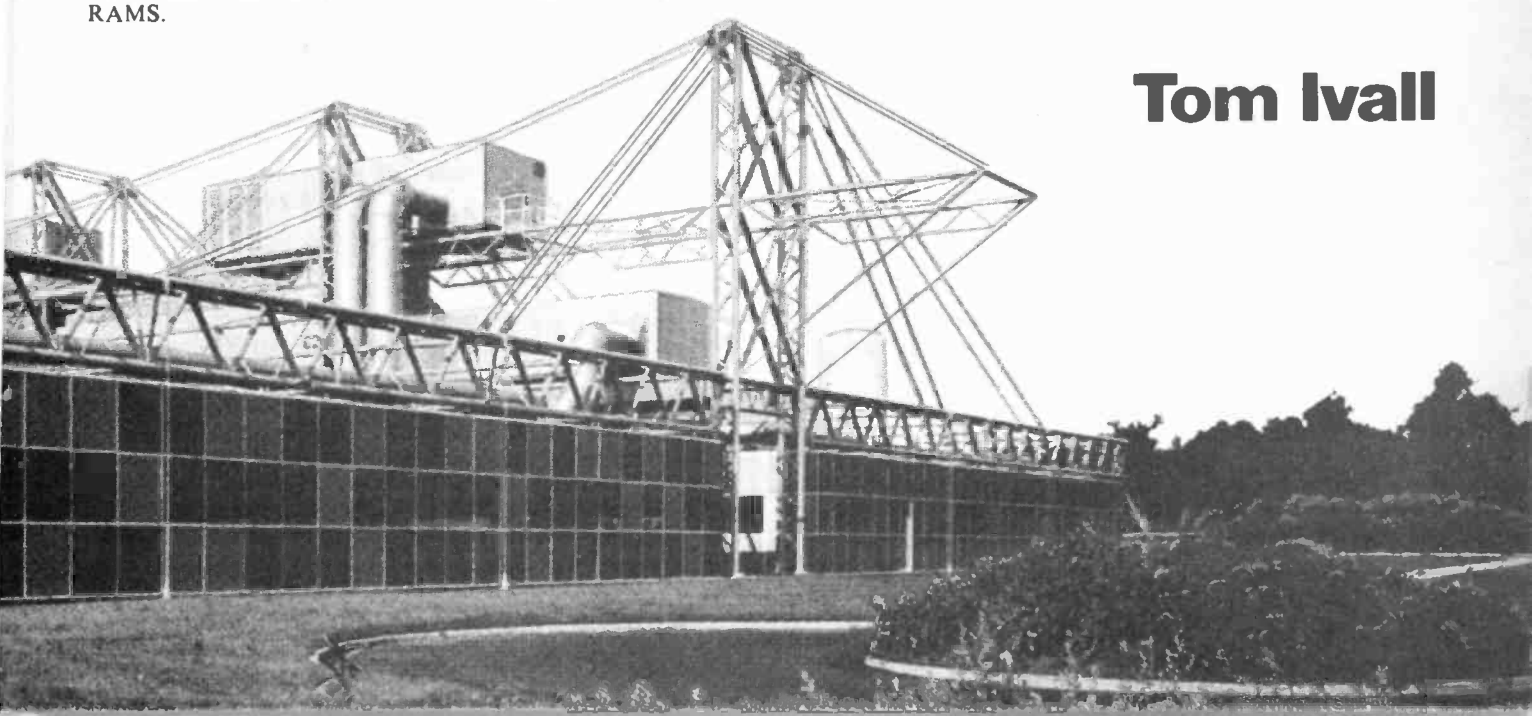
Back in the UK the government eventually decided that the factory for volume production should be built in South Wales, and in January 1981 the construction of a plant of spectacularly advanced architectural design was initiated at Cardiff Road, Duffryn, Newport, Gwent. This was conveniently just a few miles over the Severn Bridge from the Inmos administration and R&D centre in Bristol, at Whitefriars, Lewins Mead. The Newport factory started operations in June 1982 and by November of that year was producing in volume the first 16K static RAMs, initially manufactured at Colorado Springs. And in February 1983 the Newport factory started volume production of the dynamic RAMs.

Altogether these three Inmos establishments now employ an average of 1350 people. There are 750 at Inmos Corporation, Colorado Springs; 500 at Inmos Limited, Newport; and 100 at Bristol. The R&D people at Bristol work on microcomputers and computer aided design, while those at Colorado Springs are concerned with memory products and process technology.

INMOS TODAY

What, then, is the position of Inmos now, in terms of its products, markets, technical developments, commercial viability and plans for the future?

Tom Ivall



First, the products. At the time of writing the i.c.s in production and on the market are all semiconductor memories. Categorized purely in terms of storage capacity and/or chip organization there are seven basic products, but these have variants with different specifications, packaging etc. that make a total of 32 type numbers.

The range of 16K static RAMs contains the 16K × 1 type IMS1400 in versions with access times down to 35ns; the 4K × 4 type IMS1420; and the slightly different 4K × 4 IMS1421, both in versions with access times down to 45ns.

All these are available in plastic or ceramic d.i.p. or in chip carrier packaging. In addition there are military specification versions, the IMS1400M and 1420M, both available in d.i.p. or chip carrier form. Inmos claim that the 16K IMS1400 and 1420 are "the fastest static RAMs available for use in military and computer applications."

The company also make a range of 64K dynamic RAMs. The 64K × 1 type IMS2600 comes in versions with access times down to 100ns and is available in either d.i.p. or chip carrier packaging. IMS2620 has a 16K × 4 organization and is also in versions with access times down to 100ns, while the IMS2630 is an 8K × 8 memory in versions with access times down to 120ns—these two devices both being packaged in d.i.p. form. Recently Inmos and the Intel Corporation have agreed a common specification for future dynamic RAMs made by a new high speed CMOS process, so that users will have two sources of functionally identical products.

Finally, to complete the seven basic products, the latest to be marketed is a 64K electrically erasable programmable read-only memory (EEPROM) in a d.i.p. package, the IMS3430. Made by a process called Nitrox which produces memory cells of very small area, this device has an 8K × 8 organization and requires only a single 5V supply. The whole ROM can be programmed in 1·3s.

In the dynamic RAMs, two particular features contributing to good performance and convenience in use are what are called the 'nibble' mode of operation and the '$\overline{\text{CAS}}$ before $\overline{\text{RAS}}$' method of refresh assistance. The term 'nibble' means simply half a byte (a metaphor built on a pun!), or four bits. It describes a facility in the 64K dynamic RAM which allows four data bits to be read or written sequentially for a single address access. It is a design response to the electronic industry's demand for faster and faster memory operation and is provided by other manufacturers under the name 'serial access'. In the IMS2600, for instance, the nibble mode allows serial access to two, three or four bits at a bit rate of 25MHz.

All dynamic RAMs need refresh assistance, but the techniques used by some manufacturers have the effect of restricting memory expansion and increasing the standby power dissipation. The Inmos method of refresh assistance avoids these problems. To determine whether a normal access or a refresh cycle should be performed the chip samples the high/low state of the column address strobe ($\overline{\text{CAS}}$) as the row address strobe ($\overline{\text{RAS}}$) falls to the low state. If $\overline{\text{CAS}}$ is low as $\overline{\text{RAS}}$ goes low, the memory ignores any address inputs and substitutes the contents of an on-chip 8-bit counter to determine the row to be refreshed.

MANUFACTURING PROCESSES

All these memory devices are manufactured by advanced VLSI processes, in which Inmos invested very heavily in order to remain competitive. This technology has three main characteristics. First, the etching of the different layers of material on a chip is done by the plasma, or dry, method, to achieve greater dimensional stability than is possible by the use of acids.

Secondly, ion implantation is used to give a more controllable depth of impurity atoms in the crystal lattice below the semiconductor surface than is possible with the conventional diffusion method. Depth of penetration is controlled by the energy imparted by acceleration to the ions bombarding the silicon surface. Thirdly, the Inmos process technology uses wafer stepping photolithography, in which the circuit patterns are projected onto the semiconductor wafer one chip at a time. This gives better line definition and alignment accuracy, and hence higher yields, than when a pattern is projected onto the whole wafer in one operation.

Another technique which improves the yield of memory chips is to introduce redundancy, in the form of spare rows and columns of cells in the memory matrix. At the wafer testing stage any failed cells are identified and this information is programmed into the chips in such a way that when these cells are addressed the device brings in the spare good cells to replace them.

MARKETS

The principal markets of Inmos memories are in the USA and these take over 70% of the company's output. The remainder are distributed throughout the rest of the world. Inmos claims to have secured "a major share" of the world market for 16K fast static RAMs, which are going mainly to the USA, Europe and Japan. In general the firm's memory products are used in mainframe and mini computers, peripheral buffers, radar systems, aircraft flight computers, video displays and telecommunications digital switching equipment.

RECENT TECHNICAL DEVELOPMENTS

In the past few years technical developments from Inmos have included the OCCAM programming language for single and multiple microcomputer applications and a set of computer based aids for designing VLSI devices. In semiconductor products probably the most advanced development is the Transputer (see January issue editorial, p.13). This name, derived from 'transistor' and 'computer', actually refers to a family of products. The first of these, due on the market soon as the IMS T424, is a 32-bit microcomputer on a single chip capable of handling 10 million instructions per second. An article by Ray Coles will explain the device in more detail next month.

The most significant thing about this device is that, as well as being suitable for conventional applications, it is designed to allow operation in arrays of similar microcomputers all working in co-ordination with each other—'concurrent processing' as Inmos calls it. For this purpose the single VLSI chip includes circuits allowing it to communicate with other such microcomputers—four 15Mbyte/s two-way serial data links. This principle of array processing is very much aimed at the future 'fifth generation' computer systems, which will probably work at about a thousand times the performance level of present computers to provide intelligent interaction between people and machines. The CMOS silicon chip of the IMS T424 contains 250,000 active devices, includes 4Kbyte of RAM and is packaged in an 84-contact ceramic chip carrier.

HOW THE MONEY WAS USED

From the beginning the Inmos management realized that the original funding of £50M would not be enough to sustain the corporate plan aimed at profitability. In the intervening years the effects of inflation and the falling value of the pound sterling relative to the US dollar have made the deficiency even worse. A market and technical assessment by independent consultants later confirmed this situation. The directors wanted to raise a further £50M in the form of loans, but the government had already set a borrowing limit of £35·5M. The upshot was that in 1983 the NEB agreed to provide a further £15M as an additional equity investment. This increased the NEB's holding in the share capital to 75 per cent and correspondingly reduced the proportion held by individual directors and employees.

Thus the capitalization was increased to £65M. On top of this, the leasing, loans and investment grants arranged with banks and other sources (including the EEC) have brought the total funding to about £100M to date.

How has all this money been used? The ultimate purpose of the investment, of course, is to create a profitable company financing itself out of its own trading activity. The NEB, having performed its function of launching the enterprise, would then be able to sell off its shareholding in a going concern to good advantage, at the least recovering the investment of public money and at the best obtaining some return for it.

The 1982 annual report is the latest account showing how far Inmos has progressed along this road. First of all, its use of the capital investment. The company now has tangible fixed assets of £44·1M, in the form of various buildings and their equipment. This sum is made up of £20·2M in freehold land and buildings, £168,000 in short-leasehold land and buildings and £23·7M in plant and equipment. There are also current assets, in the form of stocks, cash and debts, and after the current liabilities have been deducted this leaves the company with total assets of £47·2M.

Now to the current trading position. In 1982 sales of MOS memory products amounted to £13·7M. This was a very big increase from the corresponding 1981 sales figure of £2·1M. However, the operating costs relating to these 1982 sales—manufacturing, engineering, product support, distribution and administration—totalled £22·3M, resulting in an operating loss of £8·6M. Apart from this, starting up the Newport factory cost £3·6M, the continuing research and development work required £4·5M, the interest charges on loans were £1·2M, while losses on the dollar-pound exchange rate came to £2·3M.

Altogether the profit and loss account for 1982 showed a loss of £20·3M. Losses brought forward from previous years amounted to £21·6M, so the accumulated loss carried forward from 1982 was £42M.

PROFIT IN 84?

Obviously Inmos still has a long way to go. In the 1982 report the directors said that they expected the 1983 results to show "a move towards profitability", while the chairman, Malcolm Wilcox, said that if all went well "the scene will be set for a move into profit in 1984." The 1983 annual report, soon to be published, will show to what extent these optimistic comments are justified. They seem to suggest that by the end of 1983 Inmos would at least have broken even on its monthly revenues. At the turn of the year company officials were saying no more, but seemed to be quietly confident that the 1983 results would show a more than doubled turnover.

So what does the future hold for Inmos? To begin with, a company spokesman told PE that there is "no immediate danger of going bust." The firm now has enough money to keep going. But it still has to keep up with the relentless march of technical innovation to remain among the leaders in the field of manufacture, and also has to contend with equally relentless commercial competition in world markets. This means, for example, that "significant sums" will be needed to build new wafer processing facilities.

For such future investment Inmos is now looking towards private sources of finance, and the 1982 annual report stated that "discussions in this regard are now on course." One result could be that other companies or financial institutions will be buying significant minority shareholdings in the firm.

If this does indeed happen and the process continues, with the NEB gradually divesting itself of its majority shareholding as intended, Inmos will eventually end up as a public company with share prices quoted on the Stock Exchange. This transformation, from ownership by the state to a variegated ownership by pension funds, insurance companies, institutions, trade unions and even private individuals, is a process that could well be starting some time this year. ★

INTRODUCTION TO DIGITAL ELECTRONICS

MICHAEL TOOLEY BA   DAVID WHITFIELD MA MSc CEng MIEE

O & A Level   Part Six

SO FAR in the series we have only dealt with logic gates having two inputs. The time has now come to extend our knowledge to include gates having three, or more, inputs. The two-input gates which we have previously considered are: AND, OR, NAND and NOR. We shall now consider their three-input counterparts.

A three-input logic gate has inputs which we shall, for convenience, label A, B and C. Again there is no particular significance in the choice of letters other than that they are simply the first three letters of the alphabet. To be consistent with the two-input gates previously considered, we shall again refer to the outputs as X. The Boolean expression for each of the three-input gates will, of course, involve the three variables A, B and C. Taking the three-input AND gate first, we find that its output is A AND B AND C. Putting this in correct Boolean form gives:

$$X = A . B . C$$

In terms of the logical state of the inputs, the output X will be a 1 whenever A, B and C are all 1. Any other combination of inputs (e.g. A = 0, B = 0, C = 1) will produce a 0 output. Since we are dealing with a three-input gate, there are 2^3 (= 8) possible combinations of the logical input states. The truth table will, therefore, consist of eight lines covering the input states arranged in four columns, three for the inputs and one for the output, as shown in Table 6.1.

The output of a three-input OR gate is A OR B OR C. In correct Boolean form this is:

$$X = A + B + C$$

INPUTS			OUTPUT
A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

EG1269

Table 6.1. Truth table for a three-input AND gate

INPUT			OUTPUT
A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

EG1270

Table 6.2. Truth table for a three-input OR gate

The output X will be a 1 whenever any one, or more, of the inputs is a 1. The truth table will take the same form as that used for the three-input AND except that the output column will contain 1's in each line except for that which corresponds to the input state: A = 0, B = 0, C = 0. This, incidentally, yields the important result that the output of a three-input OR gate is the logical opposite (complement) of the output of a gate for which the Boolean expression is (NOT A) AND (NOT B) AND (NOT C). Thus we conclude that:

$$\overline{A + B + C} = \overline{A} . \overline{B} . \overline{C}$$

This is an important result which we shall be returning to in Part Seven when we introduce De Morgan's Theorem.

The truth table for a three-input OR gate is shown in Table 6.2. As in the case of their counterparts, three-input inverting gates, NAND and NOR, produce the complement of their respective AND and OR counterparts. The output of a three-input NAND is NOT (A AND B AND C), or:

$$X = \overline{A . B . C}$$

The output of a three-input NOR gate is NOT (A OR B OR C), or:

$$X = \overline{A + B + C}$$

The truth tables for the three-input NAND and NOR gates are respectively shown in Tables 6.3 and 6.4. Unfortunately, these two are easily confused and the recommended method for distinguishing between them is to FIRST consider the output of the corresponding non-inverting gate (i.e. AND or OR) and simply complement its output state (i.e. whenever a 1 appears in the output column change it for 0, and vice-versa).

INPUTS			OUTPUT
A	B	C	X
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

EG1271

Table 6.3. Truth table for a three-input NAND gate

INPUTS			OUTPUT
A	B	C	X
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

EG1272

Table 6.4. Truth table for a three-input NOR gate

FOUR (AND MORE!) INPUT GATES

Having dealt with three-input gates it is worth considering what happens when we are presented with gates with four, and more, inputs. The procedure for deriving the Boolean expressions and truth tables naturally follows that adopted for the three-input gates. The Boolean expression for a gate with n different inputs will have 2^n lines. The truth table will have n columns for the inputs and just one column for the output. Hence the Boolean expression for the output of a four-input gate (n = 4) will involve four variables (A, B, C and D) and its truth table will have 2^4 (= 16) lines.

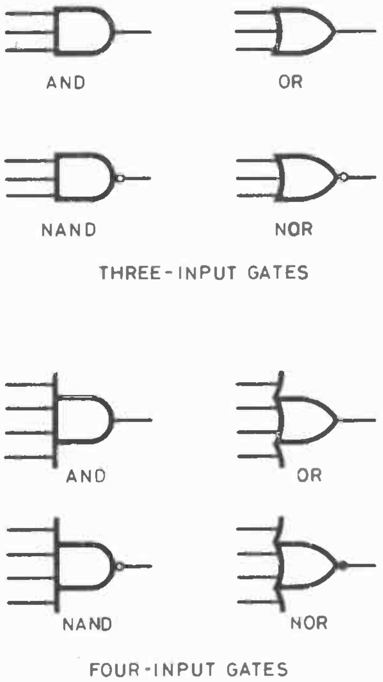
The Boolean expressions of the outputs of four-input gates are shown below. The symbols for these gates are, together with those for their three-input counterparts, shown in Fig. 6.1.

AND $X = A \,.\, B \,.\, C \,.\, D$
OR $X = A + B + C + D$
NAND $X = \overline{A \,.\, B \,.\, C \,.\, D}$
NOR $X = \overline{A + B + C + D}$

By now, readers should be familiar with Boolean expressions and truth tables for gates with up to four inputs. We shall, however, be returning to this topic in Part Seven when the important applications of De Morgan's Theorem will be discussed.

J–K BISTABLES

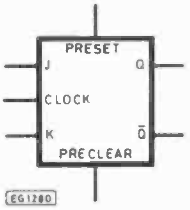
Unlike the two types of bistable which we have met previously in Part Five, the J–K bistable provides direct as well as clocked inputs. The direct inputs, usually labelled 'preset' and 'preclear', are normally used to initialise the state of the bistable before data is clocked into it by means of the J and K inputs. There is, incidentally, no particular significance in the letters J and K other than that they are consecutive letters in the alphabet and are unlikely to be confused with other letters used thus far to identify inputs and outputs.



EG1279

Fig. 6.1. Symbols used for three and four-input logic gates. Note: BS symbols follow the style of the two-input gates previously described in Part Two

The symbol for a J–K bistable is shown in Fig. 6.2. Note that there are five inputs: preset and preclear (the two direct inputs), J and K (the two clocked inputs), clock, and two outputs: Q and $\overline{Q}$. As with the previous forms of bistable, the two outputs are complementary (i.e. when Q = 1, $\overline{Q}$ = 0, and vice versa). It should also be noted that, in the case of practical J–K bistables like the 7473 that we shall be describing later, the preset and preclear inputs are often 'active low'. This means that they are normally connected to logic 1 and must be taken 'low' (to logic 0) in order to preset or preclear the Q output.



EG1280

Fig. 6.2. Symbol for a J–K bistable

In all circumstances the direct inputs dominate and clocked operation is enabled when both of these inputs are taken to logic 1. It is, therefore, necessary to consider TWO truth tables: one for the operation of the direct inputs and one for the clocked inputs. These two truth tables are respectively shown in Tables 6.5 and 6.6. The truth table for the clocked inputs is relatively complex; however, for three of the input conditions it is similar to that of an R–S bistable. The output column of the clocked input truth table (Table 6.6) shows the state of the Q output after a falling edge clock transition (i.e. after a change of clock state from 1 to 0). This is denoted by Q_{n+1} whereas the previous clock state is Q_n. We shall now consider separately the four possible conditions which can arise for both the direct and clocked inputs, referring initially to Table 6.5:

PRESET	PRECLEAR	Q
0	0	INDETERMINATE
0	1	1
1	0	0
1	1	ENABLES CLOCKED OPERATION

EG1273

Table 6.5. Truth table for the direct inputs of a J–K bistable

J	K	Q_{n+1}	COMMENT
0	0	Q_n	NO CHANGE [0 → 0 OR 1 → 1]
0	1	0	OUTPUT PRECLEARED
1	0	1	OUTPUT PRESET
1	1	$\overline{Q_n}$	O/P CHANGES STATE [1 — 0 OR 0 — 1]

EG1274

Table 6.6. Truth table for the clocked inputs of a J–K bistable

1. If both preset and preclear inputs are taken to logic 0 an indeterminate state exists and the outputs, Q and $\overline{Q}$, may no longer be complementary. This condition must be avoided.
2. If the preset input is taken to logic 1 and the preclear input is taken to logic 0, the state of the Q output immediately becomes logic 0 whilst the Q output becomes logic 1; i.e. the bistable is precleared.
3. If the preset input is taken to logic 0 and the preclear input is taken to logic 1, the Q output immediately becomes logic 1 whilst the Q output immediately becomes logic 0; i.e. the bistable is preset.
4. If both preset and preclear inputs are taken to logic 1 the bistable is ready for clocked operation and the following rules are obeyed (as in Table 6.6):

(a) If both J and K inputs are taken to logic 0 the Q and $\overline{Q}$ outputs do not change state on a falling clock transition. Thus Q_{n+1} is the same as Q_n and $\overline{Q_{n+1}}$ is the same as $\overline{Q_n}$.

(b) If the J input is at logic 0 and the K input is at logic 1, the Q output stays, or becomes, 0 when the next falling clock transition occurs. The $\overline{Q}$ output takes the opposite logical state.

(c) If the J input is at logic 1 and the K input is at logic 0, the Q output stays, or becomes, 1 when the next falling clock transition occurs. The $\overline{Q}$ output takes the opposite logical state.

(d) If both the J and K inputs are taken to logic 1, the Q and $\overline{Q}$ outputs change state when the next falling clock transition occurs. Thus Q_{n+1} is the same as $\overline{Q_n}$ and conversely $\overline{Q_{n+1}}$ is the same as Q_n.

In case (a) the bistable ignores the clock transition whilst in cases (b) and (c) the complementary states of the J and K inputs are effectively passed, on the falling clock edge, to the Q and $\overline{Q}$ outputs respectively. In case (d) the bistable is configured for operation as a binary divider. If this still appears to be a little difficult to understand the following practical investigation should help to make things clear!

THE 7473 J–K BISTABLE

The 7473 contains two independent J–K bistables, as shown in Fig. 6.3. The 74107 is electrically identical to the 7473 but has more conventional supply connections (TTL devices usually have pins 14 and 7 as the +5V and 0V connections respectively). The two internal bistable stages are themselves identical and each has the usual J, K and clock inputs. A preset input is, however, not provided and only a preclear input is available for the direct control of the bistable. The preclear is, incidentally, an 'active low' input as mentioned previously. To all intents and purposes, the bistable operates as if the missing preset input were internally connected to logic 1. Thus, for normal clocked operation, it is only necessary to connect the preclear input to logic 1. In actual fact the preclear input 'floats' to logic 1 if left unconnected. However, since leaving inputs unconnected is not generally considered good practice, it is recommended that a physical link to logic 1 be made external to the i.c. There can then be absolutely no doubt about the logical condition present on the preclear input! It should also be noted that the state of the J and K inputs should be changed once only during each clock cycle. Ideally this change should be made immediately after the clock transition. Any subsequent changes in the logical state of the J and K inputs can cause invalid states within the bistable.

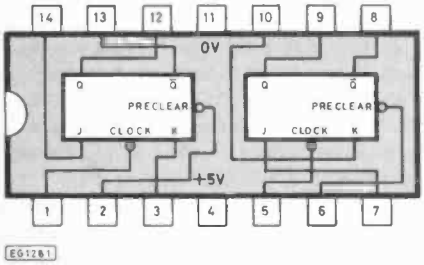


Fig. 6.3. Internal arrangement of the 7473 J–K bistable. Note: The circle on the clock and preclear inputs indicate an 'active low'

Insert the 7473 into the dual-in-line socket marked 'A' on the Logic Tutor. The chip should be orientated so that pin 1 is in position A1, pin 7 in position A7, pin 8 in position A10 and pin 14 in position A16. During this investigation we shall be using only one of the two available J–K bistables contained within the i.c. The following connections should be made in order to facilitate clocked operation of the bistable:

A1	to	S1	(S1 will act as the clock)
A2	to	logic 1	(preclear to 1)
A3	to	S4	(S4 will act as the K input)
A4	to	+5V	(positive supply)
A13	to	0V	(0V)
A14	to	S3	(S3 will act as the J input)
A15	to	D2	(D2 indicates the $\overline{Q}$ output)
A16	to	D1	(D1 indicates the Q output)

Set S3 and S4 initially to produce logic 0 outputs and note the state of the Q and $\overline{Q}$ outputs by observing the indication produced by D1 and D2 respectively. The outputs should, of course, be complementary! Now depress and release S1. This causes a 0 –> 1 –> 0 pulse on the clock input. There should be no change in the Q and $\overline{Q}$ outputs. Set S4 to produce a logic 1 K input whilst S3 should remain at logic 0. Now depress and release S1 for a second time. This time the Q output should go to logic 0 and $\overline{Q}$ should go to 1 regardless of their previous state. Set S3 to produce a logic 1 on the J input and S4 to produce a logic 0 on the K input. Depress and release S1 again and check that the Q output becomes 1 whilst the $\overline{Q}$ output becomes 0. Finally, set both S3 and S4 to logic 1. Repeatedly depress and release S1 to produce a train of successive clock pulses. This should cause the Q and $\overline{Q}$ outputs to alternate between logic 1 and logic 0, a change being made each time S1 is operated.

MASTER-SLAVE BISTABLES

At this point readers may be wondering what the internal logic of a J–K bistable looks like. It is, in fact, an elegant and ingenious arrangement known as a 'master-slave'. Both the master and the slave are simply conventional R–S bistables, the trick comes in the arrangement of the logic gates which interconnect them.

The basic arrangement of a J–K master-slave bistable is shown in Fig. 6.4. Let us assume that, initially, J, K and clock are all at logic 0. If preset is taken to logic 1 whilst preclear remains at logic 0 then the master bistable is set and its Q output becomes logic 1. Since the clock is at logic 0, the inverted clock will be a 1. This, together with the Q output from the master bistable, is fed to a two-input AND gate which generates a logic 1 to set the slave bistable. The final Q output of the complete arrangement is thus logic 1. The operation of the preclear input is similar. In this case, however, the resulting final Q output is a 0. When both preset and preclear are taken to logic 1 an attempt is made to set and reset both bistables at the same time. It is thus impossible to predict what will happen and the final output is indeterminate. When both preset and preclear are taken to logic 1 the two OR gates are ready to pass data from the three-input AND gates to the set and reset inputs of the master bistable. Note that the final Q and $\overline{Q}$ outputs are fed back to the three-input AND gates and thus they must generate complementary logic states by virtue of the opposite state of the Q and $\overline{Q}$ outputs. The master is thus set or reset depending upon the state of the J and K inputs whenever the clock is at logic 1. When the clock changes to logic 0, data is transferred from the master to the slave by means of the two-input AND gates.

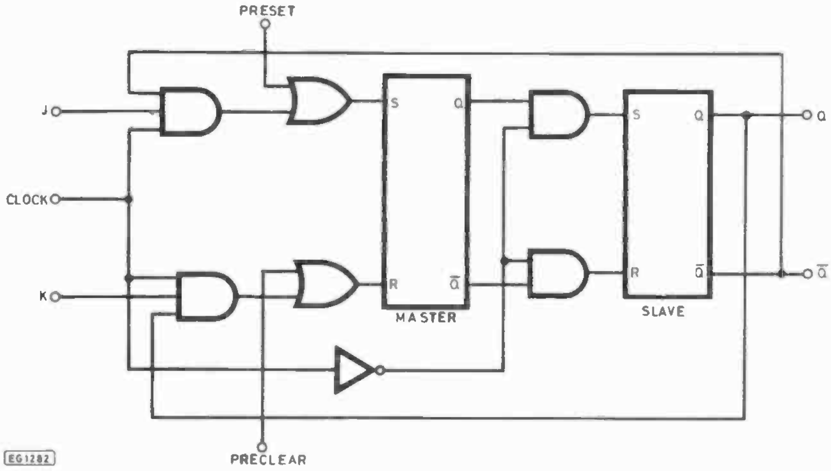


Fig. 6.4. Basic arrangement of a master slave bistable

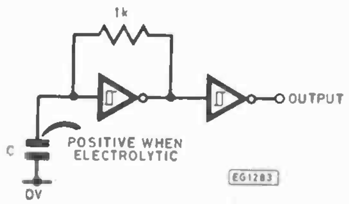


Fig. 6.5. Simple TTL oscillator using Schmitt inverters

C	f out
470µ	1·5Hz
47µ	15Hz
4µ7	150Hz
470n	1·5kHz
47n	15kHz
4n7	150kHz
470p	1·3MHz
47p	8MHz

EG1275

Table 6.7. Values of C and corresponding output frequency for the circuit in Fig. 6.5

In practice J–K bistables may also be of the edge-triggered variety. Unlike the master-slave type, where data is fed into the bistable during the logic 1 part of the clock cycle and appears at the output when the clock goes to logic 0, the edge-triggered bistable transfers data from input to output on the same edge of the clock cycle. This is achieved by means of an internal pulse narrowing circuit which converts the clock to a narrow 'spike' shorter in duration than the delay which occurs in the bistable changing its state. The truth table is, however, identical for both types.

CLOCKS AND OSCILLATORS

Clocks are vital to the correct timing of operations in digital logic circuits. The basic requirement of a clock is that it provides a repetitive pulse waveform of accurate period. The most basic form of clock is merely a TTL compatible oscillator which produces a square wave output of 5V pk-pk at a known frequency. More complex clocks, such as those which are used for 'real time' applications, may be required to operate with a frequency stability and accuracy of better than ten parts per million. Oscillators may also be required for purposes other than purely timing. These applications include the testing of logic systems, the generation of alarm and warning signals, and the transmission of data in serial form. Before examining the subject in greater detail it is worth defining some of the relevant terms in popular use.

FREQUENCY: The frequency of an oscillator is the number of cycles of its output which occur in a second. An oscillator which, for example, generates 50 pulses per second has a frequency of 50Hz. Similarly, an oscillator which provides an output of 1kHz is producing 1000 pulses per second.

PERIOD: The period of an oscillator is the time for one complete cycle of its output. Naturally, the higher the frequency the smaller the period will be. In the previous examples the periods are 1/50 second (or 20ms) and 1/1000 second (or 1ms), respectively. The period of a waveform (in seconds) is thus simply the reciprocal of its frequency (in Hz).

MARK TO SPACE RATIO: The mark to space ratio of a pulse waveform is the ratio of 'on' (logic 1) to 'off' (logic 0) time. For a perfect square wave the 'on' and 'off' times will be the same, hence it is said to exhibit a 1:1 mark to space ratio.

DUTY CYCLE: The duty cycle of a pulse waveform is the ratio of the 'on' to ('on' plus 'off') times, normally expressed as a percentage. A perfect square wave would thus exhibit a 50% duty cycle.

OSCILLATOR USING SCHMITT INVERTERS

A very simple TTL oscillator configured around two gates of a hex inverter is shown in Fig. 6.5. This arrangement uses a 7414 device rather than the more familiar pin-compatible 7404. The 7414 is much to be preferred for this particular application by virtue of its internal Schmitt action which offers an amount of hysteresis in the voltage levels for the logic 0 and 1 thresholds. The 7404 will not operate reliably in this circuit.

The first of the two gates has two external components: a resistor which provides positive feedback from the output to the input, and a timing capacitor connected from the input to 0V. The second gate merely acts as an inverting buffer to provide a measure of isolation of the first gate from the load connected to the output.

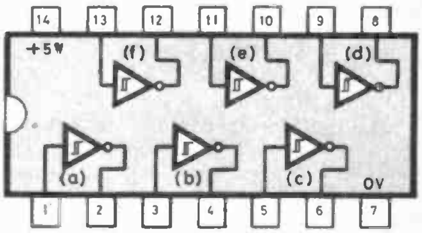


Fig. 6.6. Pin connections for the 7414 hex Schmitt inverter

In order to explain the operation of the oscillator we must consider what happens when power is first applied to the circuit (A in the waveform diagram of Fig. 6.7). Furthermore, we shall only be concerned with the first of the two logic gates since the second stage merely acts as an inverter and takes no part in the oscillatory action. The capacitor C will be initially uncharged and thus the voltage across it will be zero. The input to the first logic gate will then be logic 0 whilst its output must be logic 1 by virtue of the inverting action of the gate. The logic 1 state of the output will be represented by a voltage of somewhat less than the 5V supply. Current will thus flow through resistor R (from right to left in

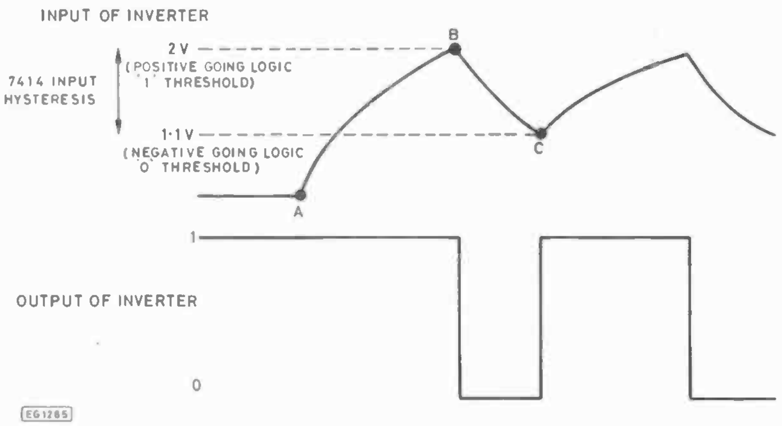


Fig. 6.7. Waveforms for the Schmitt oscillator

CHRYSTAL FREQUENCY RANGE	C_1
2 – 4MHz	220p
4 – 9MHz	68p
9 – 15MHz	47p

EG1276

Table 6.8. Typical values of C and frequency for the circuit of Fig. 6.7

the circuit diagram) to charge the capacitor. This causes the voltage across the capacitor to rise in an exponential fashion until it reaches the point at which the gate recognises a logic 1 at its input (B on the waveform diagram). For the 7414 this condition occurs at an input voltage of approximately 2V. The time taken to achieve this value of input voltage depends upon the CR time constant (i.e. the product of capacitance, C, and resistance, R). The output of the logic gate rapidly falls to 0V as the gate changes state to produce a logic 0 output. The capacitor now discharges through R (current flowing left to right in the circuit diagram) until the voltage at the input of the gate falls exponentially to the level at which a logic 0 is recognised (C on the waveform diagram). This condition is reached at approximately 1·1V and, at this point, the gate returns to its earlier state with a logic 1 output. The cycle thus repeats itself indefinitely or until the power is removed from the circuit. The output waveform of the oscillator is square and TTL compatible but has a mark to space ratio of approximately 3:1. This is not, however, a very severe drawback since we can achieve a precise 50% duty cycle by simply adding an extra bistable stage as we shall later show.

CRYSTAL OSCILLATORS

Many applications for clocks require the oscillator to be exceptionally stable in output frequency and, where precise timing is important, accurately maintained at a particular frequency. Furthermore, in many applications the clock is required to operate at a high frequency, often in excess of 1 or 2MHz. In such applications a quartz crystal may be employed to act as the frequency determining element, as shown in Fig. 6.8. This circuit is somewhat similar to that shown previously with the addition of a crystal and extra capacitor. The circuit can be considered as a free-running oscillator, like those previously described, which is locked to the crystal frequency. The value of C1 in particular has to be chosen so that the stage will operate at, or near, the desired output frequency with the crystal disconnected. Values for C1 of 47pF and 220pF are appropriate to the frequency ranges 8 to 15MHz and 2 to 8MHz respectively. A clock frequency of greater than 2MHz may appear to be somewhat high at first sight. It is, however, a relatively simple matter to divide the oscillator output frequency by a fixed amount (e.g. 10, 100, 16, 64 etc.) as we shall see in Part Seven.

Even when the circuit is correctly operating in the crystal locked condition there may still be a very slight error between the actual frequency produced and that desired (or that marked on the crystal). In such a case a small amount of capacitance may be connected in parallel with the crystal to trim the frequency precisely. This capacitance should not normally exceed a value of 68pF. A practical solution would be to connect a 50pF trimmer directly across the crystal terminals and adjusting this component using a digital frequency meter connected to the clock output.

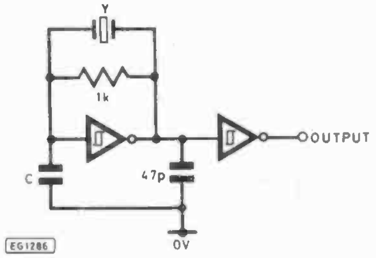


Fig. 6.8. Typical TTL crystal oscillator

C	f min	f max
470µ	0·25Hz	1Hz
47µ	2·5Hz	10Hz
4µ7	25Hz	100Hz
470n	250Hz	1kHz
47n	2·5kHz	10kHz
4n7	25kHz	100kHz
470p	250kHz	1MHz
47p	2·3MHz	9MHz

EG1277

Table 6.9. Values of C and corresponding frequency range for the circuit of Fig. 6.8

VARIABLE FREQUENCY OSCILLATORS

Occasionally one requires a variable frequency oscillator capable of adjustment over a wide range. Whilst such a signal can, of course, be readily derived from a conventional laboratory signal generator, there is a very simple and effective circuit arrangement based on the 74S124 which provides this function using only two external components.

The circuit of a variable frequency clock using a 74S124 is shown in Fig. 6.9. This produces a reasonable 50% duty cycle square wave output and is capable of reliable operation extending from below 1Hz to beyond 20MHz. The frequency is continuously variable by means of the control potentiometer which provides an adjustment range of approximately 4:1. Typical values of capacitor together with maximum and minimum operating frequencies are shown in Table 6.9.

TWO-PHASE CLOCKS

In microprocessor systems, and sophisticated logic systems generally, there is often a need for a clock which produces complementary outputs. Such a clock is known as a two-phase (or bi-phase) clock, the typical output waveform of which is shown in Fig. 6.10. Fortunately, complementary outputs are easy to obtain from a bistable element and thus a two-phase clock may simply consist of an oscillator followed by a bistable. There is, however, one minor complication: the bistable effectively operates as a binary divider and hence the oscillator must operate at twice the desired clock frequency.

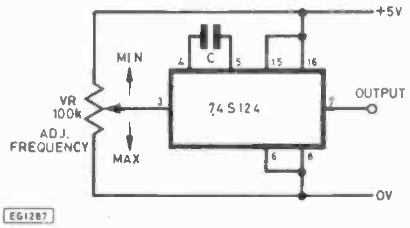


Fig. 6.9. Variable frequency clock using the 74S124

RESISTANCE, R	CAPACITANCE, C	APPX. MONOSTABLE PERIOD, t
10k	10p	70ns
2k2	100p	150ns
10k	100p	700ns
2k2	1n	1·5μs
10k	1n	7μs
2k2	10n	15μs
10k	10n	70μs
2k2	100n	150μs
10k	100n	700μs
2k2	1μ	1·5ms
10k	1μ	7ms
2k2	10μ	15ms
10k	10μ	70ms
2k2	100μ	150ms
10k	100μ	700ms

EG1278

Table 6.10. Typical values of CR and monostable period for the circuit of Fig. 6.9

TWO-PHASE CLOCK USING THE 7414 and 7473

A two-phase clock which illustrates some of the principles discussed earlier, is shown in Fig. 6.11. Here the oscillator uses a 7414 hex Schmitt inverter which produces an output at about 2Hz with a mark:space ratio of approximately 3:1. The oscillator output is fed to the clock input of a 7473 J–K bistable. The timing diagram for the circuit is shown in Fig. 6.12. It should be noted that the output frequency is a symmetrical square wave having a frequency which is exactly half that of the oscillator. This arrangement can be tested by inserting 7414 and 7473 devices in sockets A and B respectively of the Logic Tutor and then making the following connections:

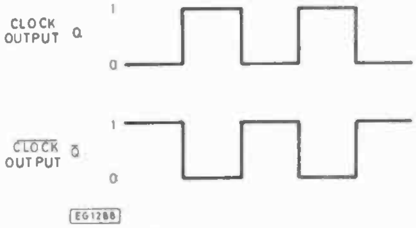


Fig. 6.10. Output waveforms for a two-phase clock

A1	to	0V via 220μF capacitor	(+ve to A1) (timing capacitor)
A2	to	A1 via 1kΩ resistor	(timing resistor)
A3	to	A2	(linking inverter stages)
A4	to	D1	(D1 indicates oscillator output)
A7	to	0V	(0V)
A16	to	+5V	(positive supply)
B1	to	A4	(bistable clock input)
B2	to	logic 1	(preclear to logic 1)
B3	to	logic 1	(K to logic 1)
B4	to	+5V	(positive supply)
B13	to	0V	(0V)
B14	to	D2	(D2 indicates the clock output)
B15	to	D3	(D3 indicates the $\overline{\text{clock}}$ output)
B16	to	logic 1	(J to logic 1)

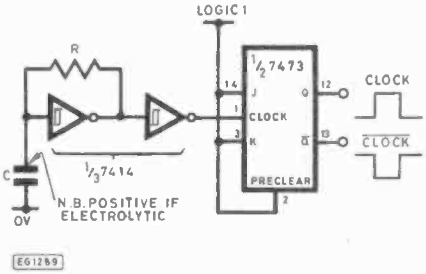


Fig. 6.11. Two-phase clock using 7414 and 7473 devices

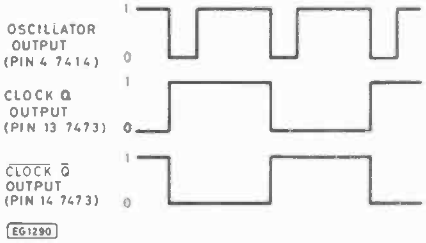


Fig. 6.12. Timing diagram for the circuit in Fig. 6.11

The state of D1, D2 and D3 are used to indicate the oscillator, clock, and clock outputs respectively. D1 should be seen to flash at approximately 2Hz whilst D2 and D3 flash at exactly half this rate and will always have opposite states. The speed of operation may be varied by making suitable changes to the value of C. The value of R should, however, not be changed since 1kΩ is optimum for this circuit. Increasing the value much above 1kΩ will render the circuit inoperative (the logic 0 input state is no longer properly maintained) whilst reducing it much below 1kΩ means that an impractically large value of capacitor has to be used in order to obtain a particular clock rate. Values of C, together with approximate output frequencies produced, with R = 1kΩ are shown in Table 6.9.

MONOSTABLES

The R–S, D, and J–K bistables which we have met so far all possess two stable states. Once put in one or other of the states they will remain in that state until something happens to produce a change of state. There are, however, a number of applications in which a momentary pulse of fixed duration is required. A device which fulfils this function has only one stable state and is known as a monostable.

The action of a monostable is quite simple: its output is initially logic 0 until a level change or edge arrives at its trigger input. This level change can be from 0 to 1 (positive edge trigger) or 1 to 0 (negative edge trigger). Immediately the trigger is received, the output of the monostable changes state to logic 1. Then, after a time interval determined by external components, the output reverts to logic 0. The monostable then awaits the arrival of the next trigger.

Monostables are available in a variety of forms and, whereas it is possible to make a simple form of monostable from individual logic gates, the use of a purpose designed integrated circuit monostable is much to be preferred. To understand the basic principles of monostable pulse generators we will, however, first consider some simple yet effective monostables which employ familiar logic gates.

SIMPLE MONOSTABLES USING INVERTERS

The simplest method of generating a monostable pulse involves the use of an inverting gate together with an external capacitance–resistance (C–R) network. The arrangement of Fig. 6.13 shows how a negative output pulse (1 → 0 → 1) can be generated by a positive edge trigger. If we need to

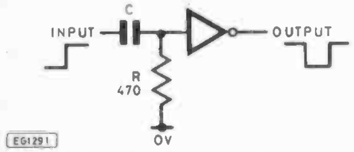


Fig. 6.13. Simple negative-going output positive edge triggered monostable using an inverter

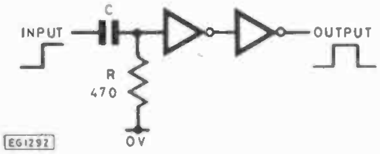


Fig. 6.14. Simple positive-going output positive edge triggered monostable using inverters

produce a positive output pulse (0 —> 1 —> 0) then we only need to add a second inverting stage, as shown in Fig. 6.14. In order to explain how the circuit operates we need to consider what happens when the trigger arrives. Initially, capacitor C is uncharged since the voltage level at the input is zero before the trigger pulse arrives. When the trigger does arrive, the input voltage rapidly rises from 0V to approximately 5V. This is conveyed, via the capacitor, to the input of the inverting gate. The inverter recognises a logic 1 input whenever the voltage at its input exceeds approximately 1·5V thus its output changes state, from 1 to 0 when the input voltage passes through 1·5V. The capacitor then charges through the resistor, R, and the voltage at the input of the gate then falls exponentially back towards 0V. When the input voltage falls below approximately 1·5V, the gate recognises a logic 0 input and its output state reverts to logic 1. Waveforms for this circuit arrangement are shown in Fig. 6.15. The time taken for the capacitor to charge depends upon the time constant of the circuit (C x R). Thus the duration of the monostable output pulse can be varied simply by changing the values present.

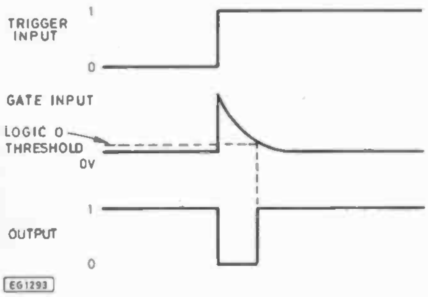


Fig. 6.15. Waveforms for the circuit shown in Fig. 6.13

Note, however, that a value of 470Ω for R is optimum for this circuit. It should not be increased much above, or below, this value and hence the value of capacitance should be varied in order to achieve different pulse durations. Long duration pulses may require the use of large value capacitors and hence electrolytic types may have to be used. In such cases, it is essential that capacitors are low leakage types and, furthermore, close tolerance varieties are necessary if an accurately defined output pulse duration is required.

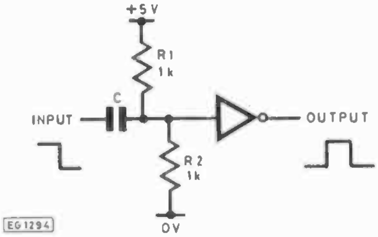


Fig. 6.16. Simple positive-going output negative edge triggered monostable using an inverter

Figs. 6.16 and 6.17 respectively show how positive and negative output pulses may be derived from a negative edge trigger. These circuits are somewhat similar in operation to those which operate from a positive edge trigger. In this case, however, the input of the inverting gate is biased into the logic 1 condition by means of an additional resistor connected to the positive supply rail. This places a quiescent voltage of approximately 2·5V at the input of the logic gate.

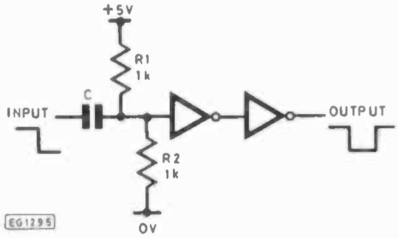


Fig. 6.17. Simple negative-going output negative edge triggered monostable using inverters

PULSE GENERATOR USING THE 7404

The two short exercises which follow are designed to confirm the operation of the 7404 hex-inverter as a monostable pulse generator. Both exercises involve the generation of a positive pulse, the first being triggered by a positive edge whilst the second is triggered by a negative edge.

The positive edge triggered monostable follows the arrangement shown in Fig. 6.14 and is constructed using the following links on the Logic Tutor:

A1	to	S1	via 100µF capacitor (+ve to S1)
A1	to	0V	via 470Ω resistor
A2	to	A3	
A4	to	D1	(D1 indicates the output)
A7	to	0V	(0V)
A16	to	+5V	(positive supply)

The 7404 should be inserted into socket A, taking care to orientate the package so that pin 1 aligns with A1. In the absence of any input from S1, D1 should remain extinguished. Immediately S1 is depressed, however, a positive edge is generated and D1 should flash momentarily (i.e. approx. 0·2 second) and then become extinguished again. If S1 is pressed, and held down, only one flash will be generated. If S1 is pressed and then released repeatedly D1 will flash once for each positive edge generated.

The negative edge triggered monostable follows the arrangement shown in Fig. 6.16 and uses the following links on the Logic Tutor:

A1	to	S1	via 100µF capacitor (−ve to S1)
A1	to	0V	via 1kΩ resistor
A1	to	+5V	via 1kΩ resistor
A2	to	D1	(D1 indicates the output)
A7	to	0V	(0V)
A16	to	+5V	(positive supply)

The 7404 should again be inserted into socket A. In the absence of any input from S1, D1 should again remain extinguished. When S1 is depressed nothing should happen and D1 should remain extinguished since the circuit is designed to ignore a positive edge transition. Releasing S1, which produces a negative edge, should cause D1 to flash momentarily and then become extinguished again. If S1 is pressed and released repeatedly D1 should flash once for each negative edge generated.

NEXT MONTH: We continue by looking at the 74121 monostable, pulse stretching techniques, a variable width pulse generator, De Morgan's Theorem, Karnaugh Maps and an intruder alarm for our electronic shop.

MICRO-BUS

and MICROPROMPT

Appearing every month, Micro-Bus now presents ideas, applications and programs for the most popular micro-computers and all micro-related projects so far published in PE. Ideas must be original, and payment will be made for any contribution featured.

COPYING M/C

Sir—when copying machine code tapes for the UK101 to make back-up copies or for a high speed cassette interface, there can be problems due to some programs overwriting e.g. page zero memory. Also in order to exit machine code games etc. it is very often necessary to press reset, and this may foul up the program making it pointless to attempt to save it.

A way round this problem is to use the NMI (non-maskable interrupt). By connecting a push-to-make switch from ground to either pin 6 of the 6502 or pin 2 of J1 you can jump to any memory location via the NMI vector at HEX 0130. With Cegmon the ideal place to jump to is FEOC, the machine code monitor warm start. To do this enter the monitor by reset M and enter 0130 4C,OC,FE. (0130 JMP FEOC.)

Before the program can be SAVED you need to know the start, end and entry points (RAM addresses) of the code. To make it easy to find the end address it is advisable to fill all RAM with the same number so that when loading the program it will only overwrite the RAM it occupies. For example the original BASIC 4 chip will, when cold-starting, fill all user RAM with HEX 24, and by finding the last "24" overwritten you can find the end address of the code to be saved.

The start and entry (or "Go") addresses can usually be found by watching the screen when loading. When loading with Cegmon the start address appears first, followed by Hex pairs of digits and then the "Go" address. It is possible that the first address may be that of a checksum or other loader so this method may not work in every case. A better way is to use Exmon but you may need a relocated version that doesn't clash with the program for memory space.

To summarise, cold start (if RAM test doesn't fill RAM then fill all RAM with a FOR-NEXT loop e.g. FOR J = 768 TO 16348 : POKE J,36 : NEXT), then enter the machine code monitor and enter 0130 4C,OC,FE. Now LOAD the program to be SAVED and note down the start address and entry address when they appear on the screen—but you'll have to be ready as they will disappear almost immediately. The program or game will start but press the NMI switch and the computer will jump to the monitor warm start. Cegmon's tabulate command will assist in finding the last RAM location before all the "24s"—you can now tell the end address. Finally SAVE by typing S START,END ENTRY e.g. S 0240,0FFF 0800.

Here are some useful routines:

To jump out of BASIC and load M.C.:

```
POKE 251,1 : &GO£ F988
```

or

```
POKE 251,1 : CALL -1655
```

To jump out of M.C. and run BASIC :

```
JSR £A477
JMP £A5C2
```

If saving non-continuous blocks of RAM then the "Go" address is £ FA2E e.g. S 0235,02FF FA2E then S 1C00,1CFF 0000 .

To double space text on screen : POKE 15,0 .

To prevent carriage returns half way along lines when for example printing "TEST", within a loop : POKE 14,0 (within the loop).

To LIST within a program without returning to command mode :

POKE 4,194 : POKE 5,165 : LIST : POKE 4,195 : POKE 5,168

(for BASIC 5 after LIST put POKE 4,136 : POKE 5,146)

If you have BASIC 5 from Premier then try POKEing 316 with 63 or 65 when doing blocks, vertical lines etc.

Dave Henniker,
Edinburgh.

UK101 REM REMOVER

Sir—I have a UK101 with 48K of RAM and the original monitor.

The following program may be of interest to your readers. It is a "REM remover" for UK101. As the program is fairly long (303 bytes) it is shown as a memory dump. The program occupies locations 1E80 to 1FAF. Memory will need restricting if the program is to be resident while BASIC programs are running.

To use the program, have the code resident and load a BASIC program with lots of REMs. It is worthwhile doing a ?FRE(I) at this point. Press reset, M, 1E80 and G. The program returns to BASIC when it has finished. All REMs should have been removed. Do a ?FRE(I) to see how much space has been recovered.

S. Jaworski,
Walsall.

```
1E80  A9 01 85 30 A9 03 85 31
1E88  A9 00 85 38 A0 00 EA B1
1E90  30 D0 2E C8 B1 30 D0 29
1E98  A5 38 F0 22 A9 00 A8 91
1EA0  36 C8 91 36 38 A5 30 E5
1EA8  36 85 36 A5 31 E5 37 85
1EB0  37 38 A5 7B E5 36 85 7B
1EB8  A5 7C E5 37 85 7C 4C 74
1EC0  A2 A0 00 EA B1 30 85 32
1EC8  C8 B1 30 85 33 A0 04 EA
1ED0  B1 30 C9 8E D0 1B A5 38
1ED8  D0 0C A5 30 85 36 A5 31
1EE0  85 37 A9 01 85 38 A5 32
1EE8  85 30 A5 33 85 31 4C 8C
1EF0  1E A5 38 D0 2D A0 05 EA
1EF8  B1 30 F0 EA C9 8E F0 04
1F00  C8 4C F8 1E 18 98 65 30
1F08  85 36 A9 00 65 31 85 37
1F10  A9 00 88 91 30 A8 A5 36
1F18  91 30 C8 A5 37 91 30 4C
1F20  E2 1E 38 A5 30 E5 36 85
1F28  2C A5 31 E5 37 85 2D 38
1F30  A5 7B E5 2C 85 7B A5 7C
1F38  E5 2D 85 7C A5 36 85 2E
1F40  A5 37 85 2F A5 30 85 34
1F48  A5 31 85 35 A0 00 EA 38
1F50  B1 30 85 32 E5 2C 91 30
1F58  C8 B1 30 85 33 E5 2D 91
1F60  30 88 A5 33 F0 0B A5 32
1F68  85 30 A5 33 85 31 4C 4C
1F70  1F A5 32 D0 F1 A9 00 91
1F78  30 C8 91 30 88 A0 00 EA
1F80  B1 34 91 36 E6 36 E6 34
1F88  A5 34 D0 02 E6 35 A5 36
1F90  D0 02 E6 37 A5 37 C5 7C
1F98  D0 E6 A5 36 C5 7B D0 E0
1FA0  A5 2E 85 30 A5 2F 85 31
1FA8  A9 00 85 38 4C 8C 1E
```

HELP!

Sir—I would very much like to hear from any reader who might be in a position to supply me with either a R.O.M., tape or just a listing of the full advertised plot routines for the Computer User Aids UK101 High Resolution Board.

Harry Odes,
London.

ZX81 SCREEN SAVE

Sir—This should interest owners of the ZX81 (16K), and provide a means whereby the contents of the screen can be recorded on tape and then retrieved at a later date.

The program puts the contents of the display file into a numeric string, which is recorded on tape following the command Save. After a Load instruction this same string is loaded into memory and on the command GOTO 50 the string is POKED into the new display file. There is just one important proviso: Do not use the instruction Run, as its use will wipe out the string and cause the program to crash. Lines 18, 40, 42, 52, 54, 56, 76 and 78 check for just such a crash and advise the user should it happen.

The Screen Save program is meant to run with any other user program (space permitting) and has been specially condensed into less than 100 lines such that it can be sandwiched into existing programs. To illustrate the point, Screen Save (lines 10–80) has been written in conjunction with "Cheese Nibbler" (lines 95–130).

To operate the program/programs run "Cheese Nibbler" at 100. When an interesting pattern presents itself, press any key which will cause the display to be memorised in "A" string. At this stage the program and the display can be taped by "SAVE Screen Save". At a later date the tape can be loaded back with "LOAD Screen Save". The original display is available on the command "GOTO 50" or the "Cheese Nibbler" program is entered on the instruction "RUN 100". The illegal command "RUN" or "RUN 50" will cause a crash into the user advice in line 78.

Incidentally I do not claim any originality for "Cheese Nibbler"; it is straight out of the ZX81 BASIC programming book chapter 18.

J. Vella,
Carlisle.

```
10 REM "SCREEN SAVE"
12 REM "TO RETRIEVE DISPLAY,
        ASK ZX81 TO GOTO 50"
14 REM "A,C,D,E,L,P,Q,V USED AS
   SUBSCRIPTS IN PRG 1-90"
16 REM "MAIN PRG AT 100"
18 GOTO 76
20 FAST
22 LET D=PEEK 16396+256*
   PEEK 16397
24 LET V=PEEK 16400+256*
   PEEK 16401
26 LET L=V-D
28 DIM A (L)
30 LET Q=0
32 FOR P=D TO (V-1)
34 LET Q=Q+1
36 LET A (Q)=PEEK P
38 NEXT P
40 LET E=PEEK 16405
42 POKE 16507, E
44 PRINT AT 21, 0;"  DISPLAY
   SAVED IN MEMORY  "
46 SLOW
48 GOTO 100
50 FAST
52 LET C=PEEK 16507
54 LET E=PEEK 16405
56 IF E>C+1 OR E<C-1 THEN
   GOTO 76
58 LET D=PEEK 16396+256*
   PEEK 16397
60 LET V=PEEK 16400+256*
   PEEK 16401
62 LET Q=0
64 FOR P=D TO (V-2)
68 POKE P, A (Q)
70 NEXT P
72 SLOW
74 GOTO 140
76 SLOW
78 PRINT "  YOU HAVE WIPED OUT
   THE DATA     RELOAD TAPE
   AND GOTO 50          MAIN
   PROG AT 100"
80 STOP
95 REM "CHEESE NIBBLER"
100 PLOT INT (RND*64), INT (RND*44)
110 UNPLOT INT (RND*64), INT
    (RND*44)
120 IF CODE INKEY$=0 THEN
    GOTO 100
130 GOTO 20
140 STOP
```

NOTE: Bold characters represent inverse videc

Readout...

Temperature Sense

Sir—As a regular reader of PE, I was interested in the article *Gas Saver* in the December issue. The point of my letter concerns additional experiments (using diode sensors on a solid fuel system), and these included monitoring the hot water tank temperature to obtain a differential control of the system in a similar manner to the author's; and there may be a simpler method of assessing the hot water tank temperature indirectly. This entails siting the "remote" sensor at the boiler end of the hot water return pipe rather than on the storage tank itself.

Due to the exchange losses in the boiler the temperature in the return pipe will initially be lower than the outflow pipe, but will increase as less heat is absorbed in the heat exchanger, and it is possible to obtain a correlation between the pipes' differential and tank temperature.

The reason for my suggestion is two-fold—it removes the possible requirements of any structural work for the feed wire and access to the tank, and therefore reduces the feed wire to a foot or two. The length of this lead caused me problems, not structural as I only had a free lead, but I found that due to the length of the lead my central heating was being operated by my son's CB, even after I used screened lead and attempted several filtering methods.

This suggestion is offered to anyone suffering from a similar problem, as it would not appear to entail any circuit changes, and the original calibration could accommodate it.

N. L. Smith,
Stoke-on Trent.

Chip Query

Sir—In your current issue is a letter by E. J. Hatch about the series *"Introduction to Digital Electronics"*. I endorse what he says but I would like to query your reply, giving a list of necessary i.c.'s; the last of these is given as 745124, which doesn't exist.

Could you please tell me what was intended? Also do we need more than one of any of these i.c.'s?

J. A. J. Jarvis
Chester.

We are sorry but an error did in fact creep into our reply. The 745124 should have been a 74S124 which is available from Watford Electronics.

Only one of each of the i.c.s is necessary.

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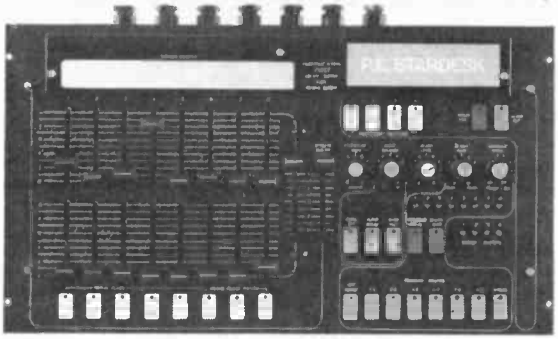

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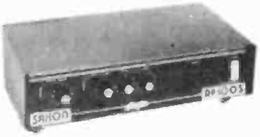

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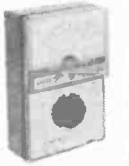

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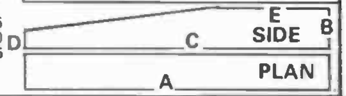

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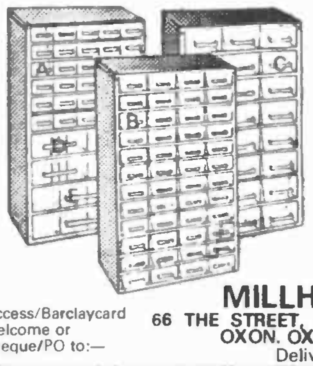

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6 8 25V	20p
6 8 35V	21p
10 16V	18p
10 35V	27p
15 10V	22p
15 16V	30p
15 25V	32p
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.47	100	9p
.47	350	30p
1	63	8p
1	100	9p
1	500	40p
2 2	25	8p
2 2	63	9p
2 2	100	11p
2 2	350	30p
3 3	25	10p
3 3	40	11p
3 3	63	12p
4 7	16	8p
4 7	25	9p
4 7	40	11p
4 7	63	12p
4 7	100	14p
10	25	8p
10	40	12p
10	63	14p
10	100	16p
10	350	55p
22	25	11p
22	40	14p
22	63	16p
22	100	21p
47	25	14p
47	40	17p
47	63	26p
47	100	28p
100	16	14p
100	25	16p
100	40	22p
100	63	25p
100	100	30p
220	10	16p
220	16	17p
220	25	22p
220	40	25p
220	63	30p
220	100	40p
470	16	22p
470	25	28p
470	40	33p
470	63	43p
470	100	60p
1000	16	30p
1000	25	38p
1000	40	46p
1000	63	65p
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uFd	V	
10	16	6p
22	10	6p
22	16	7p
47	10	7p
47	16	8p
100	10	9p
100	16	10p
220	10	11p
220	16	12p
470	10	17p
470	16	18p
1000	10	20p
1000	16	24p
2200	10	34p
2200	16	44p
3300	10	50p
3300	16	65p
4700	10	65p
4700	16	95p

74TTL

7400	19p
7401	19p
7402	19p
7403	19p
7404	19p
7405	19p
7408	19p
7409	19p
7410	19p
7411	19p
7412	19p
7413	25p
7414	50p
7416	40p
7417	40p
7420	19p
7421	19p
7422	19p
7423	19p
7425	19p
7426	19p
7427	19p
7428	26p
7430	19p
7432	24p
7433	24p
7437	25p
7438	36p
7440	22p
7441	55p
7442	32p
7443	89p
7444	89p
7445	69p
7446	59p
7447	70p
7448	70p
7450	15p
7451	15p
7453	15p
7454	14p
7460	29p
7470	34p
7472	29p
7473	55p
7474	55p
7475	55p
7476	55p
7480	49p
7481	1 19
7482	90p
7483	38p
7484	90p
7485	90p
7486	30p
7489	1 68
7490	19p

7491	44p
7492	44p
7493	44p
7494	72p
7495	36p
7496	48p
7497	1 19
74100	1.25
74104	49p
74105	55p
74107	26p
74109	30p
74110	35p
74116	90p
74118	90p
74119	75p
74120	99p
74121	30p
74122	40p
74123	40p
74125	35p
74126	34p
74128	35p
74132	39p
74136	39p
74141	55p
74142	1 95
74143	2 08
74144	2 08
74145	70p
74147	88p
74148	75p
74150	1.20
74151	39p
74153	39p
74154	1.20
74155	45p
74156	45p
74157	45p
74159	1 50
74160	59p
74161	59p
74162	49p
74163	49p
74164	56p
74165	76p
74166	99p
74170	1 25
74172	2 49
74173	59p
74174	54p
74175	49p
74176	39p
74177	45p
74178	79p
74180	40p
74181	1 40
74182	80p
74184	89p
74185	69p
74186	4 69
74188	2 48
74190	60p
74191	60p
74192	60p
74193	60p
74194	60p
74195	60p
74196	45p
74197	45p
74198	1 50
74199	1 50
74221	73p

74LS TTL

74LS00	19p
74LS01	19p
74LS02	19p
74LS03	19p
74LS04	19p
74LS05	19p
74LS08	19p
74LS10	19p
74LS11	19p
74LS12	19p
74LS13	39p
74LS14	39p
74LS15	15p
74LS20	19p
74LS21	19p
74LS22	19p
74LS27	19p
74LS28	19p
74LS30	19p
74LS32	19p
74LS33	19p
74LS37	19p
74LS38	19p
74LS40	19p
74LS42	35p
74LS47	60p
74LS51	19p
74LS54	19p
74LS55	19p
74LS73	28p
74LS74	28p
74LS75	28p
74LS76	28p
74LS78	35p
74LS83	40p
74LS85	60p
74LS86	22p
74LS90	32p
74LS92	45p
74LS93	24p
74LS95	39p
74LS96	93p
74LS107	35p
74LS109	35p
74LS112	35p
74LS113	35p
74LS114	35p
74LS122	35p
74LS123	60p
74LS124	1 50
74LS125	24p
74LS126	25p
74LS132	40p
74LS133	35p
74LS136	29p
74LS138	39p
74LS139	39p
74LS145	99p
74LS147	99p
74LS148	1 19
74LS151	47p
74LS153	49p
74LS154	1.50
74LS155	39p
74LS156	46p
74LS157	40p
74LS158	35p
74LS160	50p

74LS161	50p
74LS162	50p
74LS163	50p
74LS164	50p
74LS165	60p
74LS168	1 40
74LS169	1 09
74LS170	1 19p
74LS173	90p
74LS174	40p
74LS175	40p
74LS181	1 20
74LS183	1.20
74LS190	60p
74LS191	60p
74LS192	60p
74LS193	60p
74LS194	50p
74LS195	50p
74LS196	59p
74LS197	59p
74LS221	95p
74LS240	1 40
74LS241	1 40
74LS242	1 40
74LS243	1 40
74LS244	1 40
74LS245	1 40
74LS247	1 40
74LS248	1 40
74LS249	1 40
74LS251	45p
74LS253	45p
74LS257	45p
74LS258	45p
74LS259	80p
74LS261	99p
74LS265	25p
74LS273	75p
74LS275	1.25
74LS279	33p
74LS280	1 80
74LS283	49p
74LS289	4 70
74LS290	55p
74LS293	49p
74LS295	74p
74LS298	79p
74LS299	1 95
74LS323	1 95
74LS324	1 95
74LS325	3 50
74LS326	3 50
74LS327	3 50
74LS347	1 35
74LS348	1 40
74LS352	71p
74LS353	71p
74LS362	7 25
74LS365	40p
74LS366	40p
74LS367	40p
74LS368	40p
74LS373	99p
74LS378	99p
74LS386	1 14
74LS390	46p
74LS393	99p
74LS395	89p
74LS396	1 90
74LS398	2 70
74LS399	1 59
74LS445	1 40
74LS490	1 40
74LS540	89p
74LS541	79p
74LS640	2.00
74LS641	2 00

CMOS

4000	16p
4001	16p
4002	16p
4006	49p
4007	19p
4008	32p
4009	24p
4010	24p
4011	16p
4012	19p
4013	19p
4014	46p
4015	39p
4016	19p
4017	32p
4018	45p
4019	24p
4020	42p
4021	39p
4022	39p
4023	19p
4024	32p
4025	19p
4026	79p
4027	28p
4028	39p
4029	43p
4030	19p
4031	1 19
4032	79p
4033	1 19
4034	1.29
4035	44p
4036	2.49
4037	1 13
4038	99p
4039	2 45
4040	39p
4041	39p
4042	39p
4043	39p
4044	39p
4045	99p
4046	44p
4047	69p
4048	39p
4049	22p
4050	23p
4051	44p
4052	58p
4053	49p
4054	79p
4055	83p
4056	83p
4059	4 35
4060	42p
4063	79p
4066	22p
4067	2 39
4068	19p
4069	19p
4070	19p
4071	19p

4072	19p
4073	19p
4075	19p
4076	45p
4077	19p
4078	19p
4081	19p
4082	19p
4085	49p
4086	60p
4089	1 23
4093	19p
4094	69p
4095	71p
4096	69p
4097	2.88
4098	74p
4099	89p
4502	55p
4503	39p
4507	33p
4508	1.26
4510	44p
4511	44p
4512	48p
4514	1 13
4515	1 13
4516	55p
4518	39p
4519	29p
4520	48p
4521	88p
4526	68p
4527	62p
4528	74p
4532	69p
4534	3 96
4536	2 59
4538	78p
4539	89p
4543	68p
4553	2 25
4555	35p
4556	35p
4560	1.49
4566	1.49
4569	1.65
4584	39p
4585	59p

LOGIC

CPUs

1802	6.50
2550A	11 99
6502	3.24
6800	2.10
6802	2.40
6809	6.20
8035	3.49
8080A	2.50
8085A	3.49
Z80A	2.98
Z80B	8.60

MEMORIES

2114(200ns)	99p
2532	3 25
2564	6 25
2708	3 50
2716 (5v)	2.65
2764	4.25
4116(200ns)	99p
4118 3	3 25
5204	7 50
6116P3	3.85
6514	3 30
6810	1.45
7489	1.65
74189	4.00
74LS188	2.25
74LS287	3.05
74LS288	2.25
74LS289	3.25

MISC LOGIC IC s

ADC0804	4.40
ADC0816	14.95
ADC0817	10.39
INS1671	20 00
INS1771	14 50
RO2513LC	7 50
RO2513UC	7 50
SAA5000	3.00
SAA5010	7 10
SAA5012	7 10
SAA5020	5 50
SAA5030	9 00
SAA5040	15 00
SAA5041	15 00
SAA5050	8 50
SAA5052	8 50
SAA5070	16 95
8T26	95p
8T28	1 20
8T95	85p
8T97	85p
81LS95	80p
81LS96	85p
81LS97	90p
81LS98	85p
6522	3 19
6532	5 70
8154	9.00
8155	3 50
8212	1 70
8216	99p
8224	1 95
8226	2 50
Z80ACTC	2 60
Z80ADART	5 50
Z80ADMA	6 70
Z80APIO	2 70
ZN425E8	3 39
ZN426E8	2 97
ZN427E8	5 99

V REGS

Positive 100mA

78L05A	29p
78L12A	29p
78L15A	29p
78L24A	29p

1 Amp TO202

7805T	45p
7812T	45p
7815T	45p
7824T	45p

Negative 100 mA TO92

79L05	49p
79L12	49p
79L15	49p

1 Amp TO220

7905T	57p
7912T	57p
7915T	57p
7924T	57p

TRANSISTORS

2N2219	27p
2N2219A	28p
2N2220	22p
2N2221	22p
2N2221A	23p
2N2222	24p
2N2222A	25p
2N2223	2.60
2N2223A	4.15
2N2368	25p
2N2369	19p
2N2369A	20p
2N2904A	27p
2N2905	28p
2N2905A	29p
2N2906	25p
2N2906A	30p
2N2907	25p
2N2907A	26p
2N2920	9 25
2N2926	10p
2N3053	27p
2N3054	56p
2N3055	60p
2N3055H	1 20
2N3439	98p
2N3440	80p
2N3441	1 25
2N3442	1 35
2N3553	2 65
2N3638	55p
2N3702	10p
2N3703	10p
2N3704	10p
2N3705	10p
2N3706	10p
2N3707	10p
2N3708	10p
2N3709	10p
2N3710	10p
2N3711	10p
2N3712	2.00
2N3713	1.38
2N3714	2.98
2N3715	3.31
2N3716	3.60
2N3773	1.99
2N3819	35p
2N3820	38p
2N3866	90p
2N3903	13p
2N3904	13p
2N3905	13p
2N3906	13p
2N4030	75p
2N4031	65p
2N4032	69p
2N4036	63p
2N4037	49p
2N4240	3.00
2N4400	15p
2N4401	27p
2N4402	30p
2N4902	1.85
2N4903	1.98
2N4904	2.15
2N4905	2 75
2N4906	2 99
2N4907	3 20
2N4908	3.15
2N4909	2.90
2N5089	37p
2N5190	68p
2N5191	70p
2N5193	90p
2N5194	79p
2N5245	37p
2N5246	40p
2N5247	45p
2N5248	46p
2N5249	48p
2N5266	2.88
2N5293	98p
2N5294	1.28
2N5295	1.37
2N5401	35p
2N5415	1.10
2N5416	1.54
2N5447	16p
2N5448	19p
2N5449	21p
2N5450	23p
2N5451	25p
2N5457	29p
2N5458	29p
2N5459	29p
2N5460	72p
2N5551	37p
2N5884	5 95
2N5886	5.95
2N6121	57p
2N6122	59p
2N6123	65p
2N6124	59p
2N6125	65p
2N6126	75p
2N6129	79p
2N6130	93p
2N6131	98p
2N6132	83p
2N6133	1 14
2N6134	1 36
2N6253	1 45
2N6254	1 55
2SC1306	95p
2SC2078	1 70
2SJ49	3 95
2SJ50	4 50
2SJ82	4 75
2SK134	3 95
3SK135	4 50
2SK226	4 75
3N128	1 12
3N140	1 07
3N200	6 93
3N201	2 98
40360	60p
40361	67p
40362	67p
40363	2 95
40406	1 39
40407	75p
40408	1 59
40410	1 80
40411	3 95

40412	90p
40673	70p
40822	1 80
40871	1 00
40872	1 00
AC125	49p
AC126	32p
AC127	32p
AC128	35p
AC132	68p
AC141K	28p
AC142K	28p
AC151	51p
AC152	45p
AC153	55p
AC153K	64p
AC176	27p
AC176K	37p
AC187	25p
AC187K	28p
AC188	25p
AC188K	40p
AF239	55p
AF240	1 00
BC107	10p
BC107A	12p
BC107B	12p
BC108	10p
BC108A	12p
BC108B	12p
BC108C	14p
BC109	10p
BC109B	12p
BC109C	12p
BC140	29p
BC141	37p
BC142	29p
BC143	30p
BC147	10p
BC147A	10p
BC147B	10p
BC147C	20p
BC148	10p
BC148A	12p
BC148B	13p
BC148C	13p
BC149	10p
BC149B	12p
BC149C	13p
BC152	35p
BC153	23p
BC154	27p
BC157	11p
BC157A	12p
BC157B	13p
BC158	10p
BC158A	12p
BC158B	13p
BC159	11p
BC159A	12p
BC159B	13p
BC159C	18p
BC160	42p
BC161	48p
BC167	10p
BC167A	10p
BC167B	13p
BC168	10p
BC168B	10p
BC168C	10p
BC169	10p
BC169B	10p
BC169C	10p
BC177	16p
BC177A	25p
BC177B	26p
BC178	16p
BC178A	24p
BC178B	25p
BC179	20p
BC179A	25p
BC179B	25p
BC179C	27p
BC182	10p
BC182A	12p
BC182B	13p
BC182L	10p
BC182LA	13p
BC182LB	14p
BC183	10p
BC183A	11p
BC183B	12p
BC183C	13p
BC183L	10p
BC183LA	13p
BC183LB	13p
BC183LC	14p
BC184	10p
BC184B	12p
BC184C	13p
BC184L	10p
BC184LB	13p
BC184LC	14p
BC186	24p
BC187	24p
BC212	10p
BC212A	12p
BC212B	13p
BC212L	10p
BC212LA	13p
BC212LB	14p
BC213	10p
BC213A	11p
BC213B	12p
BC213C	13p
BC213L	10p
BC213LA	13p
BC213LB	13p
BC213LC	14p
BC214	10p
BC214B	12p
BC214C	13p
BC214L	10p
BC214LB	13p
BC214LC	14p
BC237	14p
BC237A	16p
BC237B	17p
BC237C	18p
BC238	14p
BC238A	15p
BC238B	16p
BC238C	17p
BC239	15p
BC239A	16p
BC239B	17p
BC239C	18p
BC300	45p
BC301	44p
BC302	43p
BC303	47p
BC327	14p
BC328	14p
BC337	15p

BC338	15p
BC440	32p
BC441	33p
BC460	32p
BC461	33p
BC516	40p
BC517	40p
BC546B	15p
BC547	13p
BC556B	15p
BC547A	14p
BC547B	14p
BC548	12p
BC548A	13p
BC548B	14p
BC548C	15p
BC549	13p
BC549B	14p
BC549C	15p
BC550	15p
BC550C	25p
BC557	15p
BC557A	16p
BC557B	16p
BC558	14p
BC558A	15p
BC558B	16p
BC558C	17p
BC559	15p
BC559B	16p
BC559C	17p
BC560	25p
BC560C	25p
BC650	45p
BC651	46p
BCY70	16p
BCY71	16p
BCY72	19p
BD131	44p
BD132	44p
BD135	35p
BD136	35p
BD137	37p
BD138	37p
BD139	38p
BD140	38p
BD237	98p
BD238	98p
BD239A	57p
BD239C	64p
BD240A	59p
BD240C	73p
BD241A	61p
BD241C	67p
BD242A	65p
BD242C	70p
BD243A	72p
BD143C	85p
BD244A	82p
BC244C	1 00
BD245A	1 14
BD245C	1 30
BD246A	1 20
BD246C	1 50
BC249A	2 00
BD249C	2 31
BD250A	2 11
BD250C	2 46
BD419	1 29p
BD420	1 37
BD437	88p
BD438	88p
BD439	90p
BD440	91p
BD441	91p
BD442	93p
BD529	1 20
BD530	1 30
BD535	75p
BD536	75p
BD537	80p
BD538	80p
BD539	80p
BD539C	1 10
BD540	85p
BD540C	1 20
BD675	72p
BD676	77p
BD677	78p
BD678	83p
BD711	1 32
BD712	1 32
BDX32	3 47
BDX66B	5 95
BDX67B	5 95
BDY54	1 70
BDY55	1 75
BDY56	1 80
BDY57	5 25
BDY58	6.15
BF194	12p
BF195	12p
BF196	12p
BF197	12p
BF198	15p
BF199	15p
BF200	75p
BF224J	32p
BF225J	35p
BF244A	55p
BF244B	55p
BF245A	55p
BF245B	65p
BF246	70p
BF246A	70p
BF246B	70p
BF247A	75p
BF247B	75p
BF254	39p
BF255	42p
BF256A	58p
BF256B	58p
BF256C	65p
BF257	30p
BF258	32p
BF259	35p
BF457	46p
BF458	56p
BF459	62p
BF469	86p
BF470	86p
BFR39	25p
BFR40	25p
BFR41	25p
BFR79	25p
BFR80	25p
BFR81	25p
BFR90	2 11
BFS28	2.95
BFS61	1 00
BFS98	1 10
BFX29	26p
BFX30	27p

BFY50	23p
BFY51	23p
BFY52	23p
BFY53	31p
BSX19	24p
BSX20	24p
BSX21	40p
BU104	2 22
BU105	1 70
BU108	3 95
BU109	3.29
BU126	1.47
BU204	2 25
BU205	1 75
BU206	1 89
BU208	1 98
BU226	3 95
BU326S	2 35
BU406	1.45
BU407	1 45
BU408	1.35
BU500	2.95
BUY18S	3.95
E430	5.95
J300	70p
J310	70p
MJ802	3 99
MJ900	2 90
MJ901	3 10
MJ1000	2 50
MJ1001	3.00
MJ1800	3.60
MJ2500	2.19
MJ2501	2 25
MJ2955	1 00
MJ3000	2 19
MJ3001	2 25
MJ4502	3 99
MJ15003	4 85
MJ14004	5 55
MJ15015	2 45
MJ15016	3 34
MJE340	53p
MJE350	1 50
MJE2955	1 95
MJE3055	1 95
MJE2955T	99p
MJE3055T	69p
MPSA05	23p
MPSA06	25p
MPSA10	28p
MPSA12	29p
MPSA13	48p
MPSA14	46p
MPSA16	30p
MPSA18	65p
MPSA20	48p
MPSA42	49p
MPSA43	49p
MPSA55	28p
MPSA56	30p
MPSA65	40p
MPSA66	47p
MPSA70	45p
MPSA92	39p
MPSA93	39p
MPSL01	46p
MPSL51	49p
MPSU01	84p
MPSU04	1 32
MPSU05	55p
MPSU06	56p
MPSU07	75p
MPSU51	88p
MPSU55	58p
MPSU56	59p
MPSU57	1.20
NE5532	1.65
TIP29A	29p
TIP29C	38p
TIP30A	35p
TIP30C	36p
TIP31A	33p
TIP31C	34p
TIP32A	38p
TIP32C	42p
TIP33A	65p
TIP33C	78p
TIP34A	74p
TIP34C	88p
TIP35A	1 09
TIP35C	1 28
TIP36A	1.29
TIP36C	1.39
TIP41A	49p
TIP41C	55p
TIP42A	55p
TIP42C	59p
TIP49	1 20
TIP50	1 40
TIP53	1 57
TIP54	1 59
TIP110	74p
TIP112	90p
TIP115	81p
TIP117	96p
TIP120	69p
TIP122	73p
TIP125	84p
TIP127	84p
TIP130	93p
TIP132	93p
TIP135	99p
TIP137	99p
TIP140	1 04
TIP142	1 04
TIP145	1 15
TIP147	1 15
TIP162	4 95
TIP2955	77p
TIP3055	70p
TIS43	50p
TIS88A	80p
VN10KM	60p
VN46AF	95p
VN66AF	99p
ZTX107	10p
ZTX108	10p
ZTX109	12p
ZTX300	13p
ZTX301	15p
ZTX302	15p
ZTX303	23p
ZTX304	15p
ZTX310	35p
ZTX311	32p
ZTX312	35p
ZTX313	36p
ZTX314	24p
ZTX320	35p
ZTX330	35p
ZTX341	28p
ZTX450	39p

ZTX50C	14p
ZTX50T	14p
ZTX502	14p
ZTX503	17p
ZTX504	24p
ZTX510	24p
ZTX530	24p
ZTX531	25p
ZTX650	45p

DIODES

1N34A	30p
1N821	70p
1N823	92p
1N914	4p
1N916	6p
1N4001	4p
1N4002	4½p
1N4003	5p
1N4004	5½p
1N4005	6p
1N4006	6½p
1N4007	7p
1N4009	20p
1N4148	3p
1N4150	18p
1N4448	22p
1N5400	12p
1N5401	13p
1N5402	14p
1N5404	16p
1N5406	18p
1N5407	19p
1N5408	20p
1N5024	52p
1S44	10p
BA102	25p
BA115	25p
BA133	40p
BA138	30p
BA142	20p
BA155	15p
BA156	38p
BA157	25p
BA158	30p
BA150	32p
BA182	40p
BA201	18p
BA202	26p
BA316	25p
BA317	25p
BA318	30p
BAV10	16p
BAV19	15p
BAV20	15p
BAX13	10p
BB109G	65p
BY126	11p
BY127	12p

SCR's, TRIACS DIACS

THYRISTORS 4 8 & 12 Amps Texas TO220
Suffix A - 100V
B - 200V
C - 300V
D - 400V
M - 600V

TIC106A	46p
TIC106B	47p
TIC106C	48p

4A

TIC106D	49p
TIC106M	68p
TIC116A	66p
TIC116B	68p

8A

TIC116C	71p
TIC116D	73p
TIC116M	80p
TIC126A	72p
TIC126B	72p

12A

TIC126C	73p
TIC126D	77p
TIC126M	96p

TRIACS Texas 400V TO220 Case

TIC206D(4A)	66p
TIC225D(6A)	74p
TIC226D(8A)	88p
TIC236D(12A)	1 16
TIC246D(16A)	1 22
TIC253D(20A)	1 90
TIC263D(25A)	2 11

DIACS

BR100	29p
ST2	29p

ZENER'S

many inc specials see our CAT

400 500mW E24 Series 2 4 47V 7p

1 3 Watt E24 Series 3 3 82V 14p

BRIDGE

(PIV shown in brackets)

1½ amp type

W01 (100)	28p
W02 (200)	34p
W04 (200)	38p
W08 (800)	50p

2 amp type Square with hole

S01 (100)	46p
S02 (200)	50p
S04 (400)	55p
S08 (800)	66p

6 amp type Square with hole

PW01 (100)	95p
PW02 (200)	99p
PW04 (400)	1 30
PW06 (600)	1 39

25 amp type Metal clad with hole

K01 (100)	2 62
K02 (200)	2 75
K04 (400)	3 25
K06 (600)	4 10
BYW64 35A 400V	4 50

OPTO

many inc specials see out CAT

LED LAMPS
R = Red
G = Green
Y = Yellow

Large Diffused 1 +

R5D	9p
G5D	15p
Y5D	15p

Small diffused

R3D	8p
G3D	12p
Y3D	12p

Micro 0 1"

R1M	25p
G1M	27p
Y1M	27p

Lage clear

R5C	12p
G5C	17p
Y5C	17p

Super bright high efficiency Large (100 times brighter)

R5U	38p
G5U	42p
Y5U	42p

Rectangular Stackable LEDs

R5R	17p
G5R	18p
Y5R	19p

LIN ICS

AY1 5050	95p
AY3 8910	3 99
AY3 8912	4 95
CA3048	2 15
CA3059	2 80
CA3090AQ	3 70
CA3130E	87p
CA3130T	2 35
CA3140E	39p
CA3140T	1.40
HA1366W	2.40
HA388	2 54
ICL7106	7.50
ICL7107	9 50
ICL7611	97p
ICL8038	2 99
ICM7555	80p
ICM7556	1 50
LC7120	3 20
LC7130	3 40
LC7137	3 95
LF347	1.50
LF351	47p
LF353	92p
LF355	83p
LF356	92p
LF357	1 30
LF398	4.62
LM3352	1 60
LM348N	62p
LM349N	1.09
LM350K	4 60
LM379S	5.50
LM380N14	75p
LM380NB	1.50
LM381AN	2.26
LM381N	1 40
LM382N	1 12
LM383T	3.40
LM384N	1 40
LM386	88p
LM388N	2.43
LM391N60	2.10
LM391N80	2 40
LM723CH	95p
LM723CN	35p
LM725CH	3.40
LM725CN	3.19
LM741CH	96p
LM741CN	18p
LM741CN14	80p
LM747CN	69p
LM748CH	1.00
LM748CN	35p
LM1871	3.25
LM1872	4.39
LM1877	5 95
LM1886	7 44
LM1889	3 77
LM2907N	2 75
LM2907NB	2 60
LM2917N	2 40
LM2917NB	2 40
LM3900	48p
LM3911	1 20
LM3914	3 25
LM3915	3 25
LM13600	1 15
MF10	3 50
NE531N	1 36
NE543N	2 50
NE544N	1 95
NE555	18p
NE556	65p
NE558	1.89
NE560	3.25
NE565	1 18
NE566	1.49
NE567	1.37
NE570	4 07
NE571	3.99
NE5534A	1.45
RC4194	3.95
RC4195	2.95
RC4558	44p
SL470	3.47
SL480	2.99
SL490	3.47
SN76003	2.95
SN76013	2.95
SN76023	2.95
SN76033	2.95
TA7204	1.99
TA7205	1 20
TA7222	1 75
TA7227	5 82
TBA500	2 97
TBA500Q	3 11
TBA510	2 95
TBA510Q	3.05
TBA520	2.57
TBA520Q	2.75
TBA530	2.55
TBA530Q	2.76
TBA540	2 72
TBA540Q	2 74
TBA550	3 25
TBA550Q	3 27
TBA560C	2 87
TBA570	2.37
TBA570Q	2.48
TDA1002	3 39
TDA1003	3 94
TDA1004	3.94
TDA1005	3 94
TDA1010A	2 25
TDA1022	4 95
TDA2002	3 25
TDA2003	3 25
TDA2020	2 99
TDA2030	2 85
TDA2611A	2 50
TDA7000	3 45
TL061	40p
TL062	60p
TL064	1.35
TL071	34p
TL072	45p
TL074	1 35
TL081	34p
TL082	45p
TL084	1 20
UAA170	2 49
UAA180	2 49
ULN2003	75p
UPC575C2	2.00
UPC1156	2 75
UPC1156H	2 75
UPC1182	3 75
UPC1185	1 95
UPC2002	2 95
XR2206	3 95
ZN409	2 25
ZN414	1 00
ZN1034	1 99

TRANSFORMERS

All 240V Primary
6 0 6V 9 0 9V
12 0 12V
15 0 15V

100mA	95p
1A	2.65

20 0 20V

1 25A	2.65

12 0 12V

50VA	5 25

12 0 12V

100VA	9.50

0 - 6 - 6 - 9 - 9

1 25A	4.25

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2 5 · 3 7	83p
2 5 × 5	99p
3 75 · 3.75	99p
3 75 · 5	1 14
2 5 · 17	2 99
3 75 · 17	3 85
4 79 · 17	4 93
VO Board	1.92
Dip Board	3.90
Track Cutter	1.48
Pin Insertor	1.79
100Pins	55p
Verobloc	3.99

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Spare Spool	75p
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1 Thin lines
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4 Thick bends
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6 Transistor pads
7 Dots · holes
8 0 1" edge connectors
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420 · 195mm	1 95
420 · 245mm	2 95

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203 · 114	2.40
233 · 220	5.20

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100 · 200	2.80
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Solid connecting wire

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Twin 2½ Amp	16p
3 Core 2½ Amp	18p
3 Core 6 Amp	31p
3 Core 13 Amp	56p

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Stereo	27p
Mini Single	12p
Mini Stereo	15p
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4 Core, Single Screen	54p
8 Core	61p
12 Core	80p
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16 way	39p
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32 way	82p
40 way	88p
64 way	1.49

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HP2(1.2AH)	2 39
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ANTEX SOLDERING IRONS

C240 (15W)	4.95
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Iron Stand	1.75
Elements (State Iron)	2.05

C240 Bits

No 2 (Small)	85p
No 3 (Med)	85p
No 6 (Micro)	85p

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No 50 (Small)	85p
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SOLDER 125gms

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Blk. Red. Grn. Wt or Yell	15p
Line Skts	1.20
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24pin	4 35
28pin	5 00
40pin	5 35

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TOGGLE (MINI)

SPST	49p
SPDT	59p
DPDT	69p
DPDT C OFF	90p
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Full-travel, full size

KEYBOARD

Simply plugs into expansion port on your

SPECTRUM

KIT ONLY £39.95
READY-BUILT £44.95
Case included in both prices

- ★ *Single-key selection of all major multi-key functions.*
- ★ *Plugs directly into Spectrum expansion port and extends port for other peripherals.*
- ★ *Can accept Atari-type joysticks (optional extra).*
- ★ *Absolutely no soldering or dismantling of Spectrum.*
- ★ *Available in kit-form or ready-built.*

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Full construction details in Projects Book 9.

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PE LOGIC DESIGN CARD

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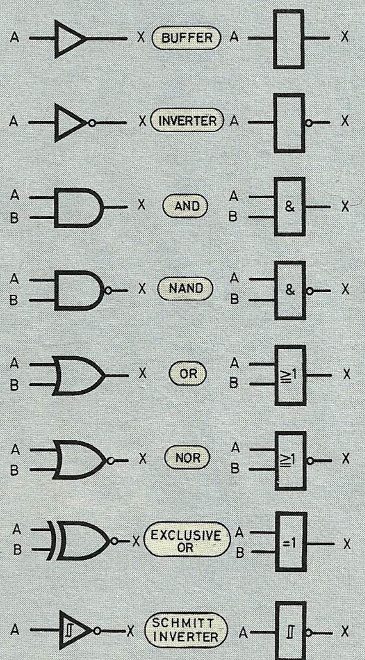
DIGITAL LOGIC

Digital logic is based on the idea of only two (binary) states. These two states are known variously as true & false, on & off, logic 1 & logic 0, or more frequently just 1 & 0. A digital signal is always in one of these two states (or moving between them). Digital logic gates allow these signals to be manipulated. Suitable combinations of digital signals and logic gates allow circuits to be built to perform a wide range of useful functions.

LOGIC SYMBOLS

Digital circuit diagrams use standard symbols to represent logic gates. The most frequently used symbols are from the BS or the MIL series. The common symbols from these two series are shown below.



PIN NUMBERING

TTL i.c.s are usually in dual-in-line (d.i.l.) packages. These have oblong plastic or ceramic bodies which protect the silicon chip. Parallel rows of pins 0·1″ apart protrude from the two long sides of the i.c., with a total of usually 14, 16 or 24 pins. The pins are numbered anti-clockwise from 1 when looking from the top (i.e. pins pointing downwards). The end of the package containing pin 1 is identified by an indentation, and/or there is a smaller hole next to pin 1.

GATE FUNCTIONS

A two-input gate can have 16 possible functions. Not all of these are actually available as logic gates. The table below identifies the possible inputs, with their corresponding outputs, for all 16 functions.

LOGICAL FUNCTION	INPUTS				
	A=0 B=0	A=0 B=1	A=1 B=0	A=1 B=1	
LOGIC 0	0	0	0	0	OUTPUTS
$A \cdot B$	0	0	0	1	
n/a	0	0	1	0	
A	0	0	1	1	
n/a	0	1	0	0	
B	0	1	0	1	
$A \oplus B$	0	1	1	0	
$A+B$	0	1	1	1	
$\overline{A+B}$	1	0	0	0	
$\overline{A \oplus B}$	1	0	0	1	
$\overline{B}$	1	0	1	0	
n/a	1	0	1	1	
$\overline{A}$	1	1	0	0	
n/a	1	1	0	1	
$\overline{A \cdot B}$	1	1	1	0	
LOGIC 1	1	1	1	1	

7400 TTL FAMILY

Logic families are collections of logic gates based on the same basic gate, and they greatly simplify the construction of logic circuits. Gates from a family all use a common power supply, and they may be connected together using a simple set of rules, safe in the knowledge that they are all compatible. The most common family is the 7400 series of TTL gates. Within this family there are a number of sub-families, and the numbering of TTL i.c.s is according to the following general rules.

SN74LS86N

SN	Manufacturer's prefix (may be any letters)
74	Indicates 7400 series TTL
LS	Indicates which TTL sub-family: null = standard H = high speed L = low power LS = low-power Schottky S = Schottky
86	Indicates gate function e.g. 00 = quad 2-i/p NAND 86 = quad 2-i/p Ex-OR
N	Manufacturer's package code e.g. N = plastic d.i.l. pack

Typically, TTL i.c.s are referred to in circuits without any reference to the manufacturer's prefix or suffix, e.g. the device above would be described as a 74LS86.

LOGIC LEVELS

The voltage levels used to represent logic 0 and logic 1 are defined for TTL signals as below. Voltages between these levels are not permitted TTL levels.

Gate outputs:	Logic 0	0V to +0·8V
	Logic 1	Above +2·4V
Gate inputs:	Logic 0	0V to +0·8V
	Logic 1	Above +2·0V

An unloaded standard TTL gate has output levels of around +0·2V for logic 0 and +3·5V for logic 1. These levels tend to move up and down, respectively, as more gates are connected to the output.

BOOLEAN SYMBOLS

Boolean Algebra is a shorthand way of representing the behaviour of gates. It uses true and false to represent logic 1 and logic 0. For inputs of A and B, and an output of X, the Boolean shorthand for the common gates is as follows.

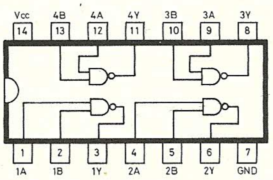
Buffer	$X = A$
Inverter	$X = \overline{A}$
AND	$X = A . B$
OR	$X = A + B$
NAND	$X = \overline{A . B}$
NOR	$X = \overline{A + B}$
Exclusive-OR	$X = A \oplus B$

USEFUL IDENTITIES

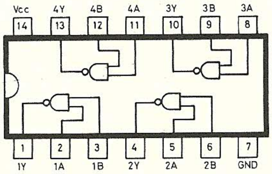
The following are useful Boolean Identities which allow simplification of logic circuits, or the use of a smaller number of different gates, to perform the same function.

$A + 0 = A$	$A . 0 = 0$	$A \oplus 0 = A$
$A + 1 = 1$	$A . 1 = A$	$A \oplus 1 = \overline{A}$
$A + A = A$	$A . A = A$	$A \oplus A = 0$
$A + \overline{A} = 1$	$A . \overline{A} = 0$	$A \oplus \overline{A} = 1$
	$\overline{\overline{A}} = A$	

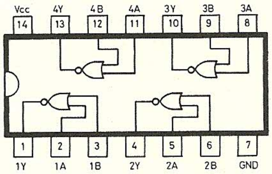
When looking at inverting gates, each logical inversion introduces an over-rule on the signal (to represent the inversion). Over-rules of *identical* length cancel out in pairs, as indicated in the last identity.



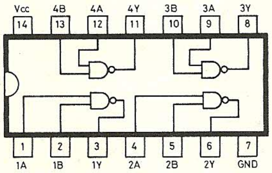
7400 Quad
2-input NAND



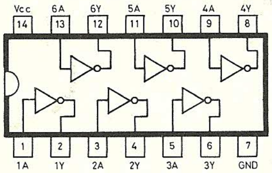
7401 Quad
2-input NAND oc



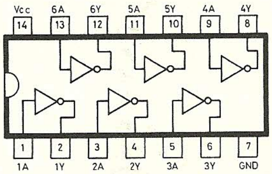
7402 Quad
2-input NOR



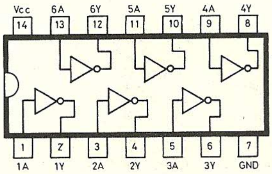
7403 Quad
2-input NAND oc



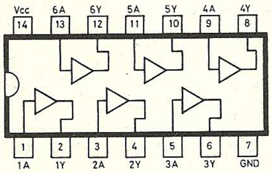
7404 Hex
inverter



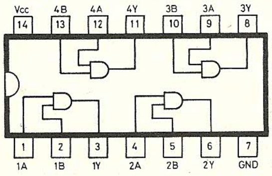
7405 Hex
inverter oc



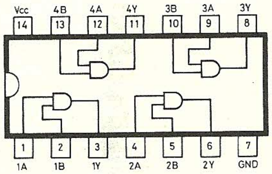
7406 Hex
inverter 30V o/p



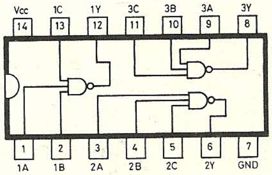
7407 Hex
buffer 30V o/p



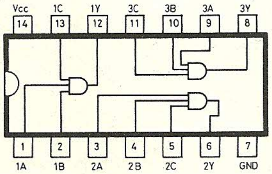
7408 Quad
2-input AND



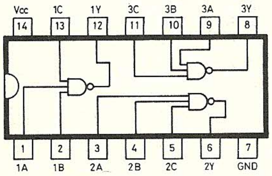
7409 Quad
2-input AND oc



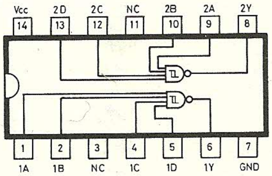
7410 Triple
3-input NAND



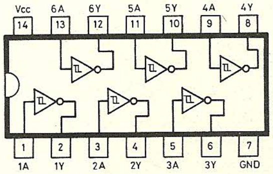
7411 Triple
3-input AND



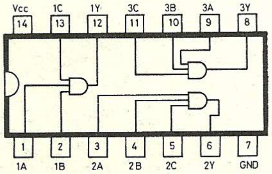
7412 Triple
3-input NAND oc



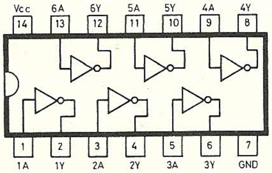
7413 Dual
4-input NAND Schmitt



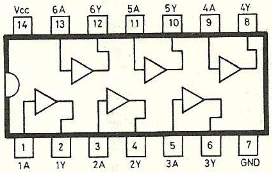
7414 Hex
inverter Schmitt



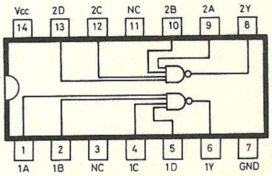
7415 Triple
3-input AND oc LS



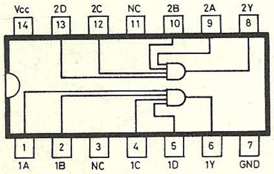
7416 Hex
inverter 15V o/p



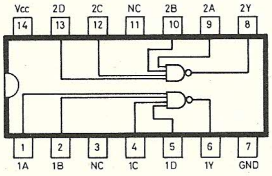
7417 Hex
buffer 15V o/p



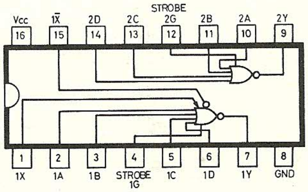
7420 Dual
4-input NAND



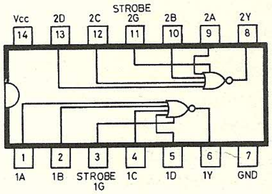
7421 Dual
4-input AND



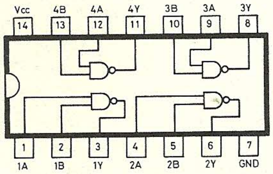
7422 Dual
4-input NAND oc



7423 Dual
4-input NOR expand



7425 Dual
4-input NOR strobe



7426 Quad
2-input NAND high volts