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ELECTRONICS

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HEART BEAT MONITOR

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PE ROBOTICS MICROS ELECTRONICS INTERFACING

ISSN 0032-6372

VOLUME 21 Nº3 MARCH 1985

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

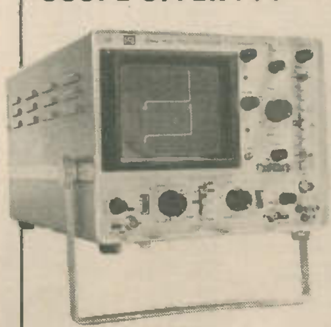
NEWS & COMMENT

The INMOS CAD design system lays out and simulates VLSI circuits.

A designer instructs the system where a transistor, or other structure is to be placed, and the screen displays an appropriate layout, obeying the design rules. It also stops the designer from for example, attempting to put two structures too close together.

Created for the design of INMOS' transputer the system is now available from Racal Redac as part of their CIEE electronics design and engineering package.

SCOPE OFFER . . .



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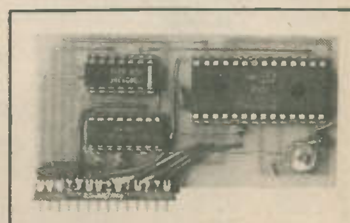

OUR APRIL ISSUE WILL BE ON SALE FRIDAY, MARCH 1st, 1985 *(see page 35)*

WATFORD ELECTRONICS

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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 **48p;** 2200 **90p;** **25V:** 4·7, 10, 22, 47 **8p;** 100 **11p;** 150 **12p;** 220 **15p;** 330 **22p;** 470 **25p;** 680, 1000 **34p;** 1500 **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 **38p;** 4700 **79p.**

TAG-END TYPE: 64V: 4700 **245p;** 3300 **145p;** 2200 **120p;** **50V:** 3300 **155p;** 2200 **95p;** **40V:** 4700 **160p;** 2200 **70p;** 3300 **85p;** 4000, 4700 **75p;** 10,000 **250p;** 15,000 **270p;** **16V:** 2200 **200p;** **25V:** 4700 **98p;** 10,000 **320p;** 15,000 **345p.**

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

500W, 1K & 2K (LIN ONLY) Single	**35p**
5KΩ-2MΩ single gang	**35p**
5KΩ-2MΩ single gang D/P switch	**95p**
5KΩ-2MΩ dual gang stereo	**99p**

TANTALUM BEAD CAPACITORS:
35V: 0·1µ, 0·22, 0·33 **15p** 0·47, 0·68, 1·0, 1·5 **16p** 2·2, 3·3 **18p** 4·7, 6·8 **22p** 10 **28p** **16V:** 2·2, 3·3, **16p** 4·7, 6·8, 10 **18p** 15 **36p** 22 **36p** 33, 47 **50p** 100 **95p** 220 **100p** **10V:** 15, 22 **26p** 33, 47 **50p** 100 **75p.**

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm track
5KΩ-500KΩ Single gang **80p**

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;** 1MF **34p;** 2M2 **50p.**

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

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**

RESISTORS S.I.L. Package: 7 Commoned, 100Ω, 470Ω, 680Ω, 1K, 2K2, 4K7, 10K, 47K, 100K **24p.**
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K, 100K **26p.**

TRANSISTORS

AC127/8	35
AC141/2	35
AC176	35
AC187/8	35
AC188	35
AD142	120
AD149	79
AD161/2	42
AF118	95
AF139	40
AF239	55
BC107/8	12
BC107B	14
BC108B	14
BC108C	14
BC109	12
BC109B	14
BC109C	14
BC114/5	30
BC117/8	25
BC140	38
BC142/3	38
BC147/8	10
BC147B	15
BC148C	10
BC149	12
BC149C	15
BC153/4	30
BC157/8	10
BC159	11
BC167A	14
BC168C	12
BC169C	12
BC171/2	12
BC173	15
BC177/8	16
BC179/81	20
BC181	30
BC182/3	10
BC184	10
BC182L	10
BC183L	10
BC184L	10
BC186/7	28
BC212/3	12
BC212L	10
BC213L	12
BC214	10
BC214L	12
BC237/8	15
BC307B	15

BC308B	16
BC327/8	15
BC337/8	15
BC441	34
BC461	34
BC477/8	40
BC516/7	40
BC547/8	12
BC549C	15
BC556/7	15
BC558/9	15
BCY41/42	30
BCY70	18
BCY71	20
BCY72	25
BCY78	30
BD131/2	65
BD133	60
BD135	45
BD136/7	40
BD138/9	40
BD140	40
BD158	68
BD245	65
BD434	70
BD695A	150
BD696A	150
BF115	45
BF154/8	30
BF167	35
BF173	35
BF177	35
BF178	35
BF179	40
BF194/5	12
BF198/9	18
BF200	30
BF224	40
BF244A	28
BF244B	29
BF245	50
BF256B	50
BF257/8	32
BF259	40
BF394	40
BF451	40
BF494/5	40
BF594/5	30
BFR39/40	25
BFR41/79	25
BFR80/81	25

BFR98	105
BFX29/84	35
BFX84	35
BFX85/86	35
BFX87/88	28
BFY50/51	30
BFY52	30
BFY53	35
BFY55	35
BFY56	35
BFY64	40
BFY90	80
BRY39	30
BSX20	30
BSX29	45
BSY26	35
BSY95	35
BU105	180
BU205	190
BU206	200
BU208	200
MJ2955	90
MJE340	54
MJE371	100
MJE2955	99
MJE3055	70
MPF102	40
MPF103/4	30
MPF105	30
MPSA05	30
MPSA06	25
MPSA08	30
MPSA12	32
MPSA55	30
MPSA56	30
MPSA70	40
MPSU02	58
MPSU05	60
MPSU06	65
MPSU52	65
MPSU55	60
MPSU56	60
OC23	170
OC28/36	220
OC41/42	75
OC70	40
OC72	50
OC75/76	55
OC76	50
OC81/82	50
OC83/84	70
TIP29A	32
TIP29C	38
TIP30A	35

TIP30C	37
TIP31A	38
TIP31C	45
TIP32A	43
TIP32C	45
TIP33A	70
TIP33C	75
TIP34A	85
TIP34C	105
TIP35A	120
TIP35C	130
TIP36A	130
TIP36C	140
TIP41A	50
TIP41B	52
TIP42A	55
TIP42B	58
TIP120	70
TIP121	73
TIP141	120
TIP142	120
TIP147	120
TIP2955	70
TIP3055	70
TIS43	50
TIS44	45
TIS88A	50
TIS90	30
TIS91/93	32
VK1010	99
VN10KM	70
VN46AF	95
VN66AF	110
VN88AF	120
VN89AF	120
ZTX107/8	12
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	25
2N708	25

2N914/5	32
2N918	40
2N930	20
2N1131/2	40
2N1303/4/5	
2N1307	70
2N1613	30
2N1671B	160
2N2160	325
2N2219A/20A/	
21A/22A	25
2N2369A	18
2N2646	45
2N2846	80
2N2904A/05A/	
06A/07A	26
2N2926G	10
2N3053	25
2N3054	55
2N3055	50
2N3442	140
2N3615	199
2N3663	20
2N3702/3	10
2N3704/5	10
2N3706/7	10
2N3708/9	10
2N3710	10
2N3771	179
2N3772	195
2N3773	210
2N3819	35
2N3820	60
2N3822/3	60
2N3866	90
2N3903/4	15
2N3906/5	15
2N4037	60
2N4058	15
2N4061/2	15
2N4264	30
2N4286	25
2N4289	25
2N4400	25
2N4427	80
2N4859	78
2N5135	30
2N5138	25
2N5172	25
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	75
2SC495/6	85
2SC1061	250
2SC1096	85
2SC1162	45
2SC1172/3	125
2SC1306	100
2SC1307	150
2SC1449	95
2SC1679	190
2SC1678	140
2SC1923	65
2SC1945	225
2SC1953	90
2SC1957	90
2SC1969	165
2SC2028	85
2SC2029	200
2SC2078	170
2SC2091	85
2SC2166	165
2SC2314	85
2SC2335	200
2SC2465	125
2SC2547	40
2SC2612	200
2SD234	75
2SK45	90
2SK288	225
2SJ83	225
2SJ85	225
3N128	115
3N140	115
40251	150
40311	80
40313	130
40361/62	70
40408	75
40412	90
40467	130
40468	85
40594	105
40595	110
40603	110
40673	70
40871/2	90

LINEAR IC's

555 CMOS	95
702	75
709C 8 pin	35
710	48
741	16
747C 14 pin	70
748C 8 pin	30
753 8 pin	185
810	159
9400CJ	375
ADC0808	885
AY-1-1320	225
AY-1-5050	99
AY-1-5051	160
AY-1-6720	210
AY-3-8910	390
AY-3-8912	500
AY-5-1317A	630
CA3011	130
CA3012	175
CA3014	275
CA3018	86
CA3019	90
CA3020	210
CA3023	210
CA3028A	130
CA3035	255
CA3036	270
CA3043	275
CA3045	365
CA3046	70
CA3048	220
CA3059	325
CA3075	213
CA3080E	75
CA3081	190
CA3085	160
CA3086	60
CA3089E	200
CA3090AQ	375
CA3123	165
CA3130	90
CA3140	50
CA3160	95
CA3161E	199
CA3162	525
CA3189	275
CA3240	110
HA1366	175
HA1388	235
ICL7106	690
ICL7107	975
ICL7611	99
ICL7660	248
ICL8038CC	380
ICL8211	225
ICM7205	1150
ICM7207	475
ICM7215	1050
ICM7216A	£22
ICM7217A	£11
ICM7224	£11
ICM7240	300
ICM7555	105
ICM7556	150
LA3350	250
LA4031P	340
LA4032	295
LA4400	350
LA4422	320
LC7120	300
LC7130	320
LC7137	350
LF347	150
LF351	70
LF353	90
LF355	90
LF356	90
LF357	100
LF398	495
LM10	325
LM301A	30
LM307	45
LM308	75
LM311	60
LM318	150
LM319	180
LM324	45

LM334Z	160
LM335	135
LM337	275
LM339	40
LM348	60
LM349	125
LM358	50
LM377	210
LM379	495
LM380	120
LM381N	175
LM382	200
LM384	225
LM386	90
LM387	200
LM389	160
LM393	85
LM394CH	385
LM558	170
LM725CN	300
LM733	65
LM1871	300
LM1889	350
LM2907	395
LM3900	70
LM3909	85
LM3911	185
LM3914	300
LM3915	385
LM3916	300
LM13600	150
LS7220	280
M51513L	230
M51515L	320
M51516L	475
MB3712	200
MB3756	440
MC1204	250
MC1301	90
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	75
MC3401	50
MC3403	95
MC3404	85
MC3405	150
MC3442	00
MC3423P	80
MC3487	00
MC4016	00
MFC6040	75
ML924	275
NE515	275
NE529	225
NE531	140
NE543	225
NE544	200
NE555	25
NE556DB	65
NE558	170
NE560	350
NE562B	410
NE564	420
NE565A	120
NE566	155
NE567	140
NE570	400
NE571	400
NE5532	150
NE5534	160
OM335	650
RC4136D	60
RC4558	60
S566B	225
SAB3209	425
SAB3210	325
SAB3271	485

SAB4209	595
SG3402	295
SL490	350
SL924	00
SL6270	170
SN76013N	350
SN76033	350
SN76488	525
SP0256AL	625
TA7120	140
TA7130	125
TA7204	150
TA7205	90
TA7222	150
TA7310	00
TAA900	395
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
TCA965	180
TDA1008	310
TDA1010	235
TDA1022	499
TDA1024	115
TDA1034	350
TDA1054	00
TDA1490	325
TDA2002	325
TDA2003	250
TDA2004	300
TDA2006	330
TDA2020	320
TDA2030	190
TDB0791	420
TL061CP	40
TL062CP	65
TL064CN	98
TL071CP	40
TL072CP	70
TL074CN	150
TL081CP	35
TL082CP	60
TL083CP	75
TL084CP	120
TL091CP	60
TL170	50
TL430C	90
TL507	110
TL509	110
UA2240	120
UA78540	230
UAA170	180
UAA180	180
ULN2003	90
ULN2004	90
ULN2283	100
ULN2803	190
UPC556	00
UPC575	275
UPC1025H	375
UPC1156H	295
UPC1181	00
UPC1182	425
UPC1366	195
XR2206	375
XR2207	400
XR2211	575
XR2216	675
XR2266	360
ZN414	80
ZN423E	130
ZN424E	130
ZN425E-8	345
ZN426E-8	300
ZN427E-8	620
ZN428E	450

ZN429E-8	245
ZN459	245
ZN1034E	200
ZN1040E	695
ZNA234E	925

COMPUTER IC's

2102L	160
2114	325
2147-3	£3
2516	350
2532-4	400
25L32	450
2564	£6
27L08	450
2716-5V	350
2732	£4
2764-250	470
27C64	£10
26501	75
27128/250n	£13
256K DRAM	£25
3242	675
4027	95
4146	140
4164-150	395
4416-2	425
4532-3	250
4816-100ns	200
4864-15	425
5514	250
6116-150	350
6116L-120ns	350
6117-100n	575
6167-6	795
6264L-15	£14
63A03	£14
6402	350
6502 CPU	325
6502A	545
6503	650
6504	600
6505	650
6520	175
6522 VIA	340
6530 RRIOT	£11
6532 RIOT	650
6545 CRTC	899
6551 ACIA	650
6592	00
6800	220
6802	275
6803	850
6805	670
6808	520
6809E	750
68B21	150
6810	220
6821	150
6840	375
6843	800
6845	650
6845SP	750
6846	625
6847	650
6850	180
6852	250
6854	625
68B54	750
6875	500
68000	£25
8035	350
8080A	400
8085A	600
8088	£15
81LS95	140
81LS96	170
81LS97/98	140
8123	160
8131	475
8154	750
8155	400
8156	400
8202	£25
8212	220
8214	495

8216	150
8224	£3
8226	£3
8228	270
8243	300
8250	£11
8251	350
8253	370
8255	400
8256A	£15
8257A	400
8259	400
8271	£70
8272	£15
8279	750
8282	450
8283	450
8284	550
8288	£11
8748	£45
8T26A	99
8T27	150
8T31	350
8T95N	90
8T97N	90
9364AP	550
9602	220
AM26LS31C	125
AM26LS32A	125
AM26LS33	150
AM7910	£30
AY-3-1015	300
AY-5-1013	300
AY-5-1350	388
AY-5-3600	750
CD4724	150
COM8017	275
COM8116	700
DM8131	275
DP8303	450
DP8304BN	350
DS3647	00
DS3691N	£5
DS8820	110
DS8830	140
DS8831	125
DS8832	200
DS88LS120	395
E9364	800
E9365	£28
FD1691	£15
FD1771	£15
FD1791	£22
FD1793	£23
FD1795	£28
FD1797	£28
HD26501	75
HM6845	755
IM6402	350
INS8060N	1250
M58174	825
MC1488	60
MC1489	60
MC14411	675
MC14412	725
MC3242	590
MC3446	250
MC3447P	315
MC3486	175
MC3487	175
MK3886-2M	£7
MM5280D	695
MM5303	635
MM5307	1275
MM5387A	865
MM58174	875
RO-3-2513L	700
RO-3-2513U	650
SAA5050	875
SFF96364E	800
SP0256AL2	495
TCM3101J	£13
TMS2716-3	725
TMS4047	100
TMS4164-15	395
TMS4416-2	595
TMS4500A	£12
TMS4532-3	350
TMS5100	600
TMS6011	500

TMS9914	895
TMS9927	£14
TMS9928	£16
TMS9929	£16
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TMS9995	£12
ULN2003	75
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UPD7007	725
WD1691	£14
WD1770	£19.95
WD2143	850
Z80CPU 2·5	300
Z80ACPU4M	375
Z80ACTC	310
Z80B	£8
Z80DART	685
Z80ADART	820
Z80ADMA	900
Z80DMA	795
Z80P10	250
Z80AP10	300
Z80S10-1	850
Z80AS10	900
Z80AS10-2	£9
Z8002CPU	00

74S

74S00	40
74S02	40
74S03	40
74S04	40
74S05	40
74S08	40
74S09	40
74S10	40
74S11	40
74S15	60
74S20	40
74S30	60
74S22	40
74S30	40
74S32	50
74S37	50
74S38	70
74S40	40
74S51	40
74S64	40
74S65	40
74S74	70
74S85	295
74S86	100
74S112	100
74S113	100
74S114	100
74S124	300
74S132	90
74S133	50
74S134	60
74S135	110
74S138	170
74S139	170
74S140	60
74S151	140
74S153	140
74S157	200
74S158	190
74S162	300
74S163	300
74S168	00
74S169	00
74S174	250
74S175	300
74S181	00
74S182	00
74S188	200
74S189	225
74S194	280
74S195	275
74S196	00
74S197	300
74S201	250
74S225	500
74S226	500
74S240	375
74S241	375
74S244	474
74S251	225
745257	225
745258	225

74S260	70
74S262	£10
74S274	00
74S275	00
74S280	00
74S281	00
74S283	00
74S287	200
74S288	180
74S289	200
74S299	540
74S301	350
74S365	250
74S373	375
74S374	375
74S412	380
74S470	325
74S471	600
74S472	400
74S473	00
74S474	400
74S475	425
74S571	300
74S573	450

75

75107/8/9	95
75110	90
75121	00
75150	125
75154	195
75158	150
75159	140
75160	420
75162	650
75182/3	99
75188/9	100
75322	140
75353	00
75361	00
75365	00
75376	00
75450	86
75451/2	52
75454	70
75491/2	65

TTL 74

7400	25
7401	25
7402	25
7403	25
7404	30
7405	30
7406	40
7407	40
7408	25
7409	25
7410	25
7411	25
7412	25
7413	50
7414	60
7416	25
7417	35
7420	25
7421	50
7422	40
7423	35
7425	35
7426	40
7427	35
7428	35
7430	25
7432	30
7433	30
7437	30
7438	40
7440	30
7441	90
7442	65
7443	150
7444	100
7445	110
7446	110
7447	95
7448	110
7450	30
7451	30

7453	30
7454	30
7460	30
7470	50
7472	50
7473	50
7474	45
7475	55
7476	45
7480	60
7481	175
7482	100
7483	100
7484	105
7485	100
7486	40
7489	200
7490	60
7491	70
7492	70
7493	50
7494	100
7495	60
7496	75
7497	200
74100	175
74104	70
74105	70
74107	45
74109	70
74110	55
74111	55
74112	170
74116	160
74118	100
74119	160
74120	90
74121	45
74122	65
74123	75
74125	60
74126	60
74128	55
74132	70
74136	50
74141	85
74142	235
74143	250
74144	250
74145	100
74147	160
74148	130
74150	170
74151	60
74153	70
74154	130
74155	75
74156	90
74157	75
74159	170
74160	100
74161	100
74162	100
74163	100
74164	100
74165	100
74166	130
74167	250
74170	190
74172	400
74173	130
74174	100
74175	100
74176	100
74177	110
74178	130
74179	130
74180	100
74181	300
74182	120
74184	170
74185	170
74186	70
74188	75
74190	120
74191	120
74192	120
74193	120
74194	100
74195	75

74196	120
74197	100
74198	200
74199	200
74221	200
74246	130
74247	120
74248	145
74249	175
74251	90
74259	150
74265	260
74273	180
74276	130
74278	160
74279	80
74283	100
74284	440
74285	300
74290	80
74293	80
74297	175
74298	160
74351	180
74365	70
74366	70
74367	70
74368	70
74376	120
74390	100
74393	100
74425	60
74426	60
74490	100

74C

C244	150
C245	150
C373	180
C374	425
C922	625
C923	645
C925	650

74LS

LS00	25
LS01	25
LS02	25
LS03	25
LS04	25
LS05	25
LS08	25
LS09	25
LS10	25
LS11	25
LS12	25
LS13	35
LS14	55
LS15	25
LS19	45
LS20	25
LS21	25
LS22	25
LS24	55
LS26	25
LS27	25
LS28	25
LS30	25
LS32	50
LS33	25
LS37	25
LS38	30
LS40	25
LS42	55
LS47	90
LS48	90
LS49	100
LS51	30
LS52	25
LS54	30
LS55	30
LS63	55
LS73	30
LS74	35
LS75	45
LS76	40
LS78	40

LS83	70
LS85	80
LS86	35
LS90	50
LS91	90
LS92	55
LS93	59
LS95	70
LS96	90
LS107	45
LS109	45
LS112	45
LS113	40
LS114	40
LS122	70
LS123	100
LS124	125
LS125	50
LS126	50
LS132	60
LS133	50
LS135	28
LS136	50
LS138	60
LS139	60
LS145	115
LS147	165
LS148	130
LS151	70
LS153	70
LS154	200
LS155	70
LS156	70
LS157	60
LS158	60
LS160	70
LS161	70
LS162	70
LS163	70
LS164	80
LS165	110
LS166	150
LS168	140
LS169	125
LS170	160
LS173	100
LS174	100
LS175	70
LS181	190
LS183	190
LS190	85
LS191	85
LS192	85
LS193	85
LS194	75
LS195	75
LS196	85
LS197	85
LS221	85
LS240	95
LS241	95
LS242	95
LS243	95
LS244	95
LS245	160
LS247	105
LS248	105
LS249	105
LS251	75
LS253	75
LS256	175
LS257	75
LS258	75
LS259	125
LS260	70
LS261	100
LS266	60
LS273	120
LS275	350
LS279	70
LS280	185
LS283	80
LS290	80
LS292	850
LS293	80
LS294	999
LS295	140
LS297	850
LS298	100
LS299	225

LS320	210
LS322	360
LS323	360
LS324	150
LS325	150
LS326	290
LS327	290
LS347	120
LS348	140
LS352	110
LS353	110
LS355	220
LS356	200
LS363	150
LS364	150
LS365	50
LS366	50
LS367	50
LS368	50
LS373	100
LS374	100
LS375	70
LS377	130
LS378	110
LS379	130
LS380	310
LS382	310
LS384	460
LS385	330
LS386	50
LS390	80
LS393	100
LS395	110
LS396	300
LS398	195
LS399	140
LS445	125
LS447	80
LS465	140
LS467	120
LS490	150
LS540	140
LS541	140
LS624	155
LS629	130
LS640	200
LS641	150
LS645	195
LS668	90
LS669	90
LS670	170
LS673	890
LS674	800
LS682	250
LS684	350
LS687	350

CMOS

4000	20
4001	25
4002	25
4006	75
4007	25
4008	60
4009	45
4010	40
4011	25
4012	25
4013	60
4014	60
4015	60
4016	40
4017	60
4018	60
4019	58
4020	90
4021	58
4022	67
4023	30
4024	50
4025	22
4026	90
4027	48
4028	45
4029	75
4030	35
4031	130
4032	70
4033	130
4034	140

4035	70
4036	275
4037	115
4038	75
4039	280
4040	60
4041	57
4042	50
4043	42
4044	50
4045	110
4046	60
4047	60
4048	55
4049	38
4050	35
4051	70
4052	60
4053	60
4054	85
4055	85
4056	85
4057	£10
4059	435
4060	68
4061	£5
4062	995
4063	85
4066	45
4067	245
4068	25
4069	25
4070	25
4071	25
4072	25
4073	26
4075	25
4076	68
4077	25
4078	25
4081	25
4082	25
4085	60
4086	60
4089	125
4093	37
4094	70
4095	95
4096	100
4097	275
4098	80
4099	75
4160	95
4161	99
4162	99
4163	99
4174	99
4175	105
4194	105
4408	850
4409	850
4410	725
4411	750
4412	805
4415	590
4419	280
4422	770
4433	770
4435	850
4440	999
4450	350
4490	450
4500	395
4501	38
4502	60
4503	40
4504	99
4505	385
4506	100
4507	45
4508	130
4510	55
4511	55
4512	55
4513	150
4514	115
4515	125
4516	65
4517	275
4518	48

4519	32
4520	53
4521	115
4522	125
4526	60
4527	65
4528	70
4529	150
4530	90
4531	130
4532	65
4534	400
4536	275
4538	80
4539	90
4541	95
4543	70
4544	150
4549	400
4553	[illegible]
4554	180
4555	35
4556	55
4557	250
4558	120
4559	395
4560	160
4561	104
4562	350
4566	165
4568	250
4569	175
4572	45
4580	255
4581	125
4582	99
4583	100
4584	60
4585	70
4599	155
40097	45
40098	42
40100	215
40101	130
40102	140
40103	412
40104	120
40105	220
40106	60
40107	55
40108	325
40109	100
40110	235
40114	240
40161	194
40163	75
40174	75
40175	75
40181	220
40192	75
40193	95
40194	90
40195	80
40244	195
40245	195
40257	198
40373	220
40374	220

JUST PHONE YOUR ORDER. WE DO THE REST. 0923 50234

SPEAKERS

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

DIODES

AA119	8
AA129	10
AAY30	8
BA100	10
BY100	15
BY126	12
BY127	10
CRO33	198
OA9	10
OA47	10
OA70	9
OA79	10
OA81	10
OA85	10
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	12
1N5404	14
1N5406	15
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

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

DIAC

ST2	25

BRIDGE RECTIFIERS
(plastic case)

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	30
2A/50V	26
2A/200V	40
2A/400V	42
2A/600V	50
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	56

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

Range: 3V3 to 33V. 1·3W **15p each**

VARICAPS

BA102	30
BB105B	40
BB106	40

TRIACS

3A/100V	48
3A/400V	56
3A/800V	85
8A/100V	60
8A/400V	69
8A/800V	115
12A/100V	78
12A/400V	82
12A/800V	135
16A/100V	103
16A/400V	105
16A/800V	220
25A/400V	185
25A/800V	295
25A/1000V	480
30A/400V	525
T2800Q	125

SOLDERCON PINS

100	45p
500	370p

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	18
Triangular LEDs R&G	18
0·2" Flashing LED Red	56
0·2" Bi colour LEDs Red/Green	100
Green/Yellow	80
0·2" Tri colour LEDs Red/Green/Yellow	85
0·2" Red High Bright	59
High Bright Green or Yellow	100
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	140
TIL322 ·5" C.th	140
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	275
Bargraph NSM3914	500

FERRIC CHLORIDE
Crystals 1lb

195p + 50p p&p

DALO ETCH RESIST
Pen plus spare tip **100p**

0·5" LCD DISPLAYS

3½ digit	495
4 digit	530
6 digit	625

OPTO

BPX25	250
BPW21	320
BPX65	320
ILD74	145
ILQ74	275
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

4×2½×2"	100
4×2¾×2½"	103
4×4×2½"	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
10×4¼×3"	240
10×7×3"	275
12×5×3"	260
12×8×3"	295

COPPER CLAD BOARDS

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

VEROBOARDS 0·1"

	Clad	Plain
2½×3¾"	95	—
2½×5"	110	—
3¾×3¾"	110	—
3¾×5"	125	95p
3¾×17"	420	275p
4¾×18"	590	—
Pkt. of 100 pins	55p	
Spot Face Cutter	150p	
Pin Insertion Tool	185p	

'VQ' Board	180
'DIP' Board	395
Vero Strip	144
PROTO-DECs	
Veroblock	480
S-Dec	395
Eurobreadboard	590
Bimboard 1	695
Superstrip SS2	£13

VERO WIRING PEN and Spool **380p**
Spare Wire (Spool) **75p**; Combs **6p** ea.
Wire Wrapping Stakes 100 **250p**

VOLTAGE REGULATORS

1A T0220 Plastic Casing

	+ve		−ve	
5V	7805	45p	7905	55p
12V	7812	45p	7908	55p
15V	7815	45p	7912	55p
18V	7818	45p	7915	55p
24V	7824	45p	7918	55p

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		LM337T	175
+24V 5A	599	LM723	30
79HG −2.25V to		TBA625B	75
−24V 5A	685	RC4194	375
LM309K	120	RC4195	160
		78S40	225

SWITCHES

SLIDE 250V

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

TOGGLE 2A 250V

SPST	35
DPDT	48
4 pole on off	54

PUSH BUTTON
Spring loaded
Latching or Momentary 6A

SPDT c/over	150
DPDT c/over	200

SUB-MIN TOGGLE 2 amp

SP changeover	64
SPST on off	58
SPDT c/off	85
SPDT Biased	105
DPDT 6 tags	80
DPDT C/OFF	88
DPDT on/on/on	185
DPDT Biased	145
4-pole 2 way	220

MINIATURE
Non Locking

Push to make	15p
Push break	25p

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 **85p**; 6 way **80p**; 8 way **87p**; 10 way **100p**; (SPDT) 4 way **190p**.

AMPHENOL PLUGS

	IDC	Solder
24 way IEEE	465p	460p
36 way Centronix	450p	475p
24 way Female	480p	450p
36 way Centronic Female	470p	500p

ASTEC UHF MODULATORS

6MHz Standard	375p
8MHz Wideband	550p

ANTEX Soldering Irons

C15W	535p	C517W	545p
G18W	550p	XS25W	560p

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 SOCKET (TEXTOOL)

24 way	575p
28 way	695p
40 way	845p

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	25p
16	20p	30p
20	25p	40p
26	40p	65p
34	50p	80p
40	60p	90p
64	90p	125p

SPECTRUM 32K UPGRADE

Upgrade your 16K Spectrum to full 48K with our RAM Upgrade Kit. Very simple to fit. Fitting instructions supplied. **ONLY £22**

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

SPECIAL OFFER	1+	10+
2764 – 250ns	£4.50	£4.25
27128 – 250ns	£13.00	£11.50
6116LP – 150ns	£3.50	£3.25
6264LP – 150ns	£15.00	£13.00

'D' CONNECTORS:

Pins	9 way	15 way	25 way	37 way
MALE				
Solder	55p	80p	120p	150p
Angle	110p	175p	225p	300p
Strait	100p	100p	160p	250p
FEMALE				
Solder	90p	125p	180p	275p
Angle	150p	200p	260p	390p
Strait	100p	125p	195p	355p
COVERS	75p	70p	70p	85p

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

TRANSFORMERS (mains Prim. 220-240V)

3·0-3V, 6·0-6V 100mA 130; 9·0-9V 75mA; 12·0-12V 75mA; 15·0-15V 75mA. 130p
6VA: 2×6V-5A; 2×9V-4A; 2×12V-0·3A; 2×15V-25A 250p
12VA: 2×4V5-1·3A; 2×6V-1·2A; 2×12V-5A; 2×15V-4A 345p (35p p&p)
24VA: 6V-15A 6V-1·5A; 9V-1·2A 9V-12A; 12V-1A 12V-1A; 15-8A 15-8A; 20V-6A 20V-6A 385 (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)

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

EDGE CONNECTORS ·1"

2×18 way	210p
2×22 way	215p
2×23 way	175p
2×25 way	285p
2×28 way	190p
2×30 way	310p
2×36 way	360p
2×40 way	380p
2×43 way	450p
2×75 way	650p

TURNED PIN Low Profile Professional DIL SOCKET

8 pin	25p	22 pin	70p
14 pin	40p	24 pin	72p
16 pin	42p	28 pin	90p
18 pin	47p	40 pin	120p
20 pin	60p		

JUMPER LEADS
IDC FEMALE RECEPTACLE Jumper Leads 36"

	20pin	26pin	34pin	40pin
1 end	160p	200p	260p	300p
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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	240
16·0MHz	220
18·0MHz	180
18·432M	150
19·968MHz	150
20·0MHz	260
24·0MHz	170
24·930MHz	325
29·695MHz	150
26·670MHz	325
27·125MHz	295
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PE VOLUME 21 Nº3 MARCH 1985

CHIPS FOR EVERYONE

IN JUST a few short months the chip suppliers have seen the market change from one where demand outstripped supply to one where they are laying off staff and shelving immediate development plans because there are now chips for everyone. While this is good for present users since it has resulted in the reduction of chip prices (although with the present pound to dollar ratio, these reductions are unlikely to show in the UK as most components are priced in dollars for sale around the world) the situation is worrying for the progressive future of high technology in general.

Over recent months up to 3,000 workers have been laid off by chip manufacturers in America and development planned for semiconductor plant in Scotland has been shelved. These cut backs are a direct result of the supply and demand situation; fortunately many of the manufacturers are indicating that their long term development plans are not being significantly changed. For instance NEC (a Japanese company) is planning to expand its Scottish factory and Hughes Microelectronics are also planning investment in Scottish plant.

The industry in general invests massive amounts of money in the development of new production methods, larger wafers, new base materials, bigger chips and improved plant. Without the continuing profitable massive sale of chips that investment in future product cannot continue. The semiconductor industry is in the doldrums and the fifth generation is possibly staying out of reach because of it.

FUTURE

We do of course still have Sir Clive who is promising wafer scale chips from his research centre; perhaps he will sell even more computers if chip prices fall this year. Interestingly Sir Clive may make more profit because of the supply/demand situation and it may be that he invests that profit in the future of the industry, rather than the chips makers. Of course he will need a manufacturer to build the chips since it is highly unlikely that Sinclair will buy or build the necessary factory. Provided *someone* in the business is prepared to invest development should continue. That ability to invest may also be tied up with the future sales of the C5 vehicle!

Wafer scale chips will probably play a very important role in our future which seems to be tied up with fifth generation and the massive industrial advantage it could bring. One company has already shelved wafer scale development because of the massive costs involved.

Mike Kenward

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We advise readers to check that all parts are still available before commencing any project in a back-dated issue, as we cannot guarantee the indefinite availability of components used.

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We regret that lengthy technical enquiries cannot be answered over the telephone.

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

Let Battle Commence

The arrival of cellular radio in the UK this year could be said to be the thin end of a wedge that will soon provide pioneering business people, commercial enterprises and the 'well off' with a carphone or portable handset. The thick end of that wedge will eventually put us all within reach of such communicative luxury—when prices fall or market saturation convinces us all that we cannot live without one!

Last year the Government granted 25 year licences to the two operating networks—British Telecom/Securicor with their Cellnet system and Racal with their Vodaphone system. The licences stipulate that each operator must have sufficient transmitter coverage to accommodate 90 per cent of the UK population by the end of the decade.

In marketing their respective wares the two organisations have appointed many well established retail outlets, who will sell, lease, install and connect the hardware. The AA for instance are one of Vodaphone's distributors who with their membership of 5·6 million motorists have a ready made clique of potential carphone customers. Another interesting appointment is that of Granada by Cellnet. They will deal through their massive chain of High Street shops which lengthened last year when they bought out Rediffusion. Prospective roving orators will be able to get hands-on experience at these outlets.

The cost of the various options will vary, those quoted here therefore should be treated as indicative; they pertain to the Cellnet price structure.

A Class 1 carphone will cost around

£1500 if bought outright, this includes installation and connection. To lease such a unit would cost around £60 per month, this includes a £25 per month subscription charge.

A portable unit will cost around £3000, to lease such a unit will be around £80 per month including the subscription charge.

Call charges will be 25 pence per minute during peak periods and 15 pence per minute at other times.

The principle of cellular radio lies in the constant re-use of radio frequencies by utilising small adjacent cells each containing its own transmitter. This principle represents a revolution in mobile communications. Cells vary in size from one to two kilometres across in urban areas to far larger cells in rural areas where demand is lower. As a user travels from one cell to the next his call is automatically transferred to the new cell's frequency without any interruption. The original cell, as a result, becomes free for the use of other subscribers. All of this allows the network to support a far greater number of simultaneous calls than any current system.

*For further reading see **'Cellular Radio'** Practical Electronics, Jan '85; and **'Leading Edge'** in this issue.*

NEW SHOP FOR SKYBRIDGE

Skybridge Ltd., have announced the opening of their new shop in Dartford, Kent.

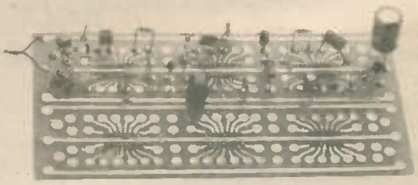
Their product range includes the usual discreet components, which are stocked in depth, with the general product range being divided into categories. They include Audio and Electronics; Home radio; Computer; RC; Servicing; test equipment, etc. In many cases several options of the same product are available enabling cost conscious buyers to stick to a budget.

Customers at the shop can consult a technical library covering subjects from component data to constructional information; helpful advice is also on hand. A catalogue is presently being compiled so that a mail order service can be introduced. Skybridge Ltd. can be found at 441 Princes Road, Dartford, Kent (0322) 91454.

DESIGN PCB

There are many avenues open to the constructor who wishes to develop prototype circuits quickly and economically, stripboard and plug-in blocks being a couple of obvious examples. A quite new option has now been developed by UK based E & H Electronics.

Protocard is a pcb measuring 210 × 100mm which houses six, 16 pin d.i.l. sockets whose pins are routed to large area solder pads. These extra large pads allow components to be tacked easily onto their surface for quick assembly of prototype circuits. There are also eight transistor pads on the board. Each i.c. is marked with a pin location, and supply tracks, signal tracks, etc., run the full length of the board.



Once the circuit has been proven the board can be stripped and used again. Admittedly, a rather self-indulgent aid for the true amateur, but nevertheless a very handy item.

Protocard costs £8.50 inc. VAT and p & p; it is supplied with 10 circuit planning cards and a small quantity of equipment, wire and solder. From E & H Electronics, 33 North Street, Keighley, West Yorkshire BD20 3SL (0535 44103).

MARKET PLACE

SPACE FLIGHT SIMULATOR

The Mitsubishi Electric Corporation, jointly with Korakuen Stadium Co., recently started marketing the "Flying Cabin", an amusement machine that moves in synchronisation with the image on a screen inside the cabin.

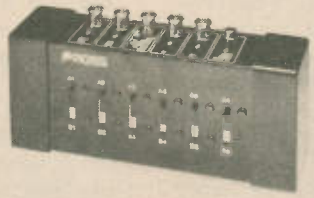
A six-axis hydraulic system used for a flight simulator is employed in the Flying Cabin for computer-controlled sychronisation of the moves of the 44-man cabin with the screen's crisp images and six-channel sound.

The Flying Cabin simulates space travel: the cabin sways, careens and dives in line with changing realistic scenes of ground surfaces and deep space, projected on a huge screen.

The two companies hope to sell 20 systems in Japan and 40 abroad in the coming five years, chiefly to amusement parks and science museums etc. The Flying Cabin will cost over £1 million.

TV Switch

For use in the fast growing number of homes where the family TV set is now the heart of an increasingly complex array of electronic entertainment equipment, Ross Electronics have introduced their RF-170 television control centre.



Measuring 205 × 90 × 65mm, the centre provides instant selection of TV, video recorder, home computer, video game, Cable TV or additional VTR dubbing and monitoring facilities. It has inputs (1 phono, 5 co-axial sockets) which may be freely interconected through a bank of six low-loss slide switches.

Supplied with a switching chart, the RF-170 retails at circa £31.95. Further details from Ross Electronics, 49/53 Pancras Road, London NW1 2QB. (01-278 6371)

Briefly...

The British Amateur Electronics Club (BAEC) is an amateur electronics club based in the UK, helping all who are interested in electronics. The key to the club's success lies in their quarterly Newsletter which contains many pages of circuits, advice, letters, news and exchanges etc. The club was formed in 1966 and now has many members from beginners to experts.

Membership for UK and Eire members is £7.00, overseas £8.50 (£12.50 air-mail). Please enclose remittance in sterling with a s.a.e. to: C. Bogod Esq., "Dickens", 26 Forrest Road, Penarth, S. Glam. CF6 2DP.

• • • •

In 1983 Britain's exports to the USA were around £8½ billion and it is expected the final 1984 figure will be around £11½ billion. Furthermore City brokers estimate, at present pound/dollar levels, an additional £4 billion worth of business could be won this year. This would mean that the UK visible exports to the USA could be said to have tripled in five years. High quality manufactured goods such as Jaguar cars and Wedgwood china have spearheaded this trend.

• • • •

A progressive application of l.c.d. technology has been adopted by Nissan for their new car, the Laurel. Its rear view mirror has an automatic feature that protects the driver from headlamp reflections. The front of the mirror is covered by an l.c.d. which is normally transparent. A photosensor in the casing detects the excessive light and activates the l.c.d. which darkens; thus reducing the dazzle.

• • • •

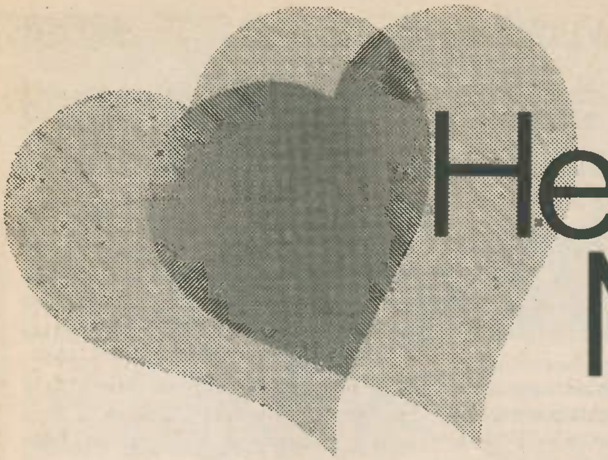
According to *Computing, the Newspaper,* Acorn Computers is withdrawing from the education market in the USA. Their hopes of capturing 10 per cent of the market were dashed following approval delays from the Federal Communications Commission. A further spanner in their works was the BBC micro's lack of success against Apple.

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.

Component Fair March 10. Carleton Community Cntr., Pontefract (on A1 to Darrington). **F2**
London Medical March 12–15. Earls Court. **S2**
IFSSEC (fire/security) April 15–19. Earls Court, London. **S**
Cast (Cable & Satellite) April 16–18. NEC, Birmingham **F5**
Communications April 23–25. Olympia. **I**
Photoworld April 23–May 6. Earls Court. **I**
CAD April 26–28. Metropole, Brighton. **K2**
Fibre Optics & Lasers April 30–May 2. Olympia. **E**
Custom Electronics & Design Techniques April 30–May 2. **E**
All Electronics Show/ECIF April 30–May 2. Olympia 2. **E**
Circuit Technology March 26–28. **E**
Field Service & Repairs April 30–May 2. Olympia 2. **E**
Automan (manufacturing) May. NEC. **T1**
IBM Computer User May 14–16. NEC B/ham. **O**
Business Telecom May 21–23. Barbican, London. **O**
Scotelex 4 June 4–6. Royal Highland Soc., ex. Hall, Ingliston, Edinburgh. **A1**
Networks June 25–27. Wembley Conf. Cntr. **O**
Cable July 9–11. Metropole, Brighton. **O**
Personal Computer World Show Sept. 18–22. Olympia 2. **M**

A1	Institute Electronics ✆ 0706 43661
E	Evan Steadman ✆ 0799 26699
F2	Pontefract Am. Rad. Soc. N. Whittingham ✆ 0977 792784
F5	✆ 01-487 4397
I	ITF ✆ 021-705 6707
K2	Reed Exhibitions, Surrey Ho., 1 Throwley Way, Sutton, Surrey
M	Montbuild ✆ 01-486 1951
O	Online ✆ 01-868 4466
S	✆ 01-387 5050
S2	Fairs & Exhibitions Ltd., ✆ 01-831 8981
T1	Cahners ✆ 0483 38085



Heart Beat Monitor

P. Leah

THERE are a wide variety of methods to measure beats of the heart from feeling the pulse in one's wrist to monitoring the differences in electrical potential through the body using an electrocardiograph. Such methods have their advantages and disadvantages. The primary disadvantage of all these methods is that they involve direct contact to the body and consequently impose a safety hazard if any mains operated electrical equipment is associated with the heart beat measurement. In this particular design of a heart beat monitor, light from a 12V bulb is shone through the finger onto a photodiode.

As there are no electrical contacts to the body, this method of pulse detection is inherently very safe. Each time the heart beats, a surge of blood is sent through the body which increases the density of the small fleshy parts of the body, particularly the fingers. Consequently the light passing through a finger will vary at each heart beat, and this variation is detected by the photodiode. The output from the photodiode is amplified in a detector circuit to provide a CMOS compatible pulse each time the heart beats.

In this particular design, the photodiode and 12V bulb are mounted on opposite sides of a 1 inch diameter plastic tube which is secured in an instrument case. For measurements to be taken, the finger is inserted into the plastic tube until it covers the photodiode and is held steady.

As a digital readout is preferred to an analogue one, the time between successive pulses from the detector is accurately measured and digitally converted into beats per minute which are subsequently displayed on a 3 digit l.e.d. display. The display is latched for approximately 3 seconds before being updated by the next measurement.

GENERAL PRINCIPLE

A conventional frequency measurement technique of merely counting the pulses from the detector over a known time period cannot be used when measuring the relatively slow time periods associated with heart beats. Even a fast heart rate such as 150 beats per minute would take at least 8 seconds to obtain an accurate reading. A low heart rate of around 60 beats per minute would take around 20 seconds to obtain an accurate reading. Consequently a novel, but simple measurement and conversion technique has had to be used which avoids the need for sophisticated devices such as microprocessors.

The block diagram of the unit is shown in Fig. 1. The output from the detector circuit to the main unit initially measures the time interval between three successive output pulses from the detector. Assuming that the detector is monitoring heart beats at 60 beats per minute, the time interval between three successive pulses is 2 seconds. Counter A is enabled for this period and is subsequently clocked from an 83·3Hz clock train. Hence, 166 will be counted and stored in the Counter A. The output from this counter is used to preset counter B to 166. Exactly 10,000 pulses are then passed into the presettable counter B. The output pulses from this counter of 10,000/166 = 60 are then counted and stored in the display counter before being displayed on the l.e.d. display. The 83·3Hz clock pulse and 10,000 pulse train generator are derived from an accurate 100kHz oscillator.

DETECTOR CIRCUIT DESCRIPTION

The detector circuit, shown in Fig. 2, comprises four operational amplifiers connected in series. A dual op amp (CA3240) IC1 was chosen for the initial amplification because of its relatively low noise and high impedance FET input. IC1a is connected as a simple amplifier which amplifies the variations in reverse leakage current through photodiode D3. The greater the intensity of light shining on the diode, the greater will be the reverse current through the diode. Resistor R17 provides additional bias current in order to ensure the output voltage of IC1a remains within the active region of the amplifier, even under extreme conditions of illumination. Resistor R13 is the feedback resistor for IC1a. Under direct illumination from the 12V bulb, the output of IC1a at pin 1 will be at almost 0V and will change to about 5·5V when placing a finger in front of D3. This output voltage is connected via resistors R19, R18 and C9 to the second operational amplifier IC14b.

This amplifier is connected as a second order, low pass filter with a cut off frequency of 15Hz, so that any mains frequency interference of 50Hz or 100Hz is attenuated. The output from this filter is coupled via C10 to another amplifier IC14a, which is connected as a straightforward, non-inverting, amplifier with a gain of approximately 50. The output from this amplifier is connected to IC1b via resistors R24 and R25. This amplifier is connected with positive feedback by connecting R26 between the amplifier output at pin 7 of IC1 and its positive input at pin 5. This feedback ensures the amplifier output voltage switches almost between the supply rails V_{DD} and 0V. Also, it ensures that the amplifier will switch between states at very small differences in input voltage, and will remain in the state to which it has switched, similar to a Schmitt trigger. As R24 and R25 are identical the current flowing through these resistors into pins 5 and 6 of IC1b will be identical. However, an additional current will flow into pin 5 from the output pin 7 via R20. Hence, if the amplifier output is at V_{DD}, pin 5 will be positive with respect to pin 6. A sudden change in light intensity impinging on the photodiode D3 will cause a rapid drop in voltage at pin 1, the output of IC1a. This fall in voltage will also appear at pin 5 of IC1b but due to the capacitor C12, pin 6 will be slower to respond to the voltage change. Consequently pin 5 will go negative to pin 6 and the amplifier output will switch states to 0V. Due to the positive feedback described earlier, the output of IC1b will remain at 0V until a positive going voltage appears at the output of IC1a.

Before connection to the Main Unit, the output pulse from IC1b is connected via the CMOS monostable of IC13a and IC13b. The amplification circuit is very sensitive, and the monostable ensures double switching does not occur, as the output pulse from the monostable is approximately 80ms.

Resistors R15 and R16 provide a voltage divider chain which supplies $V_{DD}/2$ for the bias voltage required for the operational amplifiers. C6 and C7 are supply decoupling capacitors.

MAIN UNIT CIRCUIT DESCRIPTION

The conversion and display circuits on the Main Unit are shown in Fig. 4 with CMOS being used throughout. The output pulse from the detector is initially buffered by NOR gate IC2a, before clocking the binary counter IC6a. During the time interval between the 3rd and 5th pulse from the detector, pin 4 of IC6a will be in the high state.

The signal from pin 4 IC6a is used to enable counter IC7. After the fifth pulse from the detector, pin 5 of IC6a will be in the high state and inhibits further counting of IC6a.

IC7 is also a binary counter in which the two counters are cascaded together to form an 8-bit binary counter. IC7 counts and stores the number of pulses from an 83·3Hz pulse train that can be counted during the time the counter is enabled from IC6a. The 8-bit parallel output from IC7 is immediately preset into the presettable down counter IC8.

The 83·3Hz train is derived from a 100kHz oscillator comprising IC11a and IC11d. The oscillator can be varied by adjusting VR1 to compensate for component tolerances.

IC11c buffers the oscillator output before connection to IC3, a dual decade counter. These counters are connected in series to provide an output of 1kHz which is connected to IC4b. This counter divides the pulse train by six, using gates IC12c and IC12d. The 166·7Hz pulse train from IC4b pin 13 is connected to IC6b where it is divided by 2 to obtain the 83·3Hz clock, required at the clock input of IC7.

The 1kHz pulse train from IC3 is divided further by decade counter IC4a to produce 100Hz, and by decade counter IC5a to produce 10Hz at pin 6 of IC5. IC5 is only enabled after the 5th pulse from the detector has been received and counted by IC6, and IC7 has consequently counted and stored the 83·3Hz pulses as explained earlier. Initially all outputs from IC5 are at zero. When enabled, pin 5 will eventually change to high which clears the old preset number in IC8 and clears the display counter at IC9. Approximately 1 second later pin 11 of IC5 goes high which inhibits the 'clear' output of pin 5 via the NAND gate IC12b. The output from pin 11 of IC5 is a pulse train of 5Hz having an equal

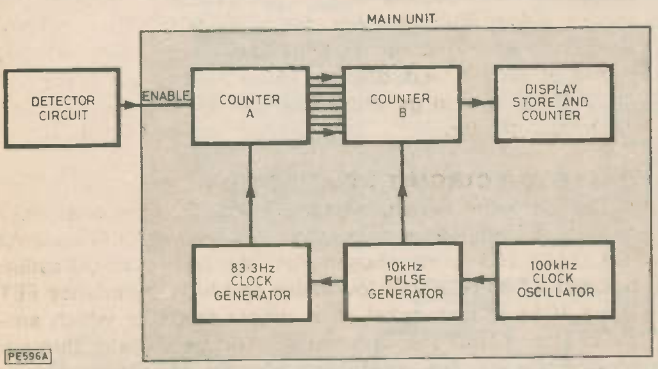


Fig. 1. Block diagram of the Monitor

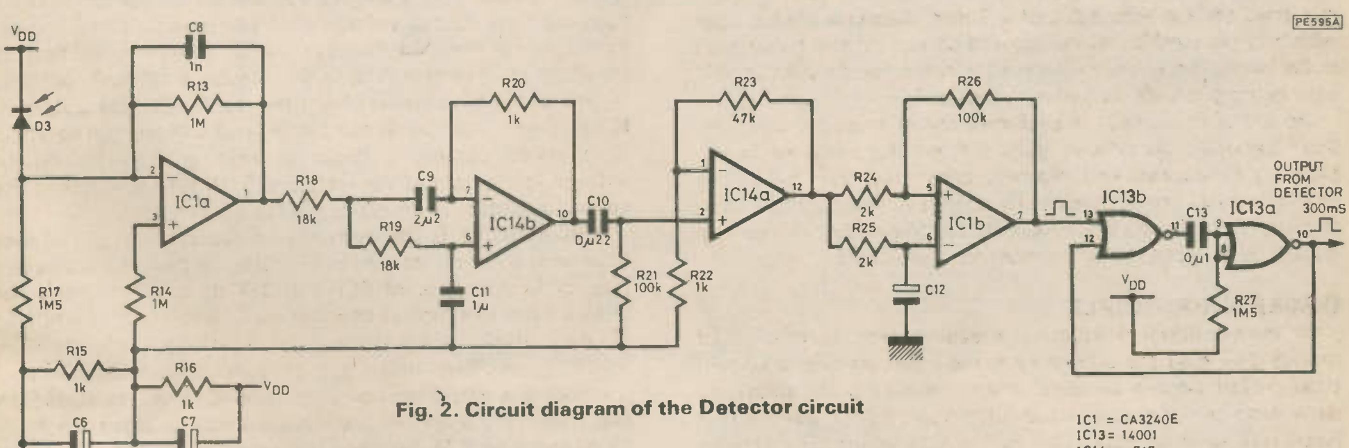


Fig. 2. Circuit diagram of the Detector circuit

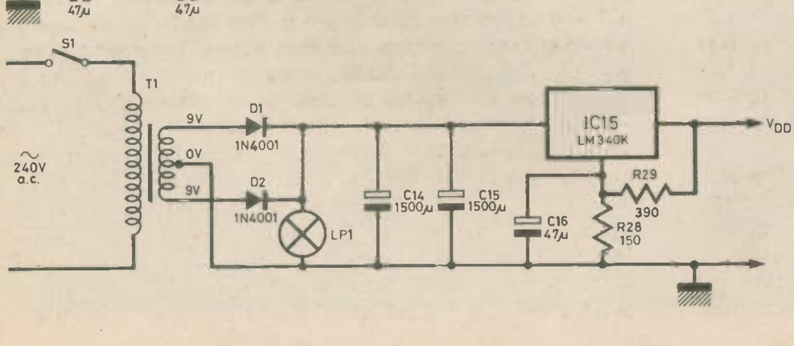


Fig. 3. Circuit diagram of the Power Supply Unit

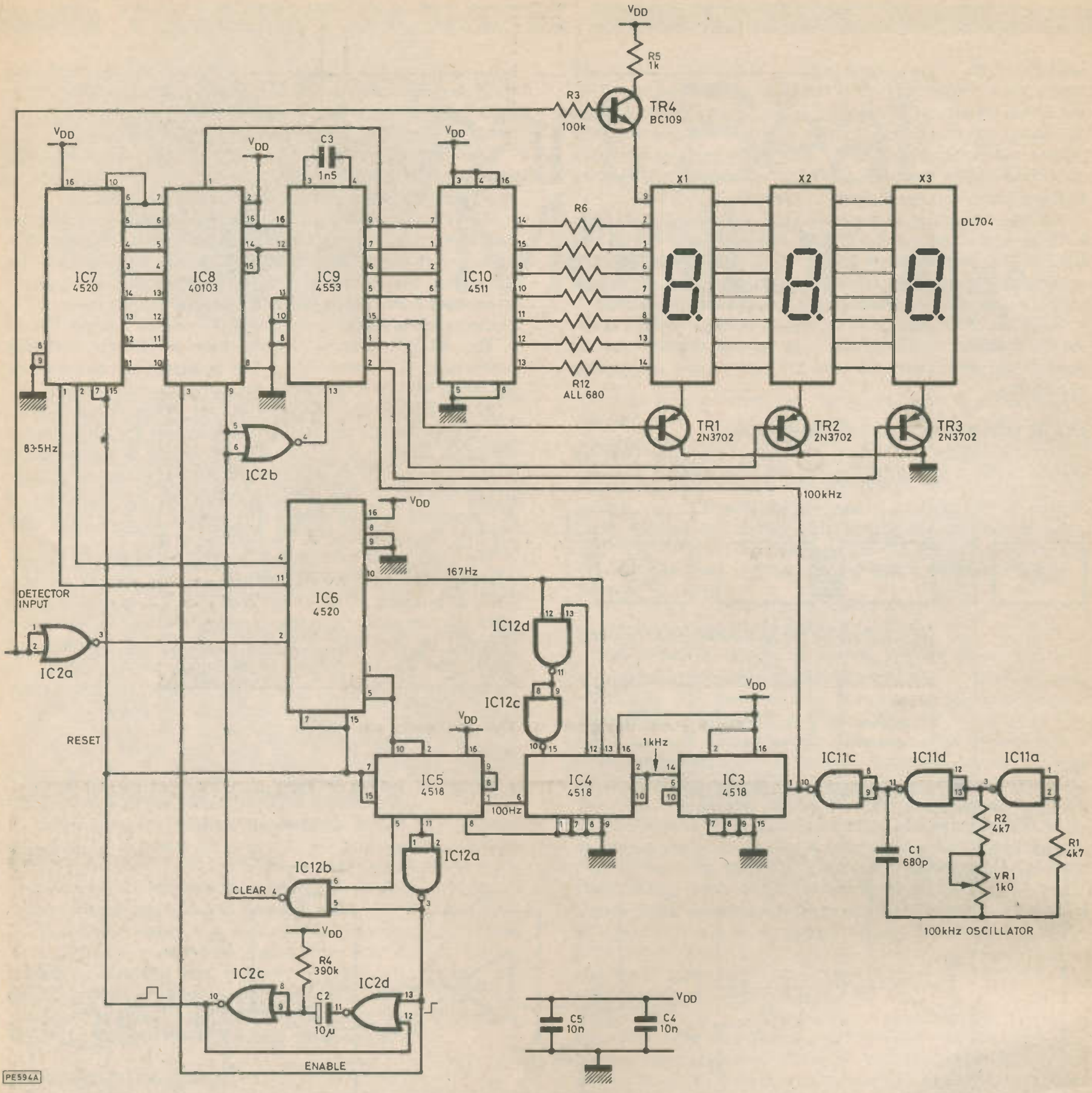


Fig. 4. Circuit diagram of the Main Unit

mark to space ratio. Hence, logic level 1 appears for exactly 100ms which is the exact time it would take 10,000 pulses to be counted from a 100kHz clock. This 100ms pulse enables IC8 while the 100kHz clock pulses from IC11c clock IC8. The resulting pulse train output from IC8 is clocked into IC9 to be counted and displayed. The falling edge of the 100ms enable pulse activates the reset monostable comprising IC2c and IC2d. The resulting reset pulse of approximately 3 seconds duration, resets counters IC5, IC6 and IC7, while inhibiting further counting during those 3 seconds. After the three second period has elapsed a further measurement may commence and the whole cycle will repeat.

IC9 is a three digit BCD counter which provides a multiplexed output, ideal for use with l.e.d. displays. The four BCD outputs are connected to IC10 a BCD-seven segment decoder driver which drives the l.e.d. displays X1, X2, X3 directly via current limiting resistors R6 to R12. The digit driver transistors TR1, TR2 and TR3 operate directly from the digit select outputs of IC9 to switch on the displays as appropriate.

The decimal point of all digits are commoned to provide an indication that a pulse is being received from the detector. If the decimal points are not illuminated it is an indication that no pulses are being received from the detector. Its usefulness will become evident when actually measuring heartbeats. Resistors R3 and R5 are the bias resistors for

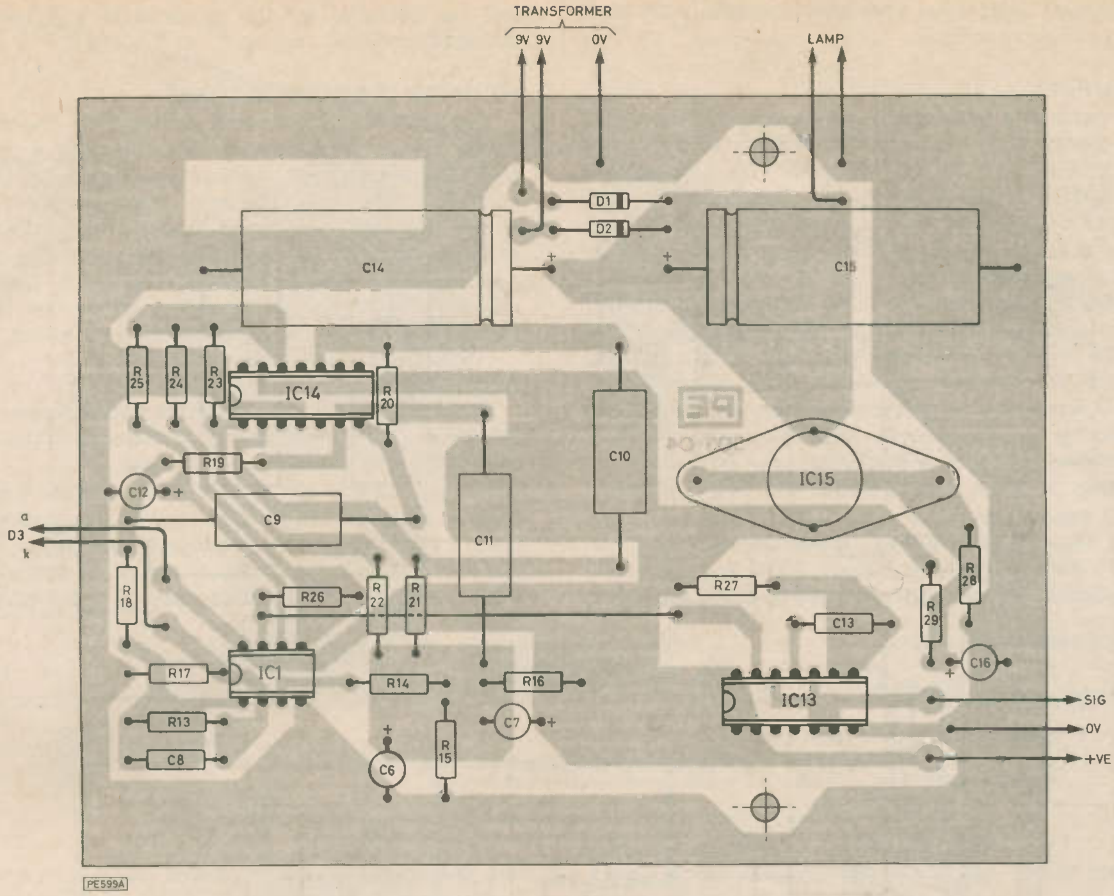


Fig. 5. P.c.b. design for the Detector and p.s.u.

COMPONENTS . . .

Resistors

R1,R2	4k7 (2 off)
R3,R21,R26	100k (3 off)
R4	390k
R5,R15,R16, R20,R22	1k (5 off)
R6–R12	680 (7 off)
R13,R14	1M (2 off)
R17,R27	1M5 (2 off)
R18,R19	18k (2 off)
R23	47k
R24,R25	2k (2 off)
R28	150
R29	390

All resistors $\frac{1}{2}$W carbon

Capacitors

C1	680p polystyrene
C2	10µ 16V tant
C3	1n5 ceramic
C4,C5	10n polyester (2 off)
C6,C7,C16	47µ 16V tant (3 off)
C8	1n ceramic
C9	2µ2 polyester
C10	220n polyester
C11	1µ polyester
C12	2µ2 16V tant
C13	100n polyester
C14,C15	1500µ 25V elect (2 off)

Semiconductors

D1,D2	1N4001 (2 off)
D3	IPL 33 photodiode
TR1,TR2,TR3	2N3702 (3 off)
TR4	BC109
IC1	CA3240E dual JFET op amp
IC2,IC13	4001 quad NOR gates (2 off)
IC3,IC4,IC5	4518 dual BCD counter (3 off)
IC6,IC7	4520 dual binary counter (2 off)
IC8	40103 256 presetable counter
IC9	4553 3 digit counter
IC10	4511 7 segment display driver
IC11,IC12	4011 quad NAND (2 off)
IC14	747 op amp
IC15	LM340K + 5V regulator
X1,X2,X3	l.e.d. 7 segment display (3 off)

Miscellaneous

S1	s.p.d.t. miniature toggle switch
VR1	1k miniature hor. preset
T1	9–0–9V transformer 0·5A

Spartolight map light (Halfords)
Single sided p.c.b. 100 x 120mm and 125 x 125mm
0·1″ stripboard 1″ x 0·4″
Instrument Case 220 x 174 x 100mm
Red perspex filter 25 x 65mm
Various 4BA and 6BA mounting nuts and bolts
Interconnection wire 0·4mm and 0·6mm
Co-ax cable (150mm length)
Soldercon pins or d.i.l. holders

TR4, the decimal point drive transistor. Capacitors C4 and C5 are decoupling capacitors.

POWER SUPPLY

The unit requires a regulated power supply of 180mA at around 8V d.c. to drive the logic and detector circuits, and around 300mA at 12V d.c. for the lamp. The p.s.u. circuit diagram is shown in Fig. 3. Briefly this comprises an 18V centre tapped transformer which is full wave rectified by diodes D1 and D2 to provide a peak voltage of 12V. This is smoothed by reservoir capacitors C14 and C15 before connection to the 5V regulator chip IC15. Any variable or +5V regulator i.c. which provides at least 500mA will suffice. The resistors R28 and R29 effectively boost the output voltage to around 8V, yet maintain regulation. Good regulation of the supply is necessary to prevent noise on the supply rail being picked up by the detector, and to ensure that the 100kHz oscillator remains within tolerance. The power to the 12V lamp is taken directly from the two 15,000µF microfarad capacitors C14 and C15. Such a high capacitance value is essential to reduce the ripple on the supply to the lamp to less than 800mV. Excessive ripple will cause variations in light intensity emitted by the lamp which will be detected by the photodiode and hence causes spurious readings.

PRINTED CIRCUIT BOARDS

Two printed circuit boards are required. The detector and power supply circuits were laid out on one p.c.b. while the Main Unit, containing the counters and display circuits, was laid out on the other. The component layout of the detector circuit p.c.b. is shown in Fig. 5 while the component layout of the counter and display p.c.b. is shown in Fig. 6. Particular care should be taken in placing the CMOS devices on the counter and display p.c.b. as the orientation of the chips varies. This was necessary to aid the track layout.

ASSEMBLY

The printed circuit board for the power supply and detector circuit is mounted directly on the base of the instrument case along with the mains transformer.

The positioning of the 1" diameter plastic tube, and the lamp to each other is critical however. It is essential that the lamp is held rigid in the instrument case as any movement, due to vibration etc., of the bulb will cause errors in the heart beat measurement. For this reason, a portable car map

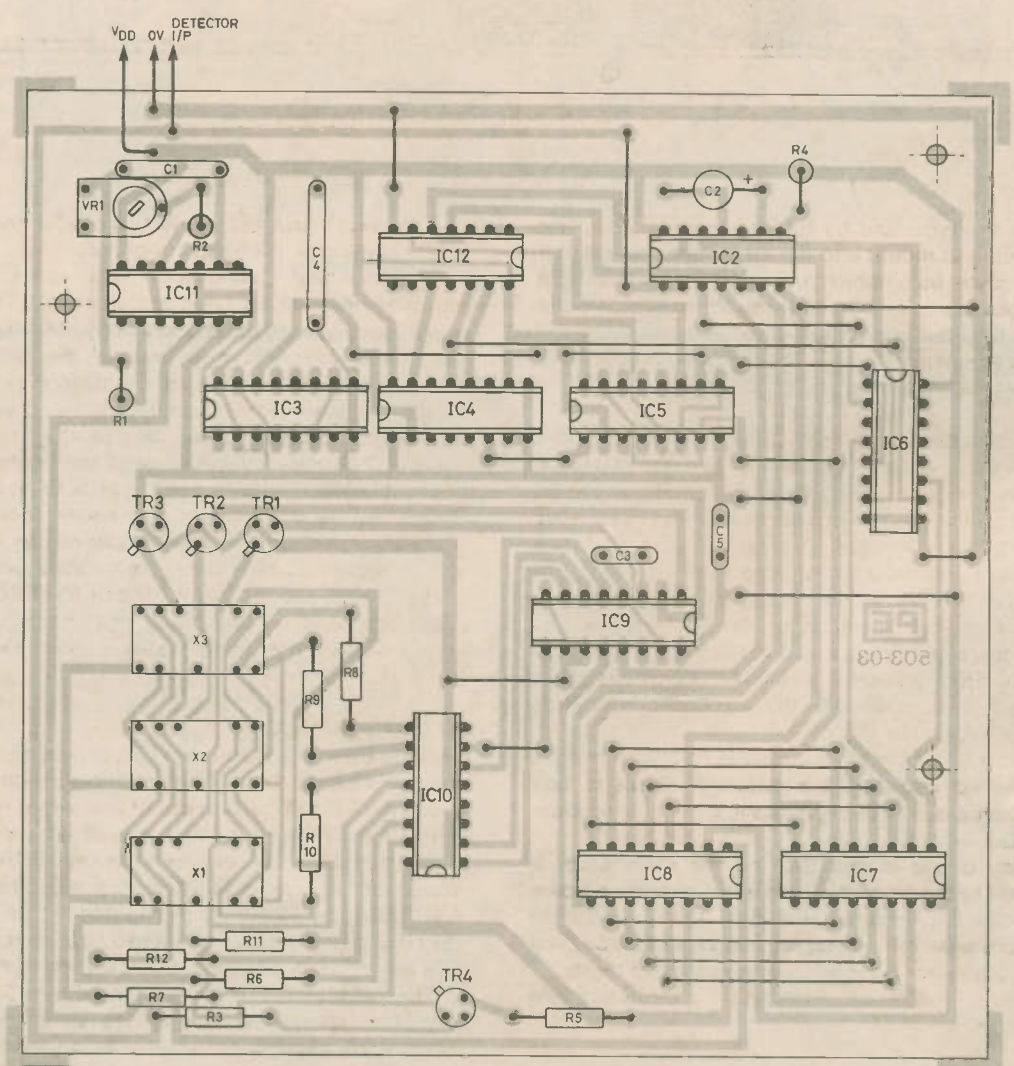


Fig. 6. P.c.b. design for the Main Unit

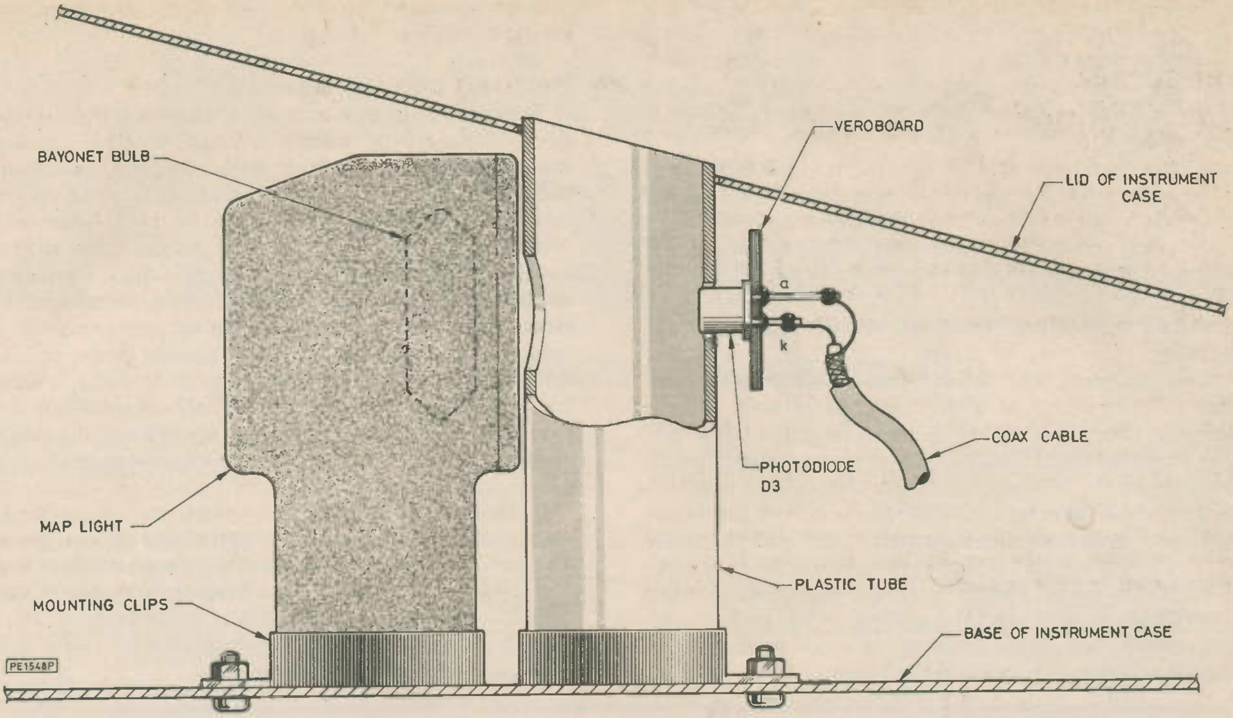


Fig. 7. Assembly diagram for the Monitor

reading lamp of the type sold by Halfords was chosen. Not only is it convenient to mount into the instrument case, but it has a bayonet style bulb which provides a superior light source. It is necessary to cut the bottom off the lamp holder in order to fit it into the instrument case, and to ensure the on-off switch is permanently 'on'. The lamp is secured by a 1" diameter vertical mounting capacitor clip, as shown in Fig. 7.

The plastic tube was cut so that it mounted directly onto the base of the case using a similar 1" diameter capacitor mounting clip as the lamp, and just protruded above the lid of the case. Hence the lid provides support against sideways movement of the plastic tube. The plastic tube must be mounted as close as possible to the lamp and immediately in front of it as shown in Fig. 7. Two holes should be drilled in the tube directly opposite each other. One hole of approximately 10mm diameter should be drilled in front of the lamp and the other of 4mm diameter should be drilled to mount the photodiode. It is essential that the photodiode is positioned exactly opposite the lamp.

The photodiode is mounted on a piece of Veroboard on which the screened cable to the detector circuit is terminated. The photodiode is then positioned in the 4mm hole in the plastic tube.

As the display circuit is mounted on the main p.c.b. it must be attached to the lid of the case using mounting holes drilled through the lid. A rectangular hole 13mm x 35mm must be cut into the lid for the display and should be backed by red perspex, araldited to the lid to emphasise the digits.

Further holes for the on-off switch and the mains cable must also be drilled.

TESTING AND SET UP

Testing and setting up the Monitor is greatly eased if an oscilloscope is available. Only the 100kHz oscillator needs to be accurately set up by adjusting VR1. This can simply be achieved by monitoring IC11c pin 10 and adjusting VR1 until a reading of 100kHz is obtained.

An initial test should show that, when the unit is first switched on, only the lamp is illuminated. This indicates the power supply is operating correctly. Moving a solid object such as a screwdriver in front of the photodiode should cause the decimal points of the display to illuminate each time the screwdriver moves across the photodiode. This indicates the detector circuit is operating correctly. Rapidly moving the screwdriver in front of the photodiode five or six times should cause a number to appear on the l.e.d. display. This indicates the counter and display circuit is operating correctly. The display will not automatically reset to zero, but will be retained until replaced by a subsequent reading.

If this sequence of events is detected the Monitor will be operating correctly and heart rate readings may be taken, after reading the Practical Considerations section.

FAULT FINDING

If the unit fails to operate correctly check for the obvious things first such as the correct voltage on the power supply. Next check the voltage levels at the output of the operational amplifiers. Check that the output of IC1a pin 1 and the output at pin 10 IC14 is approximately 5·5V when no light shines on the photodiode, and is approximately 0V when light from the 12V bulb shines directly on the photodiode. When actually measuring heartbeats, no detectable change in waveform will be apparent, however, at these outputs.

The output of IC14 pin 12 should be a 3·5 d.c. level with any light intensity shining on the photodiode, on which a 200mV pk-pk waveform should be superimposed when measuring heartbeats. The output of IC1 pin 7 should show 0V to 6·5V transitions at each heart beat.

If the counter/display circuit is suspected as being faulty, again check the power supply voltage, and then the os-

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cillator output, at IC11 pin 10. Check that there are waveforms of 100Hz and 167Hz at IC4 pin 6 and pin 13 respectively. If all is correct so far, the conversion or display circuit must be at fault. However, if the l.e.d.s are displaying something, even if it's all zeros it indicates the display circuit is operating correctly.

When fault finding on CMOS circuits, the low logic level should be at 0V while the high level logic state should be 8V. However, any voltage below 3·5V will appear as a low logic state while any voltage in excess of 4·5V will appear as the high voltage state to the input of a CMOS device.

PRACTICAL CONSIDERATIONS WHEN USING THE MONITOR

As explained previously, the detector circuit amplifies differences in light intensity which impinge directly on the photodiode. Consequently it is very sensitive. The differences in the levels of light being measured are very small, and any movement of the lamp, or the plastic tube in which the photodiode is mounted, or any movement of the finger itself will result in a false measurement. It is therefore essential that the finger is held perfectly stationary while measurements are being taken. Hence, it is recommended that the finger is placed directly onto the surface of the photodiode, without applying excessive pressure, in order to steady the finger while measurements are being taken.

The three decimal points on the l.e.d. display will illuminate each time a heart beat is detected. Hence it should be obvious when the instrument is correctly detecting heartbeats, and any double switching etc. will be indicated by several quick flashes of these decimal points. If this condition is prevalent, move the finger to a new position or alternatively, use a different finger. Note it may take a few seconds for the Monitor to 'settle down' before regular readings are obtained.

If the three decimal points appear continuously illuminated, the detector circuit is picking up noise, and the IC1b monostable is continually being activated. As the monostable has an output pulse of approximately 80ms, pulses at 80ms intervals will be passed to the counter circuit. As this equates to 750 pulses per minute, readings on the l.e.d. display of 714 or 769 will occur. Such noise is probably caused by airborne interference as detected by the photodiode if a mains operated tungsten filament is shone directly at the photodiode.

The heartbeat monitor is accurate to within 1 beat per minute over the range 40 to 200 beats per minute. Below 40 beats per minute, the readings become random. Above 200 beats per minute, the quantisation error involved in digitally converting a time period measurement into a frequency measurement, becomes significant. Hence, accuracy decreases with increasing frequency. ★

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QUAD SUPPLY & LINE MONITOR (UC3903)

MODERN electronic equipment is particularly sensitive to deviations from its normal power supply voltages. An excessively high voltage can often cause permanent damage, whereas a low voltage results in malfunction of the circuitry. The problem is compounded in multiple supply systems, where a low voltage on one supply rail can cause damage if another rail is held at the nominally correct voltage. A good example of this is in split rail supplies, where the loss of just one rail can cause damage to some types of op-amp. In order to help the designer avoid these problems, Unitrode have introduced a new i.c., the UC3903, which is intended for use as a supply voltage monitor in multiple supply rail systems.

BLOCK OPERATION

The block diagram of this i.c. is shown in Fig. 2. Essentially, it is a quad window detector capable of monitoring four voltages simultaneously. These four voltages are connected to the sense 1, 2, 3 and 4 inputs. The sense 4 input has an internal inverting op-amp provided which allows that input voltage to be either positive or negative, depending on the arrangement of external components used. Each sense input voltage is compared with two internally derived reference voltages, one which determines the over-voltage threshold, i.e. the maximum allowable limit of input voltages, and the other which determines the under-voltage threshold, which corresponds to the minimum allowable input voltage.

If one or more of the input voltages exceed the over-voltage reference, the $\overline{\text{O.V.Fault}}$ output transistor is turned on after a suitable delay period.

Similarly, an under-voltage causes the $\overline{\text{U.V.Fault}}$ output transistor to turn on. If all the supplies are within the two voltage limits then the Power O.K., $\overline{\text{O.V.Fault}}$, and $\overline{\text{U.V.Fault}}$ transistors are all turned off. However, if either an over-voltage fault or an

Characteristic	Notes	Minimum Value	Typically	Maximum Value	Units
Supply Voltage (normal operation)	Spec's measured at +15V supply unless otherwise stated	8		40	V
Quiescent Current	No faults		6	11	mA
	U.V., O.V., and line fault		10	18	mA
Temperature Range		0		+70	°C
Supply Under Voltage Threshold	Below this supply voltage threshold, fault outputs are disabled	5·5	7·0	8·0	V
Minimum Supply to Enable 'Power O.K.' Output			3·0	4·0	V
Reference Voltage	V_{REF}, at 25°C (and see Fig. 4)	2·465	2·5	2·535	V
Reference O/P Current	*i.e.* From pin 2, at 25°C			40	mA
Reference Load Regulation	O/P current (pin 2) = 0 to 10mA		1	15	mV
Reference Line Regulation	Supply = 8 to 40V		1	8	mV
Open Collector Output Voltage	Pins 11, 12 and 14			40	V
Open Collector Output Current (max)	Pins 11, 12 and 14, O/P = 2·0V	40	70		mA
Open Collector Saturation Voltage	Pins 11, 12 and 14, O/P current = 12mA		0·25	0·45	V
Sense Input Bias Current (max)	Pins 6, 7, 8, 9 and 15		±1	±6	μA
Sense Input Voltage	Pins 6, 7, 8 and 9	−0·3		+20	V
	Pin 15	−0·3		+40	V

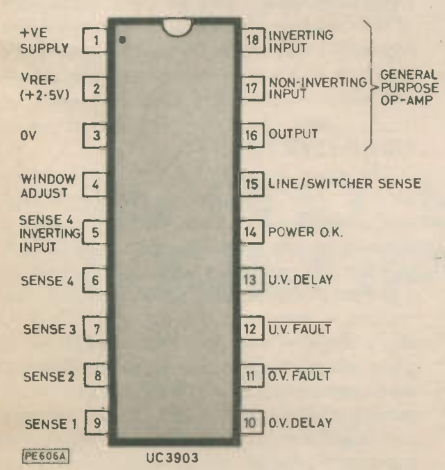


Fig. 1. Pinout and specifications

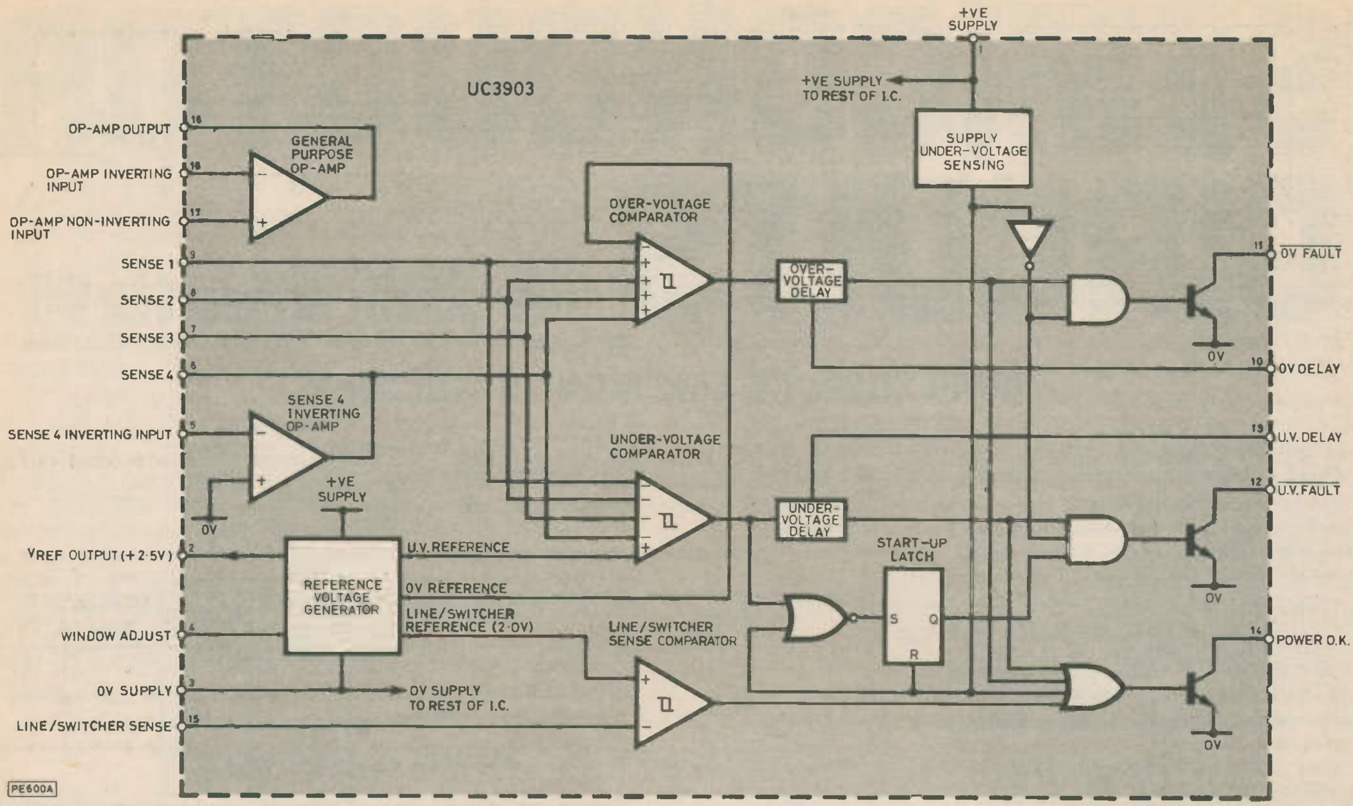


Fig. 2. Block diagram

under-voltage fault is detected, then the Power O.K. transistor is turned on, somewhat paradoxically showing that power is specifically *not* O.K.! To avoid false alarms, internal circuitry detects when the supply to the i.c. itself is at a low level (usually during turn on or turn off) and disables the outputs during this period. A separate line & switcher sense input is provided, which controls only the Power O.K. output to provide early warning of mains voltage or other power source failures. Finally, a 'general purpose' op-amp is provided to extend the flexibility of the i.c.; this is ideal for use when two negative supplies need to be monitored.

INPUTS AND THRESHOLDS

The four sense inputs have a permissible range of −0·3 to +20V, as can be seen in Fig. 1. In fact, the input circuitry includes a series 2k resistor and a 5·7V Zener diode to 0V, so at voltages above 5·7V the input impedance will be fairly low. This will rarely be a problem in practice because the i.c. is designed for a 'normal' input, i.e. a valid input voltage, of 2·5V. The input impedance at around this voltage is very high indeed, so the various voltages to be monitored can be scaled with potential dividers (or amplified externally if required) to the nominal 2·5V level.

The over and under-voltage thresholds are set by voltage reference circuitry within the i.c., in conjunction with a 'window adjust' voltage applied to pin 4. The effect of this can be seen in Fig. 3. At low window adjust voltages the fault window (in this case the range of 'acceptable' input voltages) is narrow, so the i.c. is very critical of errors in the sense input voltages.

At high window adjust voltages the fault window is wide, so the i.c. is very tolerant of variations in sense inputs. Typically, 1 volt on pin 4 will allow the inputs to vary by ±10% from nominal. Hysteresis prevents 'hunting' of the i.c. around the threshold points, and this is also shown in Fig. 3. Pin 4 is a fairly high impedance point so a simple pair of resistors can be used as a potential divider from the 2·5V reference output, pin 2. Incidentally, the voltage reference is ideal for use in other parts of the circuitry, if required. It has reasonable regulation, and tracks well with temperature as shown in Fig. 4. Furthermore, it has a high output current capability—typically 40mA.

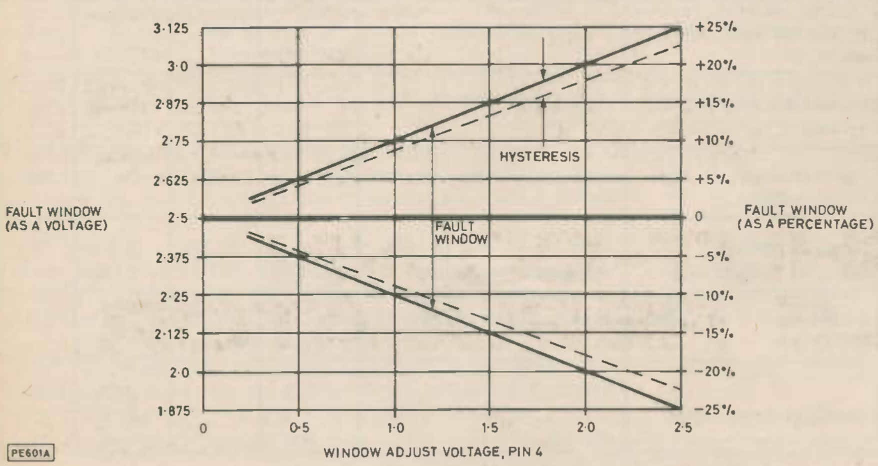


Fig. 3. The effect of the window adjust voltage on the fault window

NEGATIVE INPUTS

The sense 4 input of the UC3903 can be used as either a positive or negative voltage monitoring point. By connecting pin 5 to a high voltage the inverting op-amp output will be reverse biased, allowing pin 6 to behave as a perfectly normal sense input. However, if a resistor is connected between pins 5 and 6, and a negative voltage is connected to pin 5 via a second resistor, the op-amp will invert the negative voltage (with whatever gain or attenuation is set by the ratio of the resistors) and allow the sense 4 facility to monitor this positive derivation of the original negative

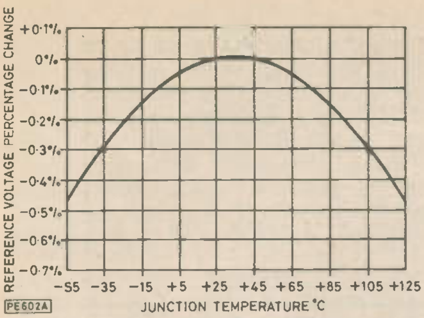


Fig. 4. Variation on 2·5V reference with temperature

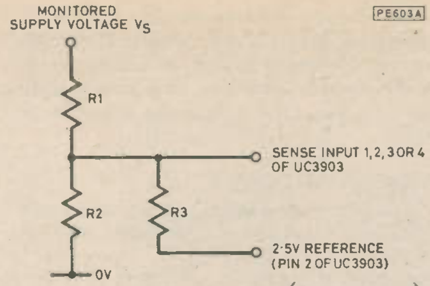
voltage. The spare 'general purpose' op-amp is provided for any suitable application, one example of which is to invert a second negative voltage, and feed this into sense 1, 2 or 3 in a similar arrangement to that used for sense 4. The op-amp can source over 20mA of current, so it will come in useful for many other purposes in other parts of the circuitry.

OUTPUTS

The three outputs from the comparators section of the i.c. are all open collector transistors. Hence, to get a voltage swing out of these outputs a pull-up resistor to a positive supply will be needed in each case. All the transistors can switch 40mA or more, so they are ideal for directly driving relays or indicators. Total dissipation for the whole i.c. should be kept below 1W (at 25 degrees centigrade). Naturally, if driving inductive loads, protection diodes should be added between the i.c.'s outputs and the load's positive supply rail.

The UC3903 is provided with sophisticated protection against erroneous outputs during power-up and power-down. Until the i.c.'s own supply has risen above a supply under-voltage threshold (between 5·5 and 8·0V) all the outputs are disabled, and the start-up latch is reset. The latch prevents any under-voltage fault being signalled until all the sense inputs have gone above their under-voltage thresholds for a first time since power was applied. When they have all gone above the threshold the first time, the latch is set, and normal operation of the U.V.Fault output can begin. This has all been designed to allow for slow-starting or supply sequencing, but should be borne in mind if immediate response to under-voltage conditions, when power is first applied, is required.

The line/switcher sense input is a general purpose facility that directly affects only the Power O.K. output. No time delay is included, and its threshold is nominally 2·0V rather



$$\text{Fault window} = \pm 10(\text{Vadj}).\left(\frac{R3 + \dfrac{R1R2}{(R1+R2)}}{R3}\right)\%$$

(Assuming that $\frac{Vs.R2}{(R1+R2)} = 2{\cdot}5V$ for correct value of Vs)

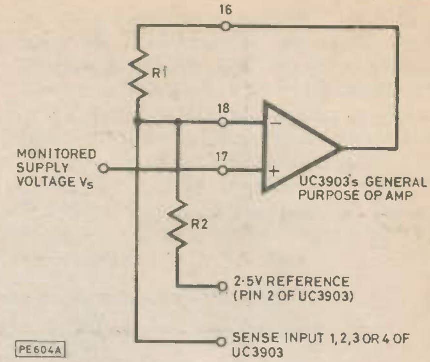
Fig. 5. Widening an individual fault window

than the 2·5V used elsewhere. The Power O.K. transistor is turned on (i.e. power is *NOT* O.K.) when the line/switcher sense input drops to below this threshold. Its intended use is to allow the monitoring of voltage levels earlier on in a power supply system, either from the secondary of the mains transformer or from a power transformer in a switching regulator. In both these cases the waveform would have to be rectified (by a series diode), smoothed (capacitor and resistor to 0V) and attenuated prior to monitoring. The smoothing capacitor should be made as small as possible to allow fast reaction to any loss of power. This arrangement could allow the UC3903 to shut down other circuitry and systems before serious damage might be caused.

DELAYS

Both the under and over-voltage systems have a delay facility. This is activated by connecting capacitors from pin 10 and 13 to 0V. The effect is to delay the activation of the U.V.Fault or O.V.Fault outputs by a time of typically 30ms per microfarad. If the fault condition at the sense input is removed during the delay period then the delay is cancelled and no fault output is signalled. This arrangement allows for immunity against noise spikes on the supply causing spurious fault outputs. Leaving pin 10 or pin 13 open circuit provides the fastest possible response to fault conditions, but the least tolerance of noise on the supplies.

It is important to note that the delay circuitry was designed primarily to operate in the microseconds and small number of milliseconds range. Although fairly large capacitors can be used to give several seconds delay, they



$$\text{Fault window} = \pm 10(\text{Vadj}).\ \frac{R2}{(R1+R2)}\%$$

Fig. 6. Narrowing an individual fault window

can cause the start-up latch to operate incorrectly. Specifically, the use of large capacitors results in under-voltage sense inputs triggering the U.V.Fault output (after the appropriate delay) directly after power-up, without having to first be taken above the under-voltage threshold as would normally be the case. (This is due to the inability of circuitry within the i.c. to charge up very large capacitors quickly enough.)

ADJUSTING WINDOWS!

Figs. 5 and 6 show techniques which can be used to alter an individual sense input's fault window. This can be necessary when just one particular input requires either tighter tolerance monitoring, as in the case of a precision reference, for example, or wider tolerance such as might be required for an unregulated supply.

The UC3903 is a very cleverly thought out device, which is ideal for use in monitoring supplies in larger electronic systems. Its uses don't end there of course, as it makes an excellent general purpose window detector for many types of transducer input, giving warning of variations in liquid level, temperature, light level, etc., as appropriate. Other devices in the family are the UC1903 and the UC2903, which are functionally identical to the 3903 but feature extended temperature ranges and slightly better specifications.

AVAILABILITY

The UC3903 can be obtained from **House of Power**, Electron House, Cray Avenue, St Mary Cray, Orpington, Kent BR5 3QJ, or **Thame Components**, Thame Park Road, Thame, Oxfordshire.

AUTO SHUT-DOWN MULTIPLE REGULATOR

THIS circuit uses the UC3903 i.c. to monitor three supply voltages, as part of a three rail power supply system. The circuit diagram is shown in Fig. 7, and its Veroboard layout in Fig. 8. If any of the supplies are taken further than ±10% from their nominal value, *ALL* the supplies are shut down, and are kept shut down by blowing a pair of fuses! This offers a comprehensive, if cautious approach to ensuring that imbalance in multiple supplies and over-voltages do not cause damage to the circuitry being powered by them.

IC2, IC3 and IC4 are the three voltage regulators in question, giving supplies of

±15V and +5V from unregulated ±20V inputs. These are provided with the usual protection diodes and stability-maintaining capacitors. R11 and R12 tap down the +15V supply to a nominal +2·5V to feed into IC1, and likewise R13 and R14 feed IC3's output to IC1. IC4 uses the sense 4 inverter, with R15 and R16 allowing, again, +2·5V to be *present at* pin 6 of IC1. Pin 8 is used to provide a push-button test facility, S1, which tests the effect of an under-voltage at the sense 2 input. In normal use, sense 2 is biased to +2·5V by R20.

Resistors R18, R19 (two resistors keep the power requirement down) and D7 provide a 'Power O.K.' l.e.d. facility. When the Power O.K. output transistor of IC1 turns on, current from R18 and R19 is sunk by IC1 pin 14, and the l.e.d. turns off. R21 and R22 set the window adjust voltage at pin 4 to 1·0V, which defines the fault window as ±10%, as shown in Fig. 3. C8 and C9 are connected as shown between terminal pins A, B and C, since their values might need some experimenting with. The line/switcher input, pin 15, is not used, so is kept biased to the positive supply rail by R17, and the general purpose op-amp likewise is unused, so it is connected as a voltage follower (pin 16 is connected to pin 18), with the non-inverting input tied to V_{REF}.

SHUTTING DOWN

The automatic shutting down is not a subtle affair, but it *is* effective! CSR1 and CSR2 are 8 amp thyristors triggered by TR1 and TR2 respectively. TR2 in turn is turned on by TR3 and TR4, with associated resistors, which provide level shifting to the negative supply rail from the all-positive supply used by IC1. The U.V.Fault and O.V.Fault outputs are wired together so that the thyristor circuit is triggered by an over-voltage, an under-voltage, or even both simultaneously. When the thyristors are triggered they immediately blow both fuses and clamp the regulated supplies near to 0V via D1, D2 and D3.

The unregulated supply should be nominally ±20V. The positive half should not exceed +24V, since damage to IC3 might occur. (Naturally, if a 7805 is not used this voltage restriction does not apply.) The supply should have enough current capability to drive the required current out from the regulated supply outputs, plus a little in hand. Naturally, FS1 and FS2 should be matched to this maximum current capability. It may seem surprising that slow-blow types are recommended, but in practice the thyristors blow them effectively instantaneously, and their otherwise slow action prevents inadvertant blowing due to minor transient pulsing of the thyristors themselves when power to the circuit is turned off. The choice of thyristor is not critical, but 8 amp types were used in this case to be safe with surge current handling capability. The thyristors only conduct for a fraction of a second before the fuses blow, so there is no time for them to get hot and no need for heatsinks. IC2, IC3 and IC4 have been placed close to the edge of the board to allow easy fitting of their heatsinks, via insulating kits due to the internal connection of their metal tabs to the centre pin. Any momentary switch, local or remote, can be used for S1.

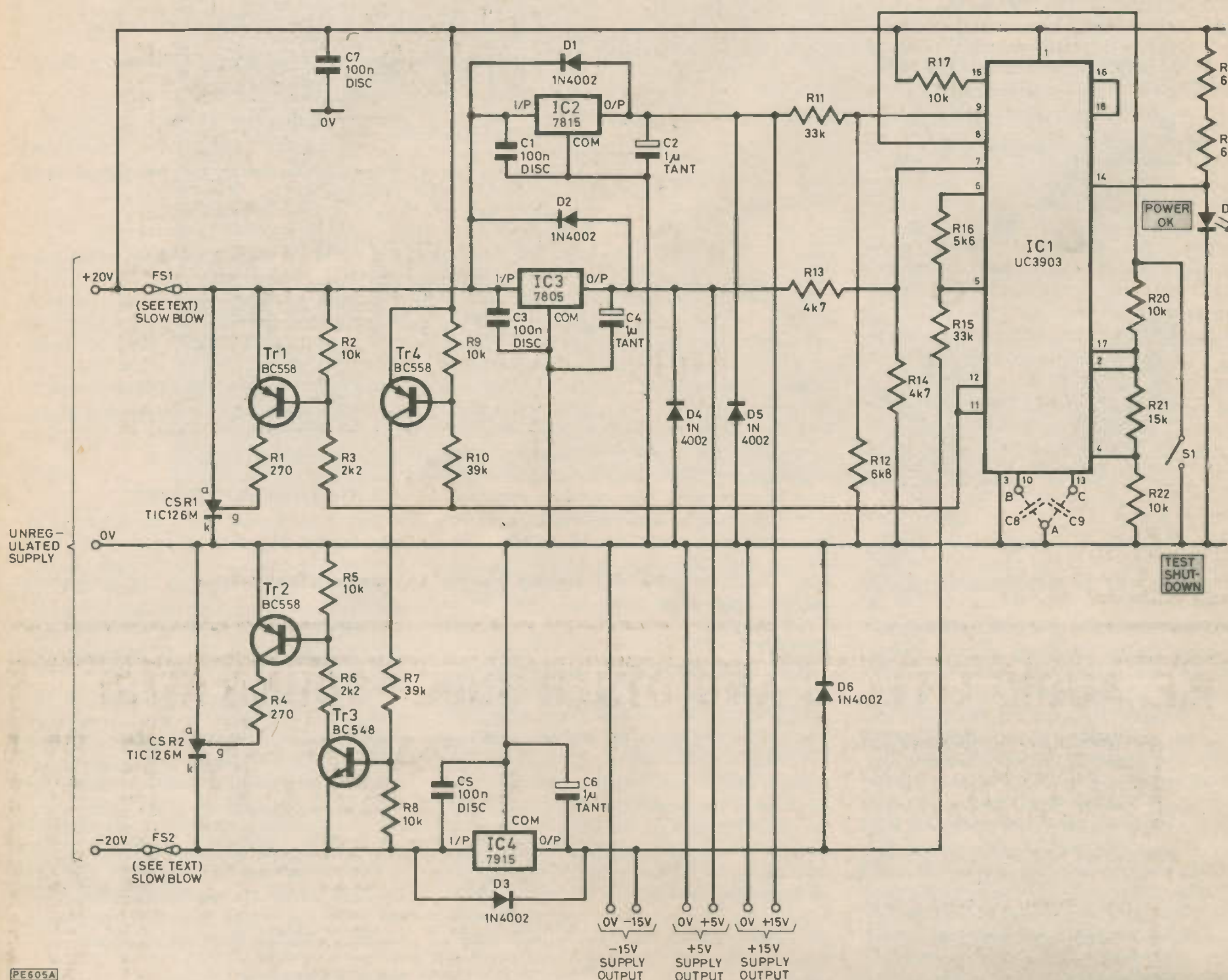


Fig. 7. Auto shut-down multiple regulator

SELECTING THE DELAYS

Capacitors C8 and C9 should be selected to give the delays required. Typically, it is suggested that the response to over-voltages should be fast, as circuits are at considerable risk, whereas under-voltages are less serious. The prototype circuit used 1nF for C8 giving an over-voltage delay of approximately 30µs, and 100nF for C9, giving an under-voltage delay of 3ms. Be aware that too short a delay for under-voltages can result in false triggering due to the regulators not charging C2, C4 and C6 fast enough during turn-on, and too long a value can cause the effects described earlier. If a regulator output is under-voltage (for example, shorted to 0V) when power is first applied, the circuit will fail to shut down; the UC3903 requires that the sense input must first be taken above the under-voltage threshold. It can be impractical to use the Power O.K. output, since that goes into the 'not O.K.' condition during power-up. If this is a concern, however, it is a fairly straightforward process to add extra circuitry to combine all three outputs satisfactorily to provide shut-down under even these conditions.

The circuit can prove rather tedious to test, since the first thing that happens if there's a fault is that it blows the fuses, at which point there's nothing to test any more! Initial tests should be done with R1 and R4 omitted, which prevents CSR1 and CSR2 being triggered. When the fuses have been blown, the supply should be turned off and the unregulated supply allowed to discharge before new fuses are inserted, or they will blow immediately in all likelihood. PCB fuse clips are used in Fig. 8, but off-board fuseholders could equally well be used, of course.

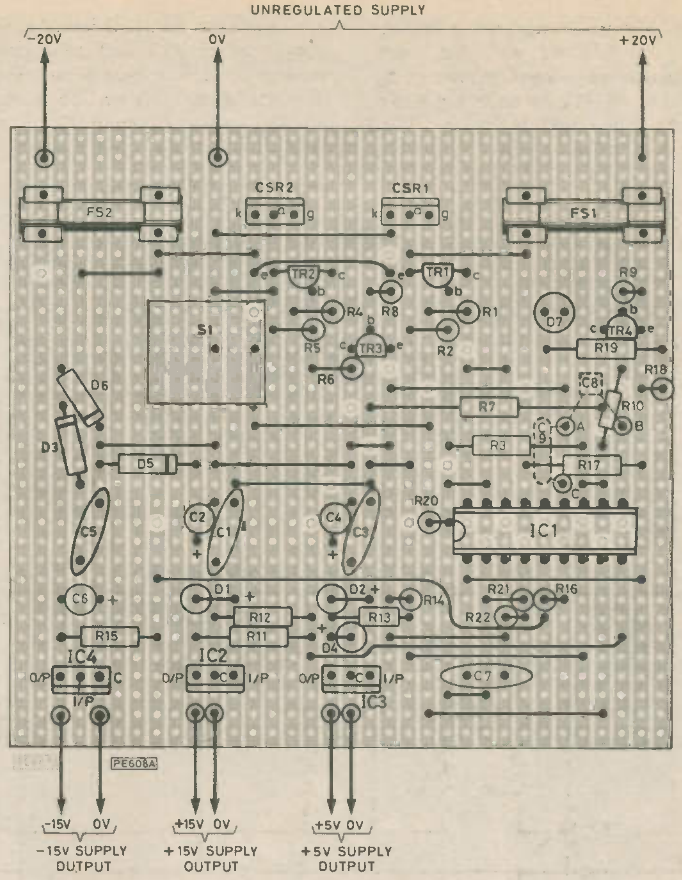
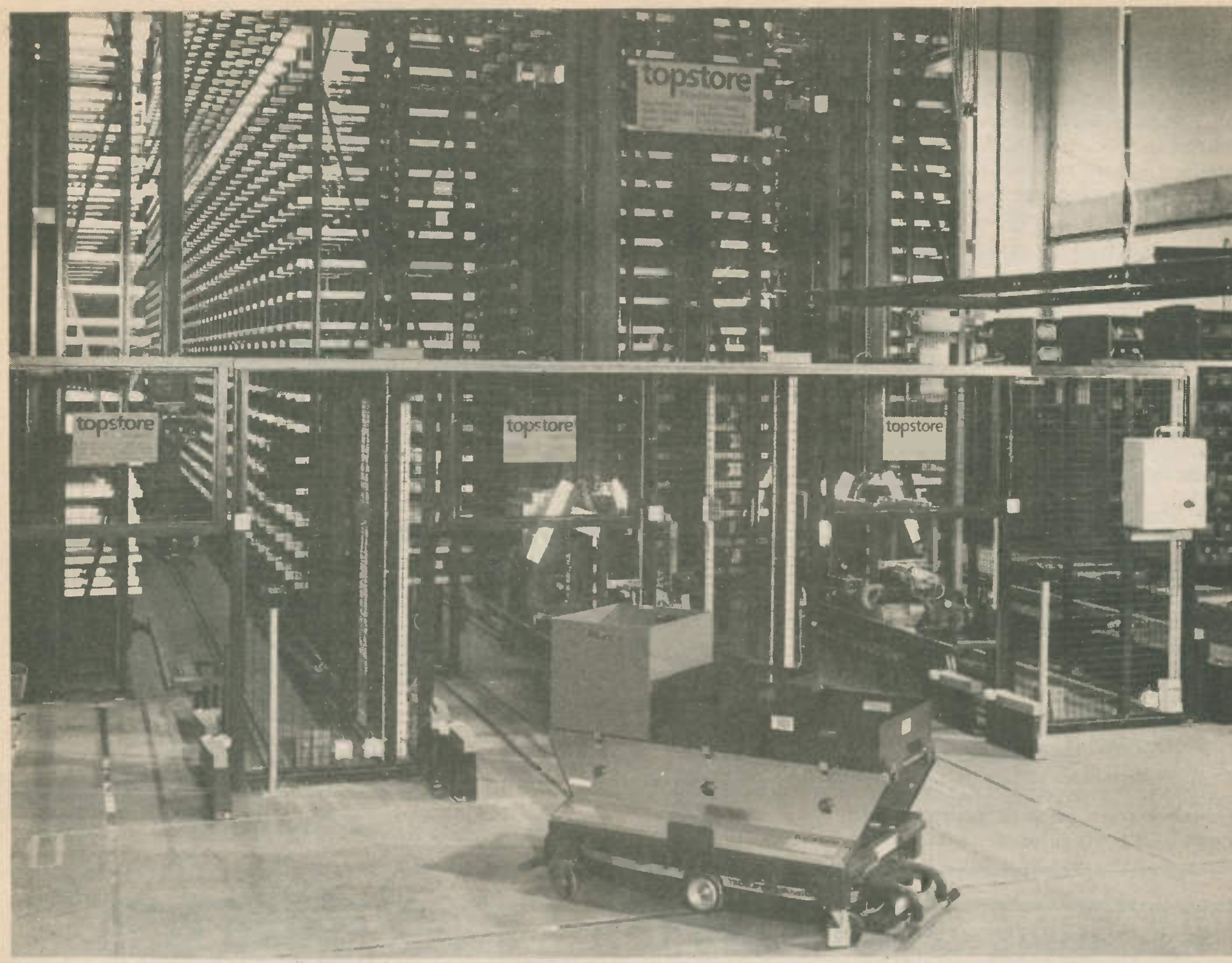


Fig. 8. Veroboard layout of the multiple regulator



MARS ELECTRONICS

As most readers of Practical Electronics will know, we have, over the last few years, maintained extensive coverage of modern developments such as micro computers and robot technology. In keeping with this policy, we are now looking at the applications and effects of these technologies in practical use.

TECHNOLOGY IN INDUSTRY

The scope and possibilities for the use of modern technology in all areas of commerce and industry are enormous. In a very short period of time, we have seen the introduction of computers, microprocessor control systems and robotics. Such acronyms as CAD/CAM, ATE and AGV have become everyday terms. Despite this, there are very few companies who have utilised this modern technology to any where near its full potential. Indeed it seems that the so called second industrial revolution is proving to be a fairly slow change.

The failure to respond by many firms, may well bring about their own downfall. However, one company which is committed to new technology is Mars Electronics which, for the last five years, had maintained a growth of 50 per cent per annum.

Mars Electronics are associated with Mars, the confectioners, and were originally set up to promote further outlets for their confectionery products. This was achieved by setting up their Money Systems Divisions in the seventies, which produced coin validation and acceptance mechanisms for vending machines. They now supply over 90 per cent of the European and 80 per cent of the world market in coin mechanisms.

Since then Mars have diversified their product range by setting up a Marine Systems Division which launched Vigil Radar in 1983. This product quickly established them as a market leader in small boat radar, a position which they look likely to maintain. In December 1984 they launched two new products, Vigil–2 and Vigil–RM which they claim will give them global supremacy for years to come.

At the moment they are working on Automatic Test Equipment (ATE), which they think will give many small electronics companies their first chance to buy advanced electronic test gear. Much of the ATE now available is far beyond the reach of these companies with prices often in the region of £100,000. Once again Mars confidently predict their superiority in the market place.

The key to the success of Mars lies in their unique manufacturing concept and clever marketing strategy. According to their Systems and Automation Manager, Nigel Kingsley *"An ultimate aim of the company is to have total automation of stock handling and manufacturing processes."* This together with their niche marketing strategy has made Mars one of the fastest growing companies in Europe.

> *"An ultimate aim of the company is to have total automation of stock handling and manufacturing processes"*

COMPUTER INTEGRATED MANUFACTURE (C.I.M.)

In one of their two British factories at Reading, Mars have created a futuristic working environment. In a fairly small building tailored to their own needs are housed over 200 terminals (keyboards and VDUs) all linked by their own local area network (LAN). With a total staff of only 600, working on three shifts per day, this gives an average of one terminal for each employee.

The factory itself is completely open plan, fully carpeted in all areas including the production line. No one has an office and the canteen caters for management and staff alike. Some rooms are cut off from others but for reasons of security rather than personnel importance.

The computer network is split into several sections each dealing with a particular task, such as design, manufacturing and commercial activity. Because all these functions are interelated information is being constantly transmitted between sections, enabling a very flexible and cost effective system to operate. Using this system almost every process is computer aided or controlled. A block diagram of the C.I.M. model is shown in Fig. 1.

COMPUTERS IN ACTION

The first stage in the production of a finished product is the design. This is only started after extensive market research into a particular area. The policy of Mars Electronics is to aim at a low to medium size market and then arrive at a product which they believe cannot be matched either in quality or price. This strategy allows them to lead a particular field and by constant improvement maintain this lead. (The reason for aiming at low to medium size markets is that it would be impossible at this stage to compete with mass production, and at the same time would drastically reduce flexibility.)

Much use is made of their CAD/CAM system (VAX 11/34), which is connected to the LAN and runs 'Aplicon BRAUD' software. The six work stations connected to the system provide a comprehensive CAD/CAM facility enabling advanced design capability. Plans are now ahead to take the system further by direct connection to the process machinery. This will allow design and manufacturing data to be transferred directly to the automated process machines making for a more efficient system.

Once a product has been designed, then the required materials are entered into the manufacturing computer system and a production line and test area is set up. At all times there is a facility to change at very short notice to another product, or modify designs to suit the manufacturing processes. In fact the Mars factory currently produce between 600 and 700 different products. This is achieved by their system of modular design whereby different production lines can easily be set up to meet changing demand.

The 'Manufacturing' computer (HP3000/48) has 3 Mbytes of on board memory with single 125 Mbyte and 404 Mbyte disc systems. Software such as: Manufacturing Management, Quality Assurance, Sales Specification and Administration are all carried out using around 40 terminals connected to the system.

the way ahead

Richard Barron

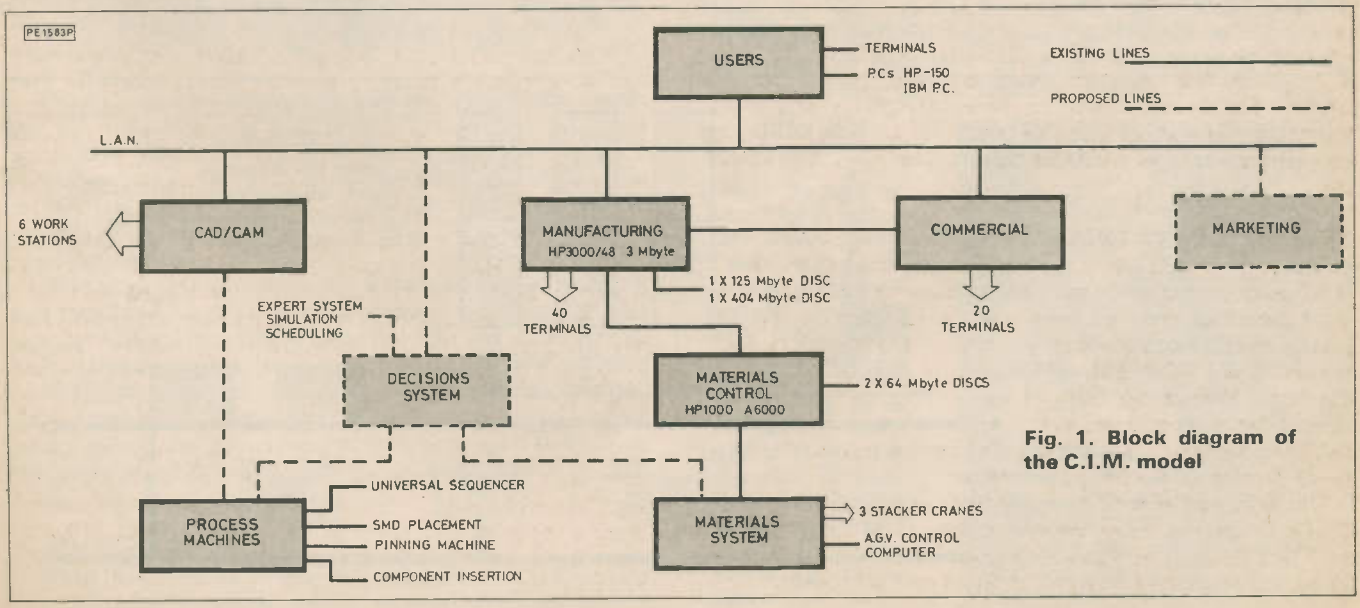


Fig. 1. Block diagram of the C.I.M. model

There are existing connections between this system, and the Commercial and Materials Control computer (HP 1000) via the DS/300 link. A further 20 terminals have access to the Commercial computer which performs: Sales order processing, Payroll, and various Ledger functions including Purchasing and Sales, to mention but a few. The Materials Control Computer has twin 64 Mbyte disks and provides all the necessary control data for the stock control system and the AGV's.

At this point automation really comes into its own. The computer's data store (memory) has all the necessary information to maintain stock levels and keep the production running smoothly. Much of the production is automatic and components can be distributed to any section of the assembly line or storage space as required. This is made possible by the use of Automatic Guided Vehicles (AGVs).

AUTOMATIC STORAGE AND RETRIEVAL SYSTEM

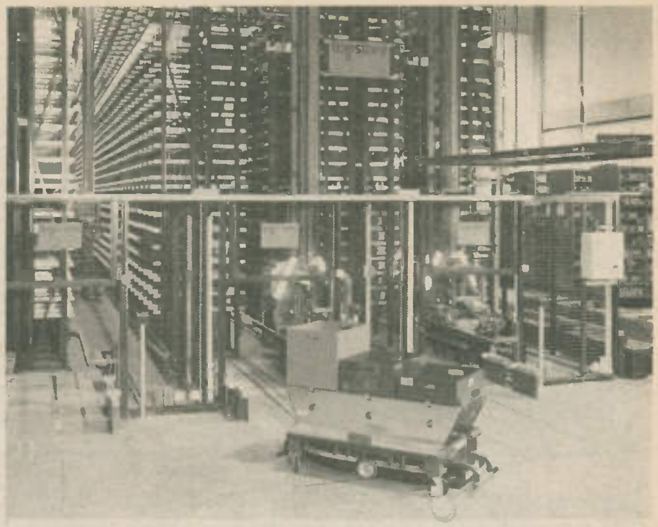
When stock is delivered to the factory it is manually placed into trays and bar coded. At the same time the relevant details are fed into the computer. AGVs then transport the trays to the storage area where they are transferred to 'automatic fork lift cranes'. The cranes move the materials to the required storage space under the guidance of the Materials System computer. This means that once goods have entered the factory, the computer has a record of the level and whereabouts of all materials. A diagram of the stock control system is shown in Fig. 2.

Throughout the factory there is a network of buried foil tracks which can guide the AGVs. This allows the movement of goods to any required area under complete control of the operating system. For example, suppose a batch of resistors is needed at a particular production area, then it is a simple task for a manual operator to key in the required code. The system will respond by checking the storage location of the item required and instructing the stacker cranes to retrieve the correct tray, and pass it to an AGV. The AGV will take the items to the selected area where they are accepted by a manual operator who will read the bar code. This will cause the computer to update its stock files and respond accordingly, maybe by producing an order form for more components.

At any one time there may be a number of AGVs moving around the factory, transporting and retrieving materials from all areas. This system offers many advantages over the old fashioned manual method of stock handling, such as: increased efficiency, smaller storage and total reliability.

PROCESS MACHINES

The process machines are not at the moment directly connected to the LAN, but plans are under way for future development. Even so there are facilities for any machine to be serviced by the CAD/CAM and the AGVs, thus even at this stage there is little manual input. Mars have several process machines in operation including automatic sequencers, axial inserters, d.i.l. inserters, pin inserters and flow soldering equipment.



Above: An AGV delivering materials to the store. Right: Complex machinery gives total control

AUTOMATIC SEQUENCER

When a production run is decided upon, then the required stock which is recorded in the computer can be retrieved as and when necessary. The stock is distributed between the various departments for use at the required time. All axial components such as resistors, capacitors, diodes and inductors can be automatically inserted into the p.c.b. This is quite a complex operation and must be done in a strict sequence. To ensure this sequence an automatic sequencer will load bandeleros of components to be fed into the insertion machine. It does this under the control of a computer program which instructs the machine to extract particular discrete components from a series of feeders and place them one at a time in the bandelero (similar to that of a machine gun). The bandelero is then transferred to the insertion machine which need not be programmed with the type of component but merely the insertion sequence.

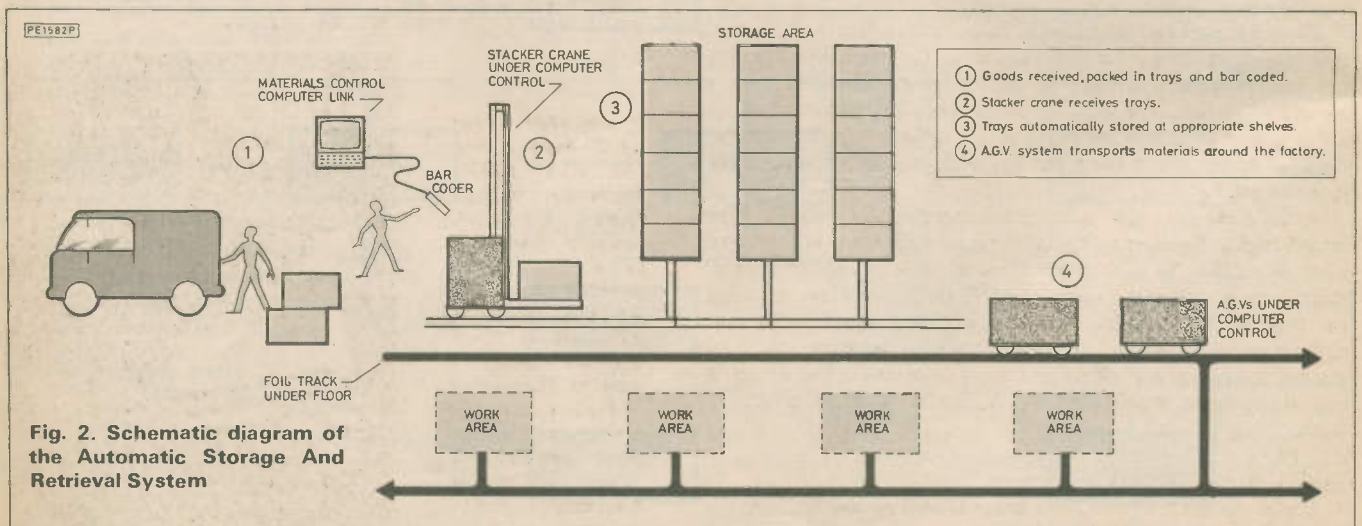
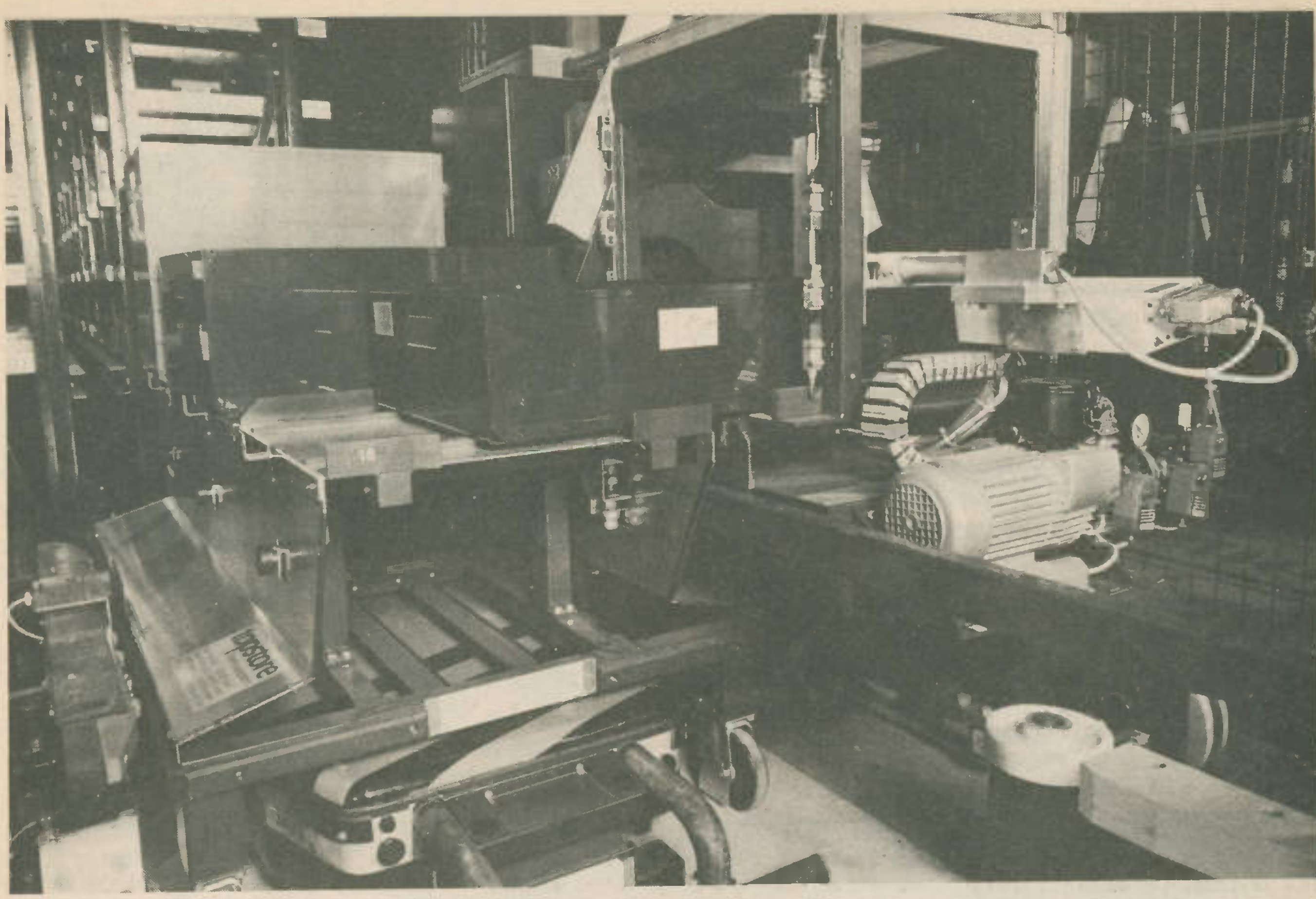


Fig. 2. Schematic diagram of the Automatic Storage And Retrieval System



INSERTION

Most of the components are automatically inserted, other than such items as relays and three terminal devices like transistors and regulators. The axial components are fed into the insertion machine already sequenced so it is a relatively straightforward task. The leads are formed to the required spacing and the p.c.b. is positioned under the insertion head. Each component is handled in much the same way. It is inserted into the predrilled p.c.b., the leads are cut and then bent over to provide mechanical strength. All parameters (lead length, bending etc.) are preprogrammable and may be altered at any time, so the whole operation may be done with the minimum of human supervision.

The d.i.l. package insertion is done in a similar way, except that the sequencing is an integral part of the operation. Feeders are loaded with a variety of devices, each feeder having a particular device. The p.c.b. is automatically positioned under the insertion head and the machine will select components in the required order, insert them, cut the leads, and bend them to the required pitch.

After these two operations are completed the p.c.b. is then transferred to the human operated production area via conveyor belts or AGVs. Here they are finished with any other components necessary before being transferred to the flow soldering machine. At any time throughout any of these operations a partially completed job may be taken back to the stores for temporary storage and at all times the computer would be aware of the progress and location of any particular component or partwork.

FLOW SOLDERING

When the p.c.b.s have been assembled they are fed into the flow soldering machines which exposes them to several processes. The boards are heated and fluxed before being fed into the solder bath. After this process the manually inserted component leads are cut and the whole board is immersed in cleaning fluid. When the boards come out they are fitted with the last few components which couldn't be immersed or exposed to heat. From here they are passed to the inspection and testing sections.

The testing departments make extensive use of ATE which on most occasions has been made or modified for their own particular needs. Test jigs are set up for each particular type of board and tests can then be made for component values and tolerances, and p.c.b. faults such as short or open circuits. Following this stage they are passed to mechanical assembly which at the moment is essentially manual.

Photo illustrating an off-loading bay for the AGV. There are many of these situated around the factory at convenient positions. At the present off-loading is a manual operation but a five-year robotics plan is underway which will eventually make all stock handling automatic

PEOPLE

The working environment for manual production is a far cry from the sweatshops and soul-destroying tasks of the first industrial revolution, although there are still a number of boring manual jobs which have to be done. *"It is the aim of the company to eventually replace any manual tedious operations with robots."* They are presently equipping a factory adjacent to their existing premises which will have all the current facilities but will be enhanced by a five year robotics plan. Particular emphasis will be on "Pick and Place" robots.

> *"It is the aim of the company to eventually replace any manual tedious operations with robots"*

As was mentioned earlier the bulk of the mechanical assembly is done manually but to increase reliability and efficiency Mars have moved away from the traditional linear production line by introducing a Swiss idea of circular production. Here one person may be responsible for a complete assembly instead of being forced to a single task of, maybe inserting one type of component all day long.

This system works by having a rotating work station split into several sections. Each section will have a working area with the main assembly, and a parts tray. The idea is to fit one part to the assembly and then rotate to the next section and fit the same part to that assembly. When the initial section is reached another part may be fitted and the sequence repeated. At the end of the operation the result is a number of complete assemblies all being the responsibility of one person. This gives rise to a much greater sense of satisfaction than could otherwise be achieved under the old system.

THE FUTURE

The consequence of modern technological developments and their use in industry has not yet been seen and it will be a few years before their full effects are appreciated. It is certain that

The human input—a fairly relaxed working environment—carpets all round!

many laborious and repetitive tasks will be undertaken by automatic machinery and that the field of communication and commercial business will become computer controlled. However, with the predicted increase in consumer goods manufacture and the so called computer revolution there may well be a social problem requiring a complete change in social attitudes.

The promised employment opportunities in the new industries have not happened and it looks now as if they never will. A report from the National Economics Development Office showed that employment in the industry has dropped by 12 per cent since 1980. It is a catch-22 situation where governments and individual companies face a difficult decision. If new technology is adopted then new jobs are unlikely in great numbers, but without it firms will find it difficult to compete with efficient manufacturers. The way ahead? ★

Ingenuity Unlimited

A selection of readers' original circuit ideas.

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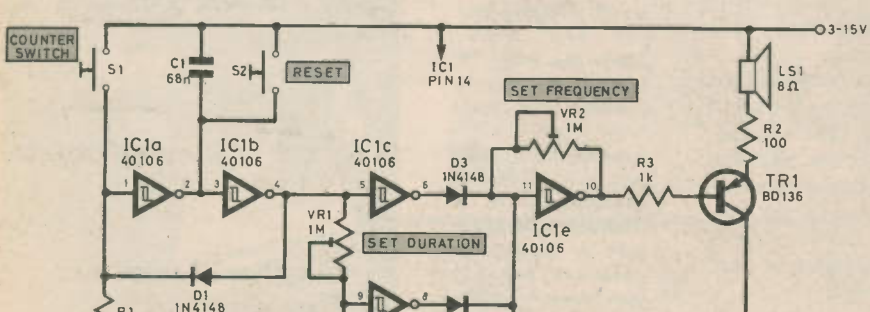
Each idea submitted must be accompanied by a declaration to the effect that it has been tried and tested, is the original work of the undersigned, and that it has not been offered or accepted for publication elsewhere. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

SHOP COUNTER BELL



ANYONE who has worked in a shop or similar workplace, having a customer operated bell, will agree that an awful lot of people are persistent button pushers.

This circuit was designed to give a single pulse train at a set frequency for a set duration. Any subsequent button pushing will be of no avail, until the circuit is manually reset by the operator.

The circuit is of simple design, employing a CMOS i.c. 40106 as an astable and a monostable. The monostable sets the oscillator into operation when the counter switch S1 is pressed and the oscillator drives a speaker via TR1. Once activated, the oscillator will run its course and further operation will be inhibited until the reset is activated.

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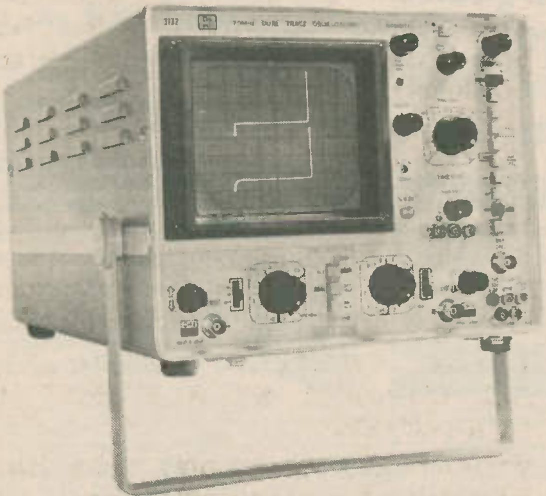

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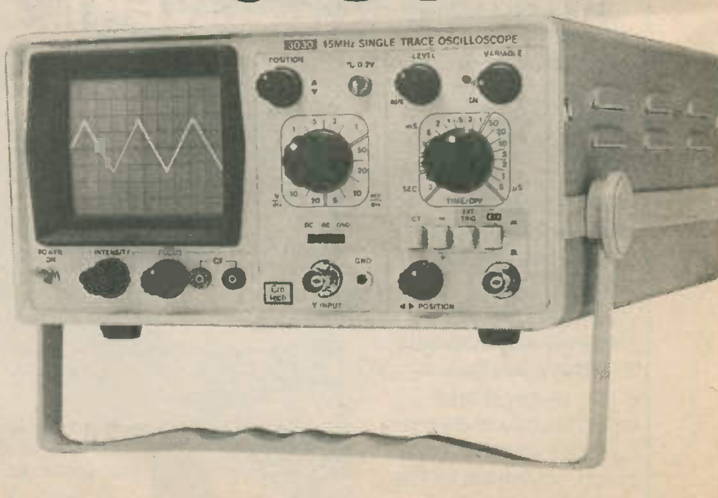

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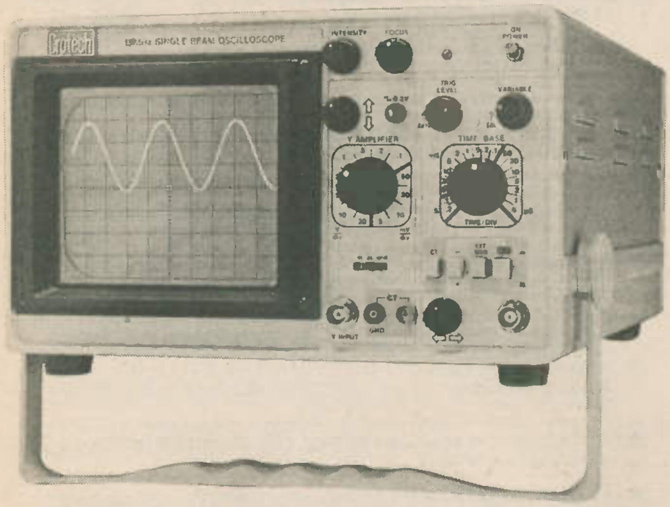

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- ★ 130mm cathode ray tube
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- ★ 6 trigger functions
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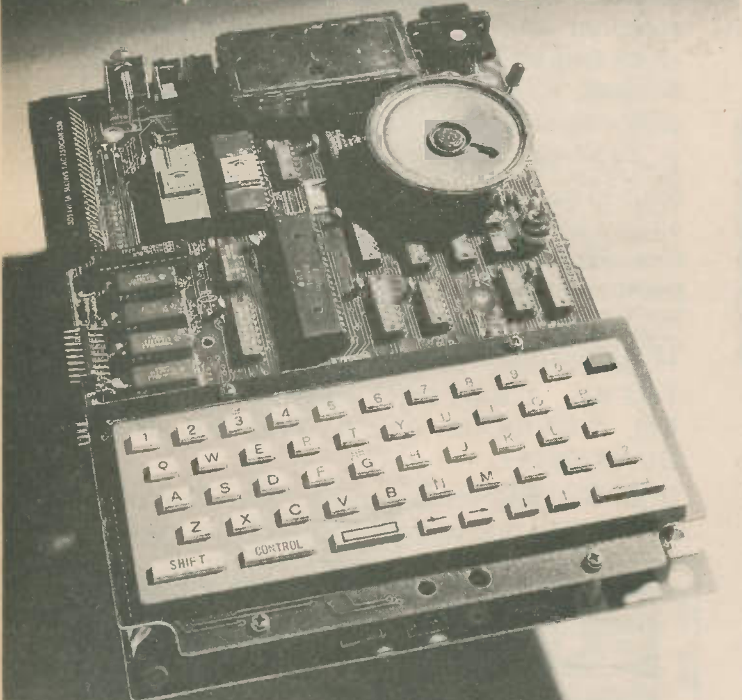
THE NEW MPF1·65



(6502 Microprocessor)

■ DISASSEMBLER: The built-in disassembler allows the user to list **6502** microprocessor instructions on both printer and video display. The disassembled data, in mnemonic symbols, translates the complex machine language of the microprocessor into symbolic form with 3 letter abbreviations. Understanding of low level operations provides learners with a comprehensive understanding of the **6502**.

■ SCREEN EDITOR: The screen editor allows for rapid alteration of data displayed on the video output console. Commands previously entered onto the screen can be verified, monitored and changed accordingly. With word processor-like functions, the screen editor is an attractive feature for programmers and industry alike.

■ MPF-1/65 MONITOR INDUSTRIAL COMMAND SUMMARY: The commands of the system monitor allow for single key programming convenience. Such software includes the following features:

- Display/Alter of selected memory contents
- Move/Verify of a block of memory contents
- Display/Alter Registers
- Select display page/mode
- Mnemonic form listing of instructions
- Single key program execution
- Read/Write data to or from cassette tape
- Easy printer select for hard copy results

■ TEXT EDITOR: The text editor provides the power of changing, adding, or deleting instructions anywhere in the program without affecting any other portions of the program. The text editor's simple commands may be displayed on video output or in hard copy form. Source code in the machine's editing buffer can be efficiently translated into machine code for faster operation. The text editor also combines with other features to provide a powerful debugging tool.

■ TWO PASS ASSEMBLER: The two pass symbolic assembler provides **6502** programmers with the ability to write extremely efficient programs for applications requiring fast execution speed. OEMs and professionals can more efficiently develop complex programs.
Students of the **6502** can use the functions of the two pass assembler to grasp the fundamentals of microprocessor programming.

■ PRINTER DRIVER: The printer driver resident in ROM provides software drive interface with Epson printers.

■ DEBUGGING FEATURES: The MPF-1/65 also packs features that provide software for programming simplicity and efficiency via strong debugging functions. These include:

- Setting, clearing and displaying breakpoints
- Single step program execution on printer or display
- Tracing of one instruction
- Displaying register contents

MEMORY

■ USER MEMORY: 64K dynamic RAM.
■ PERMANENT MEMORY: 16K of ROM stored in two 8K by 8-bit chips
■ DISPLAY MODES: TEXT: Two pages of 40 × 24 text
GRAPHICS: Bit mapped graphics in six colours controlled by machine code instructions.

INPUTS AND OUTPUTS

■ AUDIO SPEAKER: 2.25 inch 8 ohm speaker.

■ AUDIO CASSETTE INTERFACE: 1000 bit per second data transfer from memory to cassette tape

■ PARALLEL PRINTER INTERFACE: With Centronics printer interface and EPSON software driver.

■ COLOUR TV INTERFACE: R/F modulator with video and sound output provides for colour TV interface.

■ SYSTEM EXPANSION CONNECTOR: 50 pin connector to provide interface with RS-232c or ROM cartridges.

■ KEYBOARD: Standard QWERTY 49 key keyboard with 153 ASCII codes.

■ 232-MPF-1/65 CARTRIDGE: The optional RS-232c cartridge provides for an industry standard asynchronous serial communications capability.

■ Professional Documentation ..... All the Instruction You Need.

In being a total learning tool, the MPF-1/65 supports the user with clear, operating documentation. Both the User's Manual and Monitor Program Source Listing Manual are written with the beginner and professional in mind.

The **User's Manual** includes a complete introduction to the features and capabilities of the system. Detailed descriptions of both hardware and software.

The **Source Code Listing Manual** provides complete listings of the monitor software. For the programmer and learner, this provides insight into all the capabilities and functions of the complete system.

Technical Specification

■ ADVANCED INTERACTIVE MONITOR: The heart of the MPF-1/65 software resides in 16K bytes of permanent memory (ROM) located on board. The monitor is designed to provide a user friendly interface by presenting language that the microprocessor understands in an easily understood format. Self prompting single key commands also provide an easy yet powerful means of input. These features provide for the most effective means of understanding the real way in which a microprocessor operates.
The MPF-1/65 monitor includes a wide range of powerful features that offer user convenience, easy-to-learn commands and powerful programming capabilities. These include the screen editor, disassembler, text editor, two pass assembler, printer driver routines and special debugging commands.

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Low Cost
BBC Speech Synthesiser

Anthony Foord

£4·95 +VAT

A number of designs have been published in the electronics press for speech synthesis units, either intended specifically for the BBC Computer or more widely compatible. They are generally connected to the parallel printer or user port. This ties up one port and takes up valuable desk space.

A much neater solution is provided by Acorn themselves. Their system consists basically of two integrated circuits for which provision has been made on the main p.c.b. The computer's internal speaker and amplifier are used and the operating system takes care of the interfacing requirements.

On consideration however, the Acorn unit does appear to have two drawbacks; firstly, it is preprogrammed, giving only a limited selection of words and, secondly, it retails at over £50.

The design presented here uses the popular General Instruments Speech Processor to give a virtually unlimited vocabulary. If constructed as described it may simply be plugged into one of the sockets inside the computer; no track cutting or other modifications are necessary. It is compatible with the operating system, and retains the other advantages offered by Acorn's system (but will not, of course, produce intelligible speech with software written for the Acorn Unit). As a bonus, two different volume levels can be selected under program control and the total cost should not be more than about £15.

SYNTHESIS

There are several possible techniques for the production of artificial speech. One method is to record the required phrase in digital form and then play it back—hardly synthesis really. With adequate data rates this can sound extremely good (compact discs are an example). Acceptable quality can only be achieved at the cost of large amounts of memory, making this approach somewhat inflexible. At the other extreme, electronic analogues of the human vocal tract have been built. These consist of a number of filters, an oscillator and a noise source, all controlled from the computer.

At the present time the systems in widespread use fall into one of two classes. Either information describing complete words is stored (in a compacted form to reduce memory requirements); or, a collection of basic sounds, known as ALLOPHONES, are used, which may be strung together to form any desired word.

The latter approach is inherently more versatile, and it is this method which is used in the General Instruments SP-0256 i.c. The attendant disadvantage is that whereas human beings can subtly adjust the individual allophones, depending on the neighbouring sounds, to produce smoothly connected speech, electronics (as yet) cannot. Both methods are capable of adequate (though rather mechanical sounding) results.

The SP-0256 can produce 59 separate sounds (and five pauses of varying lengths) which enable English words to be built up. It should be noted that both the SP-0256 and the Texas Instruments TMS5220, used by Acorn, have digital, Pulse Width Modulated outputs. This takes the form of a series of pulses at a frequency of several kHz. Varying the width of the pulses alters the mean output voltage and this average level is recovered by low-pass filtering to give an audio signal.

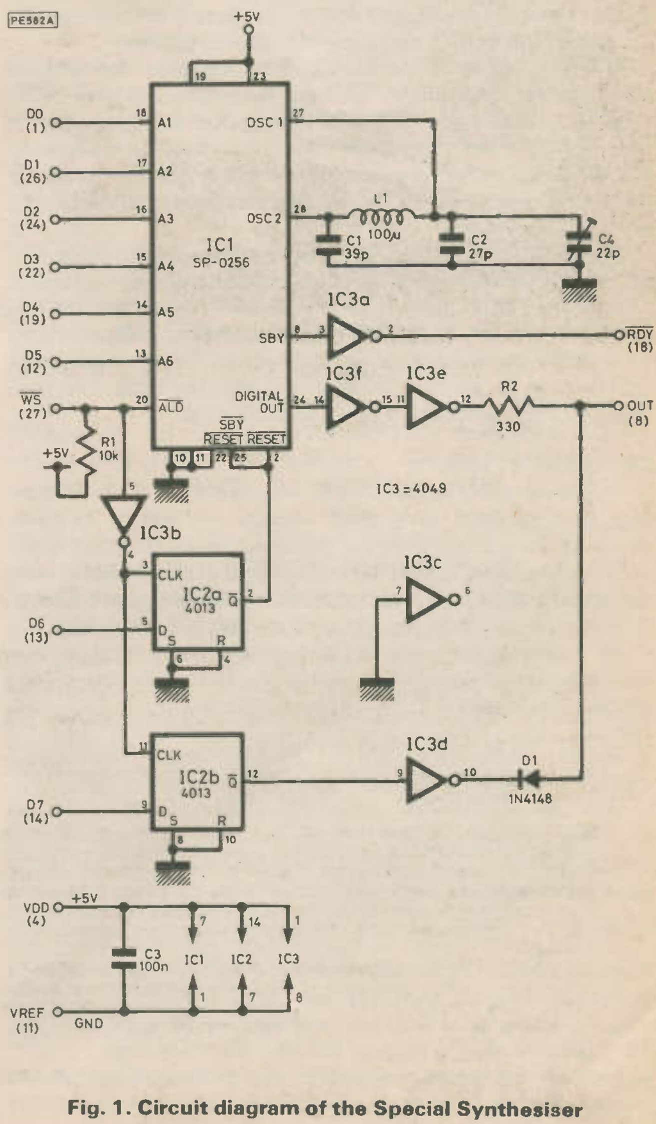


Fig. 1. Circuit diagram of the Special Synthesiser

CIRCUIT DESCRIPTION

The heart of this circuit, like many others, is the SP-0256 i.c. This device is responsible for the actual speech synthesis. The remainder of the circuitry is required to allow it to replace a TMS5220, and to provide two switched volume levels. The circuit diagram is shown in Fig. 1.

All the necessary filtering and amplification is performed by components already present in the computer. The SP-0256 accepts a six bit binary input which corresponds to one of sixty four possible output sounds (including the five which are silent). This is taken from lines DØ to D5, and is stored in internal latches on receipt of an active-low $\overline{WS}$ pulse. The remaining data lines, D6 and D7 are latched by the 4013 dual D-type flip-flop. Inverter IC3b is included as the 4013 expects an active-high clock signal. D6 is taken high by the computer as part of the procedure to reset the TMS5220, and so is used (in inverted form) to reset the SP-0256. This ensures that the unit remains silent on power-up and BREAK. D7 is used to select between volume levels. Both the output of the SP-0256 and that of the 4013 are buffered by inverters. If D7 is a logical '1', then the cathode of D1 is taken to +5V. It thus has no effect on circuit operation and full volume results. A logical '0' causes the cathode to be taken to ground and the diode clamps the voltage excursion at the output, reducing the volume obtained.

The SBY output of the SP-0256, which goes high when it has finished speaking or is reset, is inverted to give $\overline{RDY}$. This is an active-low signal informing the computer that it may send the next data byte. Using the active-low output of the SP-0256 would prevent the computer from successfully executing a reset operation as this too goes high, inhibiting the transfer of data.

L1, C1, C2 and C4 are frequency determining components for the SP-0256 internal oscillator. C4 enables some adjustment of the vocal pitch to be made, and it is worthwhile trying the effect of different settings. Increasing frequency also makes the computer talk slightly faster. Finally, note that a 4049 must be used. A 4069 has a reduced output capability, and may be too slow for this application.

CONSTRUCTION

The method of construction adopted for the prototype (see photographs) is slightly unusual in that it involves soldering the p.c.b. directly to the d.i.l. header at right angles.

This is recommended as it results in a single, rigid, self-supporting assembly and cuts down on off-board wiring. However, it is perfectly possible to use the more conventional length of ribbon cable, and even to build the circuit on matrix board. If you make your own p.c.b. from the layout given, be sure to cut it to the size shown. There is very little clearance inside the BBC Computer.

The first step is to mount all the components on the p.c.b., not forgetting the eight wire links. IC1 is a relatively expensive MOS device and should certainly be socketed. It is probably worth using sockets for the other i.c.s. as this will save a great deal of trouble if any problems occur. Soldering calls for some care as several tracks run very close to each other.

The 28 pin headers used to be hard to find, although this seems no longer to be the case. An alternative is to chop up a 40 pin header. Anything else is definitely not a good idea—sticking bits of wire in may damage the BBC's socket. The next step then is to glue the p.c.b. to the header.

First tin the tracks where they are to be soldered to the header. The p.c.b. should be placed so that it is between the

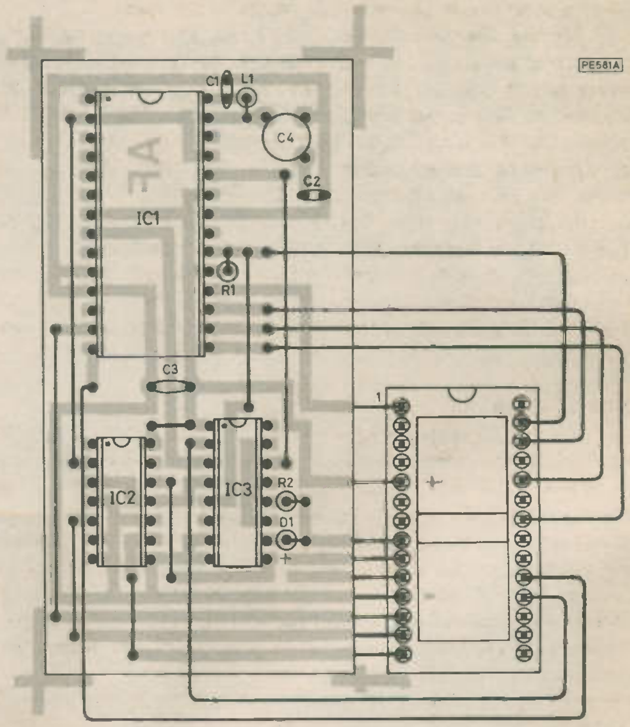


Fig. 2. P.c.b. and component layout of the Speech Synthesiser

two rows of pins and so that the tracks line up with the pins. A bracket is needed to hold it in this position. For the prototype a length of $\frac{1}{4}$" plastic channel which is generally available at modelling shops, was used, but a similarly sized strip of wood could be employed. With the p.c.b. located as shown in the photo and pressed against the header pins, glue the bracket to both it and the header, using a quick setting epoxy resin compound. This is the only tricky part. When this has set the six flying leads may be wired from the p.c.b. to the header, as shown in Fig. 2.

On the prototype it proved necessary to slightly file down one edge of the header to clear a capacitor in the computer.

COMPONENTS . . .

Resistors

R1	10k
R2	330

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

Capacitors

C1	39p metallised ceramic plate
C2	27p metallised ceramic plate
C3	100n disc ceramic
C4	22p miniature trimmer

Inductors

L1 100μ

Semiconductors

D1	1N4148
IC1	SP-0256
IC2	4013
IC3	4049

See our p.c.b. service on Page 60

Miscellaneous

p.c.b. 503-05
28 pin i.c. socket
14 pin i.c. socket
16 pin i.c. socket
28 pin d.i.l. header
$\frac{1}{4}$" plastic angle

INSTALLATION

Fitting the unit is very straightforward. The top of the computer is secured by four screws. These are situated one either side at the back and underneath at the front.

All further directions assume the computer is viewed from the normal position, i.e. the keyboard is in front. Thus the power supply lies to the left. The speech processor socket (labelled IC 99) is the righthand of the two adjacent 28 pin sockets by the p.s.u. With the computer switched off, the speech synthesiser should be plugged in so that the p.c.b. is on the left side and extends towards the back. This can be seen in the photographs. Care should be taken to ensure that all the pins are correctly sited and pressed fully home.

The sound quality will be dramatically improved if the top is put back on the computer, although it would perhaps be tempting fate to replace the screws before testing the system!

OPERATION

To send a byte to the speech synthesiser, use is made of the BBC Microcomputer's OSBYTE call (CALL &FFF4). This is entered with A% set to the parameter to be passed. An illustration of this is given by PROCspeak in the demonstration program. The program allows ten words to be defined and spoken. It was developed on a computer fitted with OS-1.2. To keep it as short as possible few REM statements have been included, but it should be quite self explanatory. PROCspeak expects data to be stored as character strings,

Allo-phone No.	+128	Example	Allo-phone No.	+128	Example
0	128	10mS	32	160	shOUt
1	129	30mS	33	161	Dot
2	130	50mS	34	162	Got
3	131	100mS	35	163	liVing
4	132	200mS	36	164	Gear
5	133	tOY	37	165	SHoe
6	134	tIE	38	166	meaSure
7	135	pEt	39	167	tRap
8	136	Cone	40	168	Fat
9	137	Pet	41	169	taCK
10	138	roGer	42	170	Cat
11	139	tiN	43	171	Zap
12	140	tIn	44	172	kiNg
13	141	Tin	45	173	Lit
14	142	Rat	46	174	Wet
15	143	dUck	47	175	AIR
16	144	Mix	48	176	WHy
17	145	peT	49	177	Yet
18	146	THat	50	178	CHip
19	147	tEA	51	179	sIR
20	148	pAY	52	180	tURn
21	149	founD	53	181	gO
22	150	tUtor	54	182	oTHer
23	151	tALk	55	183	Sit
24	152	tOp	56	184	Not
25	153	YEt	57	185	Hook
26	154	cAt	58	186	OR
27	155	Hit	59	187	pARt
28	156	haBit	60	188	EAR
29	157	THick	61	189	Go
30	158	hOOk	62	190	paddLE
31	159	mOOn	63	191	Bat

Table 1. Complete list of available allophones

Word	Allophones
B.B.C.	63 19 2 63 19 2 55 55 19
Computer	42 23 16 9 49 22 13 51
Exterminate	7 42 55 17 51 16 12 11 20 17
Peter	9 19 13 51
Piper	9 6 9 51
Picked	9 12 41 17
A	15
Peck	9 7 41
Of	23 40
Pickled	9 12 41 62 17
Pepper	9 7 9 51
E.T.	19 2 13 19
Phone	40 53 11
Home	57 53 16

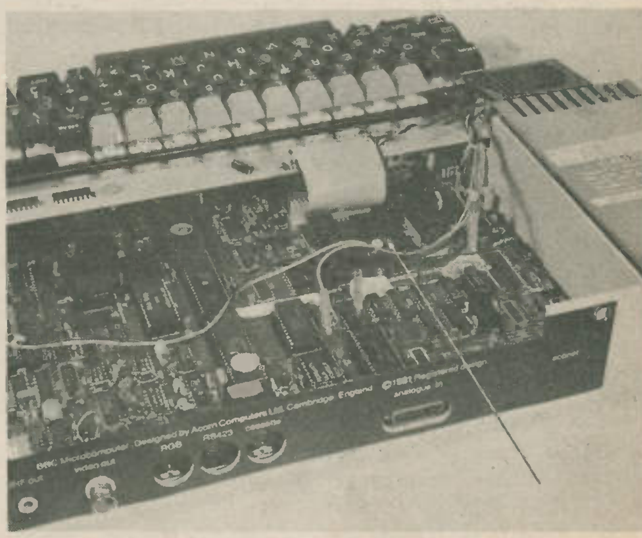
Table 2. Some (appropriate) examples of word construction

other solutions are possible, such as integer arrays.

The numbers recognised by the speech synthesiser are listed in Table 1, together with their corresponding sounds. Values in the range 0 to 63 will cause the allophones to be spoken quietly, while those in the range 128 to 191 will result in the same allophones being spoken with greater volume. Numbers between 64 and 127 or 192 and 255 inclusive will turn the unit off, as will the BREAK key.

Table 2 contains some examples. Constructing words becomes very easy with a little practice. It is important to think of them as strings of sounds and to pay no attention to spelling. There are several very similar allophones, and the best result may only be obtained through trial and error. Not all the sounds are equally good, the 'TH's seem particularly bad, and here substitution of another allophone is often worthwhile. The short vowels such as 'E' (No. 7) and the 'S' and 'F' sounds can be used twice in succession to stress a syllable. It is also possible to place short pauses in words to good effect. A 50ms pause is about right between words in a phrase, and a longer pause between phrases. It is important to end with a pause or the last allophone will continue to sound. This is taken care of in PROCspeak.

There are algorithms which convert written text to allophones and one of these might be implemented. Obviously they cannot be perfect in a language which allows "cough" and "rough", and pronounces "lead" differently in

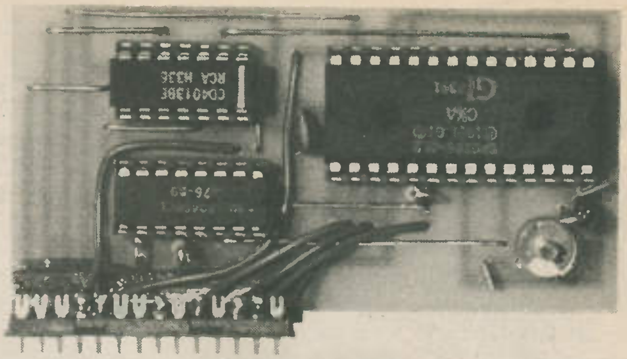


Photograph illustrating the position of the 28 pin socket (IC99) for the Speech Synthesiser

different contexts, but with judicious mispelling they are a big help, and often incorporate a dictionary of such exceptions. In addition to speech, some fascinating sound effects are possible, try a string of 'i's or 'p's or random allophones.

Like most speech synthesisers, it is much easier to understand if you are used to it and know what is being said.

Apart from its obvious applications for the blind and situations where you cannot watch a television screen, it is hard to suggest a compelling reason to build it, although there is great scope for experimentation with speaking alarm clocks etc. But, it is one of the cheapest computer peripherals available, and most people still find a speaking machine surprisingly impressive. ★



DEMONSTRATION PROGRAM

```
 10 MODE 7
 20 DIM name$(9)
 30 DIM allophone$(9)
 40 PRINT TAB(6,2); "SPEECH DEMONSTRATION
    PROGRAM"
 50 PRINT TAB(6,3); "====== =========== ==
    ======="
 60 REM title$ IS ALLOPHONE STRING FOR TITLE
 70 title$="7IS2C! GPXK7MgT%XKClg5=gZP"
 80 PROCspeak(title$,1)
 90 REM SET UP USER DEFINED KEYS
100 *FX225,128
110 *FX226,138
120 FOR index%=0 TO 9
130 allophone$(index%)=CHR$(0)
140 PROCmenu(index%)
150 NEXT
160 speakmode=FALSE
170 REPEAT
180 IF speakmode THEN PROCgetword ELSE PROCupdate
190 UNTIL FALSE
200 END
210 REM PROCupdate ALLOWS MENU TO BE ALTERED
220 DEF PROCupdate
230 PRINT TAB(2,23);"Type 'S' for Speech mode."
240 INPUT TAB(2,17);"WORD NUMBER (0-9)"; reply $
250 PROCwipe(17)
260 PROCwipe(23)
270 IF reply$="S" THEN speakmode=TRUE: ENDPROC
280 index%=VAL(reply$)
290 IF index%>9 THEN 240
300 PRINT TAB(2,19); name$(index%)
310 PRINT TAB(2,20);
320 FOR count%=1 TO LEN(allophone$(index%))
330 PRINT;ASC(MID$(allophone$(index%), count%,1));" ";
340 NEXT
350 PRINT TAB(2,23);"Press (RETURN) to continue
360 INPUT TAB(2,17);"WORD NAME ";reply$
370 IF reply$<> "" THEN name$(index%)=reply$
380 PROCwipe(17)
390 PROCwipe(23)
400 word$=""
410 REPEAT
420 PRINT TAB(2,23); "Press (RETURN) to continue."
430 INPUT TAB(2,17); "ALLOPHONE NUMBER
    (0-63) "; reply $
440 PROCwipe(17)
450 IF reply$<>"" AND VAL(reply$)> -1
    AND VAL(reply$)<64 THEN
    word$=WORD$+CHR$(VAL(reply$))
460 UNTIL reply$=""
470 IF word$<> THEN allophone$(index%)=word$
480 PROCmenu(index%)
490 PROCspeak(allophone$(index%),0)
500 FOR count%=19 TO 23
510 PROCwipe(count%)
520 NEXT
530 ENDPROC
540 REM PROCgetword GETS WORD FROM MENU
    CORRESPONDING TO KEY PRESSED
550 DEF PROCgetword
560 PRINT TAB(2,23);"Type 'A' to Alter menu."
570 PRINT TAB(2,17);"(SHIFT) to raise volume.f0-f9 ?";
580 reply$=GET$
590 IF reply$="A" THEN speakmode=FALSE
    :PROCwipe(17):PROCwipe(23):ENDPROC
600 index%=ASC(reply$)-128
610 If index%<0 OR index%>19 THEN 580
620 If index%>9 THEN loud=TRUE:index%=index%-10:
    ELSE loud=FALSE
630 PROCspeak(allophone$(index%),loud)
640 ENDPROC
650 REM PROCmenu PRINTS ONE LINE OF MENU
    SELECTED BY index%
660 DEF PROCmenu(index%)
670 PROCwipe(index%+6)
680 PRINT TAB(2,index%+6);index%
690 PRINT TAB(6,index%+6);name$(index%)
700 ENDPROC
710 REM PROCwipe ERASES ONE LINE SPECIFIED
    BY Y%
720 DEF PROCwipe(Y%)                    725 LOCAL wi Y%
730 PRINT TAB(0,Y%);SPC(40);                        A%
740 ENDPROC
750 REM PROCspeak OUTPUTS STRING TO SPEECH
    SYNTH
760 DEF PROCspeak(word$,loud)
770 IF loud THEN offset=128 ELSE offset=0
780 A%=159
790 FOR count%=1 TO LEN(word$)
800 Y%=(ASC(MID$(word$,count%,1)) AND &3F)+offset
810 CALL &FFF4
820 NEXT
830 Y%=offset
840 CALL &FFF4
850 ENDPROC
```

BBC Micro Forum...

David Whitfield MA MSc CEng MIEE

WELCOME to *BBC Forum*, P.E.'s new monthly page devoted to the BBC Micro. You may be wondering why we are intending to devote a whole page, every month, to this machine. After all this is an electronics magazine, and such columns have a habit of being full of software listings of interest only to an eccentric minority; no fit subject for a soldering iron user. Have no fear, the emphasis will be on *practical* applications of electronics to computers, and not computing for computing's sake. In this first column, therefore, we would like to take a little time to explain our approach to the subject. Incidentally, Sinclair owners may be interested to hear that our sister publication, *Everyday Electronics*, will be running a similar series aimed at the Spectrum.

Over 370,000 BBC Micros have been sold since the machines first became available in early 1982. It boasts a performance which still compares favourably with its most recent competitors, it's well equipped, widely used in schools, there's plenty of software available for it, and it can be used at the heart of all sorts of systems. Price is the BBC Micro's major drawback, but this does not prevent it from having a wide and enthusiastic following. I must confess to being a convert to the cause myself.

So much for the potted biography of the machine, but what about the reality of owning a computer? We are constantly told that computers will revolutionise our lives, but for many people 'home computer' is just another word for 'games machine'. At the next level, we see users moving on from proprietary software to writing their own, usually in BASIC. Equally, the trend is away from games to applications which actually set the machine to work, e.g. word processing. As our understanding of the machine increases, the more directly we are able to apply the power at our disposal, e.g. central heating control. To make this final step, however, we usually need to move away from BASIC, and look at the hardware of the computer itself. In this way we can add hardware to the computer to control our own peripherals such as lamps and valves, rather than the more traditional printers and cassettes already catered for. This is the objective of this column!

The projects and techniques that we will be looking at will not involve opening up the micro, and will only connect to the interfaces supplied as standard on the model B. However, even if you do not have a BBC Micro, many of the projects will be readily adaptable for many other machines, particularly those with a 6502 microprocessor such as the Commodore 64 and Apple IIe.

INTERFACES

The BBC Micro is particularly well endowed with interfaces. Even if not actually fitted with a particular interface when delivered, the main circuit board, case and power supply are all designed to take all of the interfaces *without* the need for external add-on boxes or adaptor modules. In this way, any BBC Micro can be upgraded to the full specification if required. The interfaces which can be supported are as follows:

- Cassette Interface
- RS423 Port
- Analogue Input Port
- Light Pen Input
- RGB Monitor
- UHF Television
- Composite Video
- Parallel Printer Port
- Floppy Disc Interface
- User Input/Output Port
- 1MHz Bus Interface
- Processor Bus Interface
- Econet Interface
- Speech Synthesiser
- Paged ROMs

The model B is supplied with all of these fitted except the floppy disc interface, Econet and speech synthesiser. With the now discontinued Model A 16k RAM is fitted, and the interfaces are limited to UHF television, composite video and the cassette port. The BBC Micro can thus reasonably be described as having enough I/O facilities to be going on with! Indeed, the problem is a little more like being spoilt for choice. Over the next few months, therefore, we will be exploring these interfaces, their strengths and weaknesses.

Wherever possible, we will be including a brief discussion of the internal hardware which supports the interfaces.

USER PORT

We start this month with a look at the user input/output port. Next month we will be describing this port and its uses in greater detail, but for the moment we will start by looking at its connections. The user port is the centre one of the five connectors located on the underside of the keyboard. As shown in Fig. 1, the port has eight input/output lines and two control lines. The 20-pin user port connector requires a mating insulation displacement cable mounting socket and ribbon cable for connection to the outside world. These are available, either separately or made up as leads, from a number of advertiser's in P.E. The RS part number of a suitable connector is 469–881, and of corresponding 20-way ribbon cable is 357–867. **NEXT MONTH: Using the I/O Port.** ★

FINALLY

I would be delighted to hear from readers with suggestions, hints for inclusion or problems, but would like to stress that any reply will only be through this column. Correspondence should be addressed to 'BBC Forum Letters', at P.E.'s editorial address.

Anyone considering purchasing a BBC microcomputer can obtain pre-sale advice from a number of sources, including; *BBC Microcomputer System, PO Box 7, London W3 6XJ* (send a large SAE).

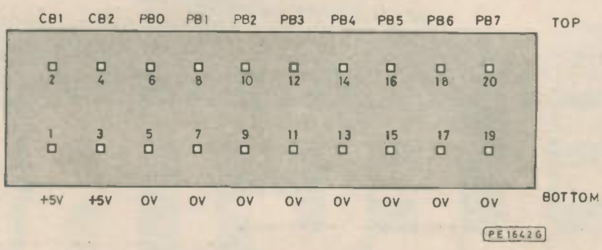
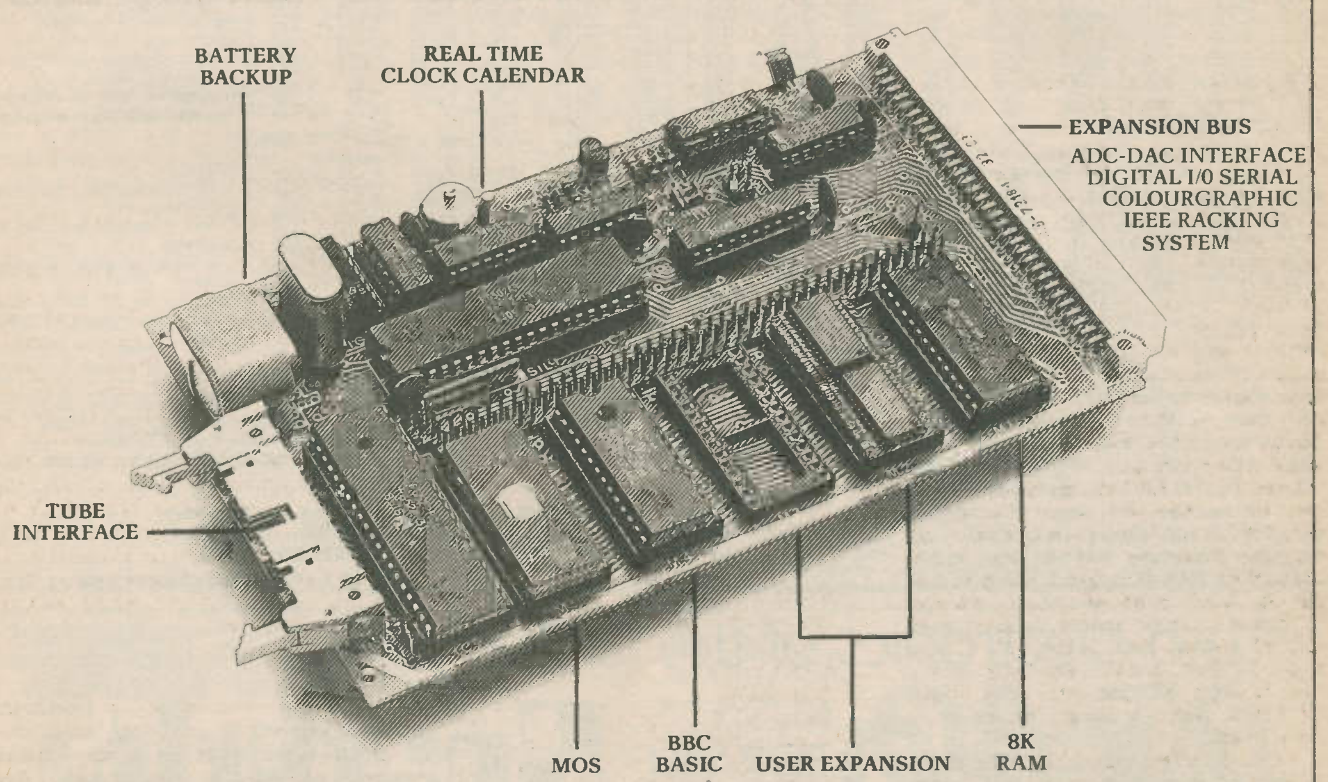


Fig. 1. Viewed looking into the socket

PUT BBC BASIC IN CONTROL USE THE 6502 2ND PROCESSOR WITH BIG CONNECTIONS



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COMMERCIAL BREAK

I make no apologies for coming back so soon to cellular radio. In no other area of electronics is so much of such importance happening so fast. By the time you read this, Britain should have its first cellular system. We shall by now be seeing how the Government policy of splitting the service between two rivals works in practice.

To recap very briefly, on the one hand there is TSCR, a joint venture between British Telecom and Securicor which will provide a service called Cellnet. The rival company is Racal which will provide the Vodafone service.

Technically both services are compatible, with transmission on the 900MHz UHF band, and 25kHz channel spacing. The British system TACS (Total Access Communication System) is derived from the American AMPS (Advanced Mobile Phone System) which operates at around 850MHz with 25kHz spacing.

Under the terms of the Government licence given to TSCR and Racal the two services have to be completely separate and running by March. The intention, of course, is to stimulate competition. In fact the situation is made even more competitive, because TSCR and Racal are only allowed to provide a service and sell air time. They cannot sell hardware to end users. This has to be done through retailers and it's where the real commercial battle is being fought.

The cellular service with the best retail backing is the one which will show a profit in the long run. In the short term it won't matter. There is a pent-up demand from people who desperately want a phone in their car or briefcase. They will buy from anyone. But once this pent-up demand has been satisfied, the service will have to be sold with a capital S.

COMPUTER SWITCH

Racal played a quiet, clever game. While saying little to the press, the company struck a deal with Ericsson of Sweden to provide the computer switch. This is a daunting piece of equipment. It controls all the base stations in a city area, so that as a mobile moves from one cell to another the signal is "handed off" from one transmitter to another with a different frequency for each call.

If you talk to anyone in the armed forces, the odds are they will have heard of Racal. The company makes radio communications and location equipment for the services. So Racal knows about frequency hopping and chose Ericsson for the switch, because the Swedish company also has a big market in the defence sector. Moreover, Ericsson built the switches for the NMT, which is the Nordic Mobile Telephone Service. This provides cellular radio for 120,000 subscribers across Finland, Sweden, Norway and Denmark, on the 450MHz band.

The Ericsson switch has two central processor units, run in synchronism, so that if one goes down the other drops in. The program is stored in a dual memory, of 1·5 megaword capacity. The words are 18 bits; 16 data plus 2 for error correction. The data store, for subscriber numbers and billing information, is of similar 1·5 megaword capacity. The power supply is 48V floating from the mains on batteries. All memories are doubled up for security.

One switch can support around 60,000 subscribers. The first Ericsson switch went to Racal for use in London and the next should by now be installed in Birmingham.

Choosing Ericsson for the switch helped Racal pull in its prize catch, retail support from Pye and Philips. In domino fashion the Pye-Philips liaison helped convince the AA to back Racal and so put the company automatically in touch with its 5·6 million members. These are all potential subscribers to cellular radio, although only a fraction will be able to afford it.

In a careful run-up to launch, Racal has been investing heavily in TV advertising which does nothing more than familiarize the public with the Racal name. Behind the scenes Racal has been talking to journalists in specialized areas, for instance broadcasting, telling them how valuable cellular radio will be to a news team on the run.

The deal with answering machine company Answercall, with Dixons as an outlet, puts Racal in touch with the high street. In fact, few people reckon that cellular radio will be a real consumer item. What is a consumer? "Someone who pays for what they buy out of their own pocket," says Len Davis of Philips, which is just about the best definition I've heard.

ONE-STOP FITTING SERVICE

Most people who use cellular radio will be spending company money. Dixons will have to organise some sort of "one stop" fitting service, where customers can leave the car in the morning and pick it up at night, with dial tone buzzing. Buying and fitting piecemeal is a potential disaster.

Cleverly, Racal has insisted that all retailers use the service name Vodafone. This should cut through some of the confusion which is bound to arise when two competitive, different but compatible, rival cellular systems hit the market.

CELLNET UPDATE

At ludicrously short notice TSCR held a press conference to bring us up to date on Cellnet activities. Invitations for a Wednesday meet were received through the post on Tuesday. With or without justification TSCR blamed the BT share flotation.

When you get behind some of the PR and management front at Cellnet, the engineering expertise is impressive. TSCR uses Motorola computer switching. Each unit handles around half the number of subscribers handled by the Ericsson switch used by Racal, around 30,000 instead of 60,000.

This will let Cellnet make its service dynamic, that is shrink and change the size of cells, reduce transmission power and change reception and hand-off thresholds to suit special requirements. For example, if every company director with a car or portable phone goes to Wimbledon tennis next summer, the Cellnet service can make more channels available for them by tightening the cells in that area. How will McEnroe react to the sound of phones ringing?

The dynamic approach may make it easier for Cellnet to provide a service for small hand portables rather than fixed car phones or bulkv transportable units. These need higher signal strength and smaller cells.

At their last-minute demonstration, Cellnet showed frequency re-use. All demonstrations before that had relied on cells using different frequencies. But, of course, cellular theory relies on different cells in the same area re-using the *same* frequencies. Cellnet ran two 4 kilometre cells, around 15 kilometres apart, each using the same 10 channels, without mutual interference.

To test signal strength, Cellnet engineers have been driving around Britain for the last year with a Rover car equipped with a magnetometer. This plots its position accurately by reading the Earth's magnetic field. The car also has a signal strength measuring system which logs reception data every three centimetres which the car travels. This lets the engineers try out transmitter sites and see how they cover an area in practice.

BE WARNED

In America some manufacturers are now selling off Japanese cellular equipment very cheap. It is likely that some of this will find its way into Britain, and will be offered for sale at under the going price of around £1,500 for a mobile transceiver.

Be warned. Unless you buy from an authorised dealer, the transceiver won't work with either the Cellnet or Vodafone system. US frequencies and channel spacings are different. The UK main computers just won't accept any calls unless the subscriber's number is stored into the Cellnet or Vodafone service memory with an OK code.

MODULAR AUDIO POWER SYSTEM

PART 2

M. TOOLEY BA
D. WHITFIELD MA MSc CEng MIEE

THE dummy load permits testing all of the power amplifier modules and configurations described without the need for adequately rated loudspeakers. A further obvious advantage is that testing can take place without damaging one's eardrums or alienating the neighbours! Unlike the loudspeaker systems which it replaces, the load is small, lightweight and inexpensive.

Although the load is somewhat conservatively rated at 100W continuous r.m.s. output power, it is capable of handling power levels in excess of 200W for short periods. Essentially the load consists of ten parallel connected flameproof ceramic resistors, each rated at 7W. The complete arrangement is immersed in an oil bath which aids cooling, hence raising the maximum total power dissipation.

The load is conveniently housed in a 1lb Golden Syrup tin, the seal between the outer case and lid being perfectly adequate to contain the oil without risk of spillage whilst the outer tin-plate casing provides further effective heatsinking. If desired the case can be painted matt black in order to assist with radiation of heat.

The load is also provided with a simple signal detector which, with the aid of a d.c. meter and the calibration graphs supplied, will enable constructors to ascertain the output power level achieved with a reasonable degree of accuracy.

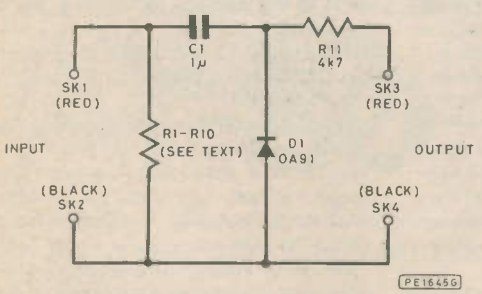


Fig. 2.1. Circuit diagram of the Dummy Load

The circuit of the dummy load is shown in Fig. 2.1 whilst the physical construction is shown in Fig. 2.2. The tin lid is prepared by marking out ten equidistant points on the flat section (near the outer rim). These points should be at intervals of 36 degrees and should be indented using a centre punch before drilling with a 1mm diameter drill. The four sockets should then be mounted and sealed (to prevent oil excaping from the container) using an epoxy resin based adhesive.

Next, the resistors should be mounted on the tin lid which provides a common termination for the resistors. The resistor leads should be fed through the 1mm holes and soldered on both sides of the lid before trimming. The other end of the resistors are then fed to a 'star' point which is linked to SK1 using a substantial conductor (e.g. 16/0·2mm stranded PVC covered wire). The remaining components are then assembled and soldered into place following the layout shown in Fig. 2.2.

Finally, the tin is filled with clean multi-grade oil to within 10mm from the top and then the lid assembly is lowered into the oil, checking that the resistor bodies are fully immersed. It is, of course, important to check that the lid is firmly in place before using the load.

Calibration graphs for 4 and 8 ohm dummy loads are shown in Figs. 2.3 and 2.4 respectively. Measurements are made with a d.c. milliammeter connected between SK3 and SK4 and with a 1kHz sinusoidal input. A suitable signal source based on a 741 operational amplifier will be described in Part Three.

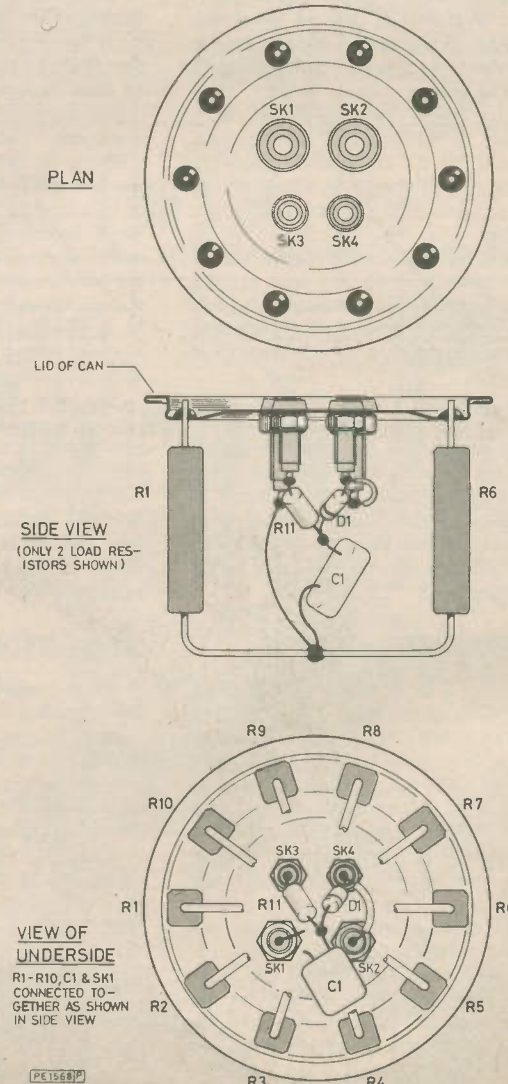


Fig. 2.2. Internal construction of the Dummy Load

COMPONENTS . . .

DUMMY LOAD

Resistors

R1–R10	39 or 82 ohm 7W ceramic (for the 4 and 8 ohm versions respectively) (10 off)
R11	4k7 0·25W

Capacitor

C1	1µ 250V polyester

Miscellaneous

D1	OA91
SK1	4mm socket (red)
SK2	4mm socket (black)
SK3	2mm socket (red)
SK4	2mm socket (black)

1lb Golden Syrup tin (see text)
400ml (approx) multi-grade oil (see text)

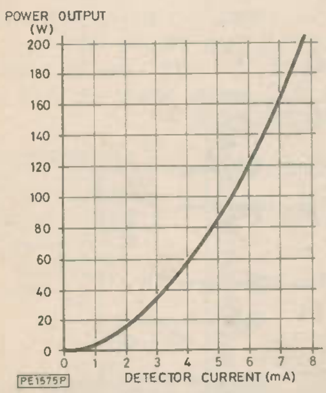


Fig. 2.3. Calibration graph for a 4 ohm load

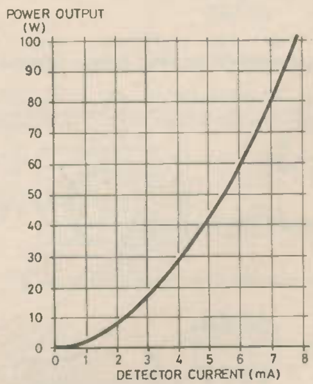


Fig. 2.4. Calibration graph for an 8 ohm load

PRE-AMPLIFIER/LINE DRIVER

The power amplifier module described last month requires an input of approximately 1V r.m.s. for full output. Where a signal source is unable to provide such an output level, extra gain will be required. Furthermore, in many applications one or more power amplifier modules will have to be driven from a remote signal source. In such applications, low impedance distribution is advantageous as is the ability to provide a balanced output.

The pre-amplifier/line driver module provides a modest value of voltage gain which is adjustable from 1 to 5 approximately. The pre-amplifier/line driver has both low and medium impedance balanced and unbalanced outputs and operates from nominally +30V and −30V. These rails can be derived either from the power amplifier itself or from the power supply module described in Part Three.

CIRCUIT DESCRIPTION

The circuit of the pre-amplifier/line driver module is shown in Fig. 2.5. A simple inverting operational amplifier is formed by IC1 and associated components. The gain of this stage is made adjustable by means of VR1. IC2 and its associated components form a unity gain phase inverter. Signal outputs at 1 and 2 are thus of equal amplitude but are in anti-phase. A Darlington transistor, TR1, is used as an emitter follower to provide a separate low-impedance unbalanced output. The supply voltage rails for IC1, IC2 and TR1, are regulated by means of shunt Zener stabilisers, D1 and D2.

COMPONENTS . . .

Resistors

R1, R2, R3	47k (3 off)
R4, R6	1k (2 off)
R5	470
R7, R8	100 (2 off)
R9, R10	100k (2 off)
R11	22
R12, R13	1k 0·5W (2 off)
VR1	220k min. horizontal skeleton pre-set
VR2	100 min. horizontal skeleton pre-set

Except where otherwise stated, all fixed resistors are 0·25W 5% carbon.

Capacitors

C1, C2	220n 250V polyester (2 off)
C3	100µ 16V p.c. electrolytic
C4, C5	220µ 16V p.c. eletrolytic (2 off)

Semiconductors

D1, D2	BZY88 C9V1 (2 off)
TR1	TIS151
IC1, IC2	TL071 (2 off)

Miscellaneous

P.c.b.
8-pin d.i.l. sockets (2 off)
Terminal pins (13 off)
Small instrument case (see text)

SK1, SK2	standard 0·25in. closed circuit jack sockets (2 off)
SK3, SK4	5-pin 270 deg. DIN sockets (2 off)

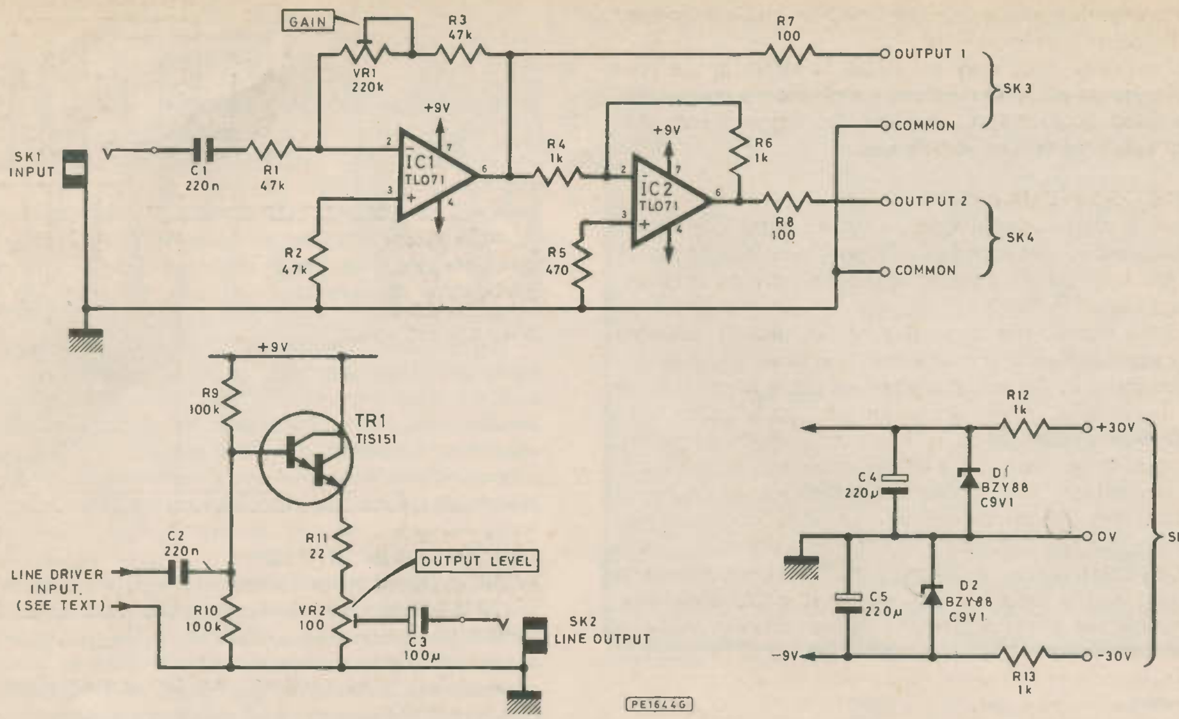


Fig. 2.5. Circuit diagram of the pre-amplifier/line driver module

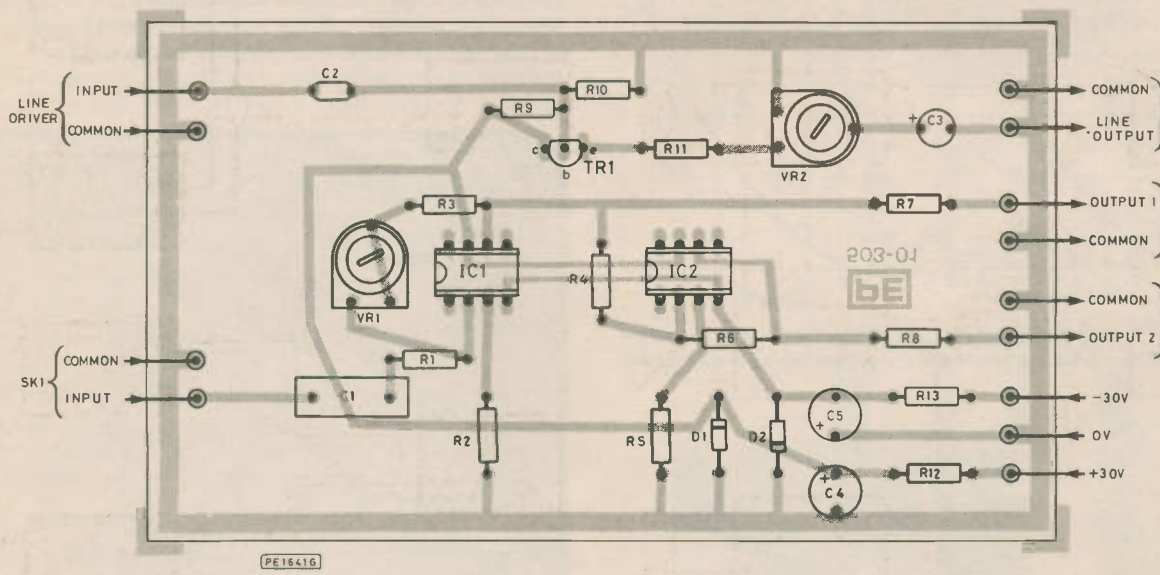


Fig. 2.6. P.c.b. design for the pre-amplifier/line driver

CONSTRUCTION

With the exception of the input and output signal connectors, all components are mounted on a single sided p.c.b. measuring approximately 65mm x 115mm (i.e. identical in size to the power amplifier module). The component overlay for the p.c.b is shown in Fig. 2.6. Components should be assembled on the p.c.b. in the following sequence; terminal pins, i.c. holders, resistors, capacitors, transistor, Zener diodes, and pre-set resistor. Care should be taken to ensure the correct orientation of all polarised components.

When the p.c.b. wiring is complete, the underside of the board should be carefully checked for solder bridges and dry joints whereas the component side should be examined paying particular attention to the correct placement of components.

In applications where the power amplifier module is to be used in the proximity of the signal source (as would be the case in a 'domestic' environment) the pre-amplifier/line driver module may be conveniently mounted within the same enclosure as that used for the power amplifier module. In this case the supply rails can be simply derived from the power amplifier.

Alternatively, where the power amplifier module is located remotely, the pre-amplifier/line driver module may be mounted in almost any small instrument case. In this case a typical wiring layout is shown in Fig. 2.7. As before, the supply rails may be derived from the power amplifier module using a 3-core cable plus a separate screened signal lead. In some applications (i.e. where a very long cable run is necessary) such an arrangement may not be convenient and hence the separate mains powered module (to be described in Part Three) should be utilised.

The line-driver input may be linked to either of the pre-amplifier outputs or, where remote distribution is concerned, may be used separately to monitor the signal input with medium/high impedance headphones.

SYSTEM CONFIGURATION

Various system configurations are possible depending upon the number and location of power amplifier modules and on the total output power required. Six typical arrangements are shown in Fig. 2.8.

Fig. 2.8a shows the arrangement for driving a single power amplifier from a pre-amplifier/line driver module. Interconnection is by means of a screened cable which may be up to 10m in length. Where convenient, power for the pre-amplifier may be derived from the power amplifier module. In this case, three extra wires will be necessary in the interconnecting cable. These, however, need not be screened and, under no circumstances should they be contained within the same screened cable as the audio signal.

For long cable runs a 'local' pre-amplifier power source is preferable. In this case a single screened cable should be used to link the pre-amplifier/line driver module with its associated power amplifier. In Part Four we shall be describing a simple power unit which is suitable for use with up to four pre-amplifier modules.

Fig. 2.8b shows how further power amplifiers can be 'daisy-chained' from a single pre-amplifier/line driver module. As many as ten such units can be driven from a

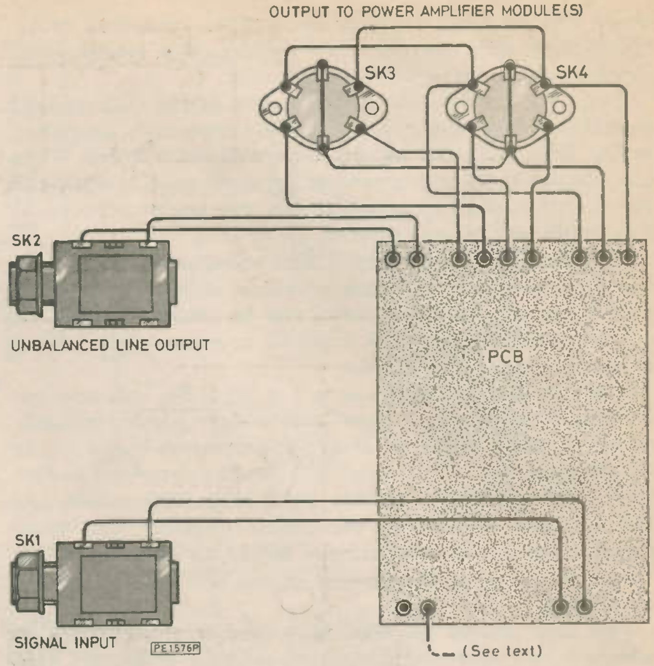


Fig. 2.7. Wiring diagram for the pre-amplifier/line driver module

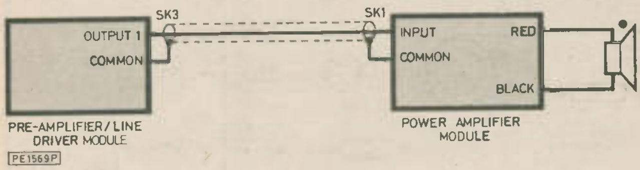


Fig. 2.8a.

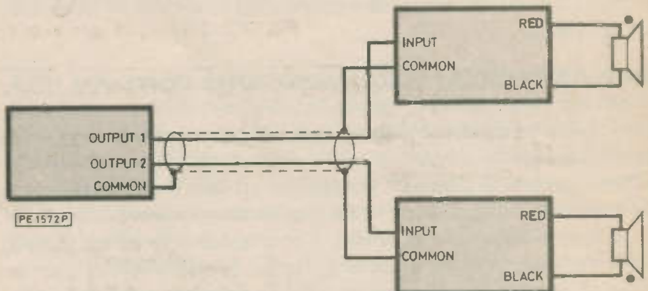


Fig. 2.8d.

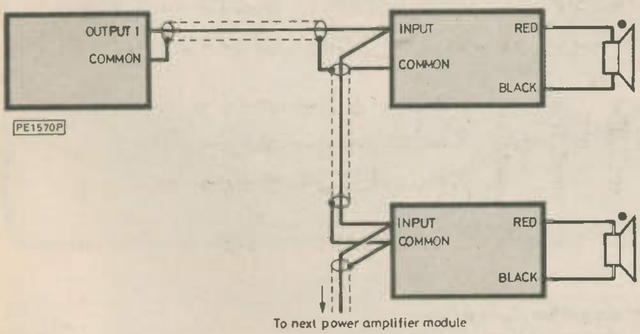


Fig. 2.8b.

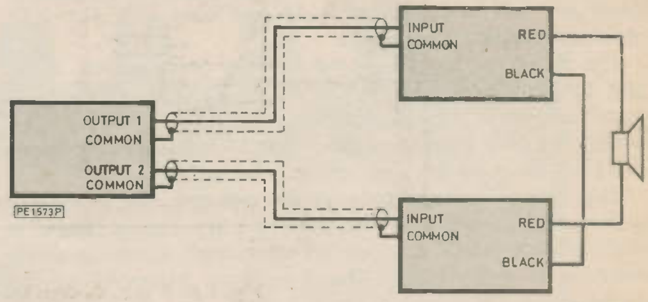


Fig. 2.8e.

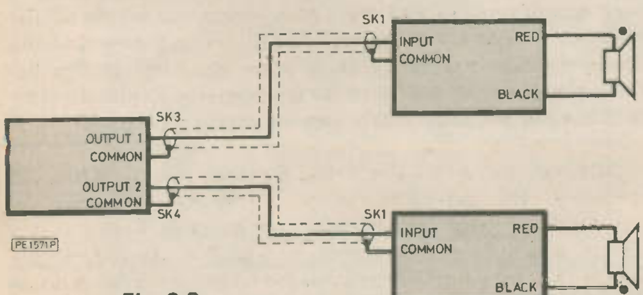


Fig. 2.8c.

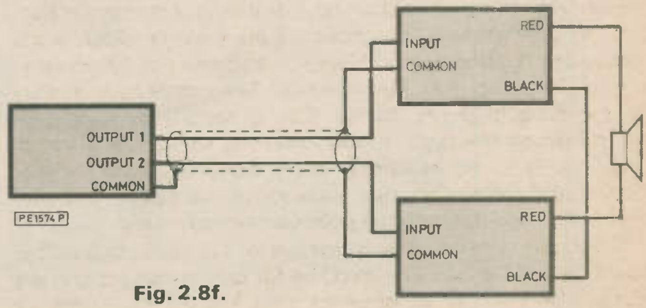


Fig. 2.8f.

Fig. 2.8. Typical system configurations

single pre-amplifier module. Each power amplifier must, however, have its own associated loudspeaker system since parallel output connection is inadvisable.

Since the pre-amplifier provides anti-phase outputs, it is possible to drive two power amplifiers separately, as shown in Fig. 2.8c. Here the important consideration is that, if the loudspeaker systems are serving the same area, or are in the same enclosure, it is essential that one set of speakers is connected with reverse polarity.

A useful alternative to Fig. 2.8c is shown in Fig 2.8d. Here the two power amplifiers are physically adjacent and thus a twin screened (balanced) cable can be employed. Like the previous arrangement, it is essential to ensure that one set of speakers is reverse phased.

A bridge output stage is shown in Fig. 2.8e. This arrangement is ideal where a single loudspekaer system (suitably rated) is to be operated at very high power levels (up to 200W from the power amplifier modules described in Part One). It is essential that both the loudspeaker system and the common outputs of the power amplifier are linked together using a very substantial conductor since, at 200W output into 4 ohm, the current in this link will be approximately 7A!

Fig. 2.8f shows an alternative bridge arrangement in which a twin screened (balanced) cable is employed. This balanced arrangement is instrumental in reducing the effects of hum and induced electrical noise and is much to be preferred in situations where cable runs in excess of 50m are unavoidable.

PRE-AMPLIFIER, MIXER AND TONE CONTROL

Whilst the simple pre-amplifier/line driver described previously is ideal for driving one, or more, power amplifier modules from a single source, there will be many occasions where several signals of varying levels are to be combined before sending to one, or more, power amplifier modules.

A typical example is where a microphone is to be mixed with the output of an electric guitar or synthesiser. In such a case, a simple mixer arrangement is required coupled with some additional tone controls and a master gain control. The unit described was designed to satisfy just such a requirement and yet is simple to build and uses only low-cost, readily available components.

The simplified block schematic of the pre-amplifier, mixer and tone control is shown in Fig. 2.9. The pre-amplifier, mixer and tone control provides four input channels, each having its own individual gain control, has separate treble and bass controls and a master gain control.

The overall voltage gain of the pre-amplifier is well in excess of 200 and thus the maximum input sensitivity is of the order of 10mV to drive an associated power-amplifier module to full output. The frequency response of the prototype unit is shown in Fig. 2.10.

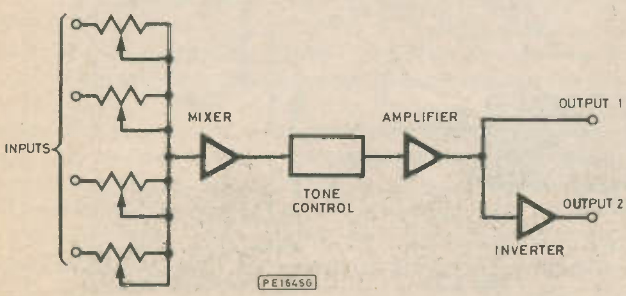


Fig. 2.9. Simplified block schematic of the pre-amplifier, mixer and tone control unit

COMPONENTS . . .

Resistors

R1–R4	(see text)
R5–R8	100k (4 off)
R9	22k
R10	1M
R11,R12	10k (2 off)
R13,R14	4k7 (2 off)
R15	100k
R16	1k 0·5W
R17	470
R18	1k 0·5W
R19,R20	100 (2 off)
VR1–VR4	50k log carbon pot (4 off)
VR5,VR6	100k lin carbon pot (2 off)
VR7	5k log carbon potentiometer

Unless otherwise stated, all fixed resistors are 0·25W 5% carbon.

Capacitors

C1–C4	220n 160V polyester (4 off)
C5,C10,C11	10µ 16V p.c. elect. (3 off)
C6,C7	47n 250V polyester (2 off)
C8,C9	10n 250V polyester (2 off)
C12,C13	220µ 16V p.c. electrolytic
C14	470p ceramic

Semiconductors

D1, D2	BZY88 C9V1 (2 off)
IC1	TL074

Miscellaneous

P.c.b.
SK1 to SK4 standard 0·25 in. closed jack sockets (4 off)
Low profile 14-pin d.i.l. socket
Terminal pins (20 off)
SK5 and SK6 5-pin 270 degree DIN (2 off)
Case and matching knobs (7 off)

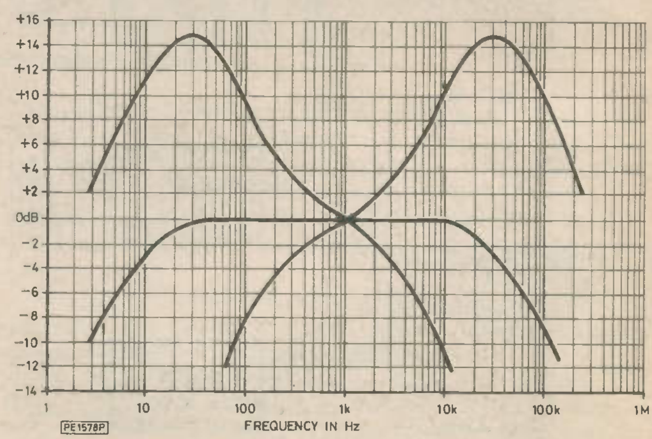


Fig. 2.10. Frequency response of the pre-amplifier, mixer and tone control unit

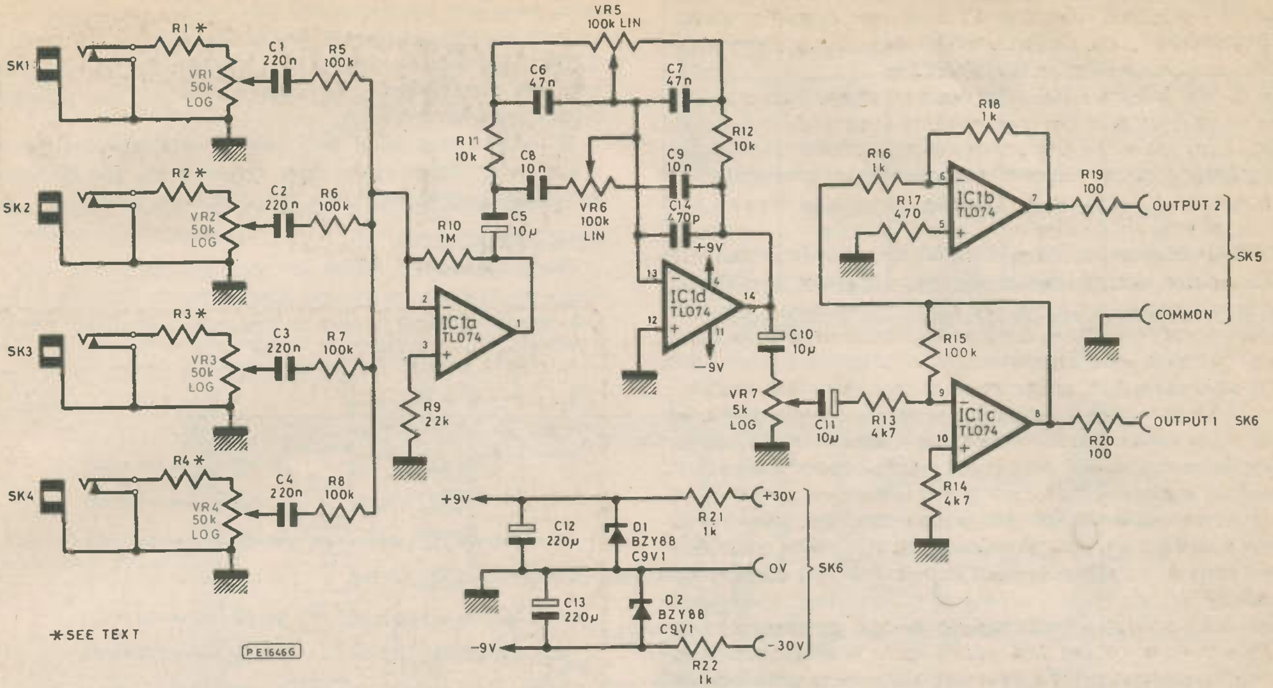


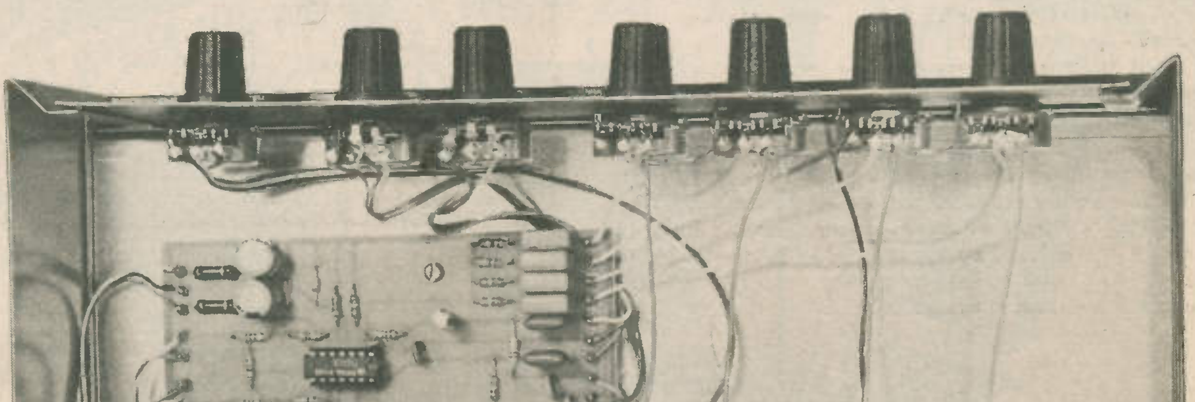
Fig. 2.11. Complete circuit diagram of the pre-amplifier, mixer and tone control unit

CIRCUIT DESCRIPTION

The complete circuit diagram of the pre-amplifier, mixer and tone control unit is shown in Fig. 2.11. A low-noise quad operational amplifier is used and this is operated from +9V and −9V supply rails stabilised by means of D1 and D2 respectively.

VR1 and VR4 act as the individual channel gain controls and R1 to R4 may be added in order to match a variety of inputs (see Table 1). IC1a forms a summing amplifier which provides a voltage gain of approximately 10 on each channel. IC1d is an active Baxandall arrangement which provides a maximum 'cut' and 'boost' of around 15dB at both LF and HF. C14 is added in order to ensure unconditional stability of the arrangement when maximum treble boost is selected.

IC1c operates as an inverting amplifier with a fixed



Internal view of the pre-amplifier

Signal source	Requires own pre-amp?	Nominal input impedance	Nominal sensitivity	Input resistance R1 to R4
Dynamic microphone (high output)	No	50kΩ	10mV	s/c
Dynamic microphone (low output)	No	600Ω	10mV	s/c
Electret microphone	No	50kΩ	10mV	s/c
Tape-deck	No	500kΩ	100mV	470kΩ
Ceramic pick-up	No	1MΩ	200mV	1MΩ
Magnetic pick-up	Yes	600Ω	10mV	s/c
Tuner	No	500kΩ	100mV	470kΩ

Table 1. Typical signal sources and input arrangements

voltage gain of approximately 20 (if desired, the gain may be increased to approximately 40 by raising the value of R15 to 220k). The output of IC1c is at a relatively low impedance and will directly drive as many as ten parallel connected power amplifier modules.

IC1b acts as a unity gain inverter and provides the low-impedance anti-phase output required for the differential and bridge output configurations described earlier.

CONSTRUCTION

The pre-amplifier, mixer and tone control unit is built on a single sided p.c.b. measuring approximately 65mm x 115mm (i.e. again identical in size to the power amplifier module).

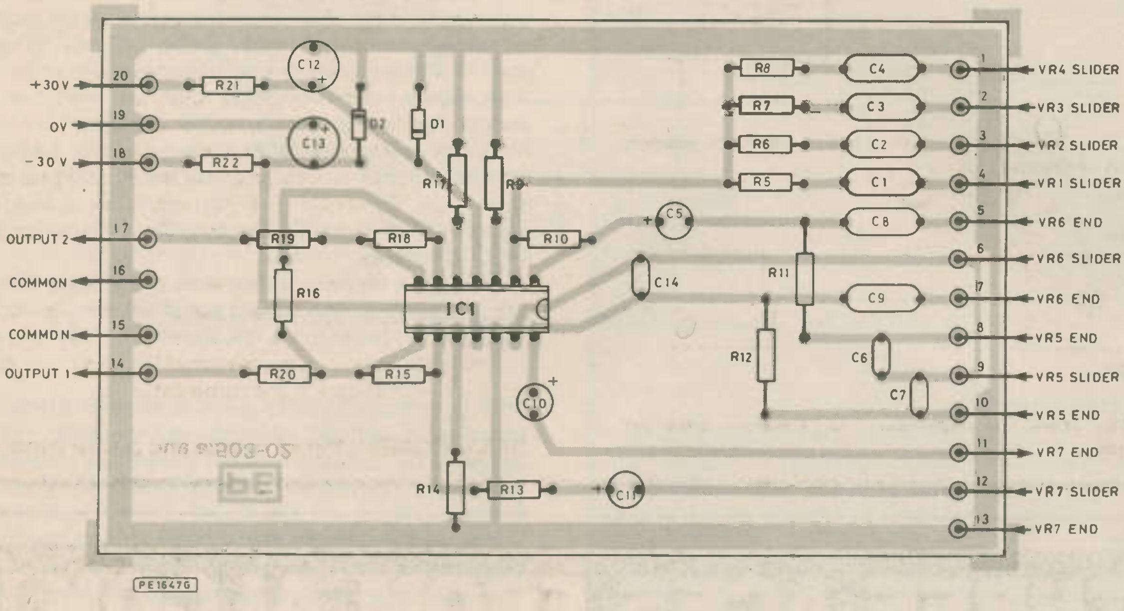


Fig. 2.12. Component layout of the pre-amplifier and tone control unit

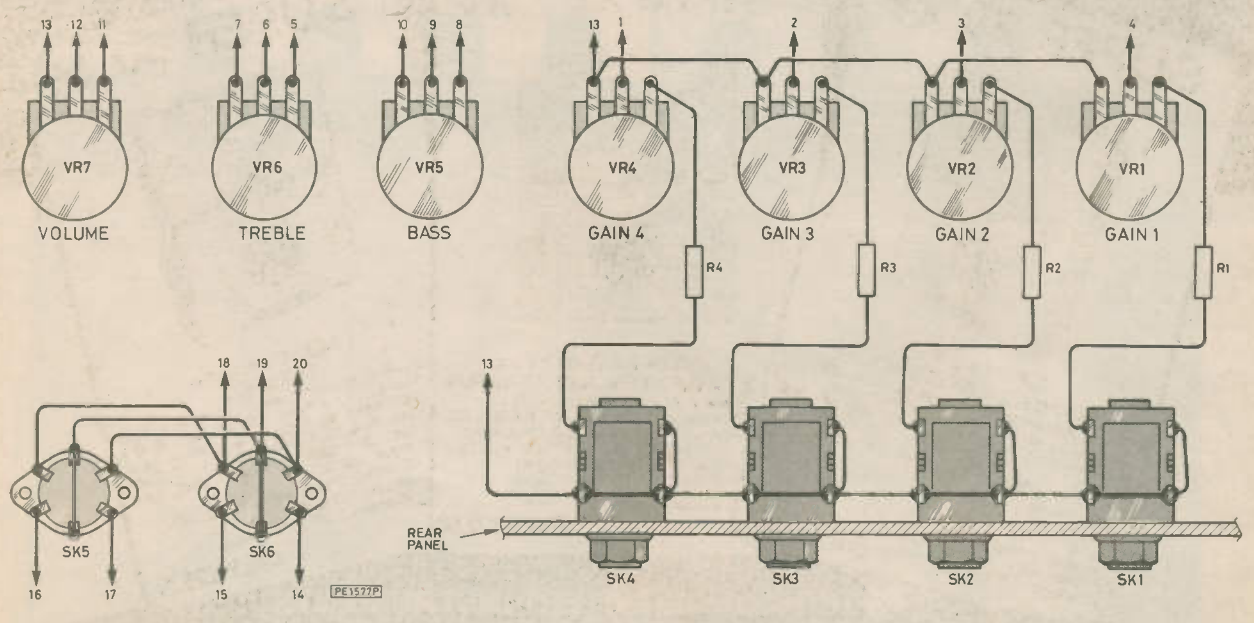


Fig. 2.13. Wiring diagram for the front and rear panel mounted controls and sockets

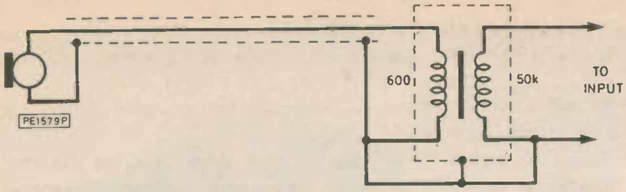


Fig. 2.14. Input arrangement for low-impedance unbalanced microphones

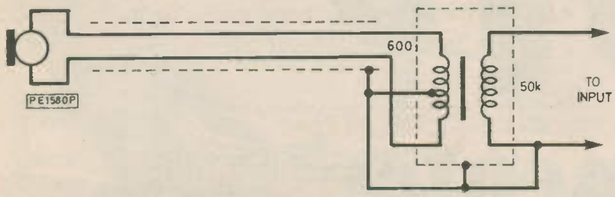


Fig. 2.15. Input arrangement for low-impedance balanced microphones

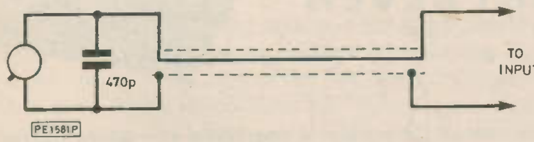
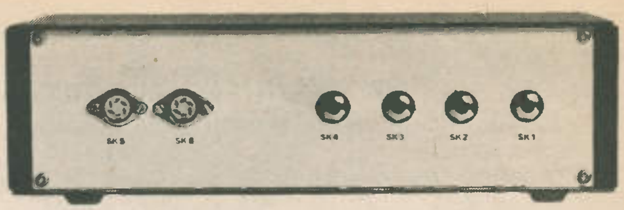


Fig 2.16. Input arrangement for ceramic pick-up cartridges



Rear view of the pre-amplifier case

The component overlay for the p.c.b. is shown in Fig. 2.12. Components should be assembled on the p.c.b. in the following sequence; terminal pins, i.c. holder, resistors, capacitors, and Zener diodes. Care should be taken to ensure the correct orientation of all polarised components.

When the p.c.b. wiring is complete, the underside of the board should be checked for solder bridges and dry joints and the component side should be examined paying particular attention to the correct placement of components.

As before, and depending upon the individual constructor's preference, the pre-amplifier may be either mounted in the same enclosure as that used for the power-amplifier module or, alternatively, may be mounted in its own equipment case. This latter arrangement is, of course, preferable when one, or more, power amplifiers are to be used from remote locations.

A suitable internal wiring diagram is shown in Fig. 2.13 and the corresponding front panel labelling is shown in the photograph. Connectors, SK5 and SK6 will, of course, not be required where the pre-amplifier and power-amplifier modules are housed in the same cabinet.

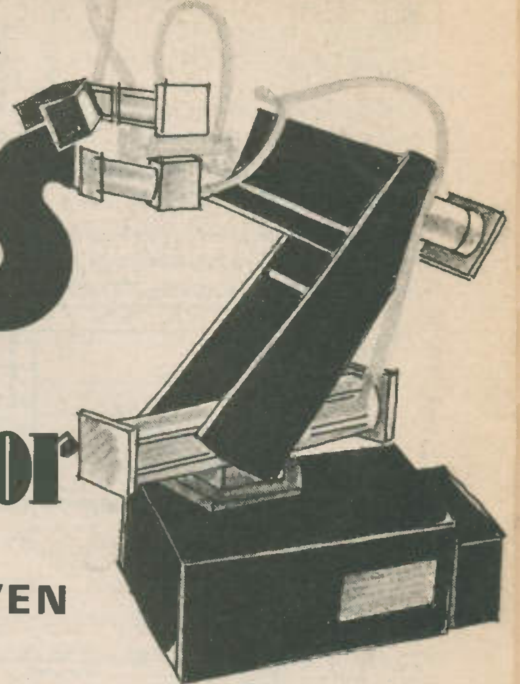
NEXT MONTH: Signal source and power supply module.

RICHARD B. H. BECKER — SYSTEM DESIGN AND MECHANICAL ENGINEERING.

TIM ORR — COMPUTER INTERFACE AND CONTROL ELECTRONICS.

ROBOTS

neptune and mentor



PART SEVEN

CONSTRUCTION of the MENTOR robot starts at the base plate of the robot (Fig. 7.1) to which the power supply board and transformer are fitted. The main wiring loom passes through a slot under the board ready for connecting to the interface board which is later sited beneath the robot.

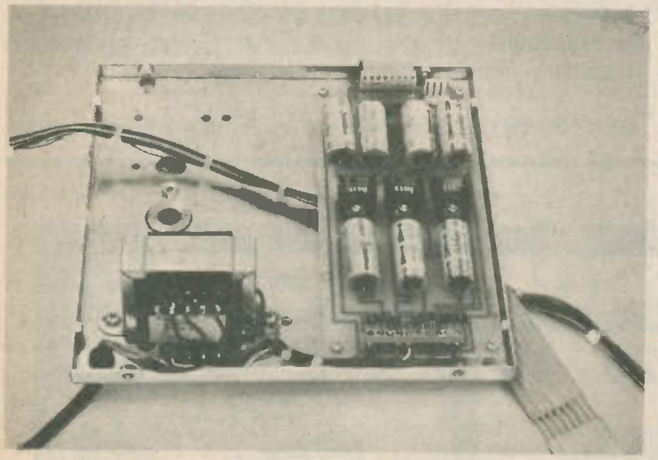


Fig. 7.1. Base plate assembly

ASSEMBLY

The two side plates are next fitted to the base plate and the top plate and then screwed down (Fig. 7.2). In the top plate is a 60mm nylon bush through which the centre column is passed.

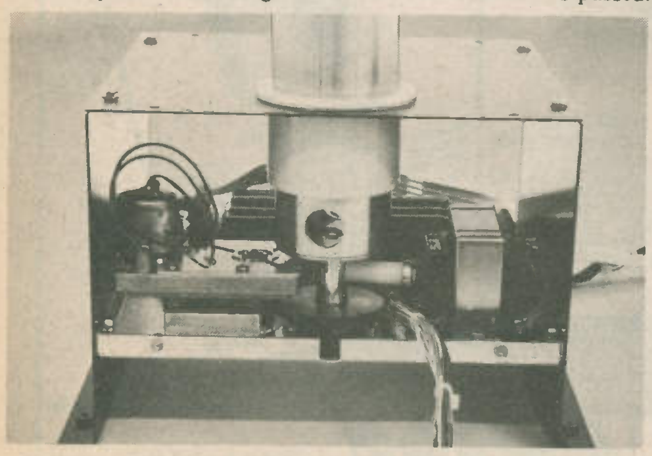


Fig. 7.2. Main chassis assembly

At the base of the column is attached a gear which then engages with another gear fitted to axis 0 motor which is then secured to the base plate.

The arm assembly is secured to the column with a nut on axis 1 axle (Fig. 7.3) and the large counterbalance weights fitted. These result in the robot's position being stable when there is no power applied to the motors. They also increase the accuracy of the robot in that no error signal from the servo system is required simply to hold a position.

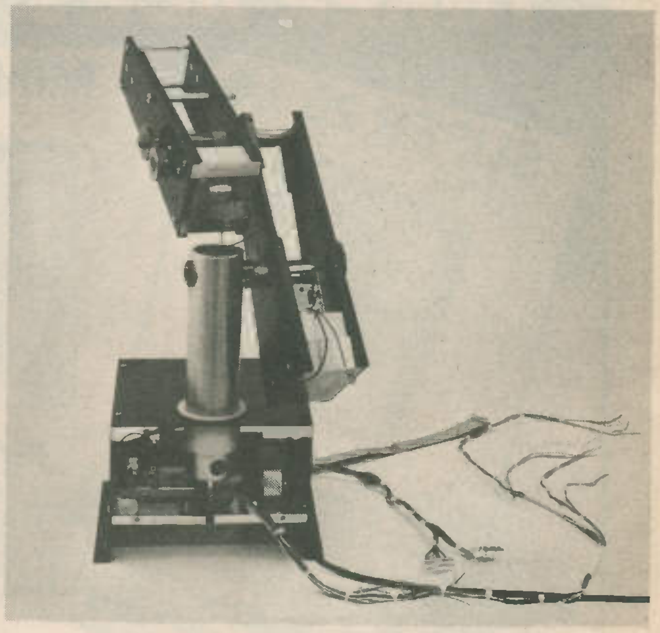


Fig. 7.3. Arm assembly

The wrist motors which together provide elevation and roll can now be screwed to axis 2 arm (Fig. 7.4) and the gears fitted. There are two pairs of spur gears to transfer torque from the motors to the wrist axles and three bevel gears to turn the torque through 90 degrees to the gripper assembly.

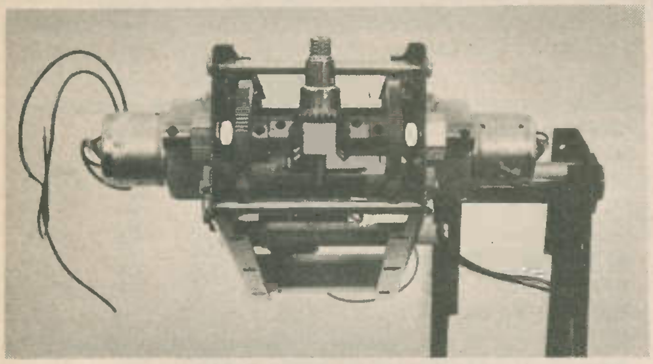


Fig. 7.4. Wrist motor assembly

The gripper components are now fitted (Fig. 7.5). A pair of torsion springs open the jaws after tension is released on the Bowden cable which closes them. The cable is driven by a motor attached to the cover of axis 1 arm (Fig. 7.6).

POTENTIOMETERS

Next, the wiring harness and position sensing potentiometers are fitted. The potentiometers are adjusted such that the voltage on the wiper will be about 10% of the 10V supply voltage when the axis is at its minimum position. The harness passes up the column and through the axles branching out on the way to connect to the potentiometers and to the motors via terminal blocks.

The interface board is now screwed to its plate (Fig. 7.7) and after checking that the power supply is operating correctly the power supply lead and the harness are plugged into the board and the robot is then ready for connecting to a computer for calibration.

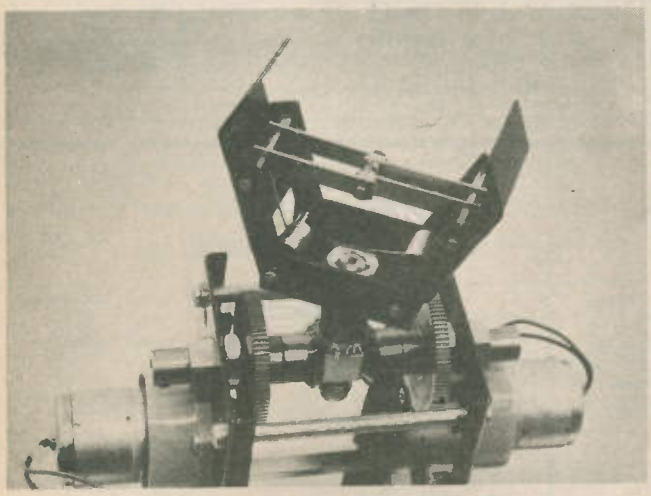


Fig. 7.5. Gripper assembly

CALIBRATION

The robot is operated as if it were part of the memory of the computer and instructions consist of POKEs for sending data and PEEKs for receiving data. Axis 0 is at the lowest address in the block allocated to the robot. As the system is defined in 8 bits each axis has 256 possible positions to which it may move, i.e. there is a resolution of 1 part in 256 (0.04%) and the data sent to each axis may be any integer from 0 to 255. To send each axis to its centre position using the BBC computer the instructions are as follows:

CALIBRATION PROGRAM

```
10 A=&FD00
20 FOR I=0 TO 5: ?(A+I)=128 NEXT I
```

Or for a ZX Spectrum:

```
10 LET a=32
20 FOR i=0 TO 5: POKE a+i,128: NEXT i
```

Or for a Commodore VIC20:

```
10 A=8192
20 FOR I=0 TO 5: POKE A+I,128: NEXT I
```

Or for a Commodore 64:

```
10 A=56832
20 FOR I=0 to 5: POKE A+I, 128: NEXT I
```

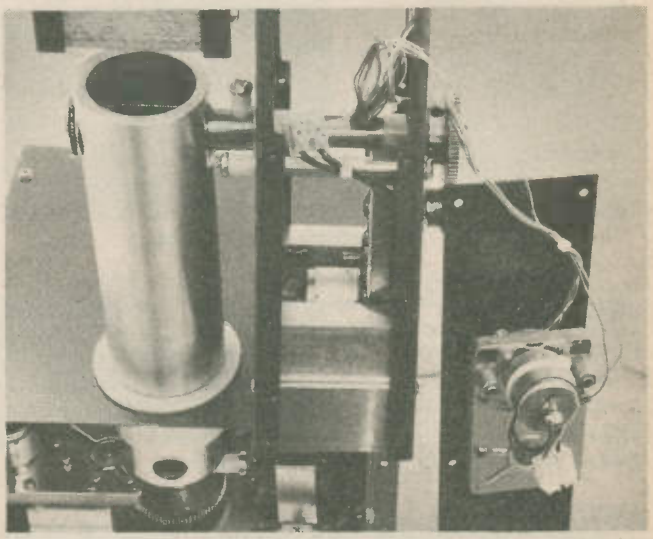


Fig. 7.6. Gripper motor assembly

The Commodore 64 plugs onto the same edge connector as the VIC20. The only significant difference between the interfaces is at the computer end where the board which plugs into the cartridge slot is laid out on a 0.1″ pitch whilst the VIC20 is on 0.156″ pitch. Virtually any 8- or 16-bit micro system or computer can be used provided there is access to the address, data and control bus.

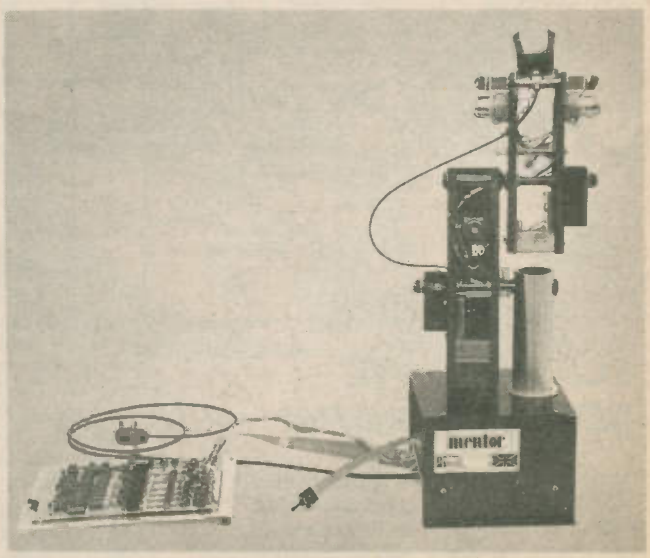


Fig. 7.7. Interface board

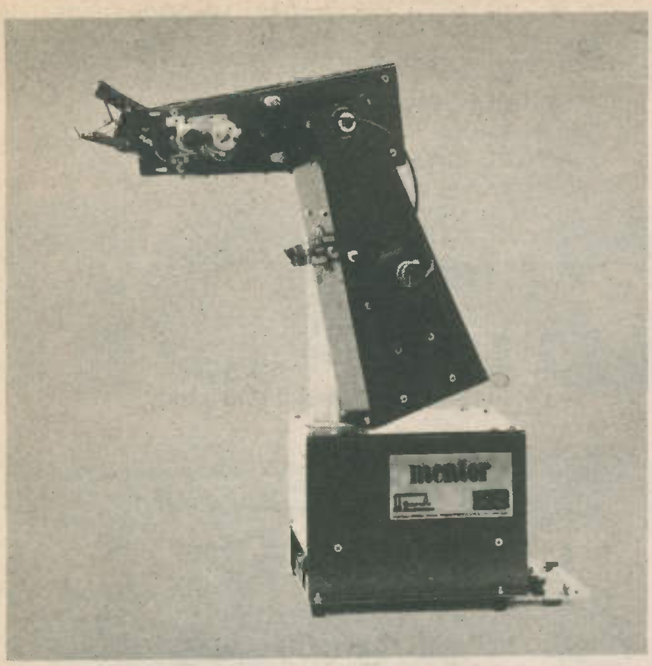


Fig. 7.8. The complete Mentor Robot

With mid-position data sent to each axis the wrist is set by slackening the gripper assembly, moving it and securing in the centre position. Fine adjustment is carried out with pre-sets P203,204.

Axes 0,1,2 are set by sending them in turn to position 0 and adjusting pre-sets VR200,201,202 so that the axis stops just before the end stop is reached. VR205 is used to make the gripper start to operate at some convenient datum such as 50.

POSITION DATA

There are ADCs on the interface board to enable the positions of the simulator and the robot axes to be read. To operate the robot it is not necessary to use the ADC but it is useful to know for certain when the required position has been reached. Otherwise a transit time would have to be calculated based upon the size of the position change.

The arm ADC is read by first writing to it, with a POKE instruction, which axis is to be read. This is defined by the top 4 bits of the data byte so the data is the axis number multiplied by 16. The ADC is then written to at the next address to tell it to start conversion. After that the arm position is ready with a PEEK instruction. For the BBC computer the instructions to read axis 0 position are as follows:

```
30 ?(A+6)=0
40 ?(A+7)=0
50 DAO=?(A+17)
```

Similarly for axis 2:

```
60 ?(A+6)=32
70 ?(A+7)=0
80 DA2=?(A+17)
```

The simulator is read similarly except that the multiplexer address is defined by the bottom 4 bits of the data byte so the data is the axis number and the ADC is at an address one lower so to read axis 2 of the simulator via a BBC computer. The instructions are:

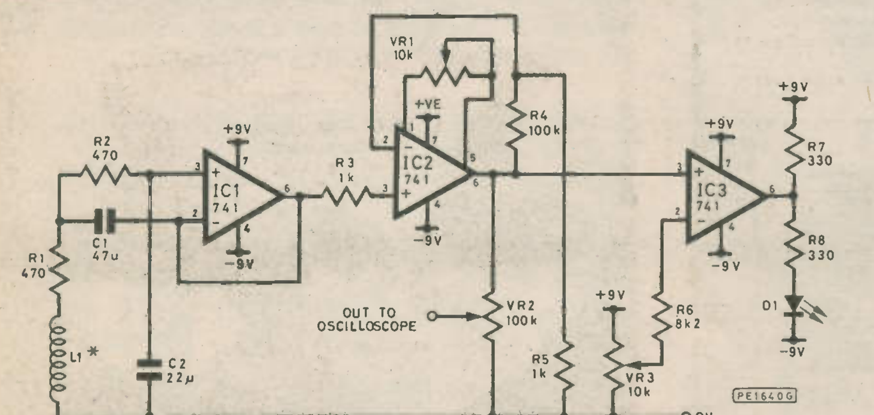
```
90 ?(A+6)=2
100 ?(A+7)=0
110 DS2=?(A+16)
```

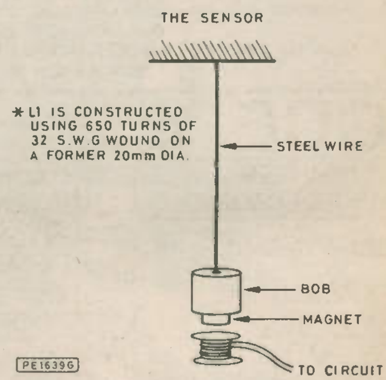
By use of the following program the MENTOR will copy in real time the movement of the hand-held simulator showing clearly the ease of use of the MENTOR control system.

```
10 A=&FD00: FOR N=0 to 5
20 ?(A+6)=N: ?(A+7)=0
30 ?(A+N)=?(A+16)
40 NEXT N: GOTO 10
```

Furthermore by being on the bus of the computer it is very simple to add additional devices into the system. The BBC computer is particularly suited to this as the 1MHz bus is buffered and daisy-chaining of other robots, sensors etc. is easily implemented. ★

Constructors' Note
MENTOR and NEPTUNE are available as kits or ready-built from: **Cybernetic Applications, West Portway Industrial Estate, Andover, Hants.**





ELECTRONIC SEISMOGRAPH

THIS circuit can detect the waves and oscillations of the movement of the earth. The sensitivity of the instrument depends upon the sensor and its construction. In this case it consists of a pendulum made up of a magnet supported by a long steel wire. The longer the wire and the heavier the bob, the greater the sensitivity. To get the most reliable and accurate measurements the magnet should be in close proximity to the pick-up coil, L1.

When the magnet is disturbed by movement, a current is induced into the coil and a signal is passed to IC1. This acts as a standard low pass filter with a cut-off frequency of around 10Hz. The filtered signal is amplified by IC2 and fed to an oscilloscope, where it can be monitored.

The signal is also fed to IC3 which is used to indicate an overload condition via D1, and VR2 is used to set the level of the oscilloscope signal.

K. Alizadeh,
Tehran,
Iran.

MARTIAN HEAD

Much has been heard recently about the 'head' on Mars, and I think I must deal with it—though as briefly as I can!

In the 1970s the *Viking* landers came down on Mars, one in the ochre desert of Chryse and the other in Utopia. Both sent back invaluable data. No definite traces of Martian life were found, but we learned a great deal about the nature of the surface and the atmosphere.

We were also able to study pictures of the areas round the grounded spacecraft. One rock bore an almost uncanny resemblance to a human face. Of course this was pure coincidence; but now, for some curious reason, there have been sensational reports that we really are seeing a piece of Martian artwork!

I have examined the evidence and the relevant pictures. There is absolutely no doubt that we are dealing with nothing more than a natural rock, with its attendant light and shade effects. Enough said.

There have been comments about the Solar Polar Mission, a joint ESA-NASA venture now officially renamed *Ulysses*. It is scheduled for launching in May 1986, from the Shuttle, and will travel out as far as Jupiter, passing round the giant planet and then coming back to pass over the Sun's poles in 1990. All kinds of investigations will be carried out, ranging from solar wind studies to measurements of the solar and interplanetary magnetic fields.

The number of asteroids with well-known orbits continue to increase. The total has now passed the three thousand mark. However, the four spaceprobes which have so far passed through the asteroid belt (two *Pioneers* and two *Voyagers*) have emerged unscathed, so it may be that there is less scattered material there than was once feared. No doubt time will tell.

BETA PICTORIS

The southern constellation of Pictor, the Painter, is by no means conspicuous. It contains no star brighter than the third magnitude, and has no obvious shape. We remember it mainly because a fairly bright nova flared up in it in 1925. Pictor is not visible from Britain; it is too far south, and it is in fact close to Canopus, which is the brightest star in the sky apart from Sirius (and is much more luminous and remote).

The second star of Pictor is Beta Pictoris, of magnitude 3.8; it has no individual name. It is white, with an A-type spectrum; its distance from us is 78 light-years, and it is approximately 60 times as luminous as the Sun. Up to now it has been dismissed as a very ordinary star indeed. But Beta Pictoris has suddenly leaped into the scientific headlines.

The story began in 1983, with observations carried out from the infra-red astronomical satellite *IRAS*. It is fair to say that *IRAS* was one of the greatest successes of the space age so far. It transmitted for the best part of a year, discovering thousands of new infra-red sources and also detecting comets, dust-tails to known comets and even a strange asteroid which ventures perilously close to the Sun.

When the equipment was being checked, infra-red excesses were found associated with several stars, including Vega and Fomalhaut. This was attributed to the presence of cool material which might well be planet-forming.

One star studied in this way was Beta Pictoris, and a few months ago two American astronomers, Drs. Bradford Smith and Richard Terrile, decided to make an optical investigation. They went to the Las Campanas Observatory in Chile, where conditions are exceptionally good. Las Campanas comes under the same management as Mount Wilson in California, and like Mount Wilson it has a 100-inch reflecting telescope—the main difference is that the Mount Wilson 100-inch is old (it was completed in 1917) whereas the Las Campanas instrument is ultra-modern.

Smith and Terrile used the telescope together with a CCD or Charge-Coupled Device, which is much more sensitive than any photographic plate. The results were startling. Beta Pictoris is surrounded by a disc of material which extends nearly 50,000 million miles from the star. The disc is seen nearly edge-on, and is probably no more than a few hundred million years old.

LIFE FORMING

It is possible to make a shrewd estimate of the composition of the disc. Ices, silicates and carbonaceous substances are strong candidates. Now, these are the materials from which the planets in our own Solar System were formed well over 4,000 million years ago. Analysis of the density of the Beta Pictoris ring material indicates that planets may have been formed there too, and by extrapolation it seems that the interior particles in the disc have been swept away, possibly by orbiting planets.

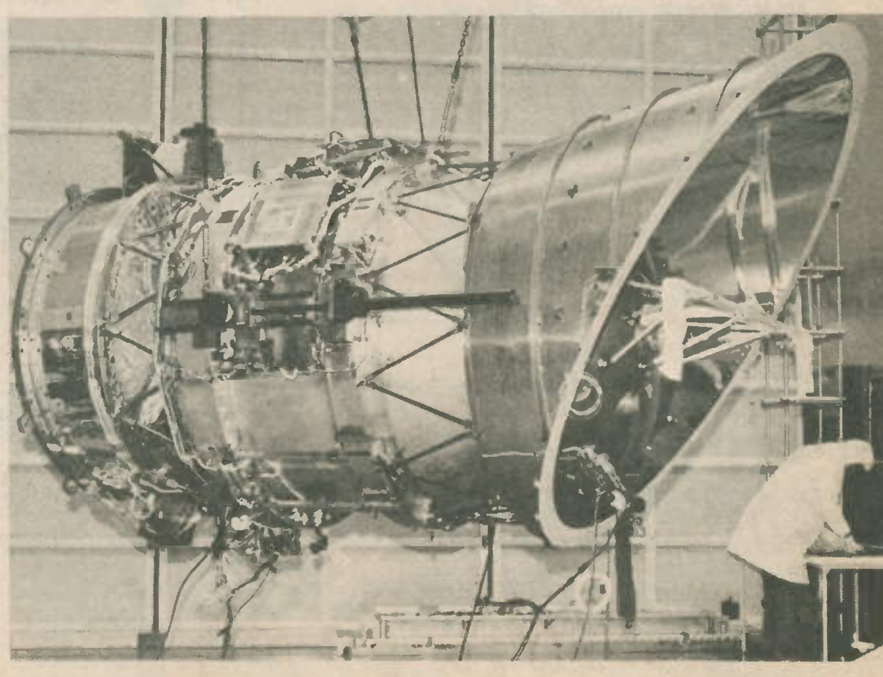
What can we make of all this?

The main importance is that for the first time we have actually seen what may be an extra-solar planetary system; up to now we have had to rely either upon infra-red work, or upon the admittedly very uncertain measurements of nearby stars which 'wobble' slowly as they are perturbed by associated bodies which may be of planetary rather than stellar mass. There is absolutely no doubt that the Beta Pictoris shell does exist, and although we cannot be over-confident it seems that a planetary system is much the most likely explanation for it.

Beta Pictoris itself is a normal star; neither particularly luminous nor particularly dim, neither a cosmic heavyweight nor a stellar minnow. And if it is indeed the centre of a family of planets, the evidence in favour of numerous similar systems becomes almost overwhelmingly strong.

Investigations are proceeding, and there is every hope that more discs of the same kind will soon be found round other stars. Whether any of these hypothetical planets are inhabited is quite a different matter, but there seems no valid reason why not. Beta Pictoris has taught us a great deal, even though as yet we cannot claim to have done more than scratch the surface of the main problems.

IRAS (International Infra-red Astronomical Satellite), shown here on test at the Fokker B.V. plant in the Netherlands. This was probably one of the greatest successes of the space age so far.



THE SKY THIS MONTH

Throughout this month the early-evening sky continues to be dominated by the planet Venus. It reaches its greatest brilliancy on 26 February, when its magnitude will be 4.3. Under such conditions it is easily found with the naked eye even when the sky is still bright, and is obvious with binoculars—though I must again repeat my oft-given warning never to sweep around with binoculars or a telescope unless the Sun is completely below the horizon.

As Venus draws in towards inferior conjunction, which will be reached on 3 April, its phase decreases. The amount of disc illuminated is 44 per cent at the beginning of February and only 25 per cent into March.

This being so, it may seem strange that Venus is at its brightest when less of the sunlit face is turned toward us. The answer is that as the phase decreases, the apparent diameter increases, because the planet is coming closer to us. At its very closest, of course, it is at inferior conjunction—more or less between the Earth and the Sun—and cannot be seen at all.

The only chances of seeing Venus when it is directly aligned with the Sun occur at the times of transit. However, the last transit took place as long ago as 1882, and the next will not be until 2004.

Of the other planets, Mercury is to all intents and purposes out of view; Jupiter and Saturn are morning objects, but badly placed; Mars is still visible in the evening, but its magnitude is now only 1.4, so that no telescope will show much on its surface. The apparent diameter of Mars is now less than 5 seconds of arc.

HALLEY'S COMET

Halley's Comet is now under regular observation, and is becoming brighter as it moves inward, but it is still beyond the reach of any but giant telescopes. However, there is one mildly encouraging sign. The comet is starting to become active earlier than expected, and it may eventually be brighter than was at first predicted, though it will certainly not be spectacular—as it has been at some past returns. The most we can really hope from Britain is that it will become a naked-eye object late this year.

Among the stars, Orion remains dominant. It is high in the south during February evenings, and is quite unmistakable, together with its brilliant retinue. Sirius also is at its best. It is a pure white star of spectral type A, but because it is so bright, and because it is never very high up as seen from Britain, it seems to flash various colours of the rainbow.

Sirius is, in fact, the supreme "twinkler", though when seen from countries south of the equator, where it can pass overhead, it looks much steadier. It is rather surprising to remember that Sirius is an ordinary Main Sequence star, a mere 26 times as powerful as the Sun—whereas Rigel in Orion, which looks well over a magnitude and a half fainter, is equal to 60,000 Suns combined.

There are opportunities this month for seeing Algol, in Perseus, at minimum light. Algol is an eclipsing binary. Its 'rest' magnitude is just below 2, approximately equal to the Pole Star, but during mid-eclipse the magnitude falls to below 3.

Fading takes 4 hours, and minimum lasts for only 20 minutes, after which a further 4 hours is needed for Algol to regain its lost light. Minima occur at 3.1 hours GMT on 18 February, 23.9h GMT on 20 February, and 20.7h GMT on 23 February. Of course, there are mimima every $2\frac{1}{2}$ days; I merely give these as being convenient to observe.

Sequential Logic Techniques Part 6

M.TOOLEY BA and D.WHITFIELD MA MSc C Eng MIEE

IN Part Five of the series we looked at a family of devices which allow us to route several incoming data signals along the same path. We shall now look at the opposite problem; that of connecting a single incoming line to one of several output lines.

When explaining the action of the de-multiplexer we can, as before, use a simple switch analogy. A four-way de-multiplexer is, like its multiplexer counterpart, equivalent to nothing more than a single pole four-way switch. The important distinction is that, in the case of the data multiplexer data is being selected from one of four incoming signal lines whereas, in the case of the de-multiplexer, data is being routed to one of four outgoing lines. This vital difference is illustrated in Fig. 6.1. Furthermore, since digital multiplexers and de-multiplexers rely on logic gates (which are unidirectional devices) for their operation, the two functions are quite distinct.

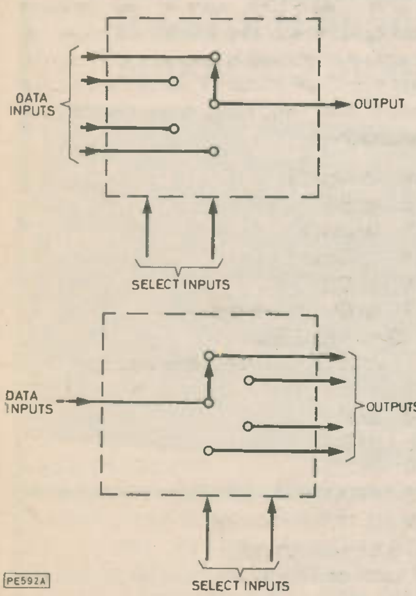


Fig. 6.1. Simplified switch equivalents of four-way data multiplexers and de-multiplexers; (a) four-way multiplexer, (b) four-way de-multiplexer

THE 74LS139

The 74LS139 is a common example of a data de-multiplexer which contains two independent four-way de-multiplexers within a 16-pin d.i.l. package. Each four-way de-multiplexer has a single active-low enable input, $\overline{EN}$, two select inputs, S0 and S1, and four outputs, 0 to 3. The pin connections for the 74LS139 are shown in Fig. 6.2. As for its data multiplexer counterpart (the 74LS153) the two halves of the device (referred to as A and B) are conveniently brought out to pins on opposite sides of the package; the A-side using pins 1 to 7 whilst the B-side uses pins 9 to 15. The supply, which follows the normal convention of pin-8 (0V) and pin-14 (+5V) is common to both halves of the device.

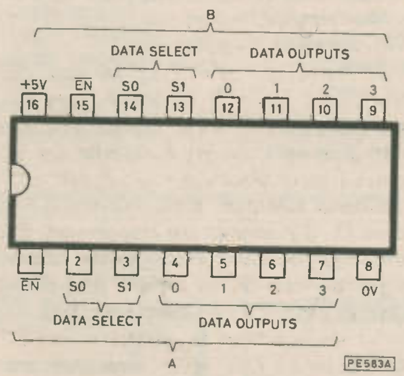


Fig. 6.2. Pin connections for the 74LS139

The internal logic of the 74LS139 is shown in Fig. 6.3. This shows how the two select signals, S0 and S1, are gated with the enable signals, $\overline{EN}$, in each of the four three-input NAND gates. It should be noted that, since NAND rather than AND gates are employed, the outputs go to logic 0 in the selected state and revert to logic 1 in the de-selected state. This is important since, in typical applications, the 74LS139 is used in conjunction with other devices which have active low select or enable inputs. If this is a little hard to follow don't despair as we shall be returning to this topic with a practical example a little later!

The complete truth table for the 74LS139 is shown in Table 6.1. This

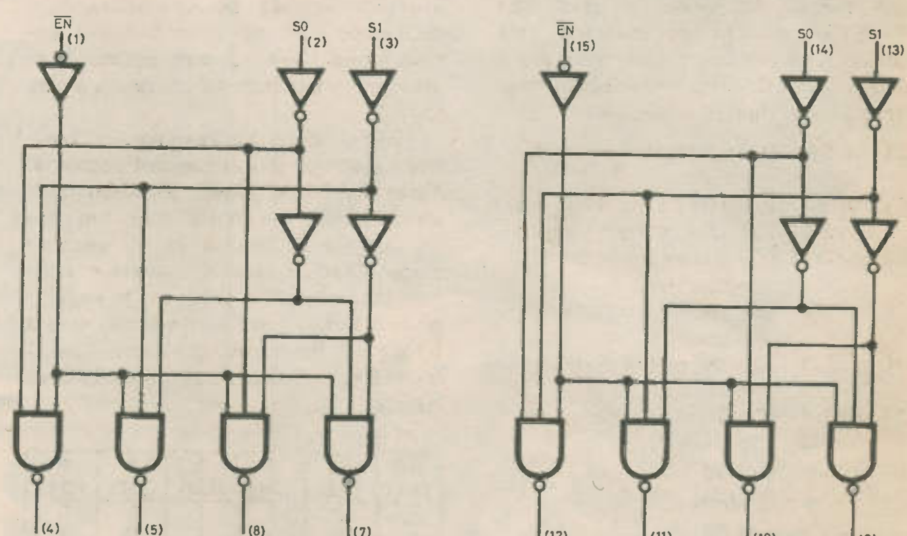


Fig. 6.3. Internal logic of the 74LS139

INPUTS			OUTPUTS			
$\overline{EN}$	SØ	S1	3	2	1	Ø
1	x	x	1	1	1	1
0	0	0	1	1	1	0
0	1	0	1	1	0	1
0	0	1	1	0	1	1
0	1	1	0	1	1	1

x = don't care

Table 6.1. Complete truth table for the 74LS139

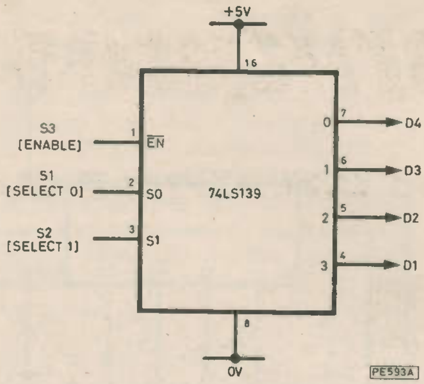


Fig. 6.4. Circuit arrangement used in the practical investigation of the 74LS139

truth table is, of course, identical for each half of the device. When the $\overline{EN}$ line is at logic 1 all four outputs go to logic 1 regardless of the state of the select inputs, SO and S1. When both select inputs are at logic 0 and the $\overline{EN}$ line is taken low, the 0 output line goes to logic 0 (the other three outputs remain at logic 1). With SO at logic 1 and S1 at logic 0 the 1 output line goes to logic 0, and so on.

Developing the four-way switch analogy a little further, it should be noted that, the enable line effectively acts as a data signal input; the selected output reflecting the state of this line. To further explain this action, if we have selected output 0 (by placing a logic 0 on both SO and S1), the 0 output line will follow the logical state of the EN input; i.e. when $\overline{EN}$ goes low the 0 output will go low and when $\overline{EN}$ goes high the 0 output will go high.

We shall now turn our attention to a practical investigation of the 74LS139 using the circuit arrangement shown in Fig. 6.4. It should be noted that only one half of the device is used. The 74LS139 should be inserted into socket C of the Logic Tutor with pin-1 aligned with C1. The following connections should then be made:—

- C1 to S3 (S3 acts as the enable input)
- C2 to S1 (S1 acts as the SO input)
- C3 to S2 (S2 acts as the S1 input)
- C4 to D1 (D1 shows the state of output 0)
- C5 to D2 (D2 shows the state of output 1)
- C6 to D3 (D3 shows the state of output 2)
- C7 to D4 (D4 shows the state of output 3)
- C8 to 0V (common)
- C16 to +5V (supply)

(A total of 9 links)

The enable input is produced by latching switch, S3, which should initially be adjusted to produce a logic 1 (disabling the de-multiplexer). The two momentary action switches, S1 and S2, will in the absence of a depression produce logic 0 on both of the select inputs, SO and S1. In this state all four of the output indicating l.e.d.s, D1 to D4, should be illuminated.

S3 should now be adjusted to produce a logic 0 to enable the de-multiplexer. D1 should now become extinguished showing that, with the SO and S1 inputs both at logic 0, output 0 has been selected. Now, leaving S3 at logic 0, S1 should be depressed. D2 will then become extinguished showing that, with SO at logic 1 and S1 at logic 0, output 1 has been selected.

S1 should then be released and S2 depressed. D3 will now be extinguished confirming that, with the S1 input at logic 1 and the SO input at logic 0, output 2 is selected. Finally, S1 and S2 should be simultaneously depressed. D4 will then become extinguished showing that output 3 is selected when both select inputs are at logic 1.

The results of this investigation have been summarised in the truth table of Table 6.2. This table has been constructed on the basis that the de-multiplexer is always in its enabled state. Readers should, however, confirm that whenever S3 is set to logic 1, all four outputs will immediately revert to logic 1 (illuminating all four l.e.d.s) regardless of the state of the two select inputs.

SØ (S1)	S1 (S2)	3 (D4)	2 (D3)	1 (D2)	Ø (D1)
0	0	1	1	1	0
0	1	1	1	0	1
1	0	1	0	1	1
1	1	0	1	1	1

Table 6.2. Truth table for the practical investigation of the 74LS139

FOUR-CHANNEL SEQUENCER USING THE 74LS139

In Part Four we showed how a sequencer could be constructed using a shift register. We shall now consider an alternative arrangement based on a

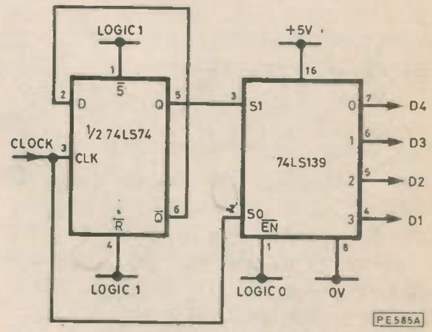


Fig. 6.5. Four-channel sequencer using the 74LS139

74LS139 de-multiplexer as shown in Fig. 6.5.

The two select inputs of the 74LS139 are fed from the outputs of a simple binary divider configured around a 74LS74 D-type bistable element. The select inputs are thus supplied with a binary count sequence and thus a low is transferred from one output of the de-multiplexer to the next on each falling clock edge.

The 74LS139 should be left in socket C whilst the 74LS74 should be inserted in socket B checking, as usual, that pin-1 aligns with B1 on the Logic Tutor. The following connections are required:—

- B1 to logic 1
- B2 to B6
- B3 to clock
- B4 to logic 1
- B5 to C3
- B7 to 0V (common)
- B16 to +5V (supply)
- C1 to logic 0 (active-low enable)
- C2 to B3
- C4 to D1
- C5 to D2
- C6 to D3
- C7 to D4
- C8 to 0V (common)
- C16 to +5V (supply)

(A total of 15 links)

The sequence produced by the circuit should follow that shown in the timing diagram of Fig. 6.6. This shows that, at any time, three of the output indicating l.e.d.s are illuminated and one is extinguished. The effect is that a logic 0

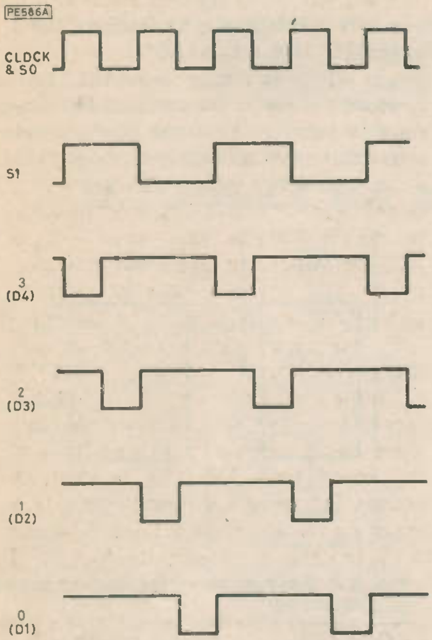


Fig. 6.6. Timing diagram for the four-channel sequencer

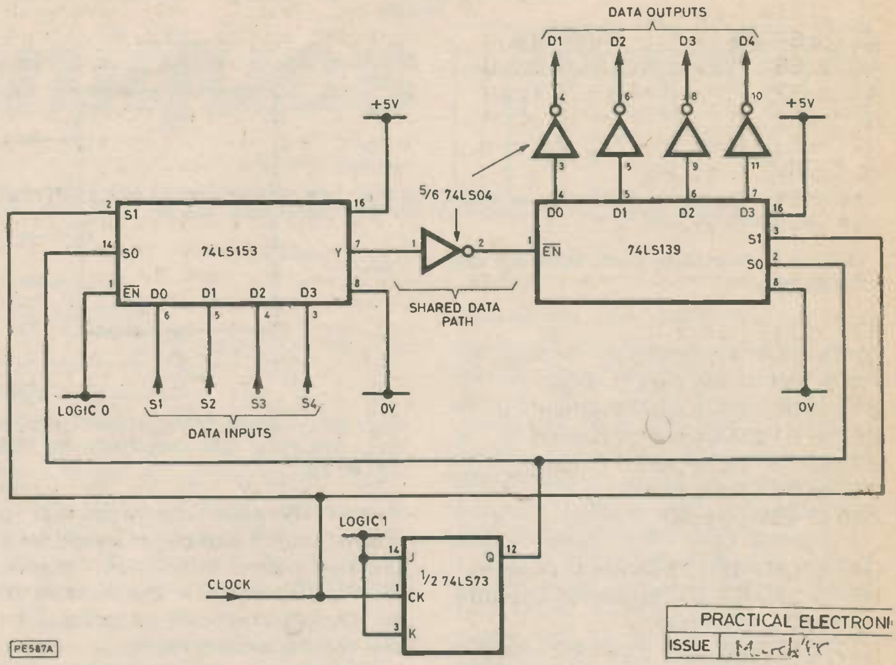


Fig. 6.7. Time domain multiplexing using 74LS153 and 74LS139 devices

circulates from D4 –> D3 –> D2 –> D1 and then restarts at D4.

TIME DOMAIN MULTIPLEXING

Thus far we have only separately considered the actions of the multiplexer and de-multiplexer. The time has now come for us to put these two devices together in an arrangement which allows us to send several data signals over a common path and yet still separate them again at the far end.

Since we have restricted ourselves to the use of four-way multiplexers and de-multiplexers in this series we shall provide for four inputs at the 'sending end' and four outputs at the 'receiving end'. The multiplexer at the sending end provides us with a means of routing each data line to the common signal path for a pre-determined time whilst the de-multiplexer at the receiving end connects the common signal path to each output line for a similar pre-determined time.

It is, of course, important to ensure that the data appearing on each data input line is correctly routed to the corresponding data output line. It should, therefore, be apparent that some means of synchronising the data at the sending and receiving ends of the path is of paramount importance. To this end we shall need to generate a common set of select signals at each end of the path.

Data communication systems of this type rely on the availability of a common clock signal at both the sending and receiving ends. At this point we should perhaps point out that, in most practical data communication systems, we would almost certainly prefer to

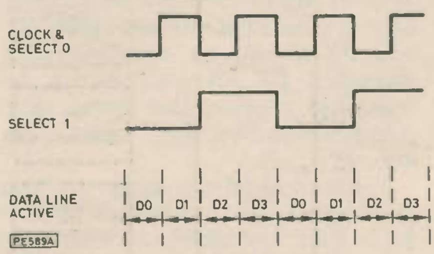


Fig. 6.8. Timing diagram for the clock and select lines of the arrangement shown in Fig. 6.7

have an asynchronous arrangement in which the data was 'self-clocking'.

The circuit arrangement employed in our practical investigation of time domain multiplexing is shown in Fig. 6.7. The common select signals are generated from the Logic Tutor's internal clock operating in conjunction with a single-stage binary divider based upon a 74LS73 J-K bistable. Fig. 6.8 shows the timing diagram of the clock and select input lines. Each data line is activated for half of the clock cycle period and follows the sequence, D0, D1, D2, and finally D3. The sequence is then repeated with one complete cycle of all four data inputs occurring in a time equal to one cycle of the signal on the S1 line.

The four data inputs are applied to a 74LS153 multiplexer and, from there, follow a time shared common data path. Since the 74LS139 has an active-low enable input, a single inverting stage (using a 74LS04) is included in the common data path. Furthermore, due to the inverting action of the internal logic of the 74LS139 (remember that the selected output line goes low whilst the other three lines remain high) we shall need to invert each of its data outputs. This is achieved using a further four inverting gates of the 74LS04.

The integrated circuits should be inserted into the Logic Tutor in the following manner:—

Socket A = 74LS153
Socket B = 74LS139
Socket D = 74LS04
Socket E = 74LS73

In each case it is, as usual, important to check that pin-1 of the integrated circuit is correctly aligned with pin-1 of the Logic Tutor's connecting strip.

The following links are required:—

A1 to 0V (active-low enable)

A2 to E14 (select 1)
A3 to S4 (S4 acts as the D3 input)
A4 to S3 (S3 acts as the D2 input)
A5 to S2 (S2 acts as the D1 input)
A6 to S1 (S1 acts as the D0 input)
A7 to D1 (time shared data output)
A8 to 0V (common)
A14 to E1 (select 0)
A16 to +5V (supply)

B1 to D2 (inverted time shared data input)
B2 to A14 (select 0)
B3 to E14 (select 1)
B4 to D3 (inverted D0 output)
B5 to D5 (inverted D1 output)
B6 to D11 (inverted D2 output)
B7 to D13 (inverted D3 output)
B8 to 0V (common)
B16 to +5V (supply)

D4 to LED D1 (D1 shows D0 output)
D6 to LED D2 (D2 shows D1 output)
D7 to 0V (common)
D10 to LED D3 (D3 shows D2 output)
D12 to LED D4 (D4 shows D3 output)
D16 to +5V (supply)

E1 to clock
E2 to logic 1
E3 to logic 1
E4 to +5V (supply)
E13 to 0V (common)
E16 to E3

(A total of 31 links)

All four of the input switches, S1 to S4, should initially be adjusted to produce logic 0 data inputs. In this state, all four of the output indicating l.e.d.s should be extinguished showing that all four data outputs are similarly at logic 0.

Now depress, and hold down, S1 to produce a logic 1 on the D0 input line. The l.e.d. indicator D1 will shortly become illuminated showing that the D0 output has gone to logic 1. Note, however, that D1 only remains illuminated for the duration of each alternate low cycle of the clock (compare the indications produce by the clock l.e.d., D9 and the D0 output indicating l.e.d., D1). The corresponding timing diagram is shown in Fig. 6.9.

Readers should now check each one of the other data lines in turn, noting the correspondence between the switch depressed and the l.e.d. which becomes activated. Finally, all four switches should be adjusted to produce a logic 1 on all four data input lines. In this state the four l.e.d.s will flash in sequence, clearly showing the time shared characteristic of the arrangement.

Readers may now be wondering whether there is any way that a received logic 1 can be preserved for a period equivalent to the select 1 signal, thus maintaining the logical state of the output. This can, of course, be achieved by simply adding a suitable bistable latch to each data output such that data is latched each time the respective data line is enabled. Furthermore, if we were to use bistable latches in which the $\overline{Q}$ output was made available, we could dispense with the four output inverters. We will, however, leave this particular exercise for the more adventurous reader!

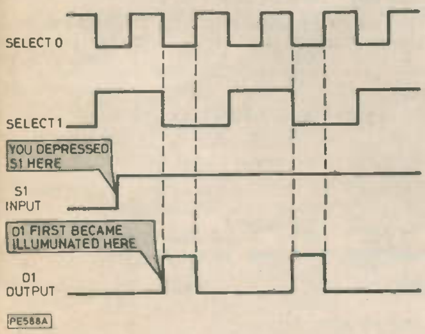


Fig. 6.9. Timing diagram for a signal on the D0 line in Fig. 6.7

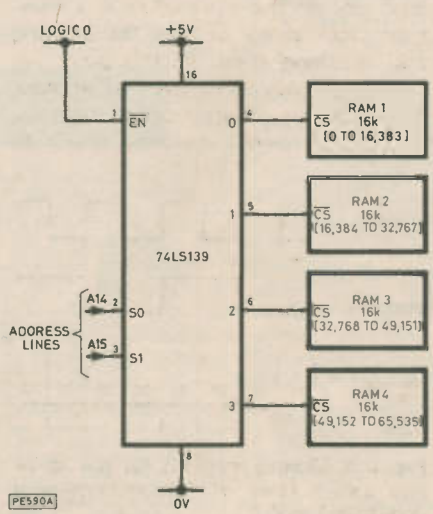


Fig. 6.10. Circuit arrangement used in the 64K memory address space decoder (Note: addresses are specified in decimal)

ADDRESS DECODING

Finally, we shall consider a typical example of the use of a de-multiplexer in the form of an address decoder for use in a microcomputer system. Let's assume that we have a 64K memory space which is occupied by four 16K random access memories (RAM). The data inputs and outputs of these memories are all connected to the system data bus (conventionally 8 bits wide). Each RAM is assumed to have fourteeen address input lines (A0 to A13 inclusive) and one active-low chip select (CS) line. The address lines on each RAM are connected to the similarly numbered address line on the system address bus hence, unless we do something to prevent a conflict, we would find that all four RAM devices were being written to or read from at the same time. What is needed, of course, is a means of decoding the two most significant address lines, A14 and A15, in order to activate the four RAM chip select lines. A suitable decoding scheme is shown in Table 6.3. In effect, we have divided the total 64K address space into four blocks of 16K, each associated with a particular RAM. RAM1, for example, corresponds to the lowest 16K (decimal addresses 0 to 16,383 inclusive) whilst RAM4 corresponds to the highest 16K (decimal addresses 49,152 to 65,535 inclusive). RAM1 is selected whenever address lines A14 and A15 are both at logic 0 whilst RAM4 is selected when these two address lines are both at logic 1.

ADDRESS LINES		CHIP SELECTED	ADDRESS RANGE (decimal)
A15	A14		
0	0	RAM 1	Øto 16,383
0	1	RAM 2	16,384 to 32,767
1	0	RAM 3	32,768 to 49,151
1	1	RAM 4	49,152 to 65,535

Table 6.3. Truth table for decoding the 64K address space

The problem of decoding the two most significant address lines is easily resolved using a 74LS139 in an arrangement similar to that shown in Fig. 6.10. The inverted logic of the 74LS139's outputs being just what is required for the active-low RAM chip select lines. (This, of course, is no mere coincidence!)

NEXT MONTH: We shall be concluding the Sequential Logic Techniques series with a look at binary full adders. We shall also include an Index to the complete series.

INDUSTRY NOTEBOOK

By Nexus

Public Ownership

The privatisation of British Telecom transformed Britain from a nation of shopkeepers to a nation of shareholders. Up to that point the company with the largest spread of shareholders was ICI with 350,000. Including overseas holdings BT enjoys the support of over 2 million shareholders. The initial figure was some 2·3 million, since whittled down by profit-taking. But this is no bad thing. First-time-ever investors, whether selling for a quick return or holding, have had a sniff of excitement which is bound to encourage them in future investment.

A Labour Party pledge to renationalise BT should they form a government fell on deaf ears. With a substantial share ownership among the electorate my guess is that the threat will be convienently forgotten and that, in any case, the famous Clause 4 was all but dead before the BT sale. Old style public ownership is out, new style public participation is in.

Self-Interest

The BT unions, following Labour policy, opposed privatisation and recommended members to ignore the share offer. In the event the free shares were taken up with gusto and the vast majority of the employees bought extra shares.

This wasn't the only example of self-interest triumphing over ideology. Strikes in the docks and in the automobile industry collapsed last year through lack of popular support. Steelmen resisted all attempts to entice them to limit output which supposedly would help the miners in their struggle. And the most extraordinary happening of all was union members taking their leaders to court.

The mining dispute, whatever the outcome, is bound to end in tears. A soap opera dragging on through months of farce as well as tragedy. The industrial result is that no government, no company, no householder will ever again rely entirely on coal as an energy source. Not the miners but their leaders have alienated the markets that alone would secure their future.

No wonder that progressive union leaders are seeking better ways to improve their members' prospects and, incidentally, their own standing in society. These include expanding the market instead of destroying it, consulting the membership, perhaps even encouraging share ownership in the enterprises in which they are employed. Self-interest can be just as noble as martyrdom if it also leads to the common good.

Change

It is of little use looking back to the great battles of 1926 (lost) or 1974 (won) as do the miners' leaders. The world is moving on and moving fast. Enterprise, the freer the better, is the fashion for the 1980s.

As I often mentioned in the past two years, China is the last of the truly great markets to be opened up. The Peoples' Republic has looked at South Korea, Singapore, Hong Kong and Taiwan, all booming economies not entirely unrelated to expertise in production of electronics goods. Why can't China be just like them?

No reason at all except that it is politically as well as practically difficult to dismantle 35 years of Chinese socialist planning overnight. So capitalism remains a dirty word while "responsibility" is newly acceptable. The first of the "responsibility systems" came in agriculture, boosting output and enriching many farmers and merchants. Now it's the turn of industry with incentives generating new levels of efficiency and more cash for workers to spend on luxuries.

Another Chinese euphemism is the "social channel" which, translated, means an individual having a financial holding in a company, in short becoming a shareholder and now permitted in some enterprises and likely to spread. In China, as in the Soviet Union, nobody is officially unemployed although plenty of people are, the blemish on society easily overcome by describing them as "waiting-for-jobs people".

Our most vigorous operator in the Chinese market is Cable & Wireless which has done wonders since privatisation. With a strong base in Hong Kong and the newly acquired Hong Kong Telephone Company there is no shortage of technical expertise and Chinese-speakers to assist the Peoples' Republic in modernising and expanding its communications systems, the prerequisite for industrial growth. In fact such is the technical standing and business trust of the company in Chinese eyes that a number of commentators suggest that C & W as a British flag carrier creates openings for newcomers.

It is interesting, too, to note that socialist France has reverted to capitalism and sound economics and that the newly elected Labour government of Mr Bob Hawke in Australia has swung decidedly right. Who could have imagined six months ago that Mrs Thatcher and President Mitterand, once mutually hostile, would be seen on TV in embraces of friendship? And yet so it is in a changing world.

Change indeed! Ever since semiconductor production started in bulk it has been the custom to send the part-finished product to the Far East for packaging because of lower wage costs. Today we see building work on a major packaging plant at Irvine, Scotland. The company is Indy, a U.S. specialist, who expect to employ 500 people when in full production.

With rising wage levels and transport costs in the Far East and improved methods of production the crossover point has now been reached when it is cheaper as well as faster to package in Europe. Packaging, in this context, includes die separation, wire bonding, sealing, testing, lead finishing and marking. Far East losses are Scotland's gain where other companies are also researching the economics and possible sites for a European packaging base.

Oversold

Not that the free enterprise system is faultless. It did well in popularising the home computer and bringing it cheaply to the buyer. But it has done some harm in overselling the product and in a frantic rush to get to market quality has suffered.

In a survey of 100 retail outlets it is reported that the top seller had a return rate of 25 percent, others between 13 and 4 percent. Three-quarters were due to technical faults, the remainder because of customer dissatisfaction.

Product promotion has been first-class in respect of games. Utility is a different matter. Does any household of reasonable intelligence need a computer to handle simple accounts or compile an address book? An amusing exercise, perhaps, but hardly economic, time-saving or necessarily more accurate than old-fashioned pen and paper. As for word-processing you need to go well up-market for a really competent machine.

With so many companies making a fleeting appearance and then disappearing, the Japanese MSX approach has much to commend it with its standardised software and complete compatability between makes. Critics are saying MSX will retard technical progress but at least customers are safe from loss of supply and know what they are paying for.

Fifth Generation

We hear a lot about fifth generation computer research with Japan often quoted as potential world leader. Yet at the fifth generation computer conference in Tokyo last November the British were prominent and highly respected contributors. Not least, interest was enormous on the Inmos transputer and its Occam language together with aspects of the British Alvey programme in which industry and the government are equal partners.

It was a surprise to see how open the Japanese were on their government-funded Icot research programme and exchanges between computer scientists from all the leading countries, including Israel, showed that while competiton is healthily fierce the outcome will benefit world industry.

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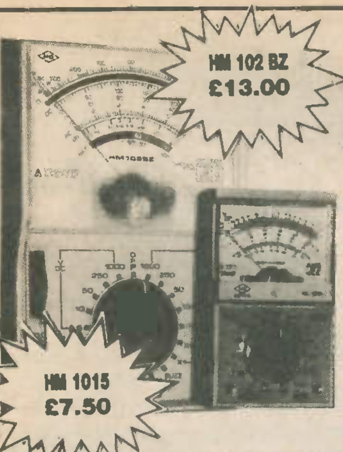

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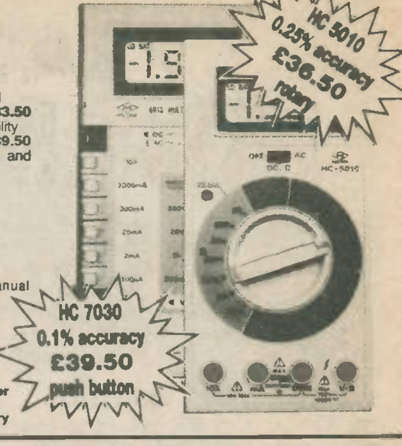

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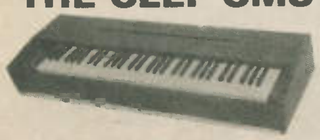

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BC107	0.070
BC108	0.070
BC109	0.070
BC115	0.100
BC118	0.110
BC140	0.190
BC141	0.190
BC142	0.190
BC143	0.190
BC147	0.055
BC148	0.055
BC149	0.055
BC157	0.055
BC159	0.055
BC182	0.060
BC182L	0.060
BC183	0.060
BC183L	0.060
BC184	0.060
BC184L	0.060
BC212	0.060
BC212L	0.060
BC213	0.060
BC213L	0.060
BC214	0.060
BC214L	0.060
BC237	0.070
BC238	0.070
BC300	0.160
BC301	0.180
BC302	0.180
BC303	0.180
BC327	0.060
BC382	0.060
BC337	0.060
BC328	0.060
BC557	0.060
BCY32	1.500
BCY33	1.500
BCY34	1.500
BCY42	0.200
BCY56	0.160

BCY70	0.160
BCY71	0.160
BCY72	0.160
BD115	0.260
BD124P	0.500
BD124	1.100
BD128	0.350
BD131	0.250
BD132	0.250
BD135	0.200
BD136	0.200
BD137	0.200
BD138	0.200
BD139	0.200
BD140	0.200
BD144	0.900
BD150	0.300
BD157	0.380
BD158	0.380
BD166	0.300
BD175	0.300
BD177	0.300
BD179	0.320
BD181	0.450
BD201	0.330
BD202	0.380
BD203	0.420
BD204	0.420
BD222	0.310
BD225	0.310
BD232	0.310
BD237	0.210
BD238	0.240
BD433	0.280
BD437	0.280
BD535	0.380
BD536	0.380
BD537	0.400
BD538	0.400
BDX32	1.000
BDX65	0.800
BF180	0.160
BF181	0.180
BF183	0.200
BF184	0.200
BF185	0.200
BF194	0.050
BF195	0.050
BF196	0.060
BF199	0.060
BF200	0.160
BF257	0.180
BF258	0.180
BF259	0.180
BF336	0.200
BF337	0.200
BF338	0.200
BF362	0.300
BF422	0.210
BF458	0.190
BF459	0.190
BFX29	0.200
BFX84	0.200
BFX85	0.200
BFX87	0.150
BFX88	0.150
BFY50	0.140
BFY51	0.140
BFY52	0.140
BFY56	0.250
BYF57	0.250
BFY64	0.250
BR100	0.140
BSX19	0.150
BSX20	0.150
BSX21	0.160
BSX26	0.160
BSX29	0.190
BZX76	0.180
BT106	0.900
BT109	0.900
BT116	0.800
BT119	1.000
BT120	1.000
BU104	1.000
BU106	0.800
BU108	1.000
BU110	1.100

BU111	1.400
BU126	0.700
BU204	0.750
BU205	0.700
BU208	0.750
BU208A	0.800
BU208D	1.200
BU326	0.850
BU406	0.850
BU407	0.750
BU408	1.000
BU500	1.100
BU526	0.800
BY126	0.060
BY127	0.080
BY133	0.080
BY164	0.220
BY176	0.850
BY179	0.350
BY182	0.320
BY184	0.320
BY187	0.320
BY196	0.200
BY206	0.110
BY207	0.110
BY223	0.720
BYX10	0.150
CA270	0.400
CA3086	0.250
CA3089	1.500
CA3240	0.900
C106D	0.230
MC1327	0.700
MJ2500	1.000
MJ2501	1.100
MJ2955	0.550
MJ3000	1.150
MJ3001	1.150
MJE29A	0.300
MJE30A	0.300
MJE340	0.250
MJE350	0.800
MJE520	0.300
MJE2955K	0.900
OA47	0.060
OA90	0.040
OA91	0.040
OA200	0.070
OA202	0.070
OC28	1.000
OC29	0.800
OC35	1.000
OC45	0.500
OC71	0.300
OC72	0.500
OC200	1.800
OCP71	1.000
ORP12	1.000
ORP60	1.000
ORP61	1.000
R2008B	0.800
R2010B	0.800
SAS560	1.100
SAS570	1.100
SN76003N	1.400
SN76013N	1.400
SN76023N	1.400
SN76033N	1.500
SN76110N	0.700
SN76115	0.700
SN76226	0.900
SN76227	0.800
T2800D	0.520
TAG06-60	0.420
TAG521-200	0.720
TAG4443	0.760
TAG4444	0.760
TAA550	0.160
TBA1205	0.450
TBA395	0.600
TBA396	0.600
TBA520	1.000

TBA530	1.000
TBA540	1.000
TBA560	1.000
TBA800	0.350
TBA810S	0.600
TBA820	0.750
TBA920	1.000
TBA950	1.000
TBA990	1.000
TCA800	2.000
TCA940	1.000
TDA1170	1.000
TDA1412	0.500
TDA2002	0.800
TDA2003	1.500
TDA2020	1.400
TDA2030	1.400
TDA2522	0.800
TDA2530	1.000
TDA2532	1.000
TDA2540	1.000
TDA2560	1.000
TDA2593	1.000
TDA2690	1.000
TIP29	0.150
TIP29A	0.220
TIP29C	0.260
TIP30	0.160
TIP31A	0.240
TIP32	0.240
TIP32A	0.240
TIP33	0.500
TIP34	0.500
TIP41A	0.220
TIP41C	0.250
TIP42A	0.220
TIP42C	0.250
TIP47	0.400
TIP48	0.400
TIP49	0.400
TIP110	0.470
TIP112	0.540
TIP115	0.450
TIP117	0.560
TIP120	0.430
TIP121	0.460
TIP122	0.470
TIP125	0.470
TIP126	0.560
TIP127	0.560
TIP2955	0.340
TIP3054	0.380
TIP3055	0.340
TIS61	0.150
TIS90	0.150
TIS91	0.180
2N 2904	0.200
2N 2905	0.200
2N 2906	0.180
2N.2907	0.180
2N.2926	0.080
2N 3019	0.280
2N 3063	0.180
2N.3054	0.350
2N.3055	0.320
2N.3055H	0.380
2N.3440	0.580
2N 3442	0.850

2N 3771	0.850
2N.3772	0.900
2N.3773	1.000
2N.4031	0.250
2N.4036	0.250
2N.4037	0.250
2N.4443	0.760
2N.4444	0.760
2N 5061	0.200
2N.5294	0.300
2N.5296	0.300
2N.6106	0.400
2N.6107	0.400
2N.6109	0.400
3N.128	0.550
3N.143	0.650
IN.914	0.020
IN.4001	0.040
IN.4002	0.040
IN.4003	0.040
IN.4004	0.040
IN.4005	0.040
IN.4006	0.040
IN.4007	0.060
IN.4148	0.020
IN.5400	0.090
IN 5401	0.100
IN.5402	0.100
IN.5403	0.110
IN.5404	0.110
IN.5405	0.120
IN 5406	0.130
IN.5407	0.130
IN.5408	0.130

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7812	0.350
7815	0.350
7818	0.350
7824	0.350
7905	0.350
7912	0.400
7915	0.400
7918	0.400
7924	0.400
78L05	0.280
78L12	0.280
78L15	0.280
74L18	0.280
74L24	0.350
LM309K	1.000
LM317K	2.200
LM317T	1.800
LM323K	4.200
LM723	0.320
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78H05KC	8.200
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79GU1C	2.150
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2SA104	0.320
2SA198	0.220
2SA203	0.300
2SA473	0.370
2SB54	0.250
2SB77	0.320
2SB337	1.200
2SB405	0.220
2SC460	0.210
2SC495	0.600
2SC733	0.400
2SC1181	1.100
2SC1172Y	1.500
2SC1279	0.240
2SC1306	1.000
2SC1307	1.000
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2SC1969	1.300
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ECC83	0.430
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ECC85	0.400
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ECH84	0.520
ECL80	0.570
ECL82	0.590
ECL84	0.570
ECL85	0.570
ECL86	0.490
EF80	0.310
EF85	0.340
EF89	0.430
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EF184	0.530
EL34	1.800
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PC97	1.000

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PCF80	0.580
PCF200	1.350
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PCL84	0.500
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BYX55/600	0.300
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BYX70/500	0.280
BYX70/500	0.310
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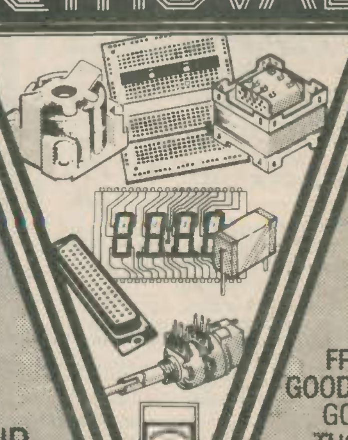

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Reverb Unit for Microphone or Musical Instruments £35 PP £1.
Electronic Echo Machine for mic/etc £85 PP £1. Deluxe £95.

BAKER LOUDSPEAKERS Post £2 each

Type	Model	Size	Watts	Ohms	Price
P.A./Disco/Group	DG50/10	10	50	8/16	£18.00
Midrange	Mid 100/10	10	100	8	£25.00
Hi-Fi	Major	12in	30	4/8/16	£16.00
Hi-Fi	Superb	12in	30	8/16	£26.00
P.A./Disco/Group	DG45	12in	45	4/8/16	£16.00
Hi-Fi	Woofer	12in	80	8	£25.00
Hi-Fi	Auditorium	15in	60	8/16	£37.00
P.A./Disco/Group	DG75	12in	75	4/8/16	£20.00
P.A./Disco/Group	DG100	12in	100	8/16	£26.00
P.A./Disco/Group	DG100/15	15in	100	8/16	£35.00

DISCO CONSOLE Twin Decks, mixer pre amp **£145**. Carr £10. **Ditto Powered 120 watt £199; or Complete Disco £300.** 120 watt £300; 150 watt £360; 300 watt £410. Carr £30.

DELUXE STEREO DISCO MIXER/EQUALISER as above plus L.E.D. V.U. displays 5 band graphic equaliser, left/right fader, switchable inputs for phone/line, mike/line.
Headphone Monitor, Mike Talkover Switch **£124** PP £2
As above but 3 Deck inputs, 4 Line/Aux inputs, 2 Mic. Inputs, 2 Headphone Monitors £145.

P.A. CABINETS (empty) Single 12 £32; Double 12 £38. carr £10. **WITH SPEAKERS 75W £54; 90W £73;** 150W £82; 200W £90. **HORNBOXES** 200 Watt £32, 300 Watt £38. Post £4.

WATERPROOF HORNS 8 ohms. 25 watt **£22.** 30 watt £25. 40 watt **£33.** 20W plus 100 volt line **£38.** Post £2.
MOTOROLA PIEZO ELECTRONIC HORN TWEETER, 3⅜in. square £6
100 watts. No crossover required. 4-8-16 ohm, 7⅜×3⅛in. £10

CROSSOVERS. TWO-WAY 3000 c/s 30 watt **£3.** 60 watt **£5.** 100 watt **£6.** 3 way 950 cps/3000 cps. 40 watt rating. **£4,** 60 watt **£6.50,** 100 watt £10.
LOUDSPEAKER BARGAINS Please enquire, many others in stock.
4 ohm, 5in. 7×4in. **£2.50**; 6½in. 8×5in. **£3.** 8in. **£3.50.** 6½in. 25W **£7.50.**
8 ohm, 2⅝in. 3in. **£2**; 5×3in, 6×4in, 7×4in, 5in. **£2.50**; 6½in. 8 × 5in **£3**; 8in. **£4.50**; 10in. **£5**; 12in. **£6.** 8in. **25W £6.50.** 8in. Twin Cone 60W **£12.50.**
15 ohm, 2¼in, 3½in, 5×3in, 6×4in. **£2.50.** 6½in 10W **£5.** 8in. **£4.** 10in. **£7.**
25 ohm, 3in. **£2**; 5×3in, 6×4in, 7×4in. **£2.50. 120 ohm,** 3¼in dia. £1.

Make	Model	Size	Watts	Ohms	Price	Post
AUDAX	WOOFER	5½in.	25	8	£10.50	£1
GOODMANS	HIFAX	7½×4¼in	100	8	£34	£2
GOODMANS	HB WOOFER	8in.	60	8	£13.50	£1
WHARFEDALE	WOOFER	8in.	30	8	£9.50	£2
CELESTION	DISCO/Group	10in.	50	8/16	£21	£2
AKAI	WOOFER	12in.	80	8	£16	£2
GOODMANS	HPG/GROUP	12in.	120	8/15	£30.00	£2
GOODMANS	HPD/DISCO	12in.	120	8/15	£30.00	£2
HNH	DISCO/GROUP	15in.		4/8/16	£44	£4
GOODMANS	HP/BASS	15in.	250	8	£72	£4
GOODMANS	HPD/BASS	18in.	230	8	£84	£4

METAL GRILLES 8in. **£3.00,** 10in. **£3.50,** 12in. **£4.50,** 15in. **£5.50,** 18in. **£7.50.** Loudspeaker Covering Vynair etc. Samples. S.A.E.

DISCO SOUND / LIGHT CONTROLLER
Ready Built Deluxe 4 Channel 4,000 watt sound chaser + speed + programme controls **£69.** Mk.2 16 programmes, **£89.** PP £2.

MAINS TRANSFORMERS	Price	Post
250-0-250V 80mA. 6.3V 3.5A. 6.3V 1A.	£7.00	£2
350-0-350V 250mA. 6.3V 6A CT **£12.00** Shrouded	£14.00	£2
250V 60mA. 6.3V 2A.	£5.00	£1
220V 25mA. 6V 1 Amp £3.00 220V 45mA. 6V 2 Amp	£4.00	£1
Low voltage tapped outputs available		
1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£6.00	£2
ditto 2 amp £10.50 3 amp £12.50 5 amp	£16.00	£2
31-26-0-26-33 volt 6 amp	£14.00	£2

LOW VOLTAGE MAINS TRANSFORMERS £5.50 each post paid
9V, 3A; 12V, 3A; 16V, 2A; 20V, 1A; 30V, 1½A; 30V, 5A+ 17-0-17V, 2A; 35V, 2A; 20-40-60V, 1A; 12-0-12V, 2A; 20-0-20V, 1A; 50V, 2A.

£8.50 post 50p **MINI-MULTI TESTER**
Pocket size instrument. o.p.v. DC volts 5, 25, 250, 500. AC volts 10, 50, 500, 1000. DC 0-250µa; 0-250ma. Resistance 0 to 600K. **De-Luxe Range Doubler Meter, 50,000** o.p.v. 7 × 5 × 2in. Resistance 20 meg in 5 ranges. Current 50µA to 10A. Volts 0.25/1000v DC, 10v/1000v AC. **£25.00** post £1

PANEL METERS 50µA, 100µA, 500µA, 1mA, 5mA, 100mA, 500mA, 1 amp, 2 amp. 5 amp, 25 volt, VU 2¼×2×1¼in. **£5.50** post 50p

EQUIPMENT CASES. Black Vinyl Covered Top, Ali Base
4 × 2½ × 2¼in. **£2.50**; 6 × 4 × 1½in. **£3.60**; 8 × 5 × 2in. **£4.00**; 11 × 6 × 3in. **£5.50**; 11¾ × 6 × 5in. **£9.00**; 15 × 8 × 4in. **£12.00.**

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4 × 2½ × 2in. **£1.20**; 3 × 2 × 1in. **£1**; 6 × 4 × 2in. **£1.90**; 8 × 6 × 3 In. **£3.00**; 12 × 5 × 3in. **£3.60**; 6 × 4 × 3in. **£2.20**; 10 × 7 × 3in. **£3.60.**

HIGH VOLTAGE ELECTROLYTICS

16/450V	**50p**	220/400V	**£2**	20+20/350V	75p
20/500V	**75p**	8+8/500V	£1	32+32/500V	**£2**
32/350V	**45p**	8+16/450V	75p	32+32/350V	**50p**
32/500V	**95p**	16+16/350V	75p	32+32+32/450V	**£1.50**
				16+32+32/500V	**£2**

SINGLE PLAY DECKS. Post £2.

Make	Drive	Model	Cartridge	Price
BSR	Belt	12 Volt	Ceramic	£20
BSR	Belt	P232	Magnetic	£28
BSR	Rim	P207	Ceramic	£20
AUTOCHANGER	BSR		Ceramic	£20
AUTOCHANGER	GARRARD		Ceramic	£24

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FM TUNING MODULE. This neat unit 75×40×19mm as used in car radios etc. Standard 10.7MHz IF output. 9-12V DC supply. Full connexion data supplied. **£2.40.**

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23rd Feb to 9th Mar.
Many bargains – worth a visit!!

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Z914 – Audio amp panel 95×65mm with TBA820 chip. Gives 1W output with 9V supply. Switch and vol. control. Just connect batt. and speaker. Full details supplied. Only **£1.50,** 10 for **£12**; 25 for **£25.**

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Much sought after 4.8V 150mA batts with PCB mntg tags on 25mm pitch. Batt size 25×16 Ø. Ideal for paralleling. **99p** ea; 10+ **85p**; 25+ **70p**; 100+ **60p.**

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Ever-Ready model CH4, this charger will take up to 4 AA, C or D cells plus 2 PP3 if required. Smart two tone grey case 212×97×60mm. **Only £7.95.**

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Computer-controlled Robot built around the gearbox described below. Complete kit of parts inc PCB, program listings for BBC (other micros soon). **£44.85.** 20W ribbon cable (min 3m recommended – 5m better) **£1.30/m.** SAE for illustrated leaflet.

The unit has 2 × 3V motors, linked by a magnetic clutch, thus enabling turning of the vehicle, and a gearbox contained within the black ABS housing, reducing the final drive speed to approx 50rpm. **Data** is supplied with the unit showing various options on driving the motors etc. **£5.95.** Suitable. Two new types of wheels can be supplied (the aluminium discs and smaller plastic wheels are now sold out). Type A has 7 spokes with a round black tyre and is 100mm dia. Type B is a solid heavy duty wheel 107mm dia with a flat rigid tyre 17mm wide.

PRICES:		
	Gearbox with data sheets:	**£5.95 ea**
	Wheel type A:	**£0.70 ea**
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Featured in Electronics & Music Maker

TAKE COMPLETE CONTROL OF YOUR MUSIC with the MCS-1

professional quality MIDI-controlled sampling unit

Once again, Powertran and E&MM combine to bring you versatility and top quality from a product out of the realms of fantasy and within the reach of the active musician.

The MCS-1 will take *any* sound, store it and play it back from a keyboard (either MIDI or Iv/octave). Pitch bend or vibrato can be added and infinite sustain is possible thanks to a sophisticated, looping system.

All the usual delay line features (Vibrato, Phasing, Flanging, ADT, Echo) are available with delays of up to 32 secs. A special interface enables sampled sounds to be stored digitally on a floppy disc via a BBC microcomputer.

The MCS-1 gives you many of the effects created by top professional units such as the Fairlight or Emulator. But the MCS-1 doesn't come with a 5-figure price tag. And, if you're prepared to invest your time, it's almost cheap!

Specification

Memory Size: Variable from 8 bytes to 64K bytes.

Storage time at 32 KHz sampling rate: 2 seconds.

Storage time at 8 KHz sampling rate: 8 seconds.

Longest replay time (for special effects): 32 seconds.

Converters, ADC & DAC: 8 bit companding. Dynamic range: 72 dB.

Audio Bandwidth: Variable from 12 KHz to 300 Hz.

Internal 4 pole tracking filters for anti-aliasing and recovery.

Programmable wide range sinewave sweep generator.

MIDI control range: 5 octaves.

+1/V/octave control range: 2 octaves with optional transpose of a further 5 octaves.

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Introduced in 1982, Powertran's DDL has brought digital quality effects to thousands of musicians. Still available in kit form at only £179.00 + VAT.

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