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The MPF1 PLUS incorporates the Z80 – the most widely used 8-bit microprocessor in the world, to form a Single Board Computer (SBC). Packed in a plastic bookcase together with three comprehensive manuals and power supply (to BS3651 standard), the MPF1 PLUS is a microprocessor learning tool for every application.

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THE MPF1 PLUS

Just look at the specification:-

Technical Specification

CPU: Z80A – 158 instructions
Software:
- Z80/8080/8085 machine code
- Z80 Assembler, line and 2 pass.
- 8K BASIC interpreter (Extra)
- 8K FORTH (Extra)

ROM: 8K Monitor (full listing and comments)
RAM: 4K CMOS (2 x 6116)
Input/Ouput: 48 system I/O lines
Speaker: 2.25" coned linear
Display: 20 character 14 segment green phosphorescent
Expansion:
- Socket for 8K ROM
- Cassette interface
- Connectors 40 way, complete CPU bus

Keyboard: 49 key. Full "QWERTY" real movement good tactile feedback
Batteries: 4 x U11 for memory back-up (batteries not included)
Serial Interface: 165 baud for read/write via audio cassette

Manuals

1. User's Manual. 8 chapters.
   1. Over view and Installation. 2. Specification (hardware and software). 3. Description of Operation. 4. Operating the MPF-1 Plus. 5. 44 Useful Sub-Routines. 6. The Text Editor. 7. Assembler and Disassembler. 8. System Hardware Configuration.
2. Experiment Manual. 16 experiments.
3. Monitor Program Source Listing with full commenting.
4. Also available the MPF-1 Plus Student Work Book (self-learning text).

Accessories

- **PRT-MPF-1P:** 20 character printer. Ready to plug in. Memory dump.
- **EPB-MPF-1P:** Copy/list/verify 1K/2K/4K/8K ROMS. Ready to plug in.
- **SSB-MPF-1P:** Speech Synthesizer. Inc. 20 words and clock program. 1200 words available.
- **SGB-MPF-1P:** Sound Synthesizer Board.
- **I/O – MPF-1P:** Input/output board

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ELECTRONICS

VOLUME 20 No. 1 JANUARY 1984

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL SUPPLEMENT

OUR FEBRUARY ISSUE WILL BE ON SALE FRIDAY, JANUARY 6th, 1984
(for details of contents see page 13/6 Micro-file)

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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:** 68 **15p**; 22 **9p**; 33 **12p**; 330, 470 **32p**; 1000 **46p**; 2200 **90p**; **25V:** 4·7, 10, 22, 47 **8p**; 100 **11p**; 150 **12p**; 220 **15p**; 330 **22p**; 470 **25p**; 680, 1000 **34p**; 1500 **42p**; 2200 **50p**; 3300 **76p**; 4700 **92p**; **16V:** 2·5, 40 **8p**; 47, 68, 100 **9p**; 125 **12p**; 220 **13p**; 330 **16p**; 470 **20p**; 680 **34p**; 1000 **27p**; 1500 **31p**; 2200 **36p**; 4700 **79p**.

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

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

CERAMIC Capacitors: 50V
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POLYSTYRENE Caps:
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AC127/8	35	BC441	34
AC176	28	BC461	34
AC187/8	32	BC477/8	40
AD142	120	BC516/7	40
AD149	79	BC547/8	12
AD161/2	42	BC549C	14
AF118	95	BC556/7	15
AF139	40	BC558/9	15
AF239	55	BCY70	16
BC107/8	10	BCY71/2	20
BC107B	14	BD131/2	48
BC108B	14	BD133	60
BC108C	14	BD135	45
BC109	10	BD136/7	40
BC109B	14	BD138/9	40
BC109C	14	BD140	40
BC147/8	9	BD245	45
BC147B	10	BD695A	150
BC148C	10	BD696A	150
BC149	9	BF194/5	12
BC149C	12	BF198/9	18
BC157/8	10	BF200	30
BC159	11	BF224	25
BC167A	10	BF244A	29
BC168C	10	BF244B	28
BC169C	10	BF256B	35
BC171/2	11	BF257/8	32
BC173	11	BF259	35
BC177/8	16	BF594/5	30
BC179/81	20	BFR39/40	23
BC182/3	10	BFR41/79	23
BC184	10	BFR80/81	25
BC182L	10	BFR98	105
BC183L	10	BFX29/84	28
BC184L	10	BFX85/86	28
BC186/7	26	BFX87/88	28
BC212/3	10	BFY50/51	23
BC212L	10	BFY52	23
BC213L	10	BFY56	32
BC214	10	BFY90	80
BC214L	10	BRY39	40
BC237/8	14	BSX20	20
BC307B	14	BSX29	34
BC308B	16	BU105	170
BC327/8	15	BU205	190
BC337/8	15	BU206	200

BU208	200
MJ2955	70
MJE340	54
MJE371	100
MJE2955	99
MJE3055	70
MPF102	40
MPF103/4	30
MPF105	30
MPSA05	25
MPSA06	25
MPSA12	32
MPSA55	30
MPSA56	30
MPSA70	30
MPSU02	58
MPSU05	55
MPSU06	55
MPSU52	65
MPSU55	60
MPSU56	60
OC23	170
OC28/36	220
OC41/42	75
OC70	40
OC76	50
OC81/82	50
OC83/84	40
TIP29A	32
TIP29C	38
TIP30A	35
TIP30C	37
TIP31A	38
TIP31C	37
TIP32A	38
TIP32C	42
TIP33A	65
TIP33C	78
TIP34A	74
TIP34C	88
TIP35A	110
TIP35C	128
TIP36A	130
TIP36C	140
TIP41A	50
TIP41B	52
TIP42A	55
TIP42B	58
TIP120	70
TIP121	73

TIP141	105
TIP142	105
TIP147	120
TIP2955	60
TIP3055	60
TIS43	32
TIS44	45
TIS88A	50
TIS90	30
TIS91/93	32
VK1010	99
VN10KM	70
VN46AF	90
VN66AF	110
VN88AF	99
VN89AF	120
ZTX107/8	11
ZTX109	12
ZTX212	28
ZTX300	13
ZTX301/2	16
ZTX303	25
ZTX304	17
ZTX320/26	30
ZTX500/1	14
ZTX502/3	18
ZTX504	25
ZTX531	25
ZTX550	25
2N696	30
2N697	23
2N698	40
2N699	48
2N706A	19
2N708	19
2N914/5	32
2N918	35
2N930	20
2N1131/2	24
2N1303/4/5	
2N1307/8	65
2N1613	30
2N1671B	160
2N2160	295
2N2219A/20A/21A/22A	25
2N2369A	18
2N2646	45
2N2846	80

2N2904A/05A/06A/07A	26
2N2926G	10
2N3053	25
2N3054	58
2N3055	40
2N3442	140
2N3615	199
2N3702/3	10
2N3704/5	10
2N3706/7	10
2N3708/9	10
2N3710	10
2N3771	179
2N3772	195
2N3773	210
2N3819	27
2N3820	38
2N3822/3	45
2N3866	90
2N3903/4	15
2N3906/5	15
2N4427	80
2N4859	78
2N5172	18
2N5180	45
2N5191	75
2N5194	80
2N5305	24
2N5457	30
2N5458/9	30
2N5485	36
2N5777	45
2N6027	32
2N6109	60
2N6290	70
2SA636	250
2SA671	250
2SA715	60
2SC495/6	70
2SC1061	250
2SC1096	85
2SC1162	30
2SC1172	125
2SC1173	125
2SC1306	100
2SC1307	150
2SC1449	85
2SC1679	190
2SC1678	140

2SC1923	50
2SC1945	225
2SC1953	90
2SC1957	90
2SC1969	140
2SC2028	85
2SC2029	200
2SC2078	170
2SC2091	85
2SC2166	165
2SC2314	85
2SC2465	125
2SC2547	30
2SD234	75
2SK45	90
2SK288	225
2SJ83	225
2SJ85	225
3N128	112
3N140	112
40251	150
40311	60
40313	130
40361/62	70
40408	76
40412	90
40467	130
40468	85
40594	105
40595	110
40603	110
40673	70
40871/2	90

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702	75	LM334Z	90
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710	48	LM339	47
741	14	LM348	60
747C 14 pin	65	LM349	118
748C 8 pin	36	LM358	60
753 8 pin	185	LM377	175
810	159	LM379	475
9400CJ	350	LM380	75
AY-1-1320	225	LM381N	145
AY-1-5050	99	LM382	115
AY-1-5051	160	LM384	160
AY-1-6720	210	LM386	90
AY-3-1270	730	LM387	120
AY-3-8910	420	LM389	95
AY-3-8912	625	LM393	45
AY-5-1230	450	LM394CH	290
AY-5-1317A	630	LM725CN	325
CA3011	130	LM1889	325
CA3012	175	LM733	70
CA3014	275	LM1871	325
CA3018	86	LM2917	195
CA3019	80	LM3302	75
CA3020	210	LM3900	50
CA3023	210	LM3909	85
CA3028A	95	LM3911	125
CA3035	285	LM3914	200
CA3036	270	LM3915	200
CA3043	275	LM3916	250
CA3045	365	LS7220	280
CA3046	70	M51513L	230
CA3048	220	M51515L	320
CA3059	285	M51516L	475
CA3075	213	M706B1	125
CA3080E	70	MB3712	220
CA3081	190	MB3756	440
CA3086	48	MC1204	250
CA3089E	200	MC1303	98
CA3090AQ	375	MC1304P	260
CA3123	165	MC1310P	150
CA3130	90	MC1445	250
CA3140	40	MC1455	50
CA3160	95	MC1458	35
CA3161E	160	MC1469	300
CA3162E	450	MC1494	694
CA3189	200	MC1495	350
CA3240	110	MC1496L	70
HA1366	175	MC1596	225
HA1388	255	MC1648	290
ICL7106	690	MC3302	90
ICL7107	975	MC3401	65
ICL7204	550	MC3403	75
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ICL7660	248	MC3432	00
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ICL8211	350	MC3423P	80
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ICM7217A	750	NE515	275
ICM7224	785	NE529	225
ICM7240	300	NE531	140
ICM7555	85	NE534	150
ICM7556	150	NE543	225
LA3350	250	NE544	210
LA4031P	340	NE555	18
LA4032	295	NE556DB	45
LA4400	350	NE558	140
LA4422	320	NE560	325
LC7120	300	NE561	395
LC7130	340	NE562B	410
LC7137	395	NE564	420
LF347	150	NE565A	120
LF351	48	NE566	155
LF353	95	NE567	275
LF355	85	NE570	410
LF356	95	NE571	400
LF357	110	NE5532	145
LF398	475	NE5534	105
LM10	350	OM335	750
LM301A	30	RC4136D	60
LM307	45	RC4558	45
LM308	95	S566B	225
LM311	55	SAB3209	425
LM318	150	SAB3210	325
LM319	195	SAB3271	485

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SL6270	150
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SN76033	350
SN76477	420
SN76488	480
SP8629	350
SP0256AL	850
TA7120	125
TA7130	125
TA7204	150
TA7205	175
TA7222	150
TAA900	395
TAA621	296
TAA661	190
TAA700	275
TAD100	159
TBA120S	70
TBA540	275
TBA550Q	330
TBA641	290
TBA651	190
TBA800	80
TBA810S	95
TBA820	80
TBA920Q	200
TBA950	300
TBA990	350
TC9109	750
TCA270	350
TCA280A	220
TCA940	175
TCA965	145
TDA1004	290
TDA1008	310
TDA1010	198
TDA1022	499
TDA1024	115
TDA1034	350
TDA1490	350
TDA2002	325
TDA2003	250
TDA2004	495
TDA2006	330
TDA2020	320
TDA2030	295
TDB0791	420
TL061CP	40
TL062CP	60
TL064CN	98
TL071CP	25
TL072CP	45
TL074CN	100
TL081CP	24
TL082CP	45
TL083CP	75
TL084CP	90
TL091CP	55
TL170	50
TL430C	90
TL507	110
TL509	110
UA2240	120
UA78540	230
UAA170	180
UAA180	180
UGN3020T	160
ULN2001	80
ULN2003	75
ULN2004	75
ULN2068	290
ULN2802	200
ULN2804	150
ULN2283	100
UPC575	275
UPC1025H	375
UPC1032	95
UPC1156H	270
UPC1182	320
UPC1366	195
XR2206	300
XR2207	375
XR2211	575
XR2216	675
XR2266	360
ZN414	80

ZN419CE	180
ZN423E	130
ZN424E	130
ZN425E-8	345
ZN426E-8	300
ZN427E-8	590
ZN428E	410
ZN429E-8	210
ZN459	325
ZN1034E	200
ZN1040E	665
ZNA234E	850

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2114L-200n	95
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2532-3	300
25L32	450
27L08	450
27L32	550
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2732	320
2764-250	425
2813	200
26501	75
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27128/250n	£16
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4027	95
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6592	00
68B54	780
6800	220
6802	250
6803	850
6805	670
6808	520
6809	630
6810	115
6820	100
68B21	220
6821	100
6840	375
6843	00
6845	750
6846	625
6847	650
6850	110
6852	250
6854	599
68B54	780
6875	500
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81LS97/98	120
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8155	350
8156	350
8202	£25
8212	150
8214	425
8216	100
8224	150
8226	250
8228	220
8243	270
8250	850
8251A	250
8253	400
8255	225
8256A	£35
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8259	395
8271	£36
8272	£17
8279	385
8282	450
8283	450
8284	350
8T26A	99
8T27	150
8T28A	120
8T31	350
8T95N	90
8T97N	90
9364AP	550
9602	220
AM26LS31C	125
AM26LS32	100
AM26LS32A	125
AM26LS33	150
AM26LS33A	125
AY-3-1015	300
AY-5-1013	300
AY-5-1350	388
AY-5-2376	600
AY-5-3600	750
COM8017	275
COM8116	700
DM8131	275
DP8304BN	250
DS3647	00
DS3691N	320
DS8820	110
DS8830	110
DS8831	125
DS8832	250
DS88LS120N	275
E9364	00
E9365	£38
E9366	£38
FD1691	£15
FD1771	£15
FD1791	£22
FD1793	£23
FD1795	£28
FD1797	£28
HA11235	200
HA17080	200
HA17083	200
HA80391	200
HD26501	75
IM6402	380
INS8060N	1050
MC1488	55
MC1489	55
MC14411	675
MC14412	725
MC3446	250
MC3447P	315
MC3486	175
MC3487	175
MK3886-2M	£7
MM5280D	695
MM5303	635
MM5307	1275
MM5387A	475
MM58174	700
RO-3-2513L	550
RO-3-2513U	650

SFF96364E	800
SP0256AL2	850
TMS2716-3	725
TMS4047	100
TMS4164-15	395
TMS4416-2	475
TMS4500	£14
TMS4532-3	350
TMS5100	600
TMS6011	500
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TMS9929	£16
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TMS9995	£12
ULN2003	75
UPD7002	425
WD1691	£14
WD1943	700
Z80CPU 2·5	299
Z80ACPU4M	300
Z80ACTC	260
Z80B	875
Z80DART	495
Z80ADART	550
Z80ADMA	895
Z80DMA	695
Z80P10	260
Z80AP10	275
Z80S10-1	850
Z80AS10	900

74S

74S00	24
74S02	24
74S03	30
74S04	30
74S05	60
74S08	60
74S10	40
74S11	50
74S20	40
74S22	50
74S30	40
74S32	70
74S37	60
74S74	75
74S85	295
74S86	70
74S112	90
74S113	90
74S114	80
74S124	300
74S132	110
74S133	60
74S138	100
74S139	115
74S140	60
74S151	180
74S153	182
74S157	250
74S158	195
74S163	300
74S174	250
74S175	320
74S188	140
74S189	140
74S194	295
74S195	275
74S197	400
74S201	350
74S225	500
74S240	300
74S241	300
74S244	290
74S251	225
745257	225
745258	250
74S260	70
74S262	850
74S287	225
74S288	210
74S289	200
74S299	540
74S301	350
74S365	250
74S373	400
74S374	365
74S412	380
74S470	325
74S471	620
74S472	1150
74S474	400
74S475	800
74S571	620
74S573	950

75

75107/8/9	95
75110	90
75150	125
75154	195
75159	125
75182/3	99
75188/9	55
75322	140
75450	86
75451/2	52
75454	70
75491/2	65

TTL 74

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

IIC

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

74LS

LS00	18
LS01	18
LS02	18
LS03	18
LS04	18
LS05	18
LS08	18
LS09	18
LS10	20
LS11	18
LS12	20
LS13	22
LS14	36
LS15	20
LS20	18
LS21	20
LS22	18
LS24	00
LS26	22
LS27	18
LS28	20
LS30	18
LS32	18
LS33	20
LS37	20
LS38	20
LS40	20
LS42	32
LS47	50
LS48	50
LS49	50
LS51	20
LS52	20
LS54	20
LS55	20
LS63	55
LS73	22
LS74	22
LS75	38
LS76	22
LS78	40
LS83	40
LS85	55
LS86	28
LS90	30
LS91	55
LS92	35
LS93	35
LS95	45
LS96	75
LS107	38
LS109	36
LS112	38
LS113	30
LS114	30
LS122	55
LS123	60
LS124	150
LS125	32
LS126	32
LS132	40
LS133	26
LS135	24
LS136	24
LS138	38
LS139	38
LS145	60
LS147	110
LS148	100
LS151	45
LS153	45
LS154	150
LS155	35
LS156	35
LS157	35
LS158	30
LS160	45
LS161	45
LS162	40
LS163	40
LS164	45
LS165	50
LS166	75
LS168	140
LS169	00
LS170	85
LS173	75
LS174	00
LS175	40
LS181	100
LS183	100
LS190	55
LS191	00
LS192	55
LS193	50
LS194	45
LS195	50
LS196	55
LS197	50
LS221	75
LS240	60
LS241	60
LS242	68
LS243	68
LS244	70
LS245	120
LS247	60
LS248	60
LS249	60
LS251	40
LS253	40
LS257	40
LS258	40
LS259	70
LS260	30
LS261	30
LS266	24
LS273	150
LS275	165
LS279	40
LS280	150
LS283	40
LS290	40
LS292	900
LS293	40
LS294	000
LS295	70
LS298	70
LS299	115
LS320	160
LS323	175
LS324	150
LS325	150
LS326	000
LS327	000
LS347	65
LS348	125
LS352	60
LS353	60
LS356	180
LS362	180
LS363	180
LS364	180
LS365	45
LS366	45
LS367	40
LS368	40
LS373	60
LS374	70
LS375	40
LS377	75
LS378	85
LS379	80
LS384	475
LS385	185
LS386	50
LS390	60
LS393	60
LS395	85
LS396	00
LS398	80
LS399	80
LS445	100
LS447	50
LS465	120
LS467	120
LS471	000
LS490	80
LS540	90
LS541	90
LS624	00
LS640	200
LS641	200
LS645	200
LS668	65
LS669	65
LS670	120
LS673	950
LS674	500

CMOS

4000	14
4001	14
4002	14
4006	50
4007	15
4008	32
4009	24
4010	24
4011	15
4012	18
4013	20
4014	46
4015	40
4016	20
4017	32
4018	45
4019	25
4020	42
4021	40
4022	40
4023	15
4024	32
4025	16
4026	90
4027	22
4028	45
4029	47
4030	20
4031	125
4032	80
4033	125
4034	140
4035	45
4036	275
4037	115
4038	110
4039	280
4040	40
4041	40
4042	40
4043	40
4044	40
4045	105
4046	46
4047	40
4048	40
4049	30
4050	30
4051	45
4052	60
4053	50
4054	85
4055	85
4056	85
4057	£10
4059	435
4060	45
4061	1195
4062	995
4063	85
4066	27
4067	245
4068	20
4069	20
4070	20
4071	22
4072	20
4073	22
4075	20
4076	55
4077	20
4078	20
4081	20
4082	20
4085	55
4086	60
4089	125
4093	20
4094	70
4095	95
4096	70
4097	275
4098	75
4099	75
4160	95
4161	99
4162	99
4163	99
4174	99
4175	105
4194	105
4408	790
4409	790
4410	725
4411	675
4412	790
4415	480
4419	280
4422	770
4433	770
4435	850
4440	999
4450	350
4451	350
4490	350
4500	675
4501	28
4502	60
4503	40
4504	75
4505	185
4506	35
4507	35
4508	130
4510	46
4511	46
4512	45
4513	199
4514	115
4515	125
4516	65
4517	275
4518	40
4519	30
4520	50
4521	90
4522	125
4526	60
4527	65
4528	50
4529	150
4530	90
4531	130
4532	50
4534	400
4536	275
4538	80
4539	90
4541	140
4543	70
4544	150
4548	40
4549	375
4553	245
4554	180
4555	35
4556	35
4557	320
4558	120
4559	395
4560	160
4561	104
4562	495
4566	165
4568	250
4569	175
4572	36
4580	460
4581	250
4582	99
4583	90
4584	48
4585	70
4597	330
4599	290
40097	45
40098	42
40100	215
40101	130
40102	140
40103	175
40104	95
40105	105
40106	35
40107	60
40108	198
40109	100
40110	300
40114	240
40161	194
40163	50
40174	45
40175	50
40181	220
40192	75
40193	95
40194	90
40195	80
40244	195
40245	195
40257	198
40373	240
40374	245

SPEAKERS
8Ω, 0.3W, 2", 2.25", 2.5", 3" 80p
0.3W, 2.5" 40Ω; 64Ω or 80Ω 80p

DIODES

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

BRIDGE RECTIFIERS (plastic case)

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	66
6A/100V	83
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	396
BY164	56
VM18	50

ZENERS
Range: 2V7 to 39V 400mW **8p each**
Range: 3V3 to 33V 1.3W **15p each**

VARICAPS

MVAM2	165
BA102	30
BB105B	40
BB106	40

TRIACS

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

SCR's Thyristors

0.8A/100V	32
5A/300V	38
5A/400V	40
5A/600V	48
8A/300V	60
8A/600V	95
12A/100V	78
12A/400V	95
12A/800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5064	38
2N4444	130

SOLDERCON PINS
100 75p
500 370p

DIAC
ST2 25

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	65
Green/Yellow	80
0.2" Tri colour LEDs Red/Green/Yellow	85
0.2" Red High Bright	59
High Bright Green or Yellow	65
LD271 Infra Red (emit)	46
TIL32 Infra Red (emit)	52
SFH205 (detector)	118
TIL78 (detector)	55
TIL38	50
TIL81 82; TIL100	90

7 Segment Displays

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

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

DALO ETCH RESIST
Pen plus spare tip 100p

COPPER CLAD BOARDS

Fibre Glass	Single-sided	Double-sided	SRBP 9.5"x8.5"
6"x6"	100p	125p	110p
6"x12"	175p	225p	

0.5" LIQUID CRYSTAL DISPLAYS

3½ digit	495
4 digit	530
6 digit	625

BPX25	250
BPW21	320
BPX65	320
IL74	65
ILD74	115
ILQ74	220
ILCT6 Darlington Isolator	135
TIL111	70
OCP71	120
ORP12	78
2N5777	50
4N33	135
Pin diode	610
Schmitt Receiver	610

OPTO SWITCH
Reflective TIL139 225
Slotted similar to RS 186

ALUM.BOXES

4x2½x2"	85
4x2½x2½"	103
4x4x2½"	120
5x4x2"	105
5x2½x1½"	90
5x2½x2½"	130
5x4x1½"	99
5x4x2½"	120
6x4x2"	120
6x4x3"	150
7x5x3"	180
8x6x3"	210
10x4½x3"	240
10x7x3"	275
12x5x3"	260
12x8x3"	295

VEROBOARDS 0.1"

	Clad	Plain		
			'VO' Board	180
2½x3¾"	85-95	—	'DIP' Board	395
2½x5"	100-110	—	Vero Strip	144
3¾x3¾"	100-110	—		
3¾x5"	115-125	95p	**PROTO-DECs**	
3¾x17"	390-420	275p	Veroblock	405
4¾x18"	495p	—	S-Dec	395
Pkt. of 100 pins	55p		Eurobreadboard	590
Spot Face Cutter	150p		Bimboard 1	695
Pin Insertion Tool	185p		Superstrip SS2	£13

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

VOLTAGE REGULATORS

1A T0220 Plastic Casing

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

100mA T092 Plastic Casing

5V	78L05	30p	79L05	50p
6V	78L62	30p	—	
8V	78L82	30p	—	
12V	78L12	30p	79L12	50p
15V	78L15	30p	79L15	50p

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

SWITCHES

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

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

PUSH BUTTON Spring loaded
Latching or Momentary 6A
SPDT c/over 110
DPDT c/over 160

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

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 65p; 6 way 80p; 8 way 87p; 10 way 100p; (SPDT) 4 way 190p.

AMPHENOL PLUG

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

ASTEC UHF MODULATORS
6MHz Standard 325p
8MHz Wideband 450p

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

DIL SOCKETS

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

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

DIL PLUGS (Headers)

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

RIBBON CABLE (price per foot)

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

SPECTRUM FORTH I/O UNIT

12K off Fig – **FORTH IN ROM**

FULL RS232 and 24 bits of I/O for Centronics and control units can be used from **BASIC** or **FORTH**. Will work on 16K or 48K Spectrum. Many more features.

ONLY £59
(Send S.A.E. for full details)

IDC CONNECTORS (Speed block type)

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

EURO CONNECTORS

Gold flashed contacts	FEMALE SOCKETS Strt.	Angle	MALE PLUGS Strt.	Angle
DIN 41617 31 way	170p	—	—	175p
DIN 41612 2x32 way	275p	320p	220p	285p
DIN 41612 2-3x32 way	295p	340p	240p	300p
DIN 41612 3x32 way	360p	385p	260p	395p

'D' CONNECTORS:

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

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

TRANSFORMERS (mains Prim. 220-240V)
3-0-3V, 6-0-6V 100mA; 9-0-9V 75mA; 12-0-12V 75mA; 15-0-15V 75mA 98p
6VA: 2x6V-.5A; 2x9V-.4A; 2x12V-0.3A; 2x15V .25A 250p
12VA: 2x4V5-1.3A; 2x6V-1.2A; 2x12V-.5A; 2x15V-.4A 345p (35p p&p)
24VA: 6V-1.5A 6V-1.5A; 9V-1.2A 9V-1.2A; 12V-1A 12V-1A; 15-.8A 15-.8A; 20V-.6A 20V-.6A 385p (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-2A; 2x30V-0.8A 480p (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x30V-1.5A; 2x40V-1.25A; 2x50V-1A 965p (60p p&p)

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

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

IDC FEMALE RECEPTACLE Jumper Leads 36"

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

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

EDGE CONNECTORS .1"

2x18 way	180p
2x22 way	199p
2x23 way	170p
2x25 way	225p
2x28 way	210p
2x30 way	245p
2x36 way	295p
2x40 way	315p
2x43 way	395p
2x75 way	550p

COMPUTER CORNER

- **SEIKOSHA GP100A** – Unihammer Printer, normal & double width characters, dot resolution graphics 10" Tractor feed, parallel interface standard. **FREE 500 Sheets** **£155**
- **SEIKOSHA GP 250X** Printer **£199**
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1.6MHz	395
1.8MHz	395
1.8432M	200
2.0MHz	225
2.4576M	200
2.5MHz	225
2.56250M	220
3.2768M	150
3.57954M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.194304M	200
4.433619M	100
4.608MHz	200
4.80MHz	200
5.0MHz	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	200
7.0MHz	150
7.168MHz	250
7.68MHz	200
8.0MHz	150
8.08333M	395
8.867237M	175
9.00MHz	200
9.375MHz	350
10.0MHz	175
10.5MHz	250
10.7MHz	150
10.24MHz	200
12.0MHz	175
12.528MHz	300
14.31818M	170
14.7456M	175
14.765MHz	250
15.0MHz	200
16.0MHz	200
18.0MHz	180
18.432M	150
19.968MHz	150
20.0MHz	200
24.0MHz	170
24.930MHz	325
29.695MHz	150
26.670MHz	325
27.125MHz	295
27.145M	190
27.648MHz	300
38.66667M	175
48.0MHz	175
55.5MHz	400
100MHz	295
116.0MHz	300
145.8MHz	225

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- **CD50E – TEAC** Twin Cased with own PSU, S/S, 80 track, 5¼", 400K **£475**
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PE VOLUME 20 No. 1 JANUARY 1984

ARRAY PROCESSING

ARRAY processing, the next step in technology, will be a reality by the end of 1984—perhaps a fitting year—if INMOS keep to their proposed production plans with the Transputer. The single chip processor, which was announced recently in the UK, USA, Paris and, by the time you read this, Japan, is set to revolutionise the face of processing.

A 32 bit processor (T424) with 4K of memory, plus communications on a single chip covering just 45mm^2 is convincing enough, but the Transputer also has the ability to cope with 10MIPS (10 million instructions per second) and memory expansion of up to 4G bytes. Add its ability to communicate directly with up to four other Transputers, in an array set up, with almost total multiplication of performance and INMOS plans for 16 bit versions, graphics and disc controllers and processors, and you have a formidable computing ability. (It is claimed that the device will be almost as universal as TTL).

Such set-ups might be capable of real time instant language translation with speech input and output, of driving a car including planning the route, arrival times and consumption etc. or of any similar complex task.

PROBLEMS

What are the problems? According to the "father of the Transputer" Iann Barron, INMOS have built and tested the individual elements of the chip and now have to put them together on one piece of silicon to be mounted in a 48 pin leadless chip carrier. How big a task is that? Well the density of the device will work out at 250,000 components in a $\frac{1}{4}$ inch square. About the same as a street map of London which also shows gas, sewerage, electricity and telephone networks condensed to $\frac{1}{4}$ inch square. Or, alternatively the power of 100 home computers on a single chip.

Provided INMOS can build it in production quantities in their planned time scale, the Transputer will undoubtedly put them ahead of the world and guarantee the long term success of the company. Incidentally the Transputer was designed in the UK headquarters of INMOS although initially chips will be produced in the US.

TO COME

Over the coming months Ray Coles—author of *MicroFile*—will be looking closely at this new device from the technical side for us and we will also carry a feature on "INMOS The Company" taking an in-depth look at the past, present and future of the UK's own chip maker. These articles will give an insight into the possible future of the electronics industry, and the direction of our hobby in years to come!

Some would say that we are now passing through a technological revolution and the Transputer may be a vital part of it. What will 1984 bring?

We hope it is prosperous for all our readers and pass on our seasonal greetings.

Mike Kenward

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Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

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Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at £1 each including Inland/Overseas p&p. Please state month and year of issue required.

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

EDUCATIONAL COMPUTER LATHE

1982 was Information Technology year. A year when the Government began in earnest encouraging us to put aside our micrometers and pick up the microcomputer in an effort to update our technological awareness. Many schemes were initiated offering great financial help for those in both industry and education who were willing to adopt an innovative approach to education and manufacturing techniques.

As Minister of State for Information Technology, Kenneth Baker used 1982 to launch schemes including the 'micro's in schools' programme. In this scheme packages of equipment have been specified for schools and colleges and financial help offered. However a new and more flexible arrangement is now on offer to further education establishments who wish to explore computer based numerical control systems (CNC).

This new approach will allow colleges etc. who are interested in the furtherance of CNC to choose the equipment they need and have the financial backing from the Government at the rate of 50 per cent. This 'pound-for-pound' aid will enable colleges to combine new micro-electronics skills with the wealth of machine-tool expertise already available in this country, and ultimately of course apply them to industry.

One piece of equipment which hopes to find its way into the scheme is the Colne 5 CNC educational lathe—a machine tool designed for use with 8 bit p/p micros.

The user will provide the micro, the memory arrangements and the VDU. The lathe is supplied with software on the memory medium of the customer's choice and for the micro of their choice. At present software is available for the BBC micro, the Apple, Commodore, Research Machines 380Z and the Spectrum. Eventually the

manufacturers (Colne Robotics Co Ltd) will write software for all the micros.

Once the lathe, the computer and its peripherals are set up the power of the software becomes apparent. Tooling instructions are entered and converted into numerical 'G' codes. This information is then fed to the lathe where the sequential turning functions are carried out. An important feature is the ability of the operator to see what the completed workpiece will look like before it is actually made. In this way miscalculations or programming errors can be rectified before the program is run.

The control electronics are basically the computer/software, the lathe itself has only three p.c.b's—power supply, stepper motors and chuck speed.

The lathe has a centre height of 70mm and is compact and portable. Overall dimensions are 680mm length, 445mm depth and 240mm height, the total weight being 40kg. The bed is mounted in a shallow tray and supports the head and tail stocks the saddle and the cross slide. The d.c. motor is bracket mounted to the rear of the headstock; it drives the chuck via a pulley with tachometer feedback to provide speed stabilisation under load. The X stepper motor is mounted to the rear of the saddle and the Z stepper motor to the bed. The stepper motors drive leadscrews which give X and Z movements accurate to 0·025mm. Maximum workpiece diameter is 80mm with a distance between centres of 325mm.

Being an educationally based system the lathe incorporates several safety features which include limit switches on the X and Z movements and isolation switches on the perspex cover and the drive mechanism cover. A lockable cut-out button to disable the d.c. motor is also incorporated.

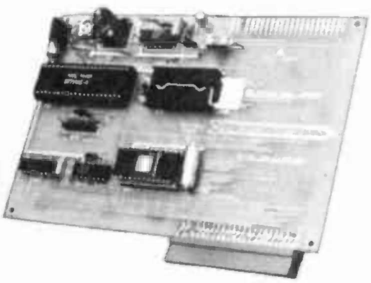
An optional extra to the system will be a capstan type rotatable tool post with its own stepper motor, allowing tool changes to be carried out during the program.

The Government will pay half the purchase price of £1,889 to teaching establishments who can satisfy the grant requirements. Further details from Colne Robotics Co Ltd, Beaufort Road, Twickenham, TW1 2PQ. (01 892 8197/8241).

PROGRAMMER

According to Enterprise Technology Ltd, their EPROM programmer, the ZP 4000, is the most sophisticated and cost effective available. It is designed for use with the ZX81 in conjunction with a 16K RAM pack.

This module will enable the user to program 2516 or 2532 type EPROMS and create prototype software or even produce EPROMS in production quantities. The p.c.b. houses a 25V d.c. generator, parallel I/O, address decode logic, ZIF socket and 2K machine code operating software.



There is no operating manual for this system as user interaction is claimed to be very comprehensive.

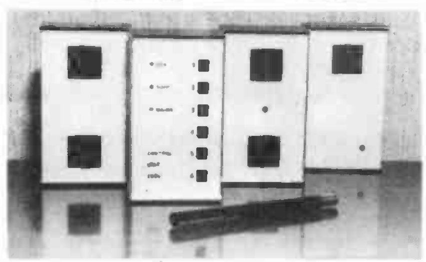
The ZP 4000 is supplied built and tested with a 12 month guarantee and costs £63·25 inc VAT and p&p. From, Enterprise Technology Ltd, PO Box 140, Wigan, WN3 6LF.

ALARM CONTROL

A matching control unit has been developed for use with the *PE Ultralight* intruder alarm (July 83).

The 2020 control unit from GJD Electronics has six buttons for time code entry and 24hr tamper selection. L.e.d. indication is provided for Alarm Off, Trip and Mains so that the system can be checked at a glance.

The four digit entry code gives 360 possible combinations. Alarm inputs are BS compatible with a 24hr panic loop and button selectable tamper loop. The controller offers auto-shut-off with alarm loop faults and variable entry and exit delays, 40 seconds on leaving and up to 20 seconds on entry.



Connections to the unit are made via a 12 way terminal block including those to the internal mains power supply; trickle charge internal ni-cad batteries are an optional extra in case of mains failure.

The unit will retail at around £30. Details from, GJD Electronics, 105 Harper Fold Road, Radcliffe, Manchester, M26 0RQ (061-724 8547).

MARKET PLACE

ZX RELAY BOARD

A low-cost relay board is now available for ZX Spectrum users.

The NMS Relay Controller has four channels each of which has a double pole 5 amp relay rated at 1kW at 240V a.c. or 100W at 25V d.c. Unlike other relay boards it plugs into the Spectrum's MIC socket leaving the expansion port free and is powered from the Spectrum supply. The controller is easy to use as any of the four relays may be turned on or off by means of a simple 'beep' command, either from within a program or direct from the keyboard. Each relay has an on/off l.e.d.

The board is supplied built into a black plastic case measuring 180 × 110 × 55mm together with 1m leads. The controllers may be daisy-chained so that more than one may be used under the control of one Spectrum.

The unit is available from Ness Micro Systems, 100 Drakies Avenue, Inverness IV2 3SD, and costs £24·95 plus £1·50 p&p.

Briefly...

Cricklewood Electronics have recently released their new components catalogue which should cater for all the needs of the average constructor.

The company who specialise in telephone sales offer a same-day despatch service for in-stock items. Usual methods of payment are employed including popular credit card services, that'll do nicely. For further information see *Index To Advertisers* in this issue.

• • • •

Constructors' note: Barrie Electronics, the transformer and components suppliers, have moved their HQ. The new address is, Barrie Electronics, Unit 211, Stratford Workshops, Burford Road, London, E15 2SP (01-555 0228).

Silicon News Corner

Mullard ▶ 1k (128 × 8 bit) static RAM with only 8-pins is called PCD8571. Data is transferred serially via I^2C bus.

▶ High speed CMOS logic circuits, called PC54/74 series now available. 240 devices will be second sourced by RCA.

▶ Low power infra-red receivers for TV offer low power consumption and can be used with RC-5 narrow or wide band transmission systems. Devices are TDA3047 or TDA3048.

▶ New high performance 10-bit multiplying DAC with a Differential Non-Linearity and output compliance voltage range of −2·5V to +2·5V. Is Signetics type NE/SE5410.

▶ New SOT-93 Darlington (BU826) has V_{CEO} 375V & I_C 6A. Fall time 0·2µs.

▶ Power transistor (BUV89) has V_{CEO} 800V & I_C 8A. Turn-off = 0·5µs resistive load.

▶ Standard Schottky (74S) family completed by introduction of four new devices—Three buffers (N74S240, N74SS241 & N74S244) and one octal latch (N74S373).

▶ Clock calendar i.c. (type PCB8573) for I^2C bus µP systems.

▶ Low cost solid-state image sensor for monochrome TV cameras. Type RGS-4. Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.

For the price of a stamp, Edwards Electric will supply information on their wide range of low power d.c. fixed voltage bench-top power supplies. The range is from 2V to 65V providing a maximum power output of 4VA or 10VA. Each supply is housed in a black plastic ABS case and comes complete with a mains plug. These items are very competitively priced and are guaranteed for 18 months, £2 will increase this cover to 5 years. Edwards Electric, PO Box 27, Unit 3, Mill Lane, Church Street, Bridgwater, Somerset, TA6 5AT.

• • • •

There have been many attempts to attract women and girls into industry at scientific and engineering levels. All have failed. Now a new start is being made with a year of intensive effort to do better. The scheme is jointly organised by the Equal Opportunities Commission and the Engineering Council and will involve schools and colleges, employers and the Department of Industry.

Women Into Science and Engineering (WISE) is a promotional movement not to be confused with a small political group using the same acronym.

POINTS ARISING...

LOGIC ANALYSER August '83

The MK4801AN–55 RAM (IC16) is a Mostek device (Mostek UK Ltd., Masons House, 1-3 Valley Drive, Kingsbury Rd., London NW9. ✆ 01-204 9322) and *should not be confused* with the Sprague octal latch/driver sharing the same generic code. It should be available from any Mostek outlet, for example: Lock Distribution, Neville St., Oldham OL9 6LF. ✆ 061-652 0431. Exact price (around £24) and availability should be checked before ordering. A hex dump of the contents of IC10 and IC11 of the Analyser's display board may be obtained from PE (Poole office) by sending a 9 × 6 inch SAE.

INGENUITY UNLIMITED

Versatile Timer, November '83

As an added precaution an extra earth wire should be connected from T1 earth tag to the output earth pin.

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.

Automatic Testing/Test/Instruments. Dec. 13–15. Metropole, Brighton. D4
Which? Computer Show 84 Jan. 17–20. NEC. T1
BEX Bournemouth 84 (Business Equipment). Feb. 8–9. Pavilion. K
Electrex 84 Feb. 27–March 2. NEC, B/ham. L3
Scotest 84 March 6–8. Anderson Exhibition Cntr., Glasgow. T
Scottish Sensors 84 March 6–8. Anderson Ex. Cntr., Glasgow. T
Home Appliances International 84 March 12–15. NEC, B'ham. M
Business Telecom 84 March 13–15. Barbican Cntr., London. O
Electro-Optics/Laser International 84 March 20-22. Metropole, Brighton. T1
Scottish Computer Show March '84. Holiday Inn, Glasgow. T1
Biotech Europe 84 May 15–17. Wembley Conf. Cntr., London. O
IBM System User Show 84 June 12–14. Wembley Conf. Cntr., London. O
Networks 84 July 3–5. Wembley Conf. Cntr., London. O
Cable 84 July 10–12. Wembley Conf. Cntr. O
Computer Graphics 84 Oct. 9–11. Wemb. Conf. Cntr., London. O
Software Expo 84 Oct. 16–18. Wemb. Conf. Cntr., London. O
Computers In The City 84 Nov. 20–22. Barbican, London. O
Data Security 84 Nov. 20–22. Barbican, London. O

D4	Network ✆ 02802 5226
K	Douglas Temple ✆ 0202 20533
L3	Electrex Ltd. ✆ 0483 222888
M	Montbuild ✆ 01-486 1951
O	Online ✆ 09274 28211
T	Trident ✆ 0822 4671
T1	Cahners ✆ 0483 38085

Part One

STARDESK

Peter Newbury

OVER the last few years groups and bands have come to realise that a proper lighting system is a desirable, if not absolutely necessary, adjunct to a decent PA set-up. Where once upon a time a couple of strategically placed spotlamps might have been considered a cut above the average, the process of mood enhancement by the use of controlled lighting is now considered so important to presentation that in more well known bands the lighting engineer is perhaps equally as important as the sound engineer. Certainly, whoever is in charge of the lighting must have, even if he or she is not a musician, a good grasp of the relationships between tempos, musical phrases etc., effective lighting changes being required to be timed exactly, to coincide with a drum beat for instance.

In the field of amateur dramatics there is an equal potential for a decent and comprehensive lighting mixing desk. Stage lighting equipment in any small auditorium is often antiquated, if functional at all.

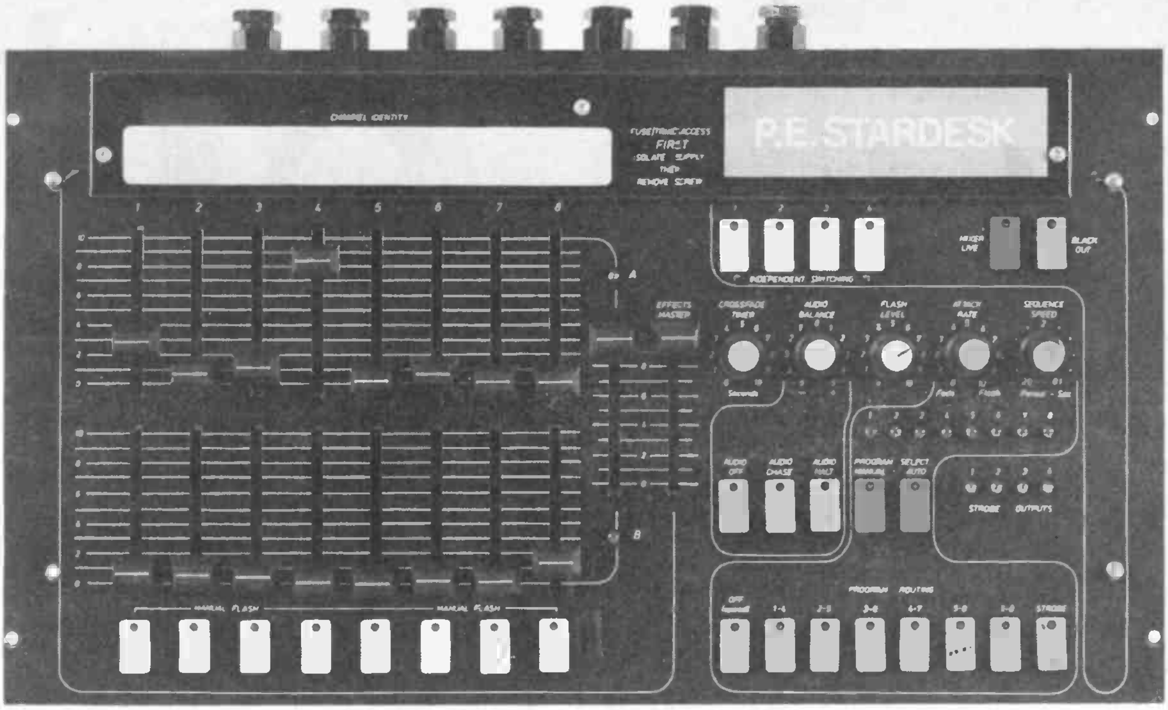
The lighting control desk which is the subject of this article was designed to meet the requirements of the two above types of end user. However, its uses are not confined to those two alone. It will provide an efficient means of secondary lighting control for clubs, discos, and even for the mobile disco, due to its compact one piece design. If for no other reason than the moderate cost of construction, it will enable many groups, musical or theatrical, and also a host of others, to enjoy the facilities of a purpose designed controller.

FACILITIES

The mixer may be divided into two sections which are situated on the left and right halves of the facia. The left hand section comprises an eight channel twin preset mixer. By this is meant that for each channel there are two preset sliders. Governing the two sets is a master A/B slider, the sets being denoted A and B respectively. With the master at A, the 'A' group of sliders are operational and the levels set are fed to the power stage, allowing the 'B' sliders to be set up in advance. When the 'B' setting is required, the master slider is then moved to the 'B' position. The transition is dipless, that is to say that the change in levels, if indeed both levels are above zero, is a smooth change from one level to the other without a null point somewhere in the middle.

Some of the more expensive mixers feature a timed crossfade between the two preset levels, discharging the operator of the responsibility of making a smooth transfer. The Stardesk has this facility and in fact it will be seen, as the article progresses, that the timer section is a lot less complicated than some of its contemporaries. Also included on the left hand side of the mixer are eight 'flash' buttons, one for each channel. This allows manual operation of the channel outputs, and this is where we see the first of the novel features. Most light mixers feature flash buttons. However, these merely bring the channel in question to full output, regardless of the slider, or fader, settings. In some instances, particularly where groups are concerned, the desire will not be to flash to full brilliance from zero or some lower level, but to interrupt a high level of illumination. As an example, a group may have several spotlights trained to illuminate them, but still wish to affect the lights in some way with the rhythm of the music. One way is to allow the flash buttons to momentarily reduce the output level, not necessarily by a large amount, but sufficiently to be in accord with the tempo and character of the music. Another somewhat startling effect is to use the flash button to momentarily black the stage out entirely. To this end the flash buttons on the Stardesk are fed from a master control that allows the flash buttons to provide any level of output required. Needless to say, since the button is not then just used to raise the channel output to maximum, operation of the flash button also disables the slider outputs for the channel or channels in question.

So much for the left hand section which, incidentally, may be termed the static section. Onto the right hand side of the



Showing the control panel of the Stardesk

mixer and thus to the kinetic section. This is basically a super chaser. In short, eight different chase programmes are provided, with an automatic facility, provision for crossfading from one stage of the sequences to the next and in addition, two types of sound to light effect are included. Incidentally, the right hand section also houses four independent zero voltage switched circuits for feeding additional apparatus, i.e. such equipment that does not need a dimming facility, namely projectors, mirror balls, etc. These independent circuits are however tied into the operation of the rest of the mixer, as will be seen.

Back to the chaser, then. In order that the sequential section may be used in conjunction with the left hand side of the mixer rather than just instead of it, the output and addressing of the chaser memory is routed in one of seven ways.

This is accomplished using a row of eight switches, the eighth being used to cancel the chase. The first five buttons allow a four channel effect to be routed to channels 1–4, 2–5, 3–6, 4–7, or 5–8. The sixth routing button selects all eight and provides an eight channel sequence effect. There are eight each of four and eight channel effects. Whatever channels are selected for the sequence effects automatically have their preset sliders disabled. The seventh button or switch puts the whole mixer into the strobe mode. Strobes work best in darkness, and for this reason, operation of the strobe button, whilst producing four low voltages for strobe triggering, disables *all* other outputs, preset dimmer outputs and independent outputs alike. When in this mode, it is useful to be able to quickly set a new lighting plot and revise the switching of the independent outputs, so as to be able to come back with a change of lighting on cessation of the strobes. This is easy enough where the presets are concerned since the physical position of the sliders can be seen. To simplify matters for the four independent channels, the channel indicator l.e.d.s continue to function at reduced brightness, allowing switch settings to be changed. This continued indication also takes place when the mixer is in the blackout mode. When the mixer is initially turned on it will assume the blackout mode with all outputs, including strobe outputs, disabled. Independent channels may be switched and the presets set up prior to operation of the mixer 'on' button, when the mixer will be fully operational.

The strobe outputs are intended to feed four strobes with a four channel sequence. This arrangement could however be modified to feed one strobe only with an authorisation signal. Few lighting control units, let alone mixing desks, offer a strobe facility.

Regardless of how the sequence programmes are routed, the programmes themselves may be selected manually or automatically. In the automatic mode, each programme, 32 stages in length, is played once before the next is proceeded to.

On some of the more expensive units available, there exists automatic crossfade on the sequence section. Rather than the sequence stages changing abruptly, the lamps dim up and down gradually. This result is only effective at low speeds and is normally, if featured at all, accompanied by a fair number of switches. The Stardesk incorporates a single 'attack' control, which in its highest setting allows a normal on/off sequence and in the lowest setting gives the slowest rate of response to the changes in sequence. This setting can be particularly useful when used in conjunction with the first of the audio functions.

AUDIO FUNCTIONS

There are two audio functions, as mentioned earlier. The first is audio chase. When this is selected, the beat of the music, derived from a signal fed into the rear of the mixer, causes the sequence to be advanced in jumps. It is this function which produces some interesting variable brilliance sequential effects. The reason for this will be discussed further in the article when we proceed to a technical description of the mixer. The second audio effect, not commonly found, is used with a fairly high chase speed and arrests the sequence in time with the beat of the music. As far as the author is concerned, this is the better of the two effects. Apart from the halting of the sequence giving a more clearly defined mark point than would jumping a stage or two, this

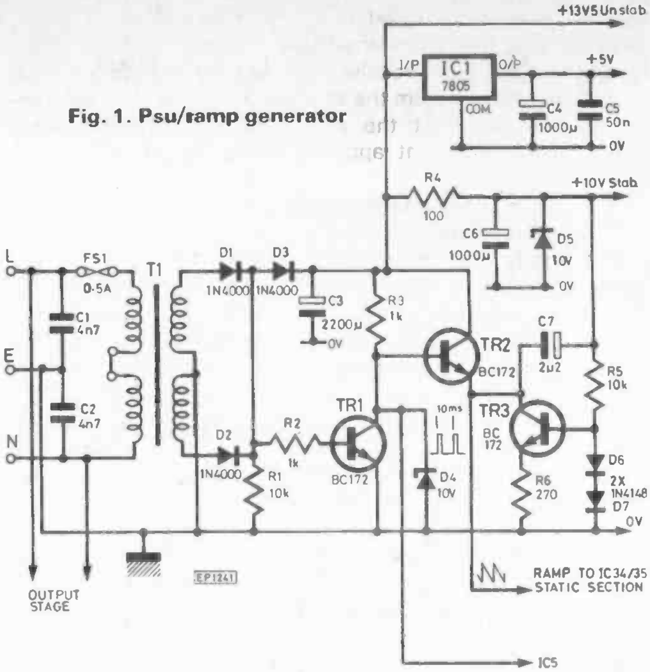


Fig. 1. Psu/ramp generator

function allows the sequence speed to be set at a normal rate. Therefore, this effect has something in common with the flash button, when that button is being used in the flash off mode. The audio input sensitivity is quite high, being a few hundred millivolts, as is the input impedance, which is 1M or 10M depending on the input range setting, which may be altered by a link wire on the board. In fact the sensitivity may be further increased, but since the more sensitive range was intended to match the output of an audio mixer, such increase in sensitivity is unlikely to be required. Having the audio sensitivity to match 0dBm precludes the necessity of running loudspeaker leads to the Stardesk, since it is highly likely that the unit will be set up adjacent to an audio mixer.

Finally the output from the right hand, or kinetic section, is patched into the static side through a master dimmer. This allows a smooth transition from purely static operation to kinetic plus static or kinetic only operation. Obviously, there is a need to ensure that controls are operated in the right order. Early in the process of design, the inclusion of a preselection facility for the kinetic section was considered, but it was felt that this could be one complication that could be done without. With the minimum of practice, a completely inexperienced operator will soon get the hang of things: for one used to operating a professional size group mixer or some such similar audio system, operation should be child's play. All the switches used are light action keyboard types.

INSTALLATION AND MAINTENANCE

Depending on the intended use, whether club, group etc., there will be differing requirements for installation. A club will almost certainly require the unit to be permanently installed.

A group will need the desk to be housed in a rugged flight-case type package, possibly with incorporated lead stowage. Given that the unit is basically portable, a theatre group may well find that for rehearsals and the initial setting up of lighting plots and cues, that the mixer would be best placed out in the auditorium, whereas once the presentation is under way, it would be situated backstage. To meet the primary requirements of all three circumstances, the mixer is safe to use freestanding, all power connections being through glands at the top or rear edge of the unit, depending on whether the mixer is upright or flat. To allow for accidental damage due to shorted leads or faulty lamps, the output stage is both accessible and repairable through a panel above the sliders. This avoids the need to demount the mixer if it is installed in a rack. Needless to say, it is vital to remove the power supply from the mixer before making any internal examination.

CIRCUITRY

The whole mixer is built on one printed circuit board, except for the interference suppression chokes used on the eight dimmed outputs. The independent channels are switched at the mains zero crossing point and therefore require no chokes. In Fig. 1 C1 and C2 are to quench any residual interference resulting from triacs being switched. They are limited to such a low value by the legally allowed maximum earth leakage current. There is no actual power on/off switch. Incoming power is fed directly to the mains transformer and the 12–0–12V output is biphase rectified and fed to the mains reservoir capacitor C3 through a further 1N4000. This blocks off the 100Hz d.c. pulses from the rectifiers, providing an input for the zero voltage pulse derivation. The raw smoothed d.c. supplies part of the ramp generator which is used to operate the dimmer, the output stages, the bilateral switches used for routing, and all such places where the control signal may reach the design maximum of 10V. A simple resistor/Zener combination provides a regulated and smoothed supply for the master dimmer section.

The chain of pulses at the output of the two rectifier diodes are fed to TR1 which acts as a limiter, producing a narrow positive pulse whilst the voltage on its base is less than 0·5V. This pulse takes two paths, first to the independent switching circuit for zero voltage control of those four outputs, and secondly to the ramp generator. The pulse from TR1 is buffered by TR2 and each positive pulse resets the voltage on C7 to that of the Zener diode, namely 10V. Once the pulse has ended, the voltage on C7 is at the mercy of the constant current generator comprising TR3, D4/5, and R5 and R6.

This stage charges C7 at such a rate so that immediately before the next pulse, the collector voltage of TR3 has reached a minimum. The next pulse restores the voltage on the collector of TR3 and so on. A feed is taken from this point to the static dimmer section which is described further on.

When power is first applied to the mixer, a flip flop comprising 74LS00 IC2 a/b is set, by virtue of the capacitor C8 connected across the blackout switch (Fig. 2). The output of IC2a is thus low, and the blackout l.e.d. illuminated. The output of IC2a is termed the blackout line and is taken to various points around the board. Firstly, to the strobe output buffer stage comprising IC23, a 74C08; secondly, to TR4/5 which provide a ground return for the drive l.e.d.s in the opto triacs controlling the four independent channels, IC6–9 and thirdly to the eight 4016 bilateral switches that control the signal feed to the individual channels, IC26–33. When the 'Mixer On' button is depressed, this line goes high allowing the outputs of the mixer to function. A common resistor, R8, is used to take the l.e.d. anodes to the positive rail since only one l.e.d. is on at a time.

INDEPENDENT SWITCHING

Two 4027, dual J–K flip flops are used, giving touch-on, touch-off control. These are positive edge triggered. R9–12 and C9–12 serve to prevent faulty operation due to contact bounce. The Q outputs of these are fed to the data inputs of a 4042 quad clock D latch. Information presented at the data inputs is only transferred to the corresponding outputs when the clock input receives the appropriate pulse, which in this case derives from the zero voltage stage TR1, as mentioned previously. At the zero crossing point the latest switching arrangement appears on the Q outputs of the 4042.

The zero crossing reference may not be thought to be perfect for two reasons.

The first is that the ratio between the knee voltage required at the base of TR1 and the peak voltage output from the diodes, say 15V, is only 30:1 giving a corresponding switching point of just under 12V of mains potential. The second point is that the phase delay in the mains transformer could produce an inaccuracy in the point of switching. In practice, the switching of 12V causes negligible interference and the phase delay caused by the transformer being under load actually reduces this voltage to a much lower value by moving the switching point back a few degrees.

The outputs of the 4042 are buffered by four BC172s, TR6/9, and fed to the four indicator l.e.d.s and to the opto triacs ICs 6/9. The cathodes of the opto triacs are returned to 0V through TR4/5 which are only on when the blackout line is high. To obtain the correct specified l.e.d. current for the MOC3020, which is 30mA, the return resistors are 270 ohms. All this current flows through the indicator l.e.d.s. However, in the blackout mode, this path is blocked and, in order to obtain an indication the cathodes of the indicator l.e.d.s are grounded also by R18–R21 which, being 2k2, give

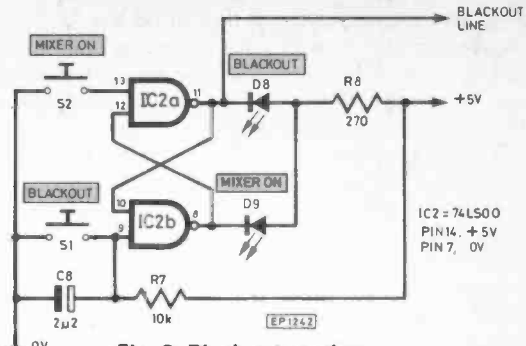


Fig. 2. Blackout section

a reduced level of illumination, and thus a further warning that the mixer is in the blackout mode.

The MOC3020 has many advantages over conventional opto-isolators, since no power supply is required on the output side. The device is coupled to the gate and MT2 terminals of the output stage triac by a 150 ohm limiting resistor. All else that is required is a snubber network, comprising a 47 ohm resistor and 0·1µ capacitor in series across the MT1 and MT2 terminals of the triac. On the other eight stages a choke/capacitor combination is also used to combat r.f. interference resulting from the steep leading edge of the switched a.c. waveform. All capacitors used in the output stages are 'X' rated: that is to say, they are especially designed to cope with being connected directly across the mains.

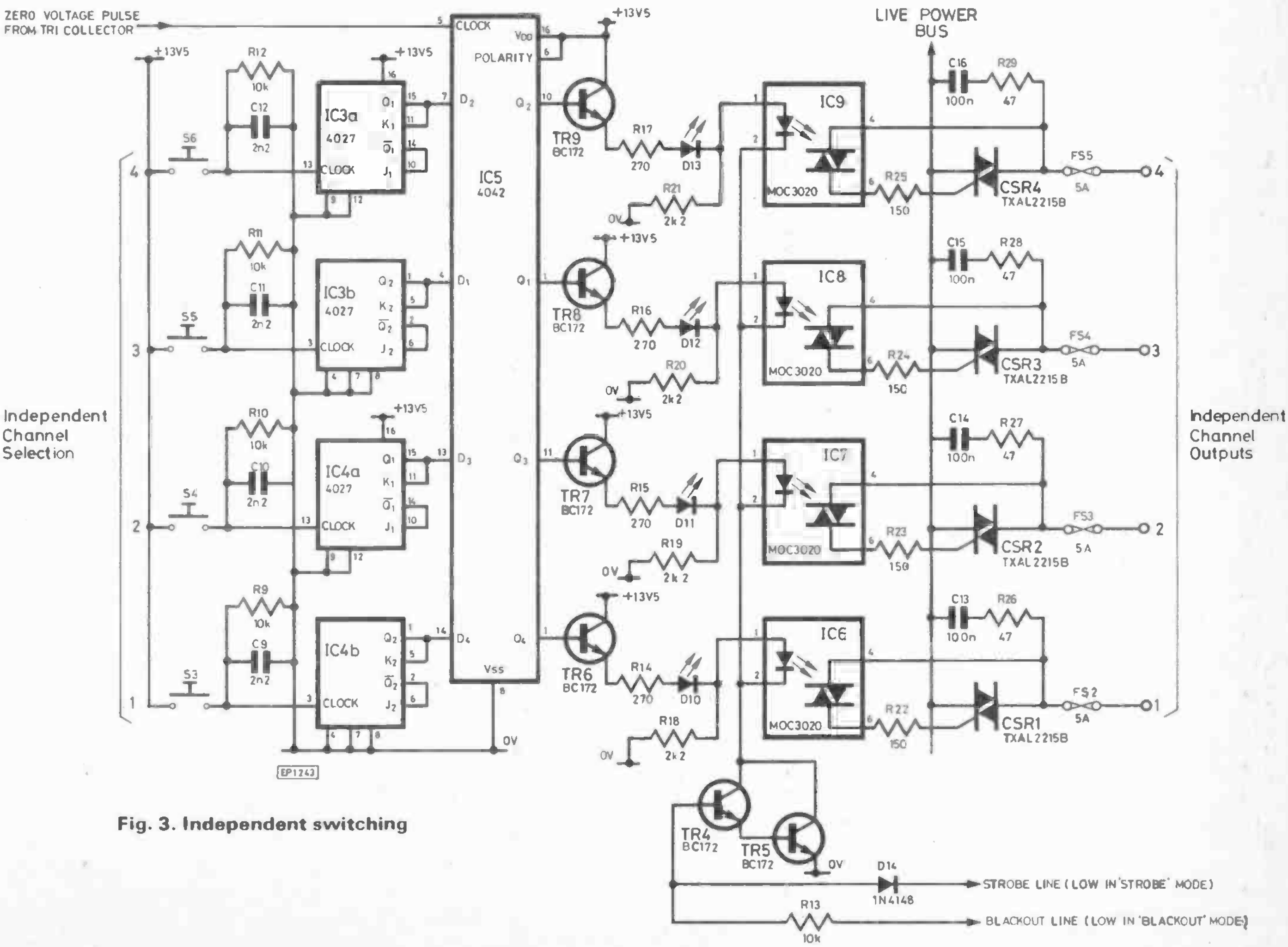


Fig. 3. Independent switching

SEQUENTIAL CIRCUITRY

There are several ways of including a fade in/fade out effect on a sequencer. The common requirement of all successful circuits is that the fading up and down must be proportional to the period of each stage of sequence. This can be accomplished using up/down counters, which are enabled by each individual output. Apart from requiring an individual counter for each output, reasonably complicated circuitry is required to vary the count rate in order to change the rate of attack. The author decided to take the simplest approach here, working on the basis that out of all the effects on the unit, the fade up/down effect would probably be the least used (do not confuse this kinetic effect with the timed crossfade: a feature felt to be amongst the most used).

The 555 timer, IC10 is arranged to run 128 times faster than required for the fastest sequence speed (Fig. 4). To obtain the correct sequence speed the 555 is used to clock a 4520 dual 4 bit cascaded counter, IC11, which then is cascaded to the second 4520, IC12, which actually addresses the sequence memory. The attack control, VR2, forms part of the resistance between pins 6 and 7 on the 555. Pin 7 is the discharge pin, which goes to ground when the threshold voltage is reached, discharging the timing capacitor, and taking the output pin 3 negative. The width of the negative edge of the output waveform of the 555 is directly controlled by the total resistance between these two pins. Unless the maximum width of the bottom or negative edge of the waveform is a substantial fraction of that of the top edge, the effective rate of oscillation will not be changed. This variable mark-space ratio signal is then fed, via a blocking diode D17, to the output enable $\overline{OE}$, pin 20 of the sequence memory IC13. The $\overline{OE}$ terminal is blocked off by a diode because it is necessary to force this pin down to ground continuously when the strobe mode is selected and thus a second diode, D18, provides a feed from the strobe control IC which is a 74C08 (IC23). This is a CMOS device and is necessary because its inputs are connected to the memory 2716 outputs. Part of the function of the crossfade circuitry relies on the fact that when the output enable pin is high, the outputs are high impedance, as will soon be seen.

The second D output, i.e. that output giving a final division of 256 of the input from the 555, is fed both to the first enable input of the sequence counter, the second 4520, IC12, and also to the first address input of the sequence memory 2716, IC13. This input A1, is pin 8. The outputs of the first counter, namely pins 14 down to 11, address the next four inputs of the 2716, giving a total of five inputs and thus a 32 stage programme capability. The fourth, or D output of the counter, pin 14, is also taken to the manual/automatic section, which is a 74LS02 (IC14). This is a quad NOR gate. The first two gates, a and b, are connected as a flip-flop, with C19 being used to set it to the manual mode when initial switch-on takes place. When the manual l.e.d.,

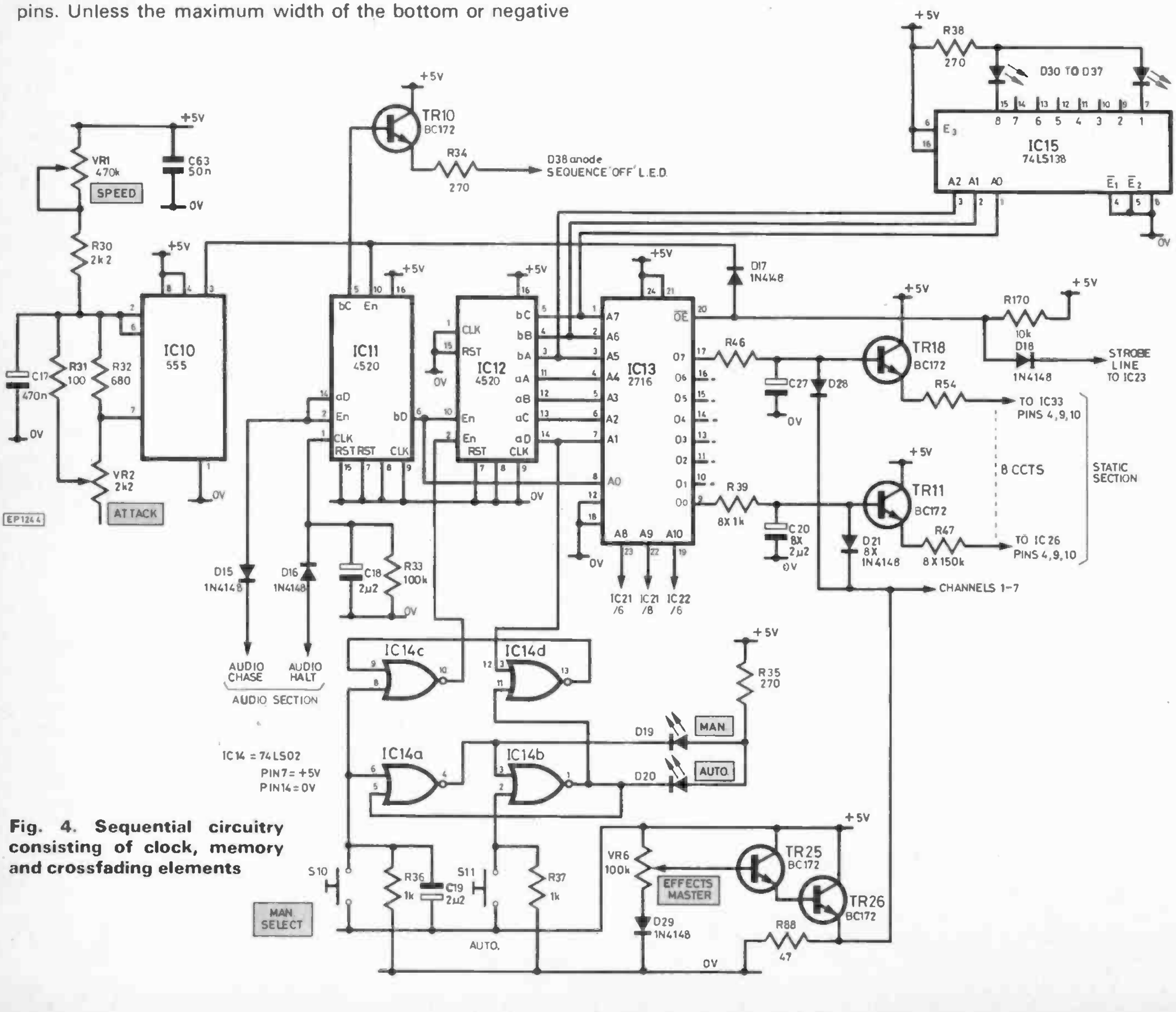


Fig. 4. Sequential circuitry consisting of clock, memory and crossfading elements

D19, is lit, b output (pin 1) is high and this holds the d output (pin 13) low since a '1' on any input will cause the output of a NOR gate to go low. This in turn means that the output of gate c, which is high, both inputs being low, will go low if the manual button is depressed. This output is taken back to the 4520, IC12, to the enable input. Each depression of the manual button will advance the counter.

The A, B and C outputs of the counter are connected to the A5, A6 and A7 inputs of the 2716, providing a choice of eight programmes. When the auto button is operated, IC14d is now free to work on information from the first half of the counter IC12, and each time the D output of the counter goes low, i.e. at the end of each count of 32, pin 13 will go high, forcing output c low and clocking the second half of the counter onto another programme. The three programme addresses A5–A7 are also taken to IC15, a 74LS138. This 1 of 8 decoder provides indication of the selected programme through l.e.d.s D30–D37. As for the blackout flip-flop, the manual/auto flip-flop and the 744LS138 indicator l.e.d.s are fed through common 270 ohm resistors, since only one is on at a time.

Having established how the sequence memory outputs come to be, with the exception of the routing circuitry and how it relates to the remaining three address pins of the sequence 2716, we can now return to the description of how the crossfade effect is obtained. For simplicity, only one stage of the crossfade section is shown, and, having established the variable mark-space pulse to pin 20 of the memory, the rest is simple.

When any output should be high, according to the stage of the programme, a series of pulses will appear at that output and will charge the 2µ2 capacitor (C20–27) through the 1k resistor (R39–46). Because the output of the memory is at very high impedance when the output is disabled, the charge will stay on the capacitor, the only other load being that of the emitter follower (TR11–18) and its load (R47–54). This load is the series input resistor to the comparator i.c. for the channel in question. The time taken for the capacitor to charge is dependent on the width of the pulse on pin 20 of the 2716. Once charged the voltage will remain constant, any leakage being topped up by each successive pulse, until that output returns to the low state, when the series of pulses will cause the capacitor to discharge at the same rate as that at which it charged. The

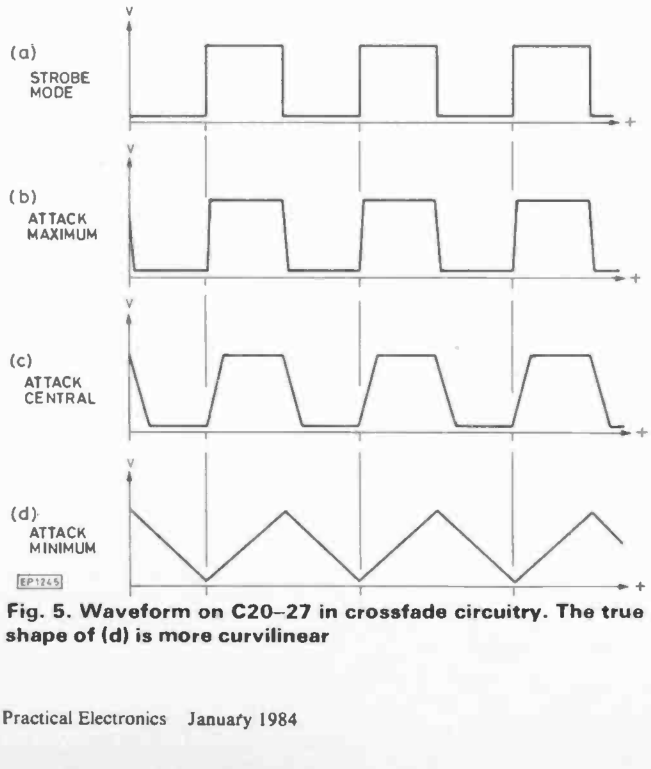


Fig. 5. Waveform on C20–27 in crossfade circuitry. The true shape of (d) is more curvilinear

waveform of the charge is not identical to that of the discharge owing to the exponential nature. However, the disparity is reduced by the fact that, on the rising waveform, the source voltage is somewhat higher than the required maximum on the capacitor; similarly, taking into account the knee voltage of the buffer stage transistor, and also that of the input to the op-amp (LM3900 type), the 2716 low voltage is lower than the lowest required voltage on the capacitor. In practice, if one is looking for it, there is a small difference between the rise and fall of illumination, but small enough to be ignored. Fig. 5 shows the waveform on the capacitor (ignoring the exponential effect) for differing settings of the attack control. One of the advantages of this circuit is that consecutive stages of the sequence overlap, thus avoiding 'holes' in the display.

There is a need for a master effects slider, if only to provide, when required, a smooth transition to kinetic effects, although there will also be occasions when a sudden switch to a sequential effect may be desired.

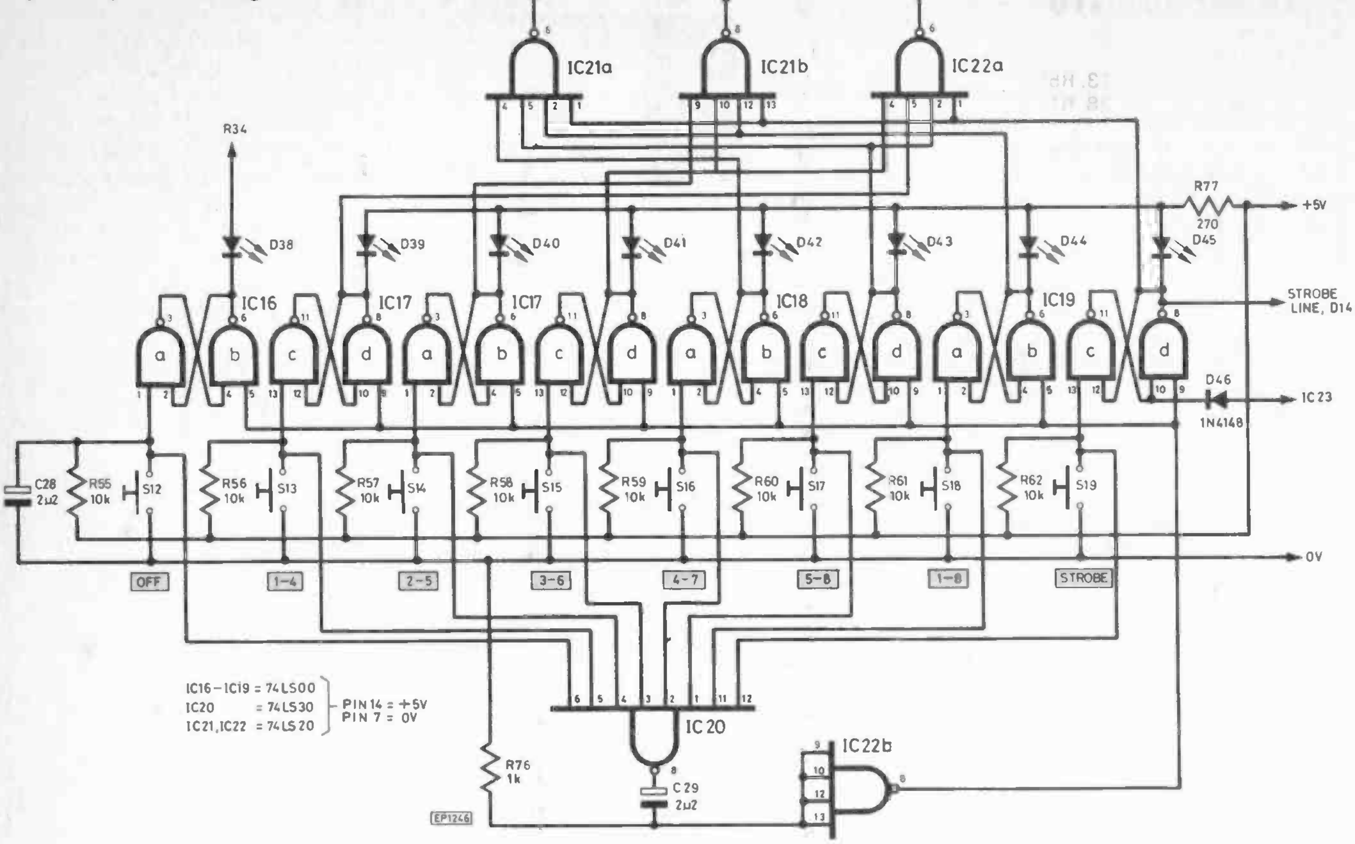
SEQUENCE ROUTING

As already mentioned, there are a total of eight buttons giving easy routing of sequential effects to five groups of four channels, all eight channels, the four strobe control outputs, or no sequential effect at all (Fig. 6). To simplify selection, each switch operates a flip-flop whilst taking an input of an eight input NAND gate (IC20) low, producing, via a second gate (IC22b) used as an inverter, a reset pulse. This reset pulse is applied to the other input of each and every flip-flop, resetting that which was previously selected. The currently selected flip-flop will not be reset because the switch is still operated, the actual reset pulse being short in duration. It may be noticed that pull-up resistors are used in this group of flip-flops, whereas only one was for the blackout/mixer 'on' flip-flop. This is because with the route selection set of flip-flops there are two inputs in parallel for each flip-flop, namely the flip-flop switched input and the corresponding input to the eight input NAND gate. Given the usual tolerances, the internal pull-up resistor for one of the gates may well beat the other input to the tape, as it were, resulting in faulty operation. For the blackout flip-flop, this is not the case and reliable operation is obtained without the need for an external pull-up resistor for the mixer 'on' switch. The blackout switch does need a pull-up because of the capacitor C8. IC21 a/b and IC22a are three four input NAND gates which produce, from the outputs of the flip-flops, a three bit code which is used to address the three remaining inputs of IC13, the sequence memory i.c. The same address lines are fed to IC24, a second 2716, which is programmed with the necessary information to ensure that the slider presets on any channel chosen as part of a sequence group, are disabled.

IC16, 17, 18 and 19 comprise the flip-flops and IC20 and IC22b perform the reset function. The 'sequence off' flip-flop indicator is not returned to +5V via the common 270 ohm resistor, R77, as are the other seven indicators but instead monitors the 'C' output of the second half of the first 4520, IC11. This is the output immediately before that feeding the A0 input on the sequence memory and therefore when the 'Sequence Off' switch is depressed that l.e.d. will pulse showing the clock speed and allowing the sequence speed to be set in advance. The anode of the l.e.d. is thus taken via R34 and TR10 to the 4520.

There may be those that think there are purer ways of effecting this switching. For instance, one could use one or two shift registers plus a 8:3 priority encoder. However, the reset circuitry would still be required and the net saving would only be one or two chips.

Fig. 6. Sequence routing



IC19 c/d, which is the strobe selection flip-flop, controls the strobe outputs, independent switching circuit and sequential/static section in the following manner: Pin 8, which goes low on strobe selection, disables the independent switching stage via D14, and ensures that the memory output is no longer pulsed by pulling the $\overline{OE}$ pin down to logic low, pin 11, having gone high, no longer holds the four commoned inputs of IC23 low (see Fig. 7) and thus the strobe outputs are enabled. The static and sequence functions are disabled via the second 2716, IC24, as a result of the three bit code presented to its inputs A0, A1, A2.

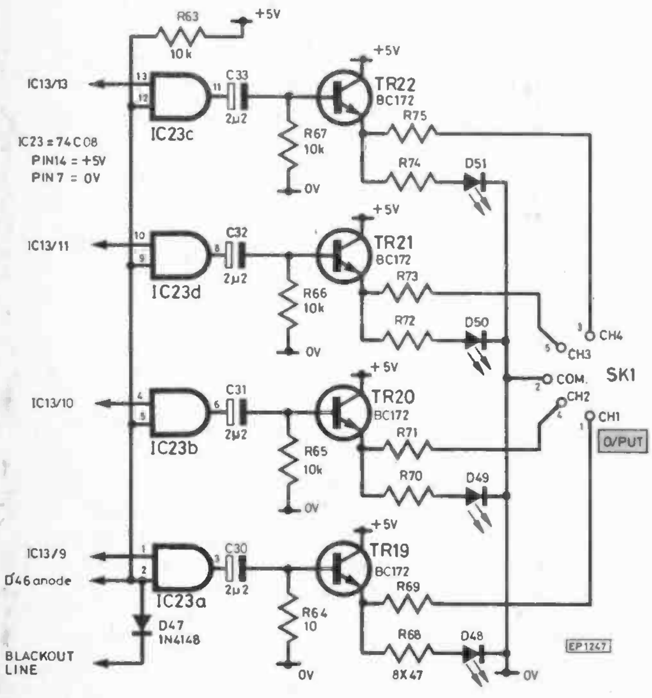


Fig. 7. Strobe output stage

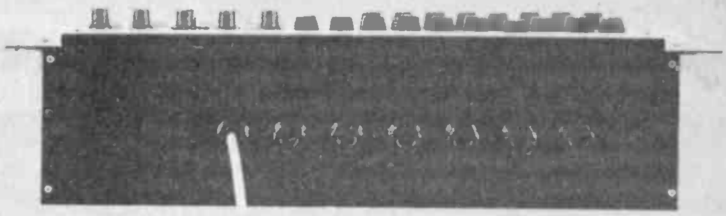
Having generated the three bit code, the sequence memory uses it to select the correct group of programmes, i.e. four or eight channel, and deliver that selection to the correct group of outputs i.e. 1–4, or 5–8 etc. The routing memory looks at the group selected and via the eight quad bilateral switches in the dimmer side of the unit, disables the presets for the channels in question. Conveniently, there are eight inputs left on this memory. One input is taken to each flash button. Whenever a flash button, or for that matter, buttons are depressed, the memory disables both the static circuitry and the sequential feed for that channel/s.

STROBE OUTPUTS

The strobe output stage is gated by IC23, a 74C08 (Fig. 7). Four of the inputs, i.e. one from each gate, are commoned, and held at +5V, unless pulled down to logic low via D46, and/or the blackout line. When not constrained by either, the four gates are free to respond to inputs from outputs 1–4 of IC13, the sequence memory. Each time a gate output goes positive, the RC combination on the base of the buffer transistors TR19–22 produces a short pulse which is fed via limiting resistors to the output socket. Four l.e.d.s give indication of the type of sequence selected.

Next Month: more circuitry, construction and testing.

COMPONENTS . . .



Resistors

R1, R5, R7, R9–13, R55–67, R78, R121–128, R153, R154, R170–174	10k (37 off)
R2, R3, R36, R37, R39–46, R76, R83, R84, R165, R175	1k (17 off)
R4	100 $\frac{1}{2}$W 5%
R6, R8, R14–17, R34, R35, R38, R77, R129–136, R169	270 (19 off)
R18–21, R30, R167	2k2 (6 off)
R22–25, R137–144	150 (12 off)
R26–29, R68–75, R145–152	47 (20 off)
R31	100
R32	680
R33, R79, R105–112, R157	100k (11 off)
R47–54	150k (8 off)
R80	2M
R81, R82, R156, R158, R162	2M2 (5 off)
R85–87, R89–194, R113–120, R159, R160, R168	1M (30 off)
R88	47 $\frac{1}{2}$W 5%
R155	10M
R161	33k
R163, R164	470k (2 off)
R166	18k

All $\frac{1}{4}$W 5% unless otherwise stated

Capacitors

C1, C2	4n7 'Y' rated ceramic disc suppression type (2 off)
C3	2200μ 16V radial electrolytic
C4	1000μ 10V axial electrolytic
C5, C63	50n 10V ceramic disc (2 off)
C6	100μ 16V radial electrolytic
C7, C8, C18–34, C52–54, C60, C61	2μ2 10V tantalum bead (24 off)
C13–16, C35–50	100n 'X' axial lead suppression type (20 off)
C17	0·47μ 10V tantalum bead
C9–12, C51, C62	2n2 ceramic disc (6 off)
C55	6·8p ceramic disc
C56	0·33μ 10V tantalum bead
C57	39p ceramic disc
C58, C59	47μ 16V radial electrolytic (2 off)

Semiconductors

IC1	7805
IC2, IC16–19, IC44, IC45	74LS00 (7 off)
IC3, IC4	4027 (2 off)
IC5	4042
IC6–9, IC36–43	MOC3020 (12 off)
IC10	555
IC11, IC12	4520 (2 off)
IC13	2716 (5V) programmed 'sequence'
IC14	74LS02
IC15	74LS138
IC20	74LS30
IC21, IC22	74LS20 (2 off)
IC23	74C08
IC24	2716 (5V) programmed 'routing'
IC25, IC34, IC35	LM3900 (3 off)
IC26–33	4016 (8 off)
IC46	74LS10
TR1–23, TR25, TR26	BC172 (25 off)
TR24	BC184
TR27–34	2N4403 (8 off)
TR35	2N3819
D1–3	1N4000 (3 off)
D6, D7, D14–18, D21–29, D46, 47, D54–69, D86–89	1N4148 (38 off)
D8–13, D19, D20, D38–45, D78–85, D90–92	3mm red l.e.d. (27 off)

(3mm l.e.d.s must have wide spaced legs, not parallel)

D48–53, D30–37	5mm red l.e.d. (long leads) (14 off)
D4, D5	10V 400mW Zener (2 off)
D70–D77	4V7 400mW Zener (8 off)
CSR1–12	TXAL 2215B triac (12 off)

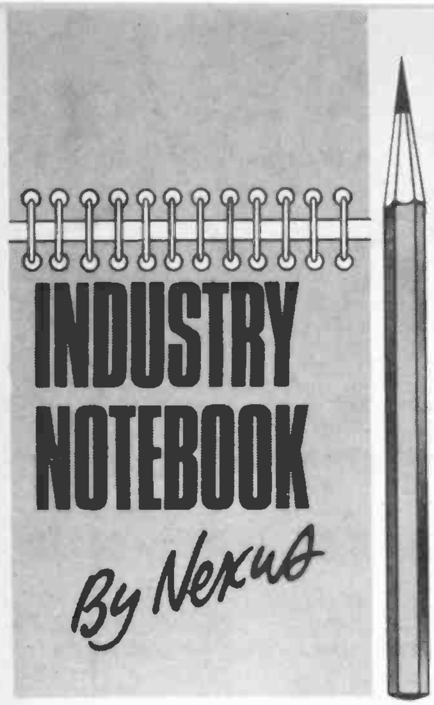
Miscellaneous

VR1, VR4, VR5	470k linear radiohm
VR2, VR3	2k2 linear radiohm
VR6, VR7, VR10–25	100k linear 60mm slider
VR8, VR9	220k vertical miniature preset (0·2in. x 0·1in. fixing centres)
FS1	0·5A 20 x 5mm fast fail fuse
FS2–13	5A 20 x 5mm H.R.C. type fuse

13 fuseholders for above, 20mm p.c. mounting types

T1	12–0–12V 0·5A p.c. mounting RS207-669 or see below for supplier see end of parts list
S1–27	TRS keyboard set—for supplier see end of parts list (comprises switch, l.e.d. holder and finger pad)
L1–8	Suppression chokes (8 off)
JK1	Mono printed circuit $\frac{1}{4}$in. jack socket
SK1	5 pin 180° printed circuit mounting DIN socket
P.c.b.	425 x 250mm doublesided and solder resisted
Also required:	18 knobs to suit slider pots, 5 knobs to suit rotary pots, internal heatsink bracket, case, front panel, back panel and various screws etc.

A full kit of parts for this project is available from:
Bensham Recording Ltd.,
327–333 Whitehorse Road,
Croydon, Surrey CR0 2HS **Tel: (01) 684 8007**
Items such as the ready painted and printed panel, plated case assembly, printed circuit board, chokes and other groups of components may be purchased individually, and a list is available on request.
The price of the complete kit is **£195 including VAT and carriage.**



Born Again

What will a born-again Labour administration do for industry? At the party's Brighton conference the 'dream-ticket' became reality. By the end of the week the delegates were infected with a crusading belief in victory.

But although the leadership had changed and was now in younger, supposedly more vigorous, hands the old policies rejected by the electorate last June remain intact. Conference insisted that the Manifesto is sacrosanct. For industry this means more nationalisation, withdrawal from the European Common Market, import controls, exchange controls and re-inflation.

I listened patiently throughout the week. Many delegates were strong in denouncing Britain's economic collapse. But others, making a case for more overseas aid and other spending programmes, constantly referred to the nation as being among the richest countries in the world. A few managed to introduce the notion of national bankruptcy and national riches in the same speech. And then, when party leaders openly admitted that the party's own finances were in tatters, one wondered if they could do any better for the nation's.

Much depends on the new leaders. Neil Kinnock, if he can retain the confidence he inspired at Brighton, could transform the party but will clearly need to moderate the policies. Oratory, however brilliant, is no substitute for common sense. Fortunately for Neil, he has four years for Labour to regain electoral credibility before being put to the test.

Education

How do you sell the idea of nuclear magnetic resonance to the lay investor? A welcome educational innovation by Oxford Instruments Group appeared in the prospectus for the sale of its shares. It included a well-written explanation of magnetism, superconductivity, cryogenics and the principles and application of nuclear magnetic resonance. Whether this assisted the sale of shares is problematical but it certainly did no harm and the issue was successful.

I coupled Oxford last month with Telemetrix, also going public. The value of shares on offer was £9·7 million. Applications totalled some £350 million, an over-subscription of 35 times. What an overwhelming success for the ex-Racal engineers who decided to go it alone only five years ago. All Telemetrix employees got full allocation of shares asked for. Outsiders got as little as three percent so the employees were rewarded and have a stake in the company.

The New Rich

Telemetrix and Oxford are just two of a lengthening list of new-technology companies making fortunes for their founders and prosperity for their investors and employees. I was tempted to generically call them high-tech companies but Alan Sugar's Amstrad is a notable exception in the low-price audio and video market. Amstrad has clocked up a 69 percent gain in pre-tax profits and is now making over £8 million a year. On second thoughts perhaps I am doing Amstrad an injustice equating low cost with low technology. One recalls the old adage that the engineer is the man who can build for five bob what the fool builds for a pound. Designing down to a price takes genuine, even superior, engineering skill.

A recent list of 24 new-rich millionaires in electronics shows a spread of 31 to 51 as the age at which they hit the jackpot, with an average of 40. All but two started their companies in the 1970s and the great majority gained experience with established large companies before taking the plunge. Perhaps surprisingly you don't need to be a large employer to make big money. As few as 50 employees in one instance, not more than 500 and an average of 200 appears sufficient. And you don't need to be in hardware manufacture. Computer leasing, component distribution and software services have also been money spinners.

The companies in which these entrepreneurs once worked and gained experience include IBM, GEC, Plessey, Racal, Rolls-Royce, British Aerospace, BL, Texas Instruments and Sinclair. Opportunity, it seems, still knocks. At least for the bright and the bold. But there is no guarantee of success. High-flyer Alan Osborne, the Britisher who made the big time in the USA with Osborne Computers, has ended up with company, if not personal, insolvency. Microcomputers is now the most treacherous high-risk area and in view of recent crashes almost any company involved could be vulnerable.

Jobs

Our 24 new millionaires mentioned above are in 13 different companies generating millions of pounds worth of business. Yet between them they employ directly fewer than 2,500 people; indirectly quite a few extra jobs through equipment, components and services bought in from outside. On the other hand their products are mostly designed to improve the efficiency of their customers thereby eliminating jobs elsewhere.

It is arguable that high-tech companies, while creating jobs, are destroying old jobs at a faster rate. Nobody yet knows whether this is so and whether high-tech is doing more harm than good in employment prospects. One argument is that without high-tech modernisation many firms would go out of business altogether so high-tech at least helps to stabilise employment. In our own industry of electronics it is well proven that more product is produced yearly with fewer workers per unit of product, meaning little expansion of the workforce and in many cases a reduction. No wonder trade unions express alarm.

An international conference of union leaders from 32 countries was recently held in Tokyo to discuss employment prospects in the electronic and electrical industries. One hundred and thirty delegates were attempting to co-ordinate a strategy to protect workers against loss of earnings or redundancy through introduction of new technology.

The problem is not new. We had it with machine tools years ago when skilled lathe operators became mere machine-minders with consequent overmanning. Resistance to change in the name of job preservation is a natural reaction but not necessarily in the interests of those seeking protection. Nobody profits if a company fails, all are then equally workless.

As a member of a union for over twenty years I find it difficult to take sides. A. J. P. Taylor, historian, one-time member of the Communist Party and a life-long socialist, sadly comments in his autobiography 'A Personal History' that the organised trade unionists have not only outstripped the well-to-do middle class, they have become the principal exploiters of the poor and humble. Like all aristocrats they cling to their privileges at the expense of everyone else.

An extreme view, perhaps, but with a grain of truth. At least it makes us all think again on what our roles are or should be. Perhaps we should also be reminded that we are on the threshold of that ominous year of 1984.

Teletext

A substantial order from Zenith Radio Corporation for teletext decoder assemblies to be supplied by Mullard marks the entry of British designed teletext into the potentially huge market in the USA. The Japanese, too, have ordered the Mullard product for incorporation into their export models for the US market.

Austria, Australia, Finland, Germany, Holland and Sweden are all now broadcasting British system teletext and a further seven countries have adopted it for their trials. So great is the interest that henceforth it is dubbed as World System Teletext. One big appeal to the Americans who are still transmitting on the original NTSC 525-line standard is that the system offered can be extended to higher display levels without obsolescence of existing equipment.

ULTRASONIC CAMERA TRIGGER

R.A. Penfold

AUTOMATIC camera and flashgun triggers are useful for certain specialised types of photography, and the most popular of these is probably wildlife photography. An automatic trigger can be used where human reactions would be too slow to catch a momentary event, or where there is likely to be a long wait before an animal appears and a photograph can be taken. In this second case the equipment is set up so that the animal, in effect, takes its own photograph and the photographer does not have to maintain a constant vigil.

TRIGGER SYSTEMS

Most photographic trigger circuits use either some form of broken light beam system to detect the event or object to be photographed, or use sound triggering. However, there are alternative systems, one of which is to use reflected light or sound. An advantage of this system is that the transmitter and receiver can be built as a single unit, and this is rather more convenient when setting up and using the equipment.

Both infra-red and ultrasonic reflection circuits were tried, and both methods seem to be perfectly feasible in practice. The infra-red circuits that were tried proved to be quite sensitive even to small objects, but the maximum range was not very large. Ultrasonic circuits were less sensitive to small objects, but an adequate range of around one to two metres was achieved with objects such as large insects and small to medium sized birds. Practical tests with an ultrasonic system gave good results, and the ultrasonic trigger finally devised forms the subject of this article. A few examples of shots taken using the unit are shown in the accompanying photographs.

Although problems with a lack of directivity were anticipated these did not materialise, and only objects within a small area straight in front of the transducers will trigger the unit. This is presumably due to the highly directional nature of ultrasonic soundwaves, and the use of new narrow beam transducers also aids good performance in this respect.

As sound travels much more slowly than light an ultrasonic system has a slower response time than an equivalent infra-red one, but as it only takes the reflected sound waves a maximum of about 6 milliseconds to be reflected back to the receiver, the response time is perfectly adequate for most purposes.

ULTRASONIC SYSTEM

The block diagram of Fig. 1 helps to explain the overall operation of the unit. The transmitter is basically just a 40kHz oscillator which drives the transmitting transducer. A frequency of 40kHz is used as it is at this frequency that the transducers have peak efficiency. The transducer is driven from the two-phase output of the oscillator so that a strong output signal is obtained.

Signals reflected from a detected object and back to the receiver are not likely to produce a very strong signal from the receiving transducer, and a high gain amplifier has to be used in order to obtain a useful signal level. A gain control is

COMPONENTS . . .

Resistors

R1	1M5
R2,R7,R8,R12,R13	10k (5 off)
R3	1M2
R4	4k7
R5	56k
R6,R14	22k (2 off)
R9	10M
R10	1k5
R11	470

All 0·25W 5% carbon except where stated otherwise

Potentiometers

VR1	10k log with switch (S4)
VR2	2M2 lin
VR3	100k 0·1W horizontal preset
VR4	47k 0·1W horizontal preset

Capacitors

C1,C9	100n polyester (2 off)
C2	1n mylar
C3	4n7 mylar
C4	2n2 mylar
C5	33p ceramic
C6,C8,C10	10n polyester (3 off)
C7	1µ 16V tantalum
C11	100p ceramic
C12	100µ 10V axial elect

Semiconductors

D1	TIL209 red l.e.d.
D2	1N4148
TR1,TR2	BC239C (2 off)
TR3	TIP41A
IC1,IC2	555 (2 off)
IC3	4001BE
IC4	4047BE

Miscellaneous

S1,S2	Miniature s.p.s.t. toggle switch (2 off)
S3	Push to make, release to break type
X1,X2	40kHz narrow beam ultrasonic transducers type TB40LB (2 off)
SK1	2·5mm jack socket
B1	9V (e.g. 6 x HP7 or AA cells)

Panel holder for D1, two control knobs, battery connector (and holder if required), printed circuit board, case about 150 x 90 x 50mm, two 14 pin d.i.l. i.c. sockets, wire, etc.

The TB40LB ultrasonic transducers are available from **Chartland Electronics Ltd., Charland, Twinoaks, Cobham, Surrey KT11 2QW**

included so that the sensitivity of the circuit can be adjusted.

The output from the amplifier is used to trigger a monostable circuit, and this in turn triggers a second monostable, but not until the end of the output pulse from the first one. The second monostable is used to trigger the camera via a switching transistor. The effect of the first monostable is to provide a delay between an object being detected and the camera being fired, and this delay is adjustable. Obviously in some situations the trigger will be required to operate as rapidly as possible, and in such applications the delay can be switched out.

A useful feature of the circuit is its ability to operate in a sort of single shot mode where it effectively switches off once the camera has been operated. This mode can be used in situations where there would otherwise be a danger of numerous almost identical shots being taken, and a lot of film being wasted. Here, the output of the monostable is used to trigger a flip/flop which switches off the transmitter until a reset button is operated.

In Fig. 2 the amplifier at the input of the receiver is a two stage common emitter circuit which gives a high maximum voltage gain of about 80dB. The two stages are capacitively coupled via gain control VR1. C5 rolls off the gain of TR2 at radio frequencies, and this reduces the risk of instability due to stray high frequency feedback.

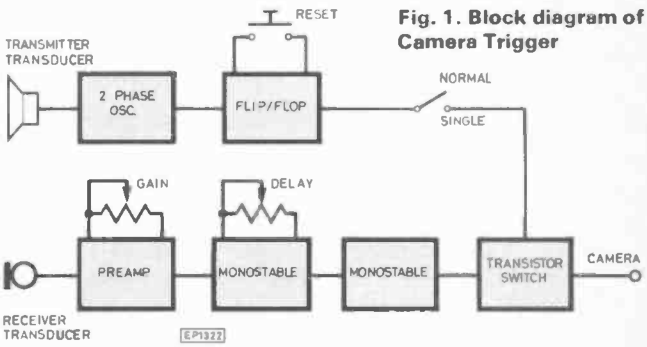


Fig. 1. Block diagram of Camera Trigger

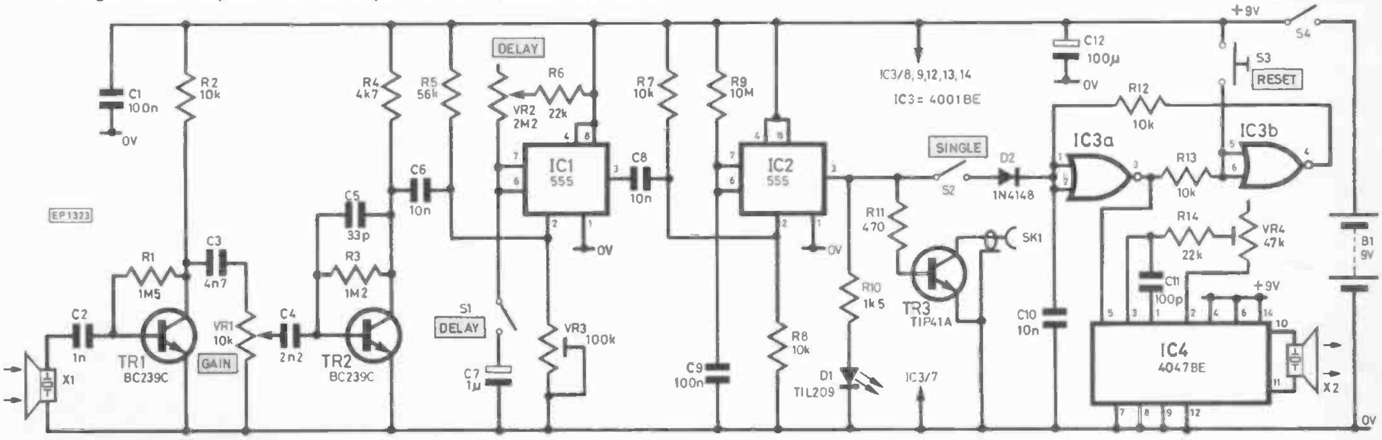


Fig. 2. Circuit diagram

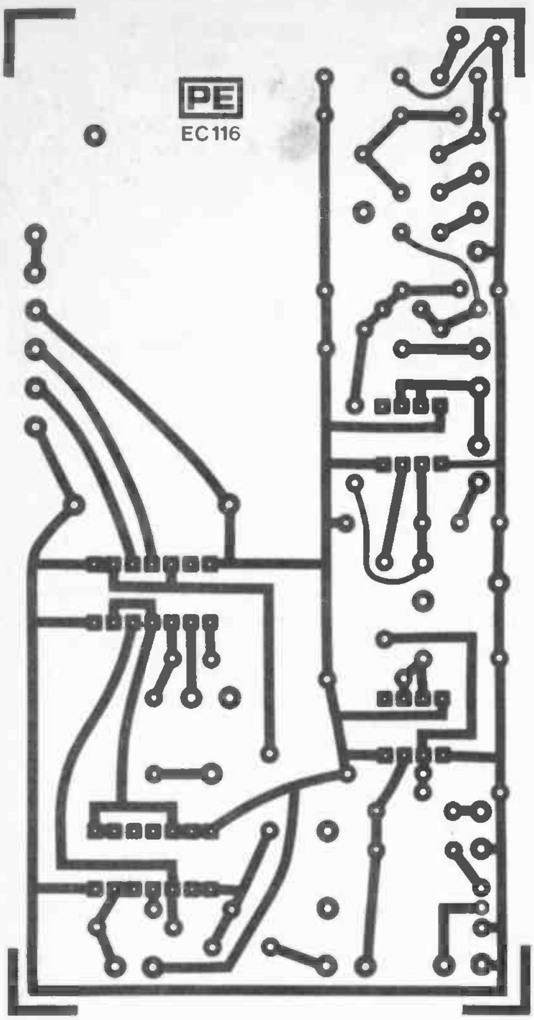
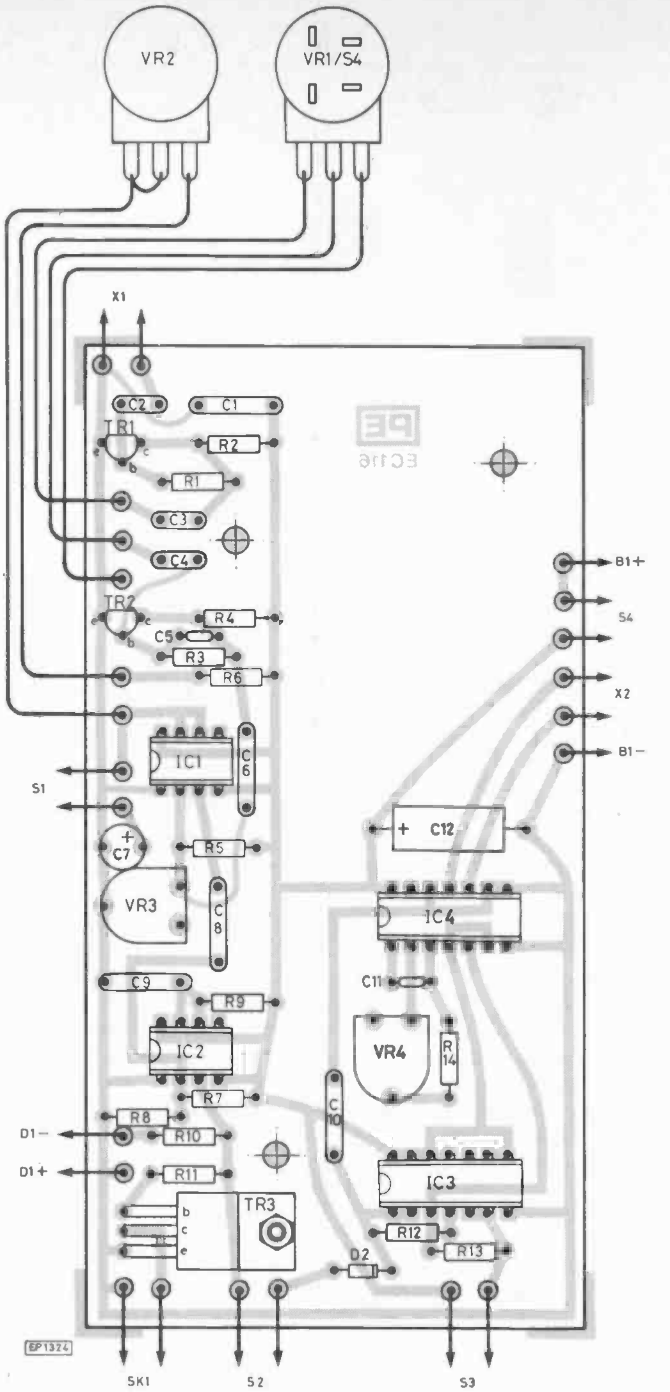


Fig. 3. P.c.b. and component layout (right)

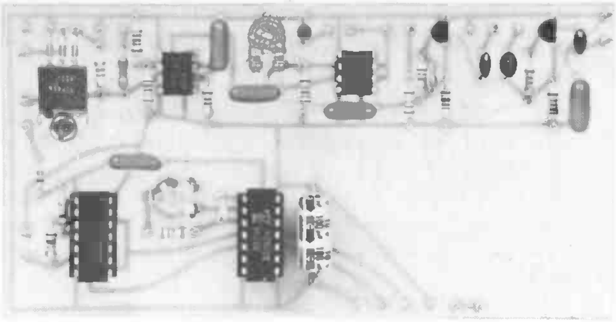
The two monostables are both based on 555 timer i.c.s. IC1 provides the delay which can be adjusted by means of VR2 from about 25 milliseconds with VR2 at minimum resistance to about 2·5 seconds with this control at maximum value. This gives a useful delay range, but obviously the value of timing capacitor C7 can be altered to give a longer or shorter delay range if desired. Any change in the value of C7 has a proportional effect on the timing range. When S1 is open C7 is switched out of circuit so that the output pulse from IC1 (and the delay) are of insignificant length. R5 and VR3 bias the trigger input of IC1 above the trigger threshold of 1/3 V+ so that the circuit is triggered by a negative output half cycle from TR2, when a suitably strong input signal is present. If necessary, VR3 can be adjusted to optimise the sensitivity of the circuit.

R8 and R7 bias the trigger input of IC2, and C8 capacitively couples the output of IC1 to the input of IC2 so that the latter is triggered at the end of the output pulse from IC1 as its output reverts to the low state. The output pulse length of IC2 is fixed at about 1·1 seconds, and this is long enough to ensure that the camera is operated reliably. Indicator D1 is switched on during the output pulse from IC2, and this is helpful when setting up the equipment ready for use. TR3 is used to trigger the camera, and as this might have to handle quite high currents a power transistor is used. If a flashgun trigger rather than a camera trigger is required it is necessary to replace TR3 with a triac (a 400V 1A type is suitable).



The transmitter is based on IC4 which is a CMOS 4047BE astable/monostable multivibrator. In this circuit it is used in the true gating mode, and the control signal at pin 5 must be high in order to produce oscillation. C11, R14, and VR4 are the timing components, and VR4 is used to trim the output frequency for optimum results. The 4047BE has both Q and not Q outputs, and the transmitting transducer is driven direct with the antiphase signals provided by these.

The latch is a simple CMOS type formed from two 2 input NOR gates wired as inverters, and having positive feedback provided by R12. The other two gates of IC3 are unused and their inputs are tied to the positive supply rail. At switch-on C10 sets the latch with the input of IC3a low and its output high so that the transmitter is switched on. When the output



The completed board

of IC2 goes positive the latch is triggered to the opposite state and the transmitter is switched off, but only if S2 is closed. D2 prevents IC2 from resetting the latch at the end of its output pulse, but the latch can be reset using S3.

As the circuit has a current consumption of about 20 milliamps or so and is likely to be used for long periods of time it is advisable to power it from a high capacity battery such as six HP7 cells or six AA NiCad batteries fitted in a plastic battery holder.

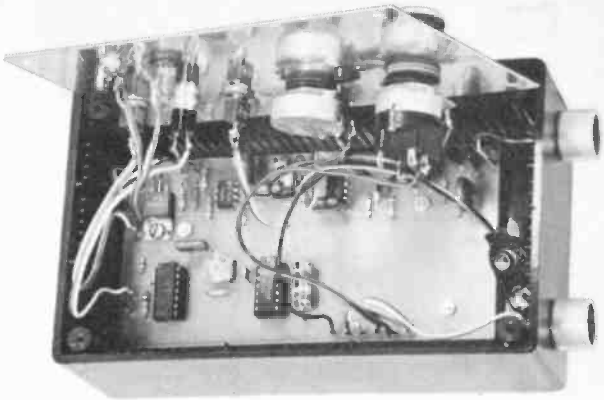
CONSTRUCTION

Details of the printed circuit board and wiring are provided in Fig. 3. As IC3 and IC4 are MOS devices it is advisable to fit them in i.c. sockets and to take the other normal MOS handling precautions. Note that IC1 and IC2 have the same orientation as IC3 and IC4. TR3 is mounted horizontally on the board and is bolted in place.

A plastic box having an aluminium lid and approximate outside dimensions of 150 by 90 by 50mm is suitable as the case for this project. The two transducers are mounted at one end of the case, as far apart as possible. The easiest way of mounting them is to drill small holes in the case to take the two terminal pins of each one, and to then glue them in place using a good quality general purpose adhesive. The controls, D1, and output socket are mounted on the lid of the case, and the printed circuit board is bolted to the base panel. The hard wiring is then added. The pin which connects to the casing of X1 is wired to the negative supply rail and the other pin connects to C2. It does not matter which way round X2 is connected. Incidentally, the two transducers are identical.

IN USE

The connection from the camera to the trigger unit is made using an electric cable release with the push button



switch removed and a 2·5mm jack plug (which plugs into SK1 on the trigger unit) connected in its place. The plug must be connected with the right polarity, and a multimeter is used to determine the polarity of the voltage on the cable when it is connected to the camera. The tip of the plug is connected to the positive lead and the barrel connects to the negative lead. Few cameras have an electronic shutter which can be triggered by an external switch, but many SLRs these days can be electrically triggered via an autowinder or motordrive. The prototype has been tested with a Minolta XD7 which is directly triggered, and a Pentax LX triggered via the autowinder, and it should work properly with any camera that can be controlled electrically.

If the unit is used with a flashgun (and this should only be attempted if TR3 has been replaced with a suitable thyristor or triac), the connection to the flashgun can be made using a flash extension lead. The plug which would normally connect to the camera is removed and replaced with a 2·5mm jack.

VR4 can simply be adjusted by trial and error to find a setting that gives good results. If an a.c. millivoltmeter is available this can be used to monitor the signal level at the collector of TR1, and VR4 is then adjusted to peak this signal level.

Results will probably be satisfactory with VR3 set at about half maximum resistance. If the unit does not trigger with the transducers aimed into empty space and VR1 set for maximum sensitivity it should be possible to obtain a small increase in the maximum sensitivity by adjusting VR3 for slightly lower resistance (turning it in a clockwise direction). If it is adjusted too far though, IC1 will be continuously triggered and the circuit will fail to operate at all.

A trigger of this type works most effectively when the object to be photographed will be well clear of anything that would provide reflected signals. VR1 can then be well advanced without any unwanted reflections triggering the unit. A little experimentation with the unit should soon determine what can and cannot be achieved, and how it can best be used. ★

The Technology

Chris Kelly

MOST of us listen to records at some time, whether as casual background music or to be entertained by virtuosos. We like to think that the sound we hear is as 'true to life' as possible and recent years have seen remarkable advances in sound reproduction. But we are about to witness a revolution in the machines we use to play back the music: we are entering the age of computerised consumer electronics and hi-fi is no exception. The digital audio disc (DAD) has been launched carrying the commercial name of compact disc or CD.

Our perception of reproduced sound quality is becoming more and more critical. Because of the poor sound quality of the first commercial records of the early twentieth century, certain musical instruments did not record well. Musicians had to play the bassoon for the part of the cello and the tuba for the part of the double-bass. Few people seemed to mind in those days. The early Edison machines were regarded as 'true to life' sound, indistinguishable from the real thing.

Today we have progressed to sophisticated replay systems where the sounds can be classed as high fidelity or hi-fi. But the conventional vinyl long playing record still depends on a stylus vibrating in a bumpy groove. The stylus recreates electrical waveforms which represent the frequency and amplitude variations of the original sound: analogue from source to loudspeaker.

GOING DIGITAL

Now a new type of 'record' and 'record player' are being marketed by the top manufacturers. The compact disc is only 120mm (5 inches) diameter yet has a playing time of up to 60 minutes with the sound information on one side.

The CD rotates like a record, it is not touched by a stylus but scanned by a small low-powered laser built into the CD player. The disc provides information about the sound in the same way that computers handle information: using binary pulses or 1s and 0s, in digital terms. The bit stream obtained by detecting microscopic pits on the disc is constant at over 4 million bits per second (Fig. 1.). The disc rotates at 500 r.p.m. when the laser starts at the centre, and slows to 200 r.p.m. as it follows the spiral of pits to the outside.

Having been detected by the laser and converted to electrical pulses by a photo-diode, the digital codes are separated into two channels for stereophonic reproduction and eventually conver-

Digital disc and Philips CD100 player

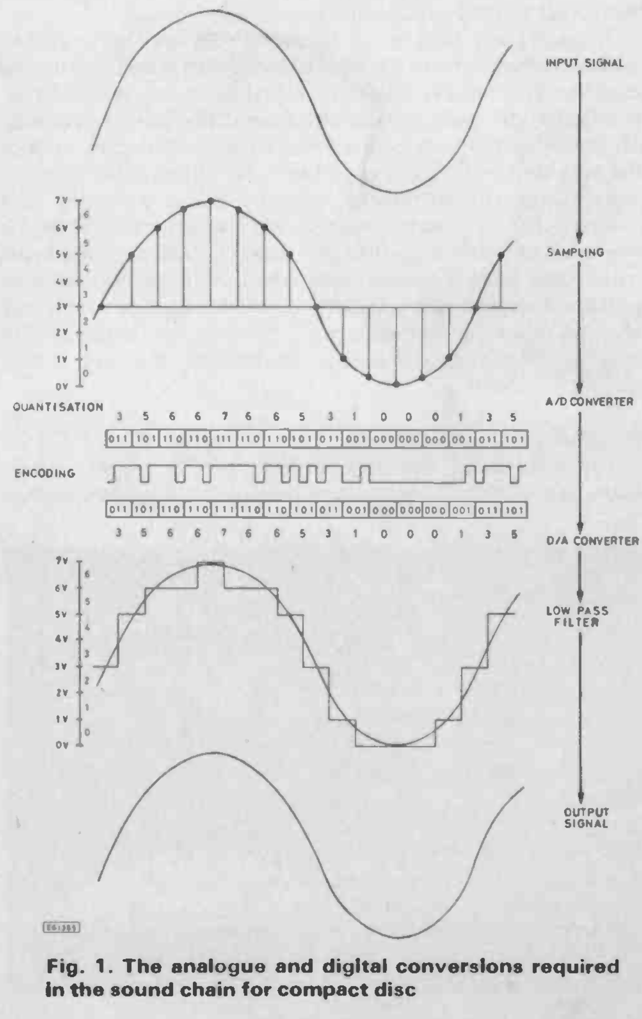


Fig. 1. The analogue and digital conversions required in the sound chain for compact disc

ted to analogue sound using digital to analogue converters (DACs). See Fig. 2.

The analogue audio output from a CD player can be connected into any line-level input of existing amplifiers or music centres. Connection is possible to tape or auxiliary inputs but never

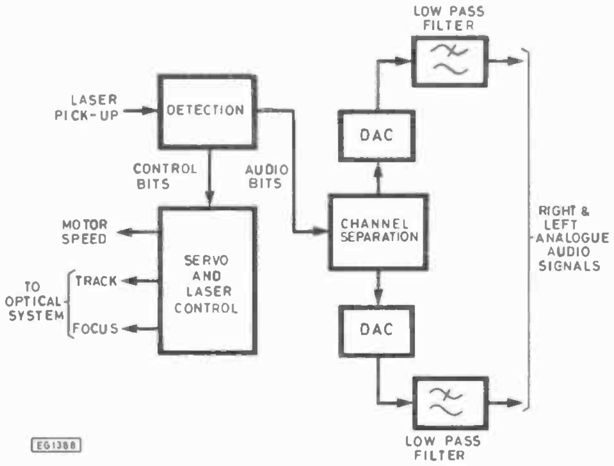
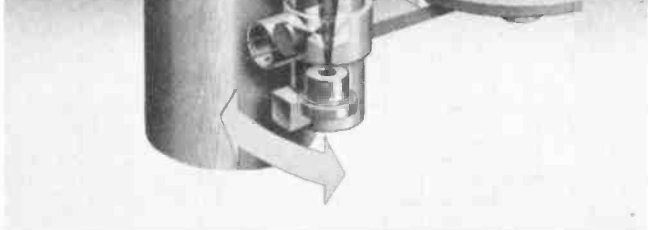


Fig. 2. A simplified block diagram showing the basic functions of a compact disc player

to the phono input because the signal level is too high. This means that conventional record decks can still be used alongside the CD player and you don't have to abandon your treasured collection of l.p.s.

The digital information on the disc is protected by a layer of clear plastic, so the discs are more robust than normal vinyl lps; we all know how easily they are scratched! The CD can suffer a number of scratches and finger marks without degrading the sound quality of the music because the laser focuses right through them.

Also, even if a certain number of bits are lost (generally called drop-outs), sophisticated error-correcting codes are used to restore the information. This does not mean that CDs can be used as beer-mats as suggested by one writer. Surface scratches, finger marks and beer stains eventually cause too many drop-



A laser beam is directed through the transparent side of the disc and onto the disc track by the optical system. This is carried on a servo-controlled arm which tracks radially from the inside to the outside. The reflected information is converted to electronic pulses by a photo-diode

outs for the information to be restored and an interruption is heard in the music. So contrary to popular belief, CDs do require careful handling and the occasional clean with a soft cloth. Some CD players *hard-mute,* meaning that the audio signal drops to zero when drop-outs occur and this is far more noticeable than the *soft-mute* as provided on the Philips and Marantz machines which are programmed to make an educated guess at what sound should be provided.

Apart from robustness, the CD offers listeners better quality sound with less distortion (typically 0·005% THD) and no audible background noise. You may be surprised how accustomed we have become to hearing scratching and hissing noises behind the music provided by conventional lps. This is caused by the stylus detecting surface roughness in the vinyl. The silence behind music from CD is uncanny! Only the occasional but quiet tape-hiss from the original master-tape can be heard if it is an analogue recording. Digitally recorded music is 'clean'.

The background silence of CD provides no audible cue as the surface noise of lps does. New users of CD may be tempted to turn the volume up far too high so that the opening bars of music could well be an un-neighbourly crescendo lifting speakers from the floor, or even worse, blasting ear drums if the listener is wearing headphones.

The stereo image, that is the apparent position of instruments and singers as presented to the listener, is rock steady from CD because of a 90dB channel separation and negligible phase shift over the whole audible sound range. Conventional pick-ups provide slightly over 30dB channel separation at best and this is subject to phase changes over the frequency range giving an unstable stereo image.

DAD DEVELOPMENT

The Dutch company of Philips began investigating the possibility of a compact disc in the late 1960s. They worked out a standard format, inviting Sony in the later stages to design the fast error-detecting codes which were very important to the feasibility of the idea. This standard was eventually adopted by almost all of the major hi-fi equipment manufacturers. Philips were anxious to avoid the proliferation of incompatible systems that resulted in the failure of quadraphonics in the early seventies and the confusion which exists today over video tape systems.

Compact disc prototype players were demonstrated in 1981 and were not enthusiastically reviewed by the hi-fi press. Poor musical material and heterodyne whistles were heard and all this produced by equipment packed into many suitcases as the very large scale integrated circuits were still being designed. Some journalists predicted its death before it was launched and they seemed particularly derisive when launch delays were announced and the disc and player prices were found to be higher than anticipated.

The actual launch in Japan in late 1982 and in Europe early in 1983 proved the critics wrong. In the first few weeks players and discs were sold out and production was stepped up to meet a healthy demand. And, as if to clinch its acceptance, recording artists such as Paul McCartney were demanding that their work be released on the new medium.

TECHNICAL DETAILS

In practice, a CD player is an extremely complex piece of equipment. Far more than just audio information is encoded on the disc such as index details which give the number of tracks and location of tracks on the disc. The more sophisticated players will display the title of the disc.

All this digital information is encoded onto the disc in a very complex format in order to reduce the possibility of errors when being read. The information is divided into frames; Fig. 3 gives one frame of the successive bit streams. There are six sampling periods for one frame, each sampling period giving 32 bits (16 for each of the two audio channels). These 32 bits are divided to make four symbols in the 'audio bit stream' B_1. In the 'data bit stream' B_2 eight parity and one C&D (Control and Display) symbols have been added to the 24 audio symbols. To scatter possible errors, the symbols of different frames in B_1 are interleaved, so that the audio signals in one frame of B_2 originate from different frames in B_1. The modulation translates the eight data bits of a symbol of B_2 into fourteen channel bits, to which three 'merging bits' are added (B_3). The frames are marked with a synchronisation signal and the final result is the 'channel bit stream' (B_4) used for writing on the master disc, in such a way that each '1' indicates a pit-edge (D). This technique is called eight to fourteen modulation or EFM.

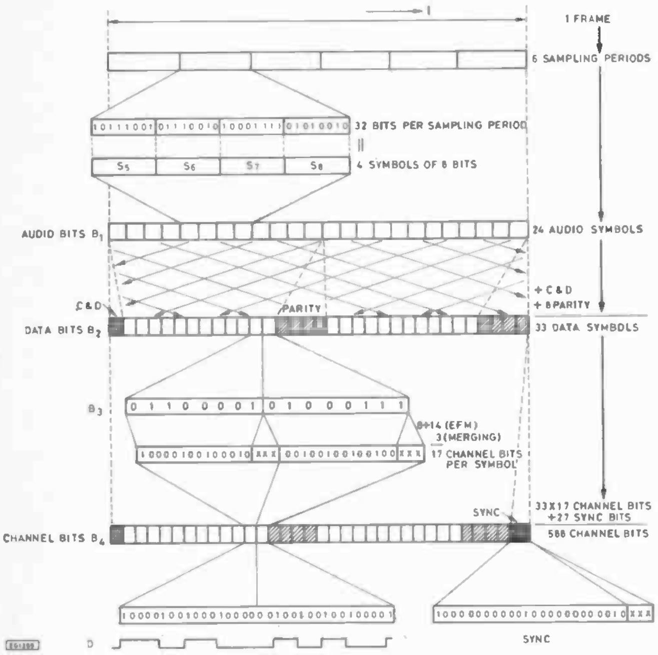


Fig. 3. Bit streams in the encoding system (Courtesy Philips Technical Review)

It can be seen that to the 14-bit data codes are added synchronisation bits, control and display information and sophisticated error correction codes CIRC (Cross Interleave Reed-Solomon Code) to make up a complete frame. This method involves a lot of extra information which is not always needed but enables the signals to be restored if some of the original information is lost or corrupted in any way.

To provide all this information quickly enough, the bit stream leaves the disc at a rate of over four million bits per second! Although the disc spins with the normal slight fluctuations of speed, a first-in first-out (FIFO) buffer store is employed to absorb the irregularities (Fig. 4). The data is clocked out of the store under the control of a crystal oscillator. However, the bit stream from the disc must be reasonably constant so a servo system spins the disc initially at 500 r.p.m. when the laser is nearest the centre and progressively slows it to 200 r.p.m. as the laser moves to the outer edge during play.

The CIM (Concealment, Interpolation and Muting) circuit deals with errors that are only detected since they cannot be corrected; these are 'masked' or concealed.

The standard sampling frequency was chosen at 44·1kHz, conveniently satisfying Nyquist's sampling theorem which states that in order to fully reconstruct a waveform it must be sampled at a rate of at least twice the highest frequency in the waveform.

Most CD player manufacturers have designed their systems around 16-bit DACs followed by analogue low-pass filters in each channel which are expensive and introduce small phase errors. Philips and Marantz, however, have opted for fast 14-bit converters which read the digital information at a rate equal to four times the normal 44·1kHz sample frequency. This is achieved by processing the 44·1kHz information from the disc using a digital transverse filter TDF in each channel.

The apparently faster sampling rate of 176·4kHz, called oversampling, spreads most of the quantisation noise out of the audio frequency range and this is filtered using sophisticated digital filters which are really mathematical processors working on the digital information prior to analogue conversion. The overall result is 16-bit performance with no phase error from circuitry which is cheaper and simpler to manufacture in the long term.

THE DISCS

Software is the name often given to the musical content of the discs and the initial batch of releases received mixed reviews. Of the 200 early titles only 20 or so were considered first rate both artistically and technically. The remainder were so exposed by the faithfulness of the CD system that poor recording techniques such as bad microphone positioning, audible edits in the master-tape and unusual balance of the musical components were scrupulously revealed.

However, considering the vast amount of mediocre to poor material published on vinyl since the advent of the microgroove l.p., we can conclude that the CD is doing somewhat better. Some reviewers tend to compare the worst of compact discs with the best of vinyl l.p.s. When compared best for best the compact disc is superior in every way.

One reason for a so-called 'bright' reproduction on some CDs is that the original master recordings were engineered for the vinyl l.p. which is known to depress the high frequencies in the pressing process. Recording engineers sometimes deliberately boosted the high frequency in recording to compensate for this loss, yet CD reproduces this faithfully. It is generally realised in the recording industry that recording techniques will be modified

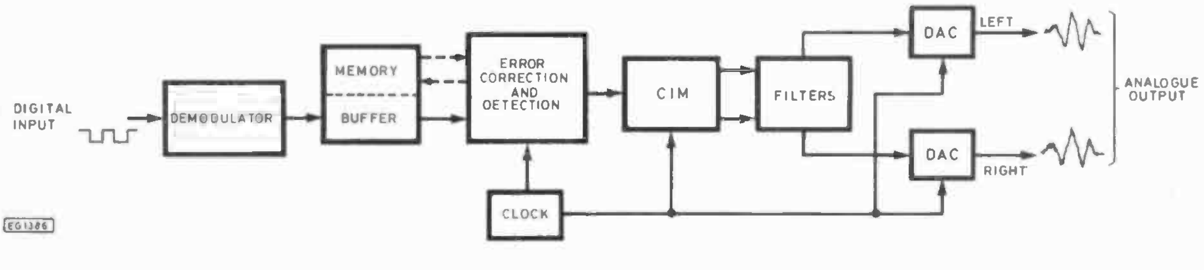


Fig. 4. Block diagram showing the signal processing in the compact disc player. The degree to which the buffer memory capacity is filled serves as a criterion in controlling the speed of the disc

to take full advantage of the new medium.

A few 'golden-eared' hi-fi reviewers have claimed that they can hear the odd harmonics caused by quantisation, particularly at lower frequencies (Fig. 5) where the transitions between levels may be much lower than 44·1kHz because of the slowly changing waveform. Some have claimed that the low frequency steps give harmonics which are not filtered from the audio range giving a 'graininess' to the music. Most of us mortals with normal audio faculties hear, as near as possible, the sound that is heard in the recording studio. To put this to the test recently an assembled group of top reviewers listened to the CD replay compared directly with the most sophisticated studio tape machine. They all conceded that they could not tell the difference.

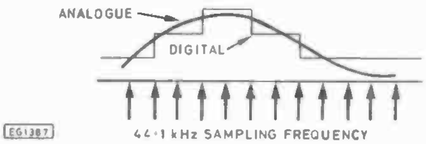


Fig. 5. A low-level low-frequency signal digitised. The transitions between levels can be at a much lower frequency than the 44·1kHz sampling rate

The conclusion is that the CD medium is almost totally transparent, permitting the listener to hear clearly what was recorded on the master-tape. But we are all subjective beings and as such hear and assess sound quality according to our own preferences. The hi-fi press have consistently hailed the Philips/Marantz machines as having a more subtle, ambient sound than the Japanese machines. Yet I know of someone with a very expensive hi-fi system who has auditioned most of the CD players at home on his own system and produced a list of preferences in reverse order to what the experts told him.

It all boils down to personal taste. If you like the sound of a particular CD player on your system, ignore the experts: they have a vested interest in controversy.

THE FUTURE

Second generation CD players are already being designed and when they are launched they will be claimed as being easier to use, providing more information (such as track titles, playing duration, etc) and probably hailed as producing better quality sound.

Present CD player prices will hold steady until the original research and development costs are recovered. This may be some time because the launch prices of £500 to £650 can only leave a lean profit margin on this highly sophisticated technology. Ultimately the prices should fall to the £200 to £400 level.

The disc prices should fall in real terms, eventually leaving little difference between the price of a CD and the conventional l.p. It is not expected that vinyl l.p. sales will rapidly decline. CD is offered as supplementary, not as a replacement. Some have predicted that the vinyl l.p. will be dead within ten years, but it is my guess that there will still be a market for the analogue enthusiast.

There is news of a possible alternative system from the USA. A company called Soundstream have developed a digital 'card' player where a postcard sized plastic card is slowly moved past a rotating lens system and a laser beam detects the information (See PE July 83, *Patents Review*). This is potentially cheaper in terms of the player and 'card' manufacture, but as yet there is no commitment by any manufacturer. As advertisements for CD claim 'Pure, perfect sound forever—and it's available now.' The first in the market-place has a distinct advantage in setting standards. ★

VERNON TRENT *at Large!*

V.T.'s views and opinions are entirely his own and not necessarily those of PE

THE rest of the kids in our street were normal enough. They all wanted to be engine drivers. Not so your humble servant. I went through an impressive list of aspirations: brain surgeon, Master of the Rolls, Chief of the Imperial General Staff, even Prime Minister until I read somewhere that Chequers can be a bit chilly in the winter.

But probably my most burning ambition was to be a farmer. That yen lasted a long time. It was sparked off by an idyllic week spent on a farm in the Home Counties under the auspices of the Children's Country Holiday Fund which in those days catered at rock-bottom cost for the offspring of parents in straitened circumstances. Mine were that alright.

Reared in the concrete jungle of Central London, it was my first real taste of the pastoral existence. Acres of green earth, an old flagstoned farmhouse, great lumbering horses pulling ploughs, friendly old cows, agile chickens, weatherbeaten men with bits of string tied below their knees (to stop the rats running up their trousers, they told me), vast quantities of wholesome food and air that tasted like new wine. It all gave me a sense of heritage.

But apart from the personal pleasure, that glorious week engendered for me an abiding respect and admiration for people who get their living from the land. They worked long hours in all weathers for low pay. There was always some chore to perform. They were never off duty. And they found their reward in doing a vital job superbly well and in a life, it seemed to me at the time, untouched by the stresses of other callings and one that appeared practically immune to change.

Just how rose-tinted were my spectacles was brought home to me recently when I went along to the Ministry of Agriculture, Fisheries & Food (I wonder who looks after Drink?) to learn how far modern electronic technology has invaded the farmer's world. The indications are that in many cases it has taken over almost completely.

The man from the Ministry—who, because Civil Servants are quite properly a self-effacing breed, must remain nameless—told me that computers have been playing a part in farm management for more than 20 years. And now that they are coming down in price and becoming more and more versatile, so their application to farming services is growing.

"The use of electronics in farming is an evolutionary process," said the M from the M. "As devices and systems become more sophisticated, so the farmer is provided with more opportunities for greater efficiency and more streamlined management.

"Take animal husbandry, for example. Many procedures have become virtually automatic." Milk can be weighed, yields can be monitored, cows can be fed, changes in temperature and deviations from the normal can be detected and recorded. Even getting a cow into a byre is becoming an automatic operation.

"The larger farms, of course, are the biggest users." But, as a result of this process of evolution I mentioned, smaller farms, too, are gradually following suit.

"So much in agriculture depends on the cycle. A cow, for instance, ovulates every 21 days." If you can't get her in calf then, you haven't a hope of doing it the day after and every month you miss costs money. She still has to be fed. The same goes for crops. A whole year can be lost in that sector if you miss out on the cycle. That's why the more information you can cull, the greater the control you can exercise, the more profitable and efficient farming—which is big business today—becomes. This is where modern technology is proving so helpful. "You can now, for example, control a tractor to plough a field."

"A cow for instance ovulates every 21 days"

The Ministry's Agricultural Development & Advisory Service goes all out to aid and encourage farmers and growers in the application of computers and electronics. Exhibitions are staged annually by ADAS at which the newest advances are shown by equipment manufacturers. The most recent of these was held at Stoneleigh, Warwickshire, last Autumn. More than 120 firms participated.

Every aspect of computers and electronics in farm management was covered, from financial forecasting and analysis to the electronic control and operation of intensive feed systems.

In a special supplement, published to coincide with the Stoneleigh show, Farmers Weekly reported a number of case histories to illustrate that the use of computers and electronics pays off. A pig farmer in North Humberside, for example, is using a computer to give him a constantly updated picture of every aspect of his activity. So is a Buckinghamshire turkey breeder. Likewise other farmers in Abingdon, Exeter and Salop.

In North Yorkshire a spraying contractor has invested £2000 in a radar control unit to take a lot of the hard work out of accurate crop-spraying. A farmer near Basingstoke reckons to have cut electricity consumption by around 30 per cent by adding automatic humidity controllers to his grain and grass drying and storage system.

Romanticists—and at heart I'm one of them, I'm afraid—may mourn the passing of the old rustic scene of yesteryear when 'Dick the shepherd blows his nail and milk comes frozen home in pail' (Shakespeare, I think, but correct me if it wasn't). But one has to be realistic. Electronics is here to stay. Even down on the farm.

The fruits of fame, though always welcome, do not always seem logical.

Take the case of our newest electronics knight, Sir Clive Sinclair. Only a churl would deny admiration of this man of talent and energy who has helped to show the supposedly invincible Japanese the side, if not the back, door. History throws up such a person only rarely and we should be thankful.

Nevertheless, it is hard to accept that because a man has achieved distinction as an innovative entrepreneur in the technical and industrial field, he should automatically be regarded as an instant pundit on everything else that affects the human life.

I have just been listening on Radio 4 to a broadcast of the programme *Any Questions* in which Sir Clive, along with others whose authority might also be brought into question, was asked to pontificate on such matters as dispersal of IRA terrorists to a number of prisons instead of being lumped together (for as long as it could hold them) in the Belfast Maze: the kind of advice one should give to a daughter about to start her first term at university (the scope here was enormous); whether children should be corporally punished at school; how to solve the labour problems at Vauxhall (how, indeed); and whether your average Civil Servant knows what day it is.

I must say that, because he's a man who thrives on challenge, Sir Clive performed well on all counts. Where he really shone, of course, was when he was asked to comment on the effect of home computers on family life. His answers were constructive, if predictable, but I did detect a wince—even though the programme was in sound—when co-panellist Gerald Kaufman MP went so far as to describe computer techniques as an advanced form of Scrabble.

But I still pose the question: is it sensible that because a man hits the jackpot in one area he should be rated as an oracle in every other? Does a mastery of one discipline spell all-embracing erudition?

Rejoice with the canary. For many years, certainly as long as I can remember, they have been carried by face-workers into mines to detect the presence of noxious gases. Now all that is to be changed. Our feathered friends are, according to a newspaper report, to be sent to good homes when their essential office is taken over by electronic devices. Giving the bird to canaries can only be a good thing. But what about other forms of animal life? Do they still have pit ponies staggering about below ground? If so, is technology looking at ways for their liberation? I only asked.

It was encouraging to hear that ITV will be launched into space by 1987. We already know that the BBC has the go-ahead for 1986. If we are to be bombarded by a plethora of programmes—irrespective of their quality and entertainment value—it is as well that the blame is evenly distributed.

PE micro-file

R.W.Coles

FILESHEET 13 Z8

STILL on the theme of single chip microprocessors, and following the cheap but primitive Intel 8748 and the elegant, new, Motorola 68701, we now come to the powerful but rather ugly Zilog entry, the Z8.

The main problem I faced in writing about the Z8 family was in deciding which particular member I should feature, since in fact there are several devices which could be used in hobby applications although none of them has the desirable feature of on-chip EPROM. The Z8 part number is really a generic title, and no one device in the family is actually coded Z8, although most people do refer to whichever chip they are using as "A Z8" anyway, which is why I have used this number as the file-sheet heading.

All the family devices share the same basic architecture, with differences only in the type and quantity of memory provided, so in the end I decided to do the Z8603 because it is the easiest to compare with the 8748 and 68701 by virtue of its use of EPROM. *Not* true on-chip EPROM, in this case however, but "piggy-back" EPROM, utilising a 2716 which plugs into a 24 pin socket on the upper surface of the 40 pin microprocessor package.

At first sight this "piggy-back" scheme seems very attractive since it allows the use of low-cost EPROMs which can be programmed in a standard PROM programmer, but unfortunately the complexities of connecting 24 address, data, and power lines to a 24 pin socket within the confines of the 40 pin microprocessor package actually makes this technique more expensive than true on-chip EPROM in which all the interconnections are made at the chip level.

The Z8603 is one of three devices in a sort of Z8 sub-family led by the Z8601 which uses masked ROM and is intended for mass production. Both the Z8601 and the Z8603 have a 2K byte ROM/EPROM space and 144 bytes of on-chip RAM organised as a large register file. Each device has 32 programmable I/O lines, a full duplex UART for serial communications and two 8 bit timer/counters. The third device in this sub-family is the Z8602 which is intended only for development tasks since it has no on-board ROM or EPROM but has 24 additional lines brought out for the connection of external memory instead. As a result, the Z8602 uses a large and expensive 64 pin package, and is unlikely to be useful for hobby applications.

Also available is the more recent Z8611, Z8612, Z8613 sub-family which has provision for 4K bytes of ROM or EPROM but is otherwise identical to the 01, 02, 03 series.

At the risk of confusing you further, there are two more family members which have special relevance, the Z8681 and the Z8671. The Z8681 is useful since it is (like the Intel 8035 and the Motorola 6803) intended for use with external EPROM but it achieves this by using a multiplexed address/data scheme so that it can take advantage of a cheaper 40 pin package.

The Z8671 is interesting (and useful) because it is a pre-programmed Z8601 featuring a 2K "Tiny BASIC" interpreter in the masked ROM. When used with an external RAM the Z8671 can accept BASIC programs entered via a VDU or similar terminal, and then run directly without the user needing to be involved with assemblers or machine code.

The advantages of high level language programming are offset to some extent by the much slower execution speed, but nevertheless the Z8671 is very useful for non-time critical applications such as burglar alarms or central heating controllers. There is more information on the BASIC used in the software section below, and in the next Microfile I will be featuring another single-chip BASIC machine, the National 8073.

The Z8 family came along after the Intel 8048 of course, but it has caught on well with users, despite higher prices, thanks to its powerful high speed architecture. One particular area where Zilog reigns supreme is in the disc drive controller market where, to-date, no other single chip processor has been able to operate fast enough to deliver the required data throughput rates.

Despite its acknowledged power however, the Z8 is a real chip off the Zilog block and suffers from all the ugly-duckling problems of its bigger Z80 and Z8000 brothers. True to form, Zilog have traded elegance and simplicity for raw power, and have shoe-horned in every possible hardware and instruction set extra in the interests of performance, even when this adds considerable complexity for the user. Also in the Zilog tradition is the lack of compatibility with any of the other Zilog microprocessor families, although Z80 fans will probably feel at home with most features of the Z8 family.

REGISTERS

All Z8 devices, including the Z8603, have 144 bytes of RAM available on the chip and every single RAM byte either is, or can be, used as a register. The only register not mapped into the RAM area is the program counter which is a full 16 bits long allowing up to 64K bytes of program memory in an expanded system.

There is no special accumulator register, since all 124 general registers in the RAM register file can be used as accumulators, address pointers, or even index registers, in addition to their use for temporary data storage. As well as the 124 general registers, there are 20 "specials" which include a register pointer which can be used to address any one of the nine groups of sixteen registers available to provide a working register area. Use of the register pointer allows rapid access to the working register group since only four bit addresses are needed and these can fit into fast one or two byte instructions. Although the register pointer is nominally an eight bit register, only the most significant four bits are used to specify the working area.

Also in the group of twenty "specials" is the 16 bit stack pointer which uses two locations. Like the 68701 the Z8 family can have a stack anywhere in memory and of any depth, allowing unlimited subroutine nesting and the use of PUSH and POP instructions for register save/restore operations.

Although a 16 bit stack pointer is useful in some extended applications it cannot be used to the full in a basic single chip system, because of course the stack will have to be in the register array, leading to a dangerous "dual-function" conflict which the programmer has to beware of. In small systems the best ploy for saving registers is simply to swap to a new working group by altering the register pointer value. Subroutine CALL and RETURN operations and interrupts, however, will always invoke use of the stack, and so some of the internal RAM will have to be set aside for that purpose, even in small systems.

Also in the "specials" is an 8 bit flag register which contains the usual Carry, Zero, Sign, Overflow and half carry flags, plus a "Decimal adjust" flag for BCD operations and two "User flags" which can be set, reset and tested as required by the programmer.

All the other special registers are associated in some way with the extensive I/O capabilities of the Z8 processor. There are four registers corresponding to the four 8 bit I/O ports available, and three more for defining the modes of these ports. Only three mode registers are needed because ports 0 and 1 share a register due to their interrelated secondary function as memory/address buses.

Z8 REFERENCE FILE SHEET

GENERAL

The Zilog Z8 single chip NMOS processor family is ideal for fast real-time applications where its dual operand instructions and high speed architecture can be used to advantage. Although there is no Z8 family member with on-chip EPROM, the Z8603 version (featured here) does have a piggy-back socket for an external EPROM such as the 2716. A rather complex chip, the Z8 features 2K bytes of ROM/EPROM, 144 bytes of RAM, a UART, two timer/counters and 32 I/O lines and has the raw power to handle most single-chip applications with ease.

REGISTERS, PORTS & MEMORY

The Z8 family all have a large on-chip register file (or RAM) memory area into which all the special registers and I/O ports are mapped together with no less than 124 general purpose registers. Only the program counter is not memory mapped. In total there are 144 bytes of on-chip register/RAM.

	7 … 0	
255	STACK POINTER LO	SPL
	STACK POINTER HI	SPH
	REGISTER POINTER	RP
	FLAGS	FLAGS
	INTERRUPT MASK	IMR
	INTERRUPT REQUEST	IRQ
	INTERRUPT PRIORITY	IPR
	PORTS 0 AND 1 MODE	P01M
	PORT 3 MODE	P3M
	PORT 2 MODE	P2M
	T0 PRESCALER	PRE0
	TIMER/COUNTER 0	T0
	T1 PRESCALER	PRE1
	TIMER/COUNTER 1	T1
	TIMER MODE	TMR
240	SERIAL I/O	SIO
	NOT USED	
127	124 GENERAL REGISTERS WORK AS ACCUMULATORS OR INDEX REGS.	
4		
3	PORT 3	P3
2	PORT 2	P2
1	PORT 1	P1
0	PORT 0	P0

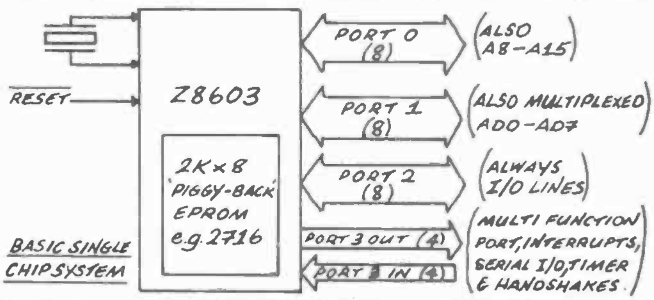
15 PROGRAM COUNTER 0

FLAGS

7	6	5	4	3	2	1	0
CY	ZERO	SIGN	OVF	DAA FLAG	AUX CARRY	USER FLAG F2	USER FLAG F1

INSTRUCTION SET & SOFTWARE

Like the Intel 8048, the Z8 has an instruction set tailored specifically for high speed controller applications where compact and efficient code is more important than ease of programming. Although the Z8 is optimised for assembly language programming, one version, the Z8671 has a Tiny BASIC interpreter in the on-chip ROM area. There are no readily available standard software packages and no DOS.



PERFORMANCE DATA Z8603

MEMORY ADDRESS RANGE :- 64KB DATA PLUS 64KB PROG.

I/O ADDRESS RANGE :- MEMORY MAPPED

CLOCK FREQUENCY :- 8MHz*

POWER SUPPLIES :- 5V

INTERRUPTS :- IRQ0 – IRQ3

* 12MHz ALSO AVAILABLE

BENCHMARKS	Z8603
ADD REGISTER TO ACCUM. ①	0·75μS
O/P ACCUM TO PORT ②	0.75μS
MOVE MEMORY TO MEMORY ③	1.25μS

① 4 BIT ADDRESSES ② 4 & 8 BIT ADDRESSES
③ 8 BIT ADDRESSES

		Z8603		
+5V	1		40	$P3_6$
XTAL 2	2		39	$P3_1$
XTAL 1	3		38	$P2_7$
$P3_7$	4		37	$P2_6$
$P3_0$	5		36	$P2_5$
$\overline{RESET}$	6		35	$P2_4$
$R/\overline{W}$	7		34	$P2_3$
$\overline{DS}$	8		33	$P2_2$
$\overline{AS}$	9		32	$P2_1$
$P3_5$	10		31	$P2_0$
GND	11		30	$P3_3$
$P3_2$	12		29	$P3_4$
$P0_0$	13		28	$P1_7$
$P0_1$	14		27	$P1_6$
$P0_2$	15		26	$P1_5$
$P0_3$	16		25	$P1_4$
$P0_4$	17		24	$P1_3$
$P0_5$	18		23	$P1_2$
$P0_6$	19		22	$P1_1$
$P0_7$	20		21	$P1_0$

OTHER FAMILY MEMBERS

Z8601	FOUNDER MEMBER USING MASKED ROM. OTHERWISE SAME AS Z8603.
Z8602	ROMLESS Z8 IN 64 PIN PACKAGE WITH ALL I/O PORTS & MEMORY BUS.
Z8681	ROMLESS Z8 IN 40 PIN PACKAGE AND WITH MULTIPLEXED MEMORY BUS.
Z8611	Z8612, Z8613 AS Z8601, 02, 03 BUT WITH 4K ROM/EPROM.
Z8671	PRE-PROGRAMMED Z8601 CONTAINING TINY-BASIC INTERPRETER.

MANUFACTURERS

ORIGINATOR : ZILOG

2ND. SOURCES : SYNERTEK, SGS

SUPPORT CHIPS

ALTHOUGH THE Z8603 IS A COMPLETE FUNCTIONAL UNIT WITH RAM, EPROM, PARALLEL PORTS, SERIAL PORT AND 2 TIMERS, IT CAN ALSO BE EXPANDED WITH EXTERNAL MEMORY MAPPED PERIPHERALS FROM THE 8080 OR Z80 FAMILY.

INSTRUCTION SET SUMMARY

Instruction and Operation	Addr Mode dst	Addr Mode src	Opcode Byte (Hex)	Flags Affected C Z S V D H
ADC dst,src dst ← dst + src + C	(Note 1)		1□	* * * * 0 *
ADD dst,src dst ← dst + src	(Note 1)		0□	* * * * 0 *
AND dst,src dst ← dst AND src	(Note 1)		5□	– * * 0 – –
CALL dst SP ← SP - 2 @SP ← PC; PC ← dst	DA IRR		D6 D4	– – – – – –
CCF C ← NOT C			EF	* – – – – –
CLR dst dst ← 0	R IR		B0 B1	– – – – – –
COM dst dst ← NOT dst	R IR		60 61	– * * 0 – –
CP dst,src dst - src	(Note 1)		A□	* * * * – –
DA dst dst ← DA dst	R IR		40 41	* * * X – –
DEC dst dst ← dst - 1	R IR		00 01	– * * * – –
DECW dst dst ← dst - 1	RR IR		80 81	– * * * – –
DI IMR (7) ← 0			8F	– – – – – –
DJNZ r,dst r ← r - 1 if r ≠ 0 PC ← PC + dst Range: +127, -128	RA		rA r = 0-F	– – – – – –
EI IMR (7) ← 1			9F	– – – – – –
INC dst dst ← dst + 1	r R IR		rE r = 0-F 20 21	– * * * – –
INCW dst dst ← dst + 1	RR IR		A0 A1	– * * * – –
IRET FLAGS ← @SP; SP ← SP + 1 PC ← @SP; SP ← SP + 2; IMR (7) ← 1			BF	* * * * * *
JP cc,dst if cc is true PC ← dst	DA IRR		cD c = 0-F 30	– – – – – –
JR cc,dst if cc is true, PC ← PC + dst Range: +127, -128	RA		cB c = 0-F	– – – – – –
LD dst,src dst ← src	r r R r X r Ir R R R IR IR	Im R r X r Ir r R IR Im Im R	rC r8 r9 r = 0-F C7 D7 E3 F3 E4 E5 E6 E7 F5	– – – – – –
LDC dst,src dst ← src	r Irr	Irr r	C2 D2	– – – – – –
LDCI dst,src dst ← src r ← r + 1; rr ← rr + 1	Ir Irr	Irr Ir	C3 D3	– – – – – –
LDE dst,src dst ← src	r Irr	Irr r	82 92	– – – – – –
LDEI dst,src dst ← src r ← r + 1; rr ← rr + 1	Ir Irr	Irr Ir	83 93	– – – – – –
NOP			FF	– – – – – –
OR dst,src dst ← dst OR src	(Note 1)		4□	– * * 0 – –
POP dst dst ← @SP SP ← SP + 1	R IR		50 51	– – – – – –
PUSH src SP ← SP - 1; @SP ← src		R IR	70 71	– – – – – –
RCF C ← 0			CF	0 – – – – –
RET PC ← @SP; SP ← SP + 2			AF	– – – – – –
RL dst	R IR		90 91	* * * * – –
RLC dst	R IR		10 11	* * * * – –
RR dst	R IR		E0 E1	* * * * – –
RRC dst	R IR		C0 C1	* * * * – –
SBC dst,src dst ← dst - src - C	(Note 1)		3□	* * * * 1 *
SCF C ← 1			DF	1 – – – – –
SRA dst	R IR		D0 D1	* * * 0 – –
SRP src RP ← src		Im	31	– – – – – –
SUB dst,src dst ← dst - src	(Note 1)		2□	* * * * 1 *
SWAP dst	R IR		F0 F1	X * * X – –
TCM dst,src (NOT dst) AND src	(Note 1)		6□	– * * 0 – –
TM dst, src dst AND src	(Note 1)		7□	– * * 0 – –
XOR dst,src dst ← dst XOR src	(Note 1)		B□	– * * 0 – –

Note 1

These instructions have an identical set of addressing modes, which are encoded for brevity. The first opcode nibble is found in the instruction set table above. The second nibble is expressed symbolically by a □ in this table, and its value is found in the following table to the left of the applicable addressing mode pair.

For example, to determine the opcode of an ADC instruction using the addressing modes r (destination) and Ir (source) is 13.

Addr Mode dst	Addr Mode src	Lower Opcode Nibble
r	r	2
r	Ir	3
R	R	4
R	IR	5
R	IM	6
IR	IM	7

CONDITION CODES

Value	Mnemonic	Meaning	Flags Set
1000		Always true	...
0111	C	Carry	C = 1
1111	NC	No carry	C = 0
0110	Z	Zero	Z = 1
1110	NZ	Not zero	Z = 0
1101	PL	Plus	S = 0
0101	MI	Minus	S = 1
0100	OV	Overflow	V = 1
1100	NOV	No overflow	V = 0
0110	EQ	Equal	Z = 1
1110	NE	Not equal	Z = 0
1001	GE	Greater than or equal	(S XOR V) = 0
0001	LT	Less than	(S XOR V) = 1
1010	GT	Greater than	[Z OR (S XOR V)] = 0
0010	LE	Less than or equal	[Z OR (S XOR V)] = 1
1111	UGE	Unsigned greater than or equal	C = 0
0111	ULT	Unsigned less than	C = 1
1011	UGT	Unsigned greater than	(C = 0 AND Z = 0) = 1
0011	ULE	Unsigned less than or equal	(C OR Z) = 1
0000		Never true	...

NOTATION

Flags. Control Register R252 contains the following six flags:

C	Carry flag
Z	Zero flag
S	Sign flag
V	Overflow flag
D	Decimal-adjust flag
H	Half-carry flag

Affected flags are indicated by:

0	Cleared to zero
1	Set to one
*	Set or cleared according to operation
–	Unaffected
X	Undefined

The port 2 mode register simply determines the I/O function of each line individually, but port 3 is a catch-all port which, in addition to providing a simple parallel I/O function, can be programmed to provide handshakes for the other three ports, serial I/O lines, timer I/O lines, four interrupt lines and a data memory select output. The port 3 mode register determines which functions are to be implemented and even has a bit to decide whether outputs should be push-pull or should have open drain connections. Some of these functions are mutually exclusive, which means, for example, that if all port 3 lines are required for simple parallel I/O then no external access will be possible to the serial UART or the two timers.

A single read/write register is provided for UART data, although I assume that this must be buffered internally by additional TX/RX registers because the UART is capable of full duplex operation with simultaneous transmission and reception. There is no special UART mode register, and so the programmer has limited control over data formats, but there is a parity ON/OFF flag tucked away in that busy old port 3 mode register.

The two Timer/Counter sections are well endowed with registers, having a total of five in fact. Each Timer has a read/write 8 bit counter register and write-only prescaler register which can divide the incoming clock frequency by from 1 to 64 using 6 bits. The other two bits in the prescalers are used to select between single pass or continuous operation, and to select between internal or external clock sources.

The fifth Timer register is a mode selector which provides great flexibility in loading, starting and disabling the two sections and in deciding the functions of the T IN and T OUT pins available on port 3.

Finally, there are three special registers provided to allow full control over the extensive interrupt facilities offered by the Z8. There are six fully vectored interrupts available, each with a 16 bit vector pointer which has to be stored in low ROM between 000H and 00BH. The interrupt sources are IRQ0 to IRQ3 (available on port 3), Serial IN, Serial OUT, Timer 0, and Timer 1, making eight in all because IRQ3 and Serial IN share a vector, as do Timer 0 and Serial OUT.

Any or all of the interrupt sources may be disabled by setting the appropriate bit(s) in the Interrupt Mask Register, and the priorities of individual interrupts can be shuffled by setting up the Interrupt Priority Register. Also available is an Interrupt Request Register so that the status of individual interrupts can be read under program control. Once again, Zilog have gone to great lengths to make their interrupt scheme the best available, one of the reasons for the success of the Z8 in high speed real-time applications.

INSTRUCTION SET

All the Z8 family share the same instruction set, which includes 47 basic instructions with six addressing modes and four data types. Like the 8048 but unlike the 68701, the Z8 instruction set has been optimised to ensure the production of fast, compact code, but the set available is very much more powerful than that of the simpler Intel device.

The Z8 can handle bits, 4 bit nibbles, bytes, and words, and has a full set of 16 condition codes for use with the JUMP and JUMP RELATIVE instructions.

Instructions can be one, two, or three bytes in length, and even the fast two byte instructions can specify both a destination and a source address thanks to the working register bank concept which allows four bit addresses to be used for inter-bank transfers.

Three byte instructions can have 8 bit source and destination addresses to give full access to the RAM array, but external addressing slows things down somewhat, by requiring a register indirect reference to generate a 16 bit address.

Zilog say there are six addressing modes, but to me it looks like seven because there are two types of register addressing. Using the Zilog nomenclature however, these are the modes available:—

Register In which the designated operand is contained in the specified RAM register. The register reference can either be four bits or eight bits long for intra or extra bank addressing respectively. This mode can also be used to specify a 16 bit data location when used with those instructions which operate on words rather than bytes.

Indirect Register in which the designated register contains the address of the operand. Once again the register reference can be to a register, working register, register pair or working register pair where the last two can be used to access external data memory.

Indexed in which an operand address is calculated by adding an offset in a working register to an index value held in a different register. Since neither the offset nor the index value are specified in the instruction (both are indirect references) this mode can also be used to provide based addressing.

Direct in which an absolute 16 bit operand address is specified in bytes 2 and 3 of the instruction. This mode is only available for JUMP and CALL instructions and cannot be used for data memory access.

Relative in which an 8 bit two's complement value in the instruction is added to the program counter to form a new address. This mode is only usable with relative jump instructions.

There are many useful instructions in the set, some of which you might not expect to find in a single chip processor. The useful Zilog DJNZ (Decrement and Jump if Not Zero) looping instruction is there, and any register in the current working bank can be used as the counter. Also available are instructions useful for moving blocks of data, including an autoincrement load instruction which can transfer a byte from external data memory, addressed by a register pair, to an internal working register with both pointers being incremented following the transfer. Using this instruction a very simple code loop can transfer blocks of data quickly.

The Z8 supports BCD arithmetic, and has 16 bit increment and decrement instructions. It does not, however, provide 16 bit arithmetic or a multiply instruction like the 68701.

SOFTWARE

Like most single chip processors, the Z8 does not enjoy a freely available software base, but the Z8671 Tiny BASIC is interesting and deserves a mention.

Squeezed into the 2K byte ROM array on the Z8671 is an integer BASIC and a monitor which allows programs and data to be downloaded from a terminal into an external RAM.

There are 16 keywords as follows:

GOTO, GO@, USR, GOSUB, IF . . . THEN, INPUT, IN, LET, LIST, NEW, REM, RUN, RETURN, STOP, PRINT, PRINT HEX.

Up to 26 variables (A to Z) are available, and numbers can be specified in either decimal or hexadecimal format. The Z8671 BASIC can directly address registers and ports which makes it easy to use in control applications, and once a BASIC program has been debugged it can be stored in an external EPROM to run automatically when power is applied.

The number crunching capability of this integer BASIC is not of course adequate for scientific or financial calculations, but in the control applications for which it has been designed, it is quite sufficient.

A number of manufacturers now produce low cost single board computers using the Z8671, and there was a useful applications article published in the July/August 1981 issue of *BYTE* magazine.

If you have a simple process to control or monitor, and are worried about the terrors of machine code programming, then the Z8671 could be for you!

INTERFACING

As you would expect in a single chip processor, the Z8 has an on-chip clock oscillator which only requires an external crystal.

A number of control lines are available to simplify system expansion, and these are worthy of note. An address strobe ($\overline{AS}$) is provided to permit the multiplexed low address information on port 1 (AD0 to AD7) to be latched, and a data strobe ($\overline{DS}$) is activated for each external data transfer to simplify memory design. Also available are the conventionsl read/write (R/$\overline{W}$) and $\overline{RESET}$ functions.

The Z8603 can address up to 62K bytes of external program memory *and* 62K bytes of external data memory. The two memory spaces can either be mapped into a common 64K byte range, or they can be kept separate by using another port 3 option, the $\overline{DM}$ control output, to select between the two areas.

The port 1 and 2 multiplexed data/address bus scheme is similar to that used by the Intel 8085 processor, and so it should be possible to use 8155 and 8755 peripherals with the minimum of logic. Other peripherals which require demultiplexed address and data can be interfaced by means of an octal address latch in the usual way.

Peripherals from the 8080/8085 family, or even the 6800 family, are probably quite suitable, and there seems little point in using the expensive Z80 peripherals with their sophisticated, but unusable, interrupt logic.

One of the most challenging interface design problems for the Z8 family is in deciding what to do with port 3, which has so many mutually exclusive options, but I suppose that's half the fun, isn't it!

APPLICATIONS

The Z8 family has many potential uses both for hobby and professional use, and is particularly well suited to those jobs where very high speed operation is required.

The device is very much a "controller" like the 8048, and is unlikely to be useful for data processing tasks where the 68701 would undoubtedly come off best.

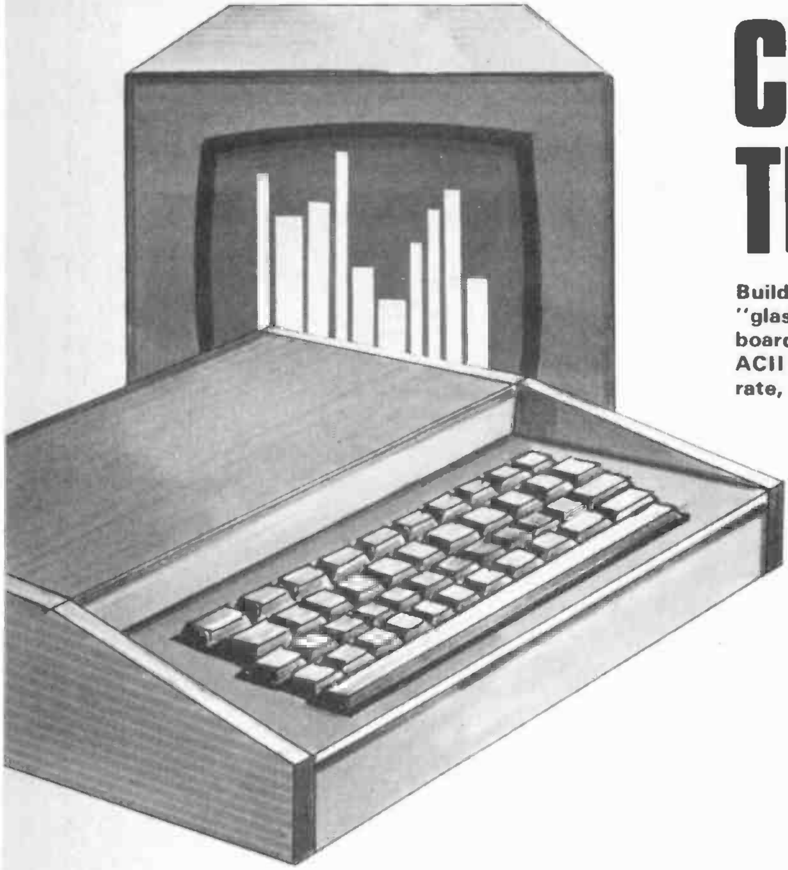
The simplest way to employ a Z8 is to build or buy a Z8671 module so that the advantages of the BASIC language can be enjoyed, but for many jobs this will be too slow, and in these cases the Z8603 piggy-back chip or the Z8681 ROMless version will be best.

Yet another application for the Z8 family is as peripheral devices for larger microprocessors like the Z8000, and there is a special device, the Z bus Z8090, which is intended specifically for this purpose. Yet another version is available for interface to the Z80, the Z8590.

all in your

FEBRUARY

issue!



COMPUTER TERMINAL

Build a serial (RS232 and BBC RS423) linked, full or half duplex "glass teletype"—remote VDU + keyboard terminal. This single-board system will drive either TV or monitor with 16 rows of 64 ACII characters, monochrome. Has hardware selectable BAUD rate, and extra functions to drive cassette, bell, reverse video etc.

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Buyers Guide

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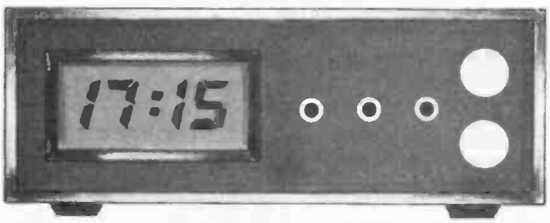


PRACTICAL

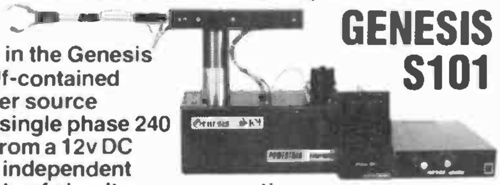
ELECTRONICS

FEBRUARY ISSUE ON SALE FRIDAY, JANUARY 6th

Low-price robots from POWERTRAN

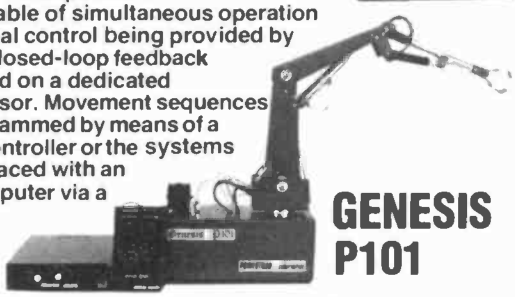
– hydraulically powered
– microprocessor controlled

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



GENESIS S101

Each robot in the Genesis range has a self-contained hydraulic power source operated from single phase 240 or 120v AC or from a 12v DC supply. Up to 6 independent axes are capable of simultaneous operation with positional control being provided by means of a closed-loop feedback system based on a dedicated microprocessor. Movement sequences can be programmed by means of a hand-held controller or the systems can be interfaced with an external computer via a standard RS232C link.



GENESIS P101

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

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

GENESIS P102

HEBOT II Turtle-type robot

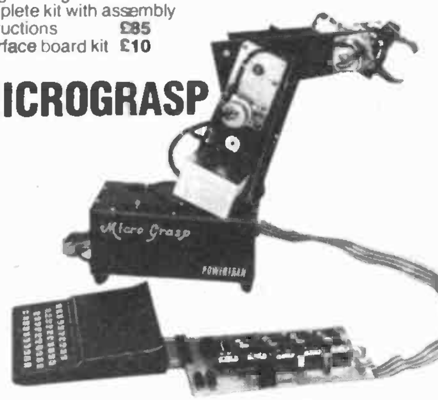
For under £100, Hebot II takes programming off the VDU and into the real world. Each wheel is independently controlled by a computer, enabling the robot to perform an almost infinite number of moves. It has blinking eyes, a two-tone bleep and a solenoid-operated pen to chart its moves. Touch sensors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

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

HEBOT II

Weight 1.8kg
complete kit with assembly instructions **£85**
Interface board kit **£10**

MICROGRASP



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

MICROGRASP

Weight 8.7kg, lifting capacity 100g
Robot kit with power supply **£145.00**
Universal computer interface board kit **£48.50**
23 way edge connector **£2.50**
AX81 peripheral/RAM pack splitter board **£3.00**

GENESIS S101

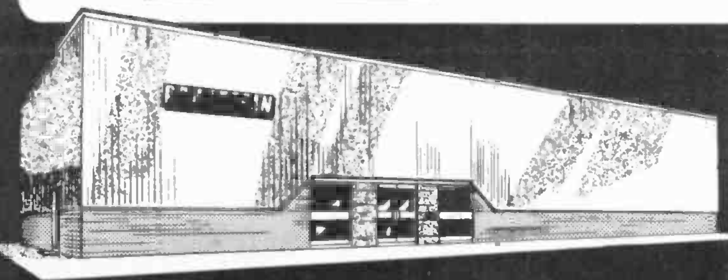
Weight 29kg, lifting capacity 1.5kg
4-axis model (kit form) **£425**
5-axis model (kit form) **£475**
5-axis complete system (kit form) **£737**
5-axis complete system (ready built) **£1,450**

GENESIS P101

Weight 34kg, lifting capacity 1.8kg
6-axis model (kit form) **£675**
6-axis complete system (kit form) **£945**
6-axis complete system (ready built) **£1,650**

GENESIS P102

Weight 36kg, lifting capacity 2kg
6-axis system (kit form) **£1175.00**
6-axis system (ready built) **£1950.00**
Powertran Cortex microcomputer
self-assembly kit **£295.00**
ready-built **£395.00**



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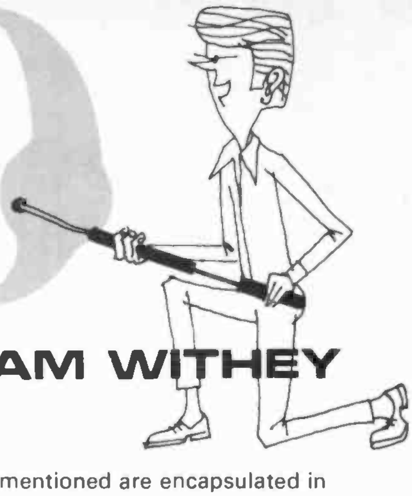
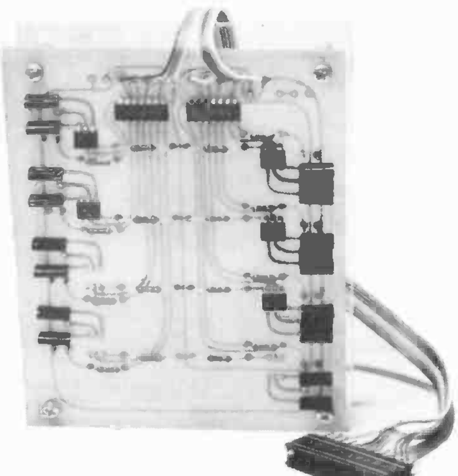
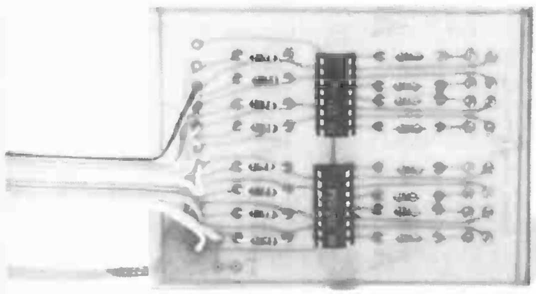


PART FOUR

SAM WITHEY

8 CHANNEL MAINS TRIAC DRIVER BOARD . . .





FOR AROUND £23

THIS month, a mains driver board, an opto-isolated input board, and the promised points which have been troubling those readers new to hardware construction.

THE HIGH VOLTAGE/POWER OUTPUT BOARD

The high power output board follows more closely the method of operation of the l.e.d.s and switches board in that it uses 4 inverters of each of 2 x 7405 open collector hex inverters to drive the l.e.d.s in the opto-isolating devices, and produce correct logic at the outputs of the isolators. A logic "1" at the port produces a logic "0" at the output of the inverter. This makes the cathode of the infra-red l.e.d in the opto-coupler low relative to the supply voltage, allowing it to draw current and light up. This in turn switches on the triac, silicon controlled rectifier, or darlington transistor stage, whichever is chosen.

Each of the opto-couplers mentioned are encapsulated in 6 pin d.i.l. packages. In each, the infra-red light emitting diode has its anode at pin 1 and cathode at pin 2. Outputs are at pins 4, 5 and 6 as indicated in Fig. 4.1.

In order to increase the versatility of the interface, provision has been made on the board to enable the use of any of the couplers illustrated.

The opto-coupled triac is capable of driving lamps or motors up to 400Va.c. and 1·2A r.m.s. On the prototype the author used Ex. WD 24V lorry side lamps connected in series (12 per circuit). They had been previously coloured with spirit based, theatre type stains and produced interesting chasing displays. The lamps were bought very cheaply some years ago from a magazine advert and might be still available.

The opto-coupled s.c.r. is capable of a similar application and has current handling capabilities of 400Va.c. and 5A.

The output from the collector of the transistor of the opto-isolator can be used to drive a further transistor stage, enabling greater current handling facilities.

Yet again, the output can be interrupted by an external electrically insulated switch pulling the logic "1" at the port down to ground potential. If triacs are used to drive disco type lighting displays, these could take the form of toggles mounted on the outside of a case.

CONSTRUCTION

As both boards are single-sided, there should be no difficulty in mounting components, all of which are readily available from *Practical Electronics* advertisers.

Connections to the boards are really an individual choice, according to the application for which they are intended. The author used p.c.b. terminal pins for grounding the outputs from the ports as this facility would not be required on all outputs and where needed, would be permanent. These were also used for connection of inputs to the Input Control Board.

Two types of 0·2in. pitch terminal blocks are available. One type enables the output leads to be screwed down, whilst the other type is suitable for use with 2mm plugs. The author chose the latter simply because the sockets were available as was a good supply of 2mm plugs. Further to this, these connectors were most suitable for experimental work.

Output sockets from the High Voltage Board presented a different problem. First, insulation had to be considered and provided the board is suitably encased, either type of connector is suitable. Another factor is the choice of opto-coupler to be used and protection of the substrate of the opto-triacs. Again, because they were available, p.c.b. test points were used. These were also suitable for use with the

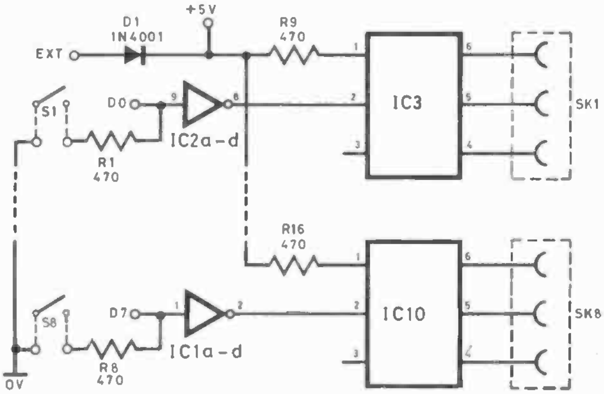
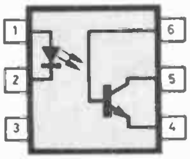


Fig. 4.1. Circuit diagram of high voltage output board (abbreviated) showing (below) the choice of opto-coupled devices for i.c.s 3–10

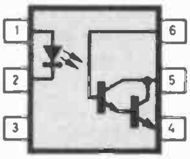
COMPONENTS . . .

HIGH VOLTAGE OUTPUT BOARD

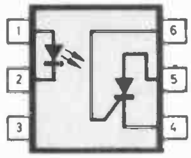
Resistors	
R1–R16	470 (16 off)
Semiconductors	
D1	1N4001
IC1, IC2	74LS05 (2 off)
IC3–IC6	opto-isolated triac (4 off)
IC7, IC8	opto-isolated thyristor (2 off)
IC9, IC10	opto-isolated Darlington (2 off)
Miscellaneous	
SK1–8	See text
P.c.b.	



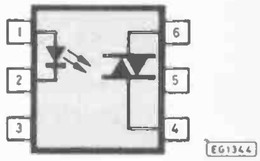
single opto-isolator



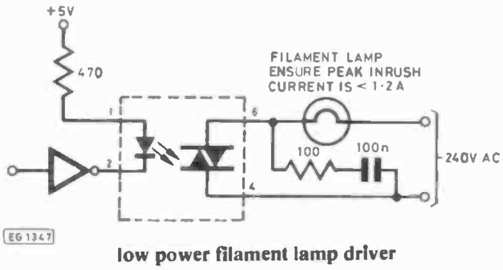
opto-isolated Darlington



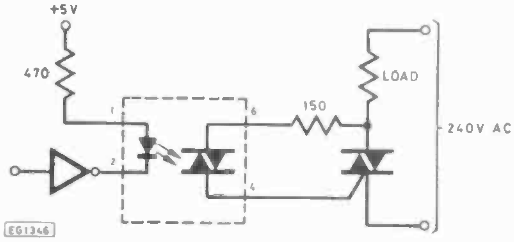
opto-coupled s.c.r.



opto-coupled triac

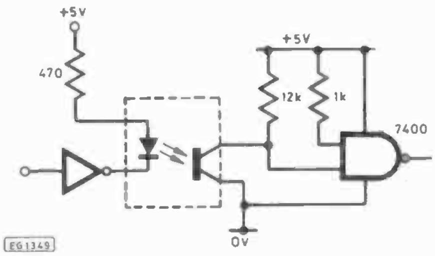


low power filament lamp driver

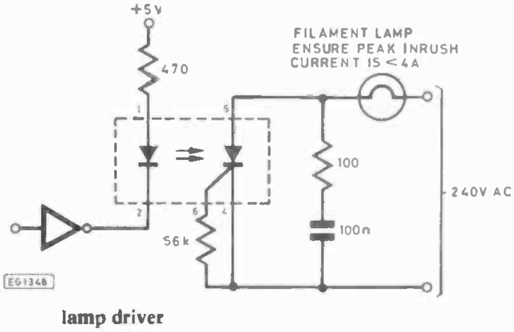


resistive load driver

APPLICATIONS



switched input isolation
offering good noise immunity



lamp driver

insulated 2mm plugs, which were plentiful. And by using individual sockets, there could be no accidental connections to the triac substrate.

It should be mentioned here that the sockets used were from ex-computer panels, that are advertised regularly in *P.E.*

The individual reader's personal experience will determine whether or not sockets are used for mounting components. In the author's case, sockets are generally used only for the more expensive i.c.s since modern TTL and CMOS devices are quite robust. If sockets are used for the High Power Board, 6 pin, d.i.l. turned pin types should be suitable for handling the current, otherwise wire-wrap sockets can be cut to fit.

INPUT CONTROL BOARD

Finally this month, is the Input Control Board. For this interface, only 2 Quad Opto-Isolators are required, but for those who have Dual Opto-Isolators at hand, these will fit neatly into place and are fully compatible internally and pin-wise. See Fig. 4.7.

Input resistors to the anodes of the infrared light emitting diodes at pins 1, 4, 5 and 8 vary according to the input supply voltage and could very well vary with each input. Typical values are 470ohm for +5V, 1K0 for +12V and 1K5 for +15V. A formula is given by the manufacturer:

$Ri = \frac{Vs - Vf}{If}$ Where Ri is input resistor, Vs is supply voltage, Vf is forward voltage drop across diode and If is forward diode current.

The cathode of each diode, pins 2, 3, 6 and 7 is coupled to its individual ground.

The transistors of the opto-couplers are completely isolated from the input supply voltages and are used in a quasi common emitter mode. RL is typically 12k, but 1M's were used on the prototype to limit current drain at the port.

Inputs to the port are from the collectors of the internal transistors and the emitters are tied to ground.

When there is no input from the l.e.d., (i.e. the l.e.d. is off) the transistor is also off and output from the collector to the port is at logic "1". When an input signal turns the l.e.d. on, the transistor conducts, bringing the input from the collector to the computer to logic "0". (Remember that it is a logic "0" that the computer recognises as an input.)

Note: When all lines are set as inputs, the I/O Register at memory location 37136 shows all logic "1"s, (in other words, NOT inputs) therefore decimal 255 will be indicated on the screen. As each data line is brought to logic "0", when inputs are sensed, the decimal value of the data line is subtracted.

Try this program again, putting signals on the inputs and monitor the changes.

```
10 POKE 37138,0
20 PRINT PEEK (37136)
30 GOTO 10
```

It should not be difficult to write a screen indicator, to monitor the I/O Register and either draw a graphic display representing the state of the port, or simply output sound and visual messages. (e.g. Digi-Talker).

The board has many useful applications about the home, laboratory and workshop as a sensor for alarms, levels of liquids and distance of travel, to mention but a few.

APPLICATIONS

These interface boards are a means of communication between the computer and the outside world, whilst offering complete immunity from destruction by the external devices to which they are connected, provided that the overloading and insulation precautions are observed.

It was found when testing the opto-coupled triacs, that they remained turned on after removing the logic "1" from the gate. It was also found that they were sometimes turned on, merely by switching on the mains and remained on

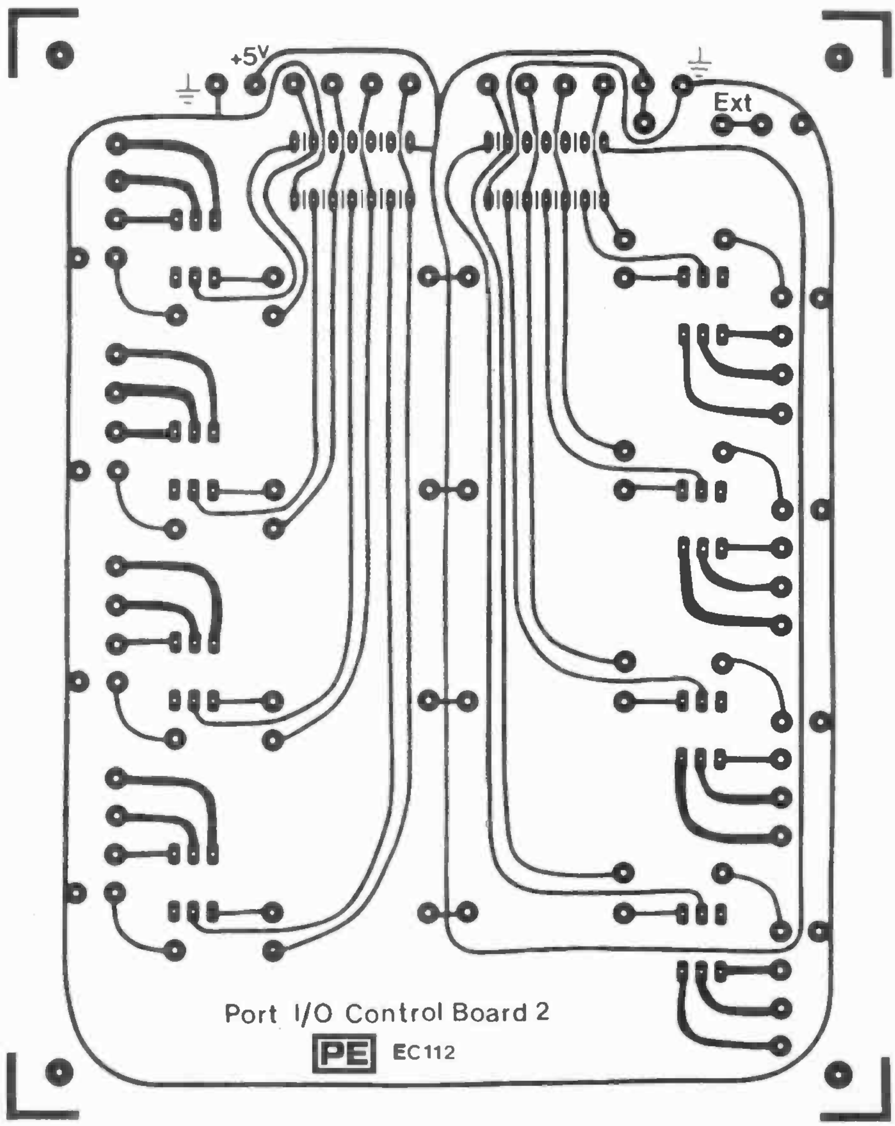


Fig. 4.2. Printed circuit layout for high voltage board (actual size)

NOTE: If this board is intended for high voltage applications it is suggested that it should be suitably encased to avoid accidents.

despite instructions from the port. (It must be remembered that the triac is bi-directional and can be activated by either a logic "1", or a logic "0" at the gate.) The problem was overcome by inserting a 'snubber' network across the MT1, MT2 terminals. A 'snubber' network comprises a 0·1µ capacitor and 100ohm resistor, connected in series and can be inserted anywhere in the external circuit across the mains wiring, to suppress interference caused when switching inductive loads. This cured the problem. The networks can be purchased in an encapsulated package for approximately £1, or made up from a 100n polyester capacitor and a $\frac{1}{4}$ watt 100ohm carbon film resistor, for a few pence.

It is not the intention of the author, to elaborate on the application of these boards, since school, workshop and home situations abound with opportunities for the computer to break away from the games and graphics modes. The computer can be utilised to control precisely timed cyclic operations in external apparatus, whilst monitoring the progression on the screen, or there can be manual control from the keyboard, of motors and lighting. Use can be made of microswitches and glass reed relays (and magnets) to provide switching of the inputs to logic "0" and grounding of the output lines to disable the outputs.

It should also be noted that the inputs can be activated by external TTL or CMOS circuitry.

Care should be taken with the Low Voltage Output Board that the load does not exceed 500mA since the internal contacts could be damaged or destroyed by excessive overloading.

It cannot be over-emphasised, that insulation of outputs from the High Voltage Board, must be checked and rechecked before connection to the mains, in the interest of safety.

The High Power Board especially, could provide bright and colourful Christmas lighting, whilst the Input Board guards the presents on the tree.

MIXING THE FACILITIES OF THE CONTROL BOARDS

Now that the boards have been fully or partially furnished, for low and high voltage output and for input applications, it might be necessary to mix the signals.

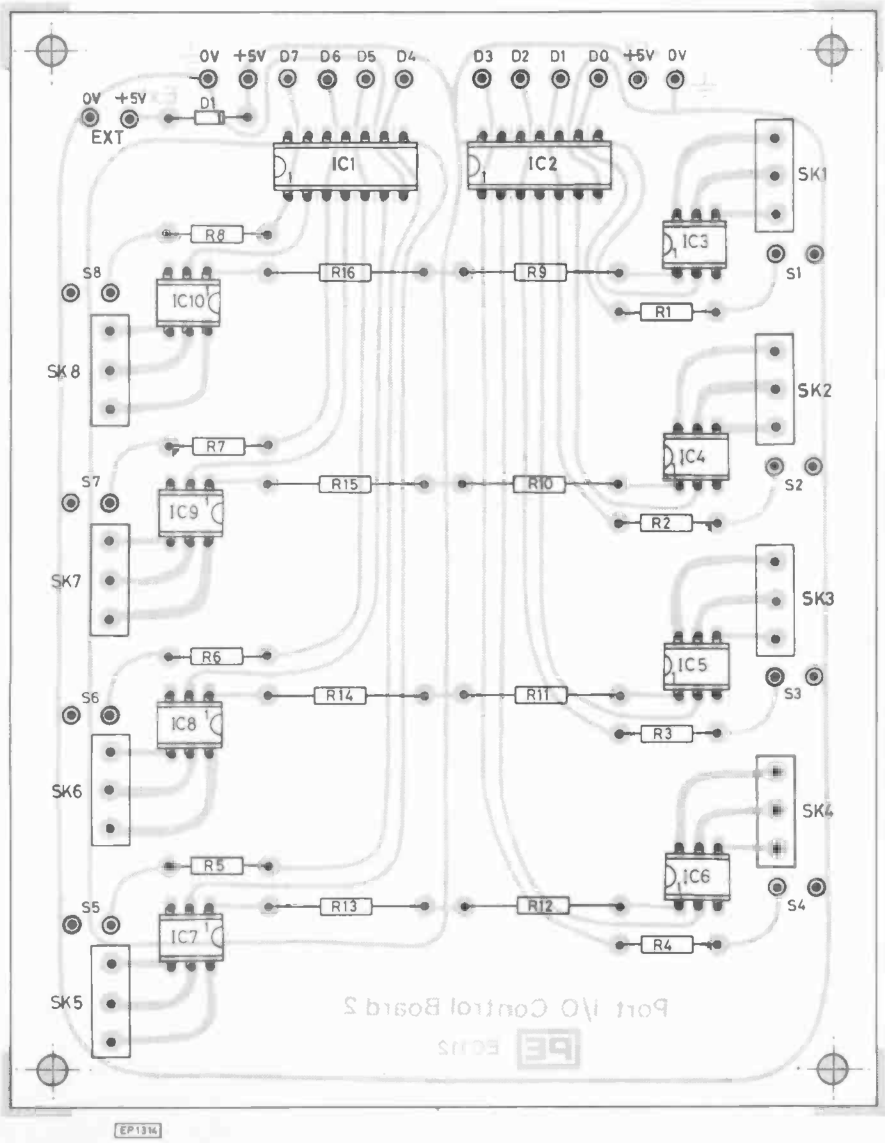


Fig. 4.3. High voltage board component layout

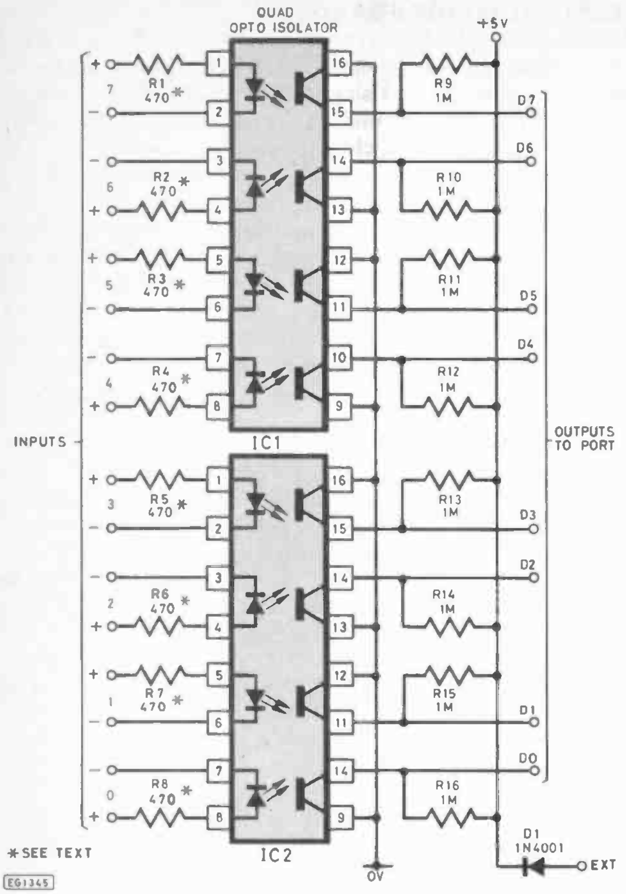


Fig. 4.4. Input control board circuit diagram

COMPONENTS . . .

INPUT CONTROL BOARD

Resistors

R1–R8	470 ¼W 5% (8 off)
R9–R16	1M ¼W 5% (8 off)

Semiconductors

D1	1N4001
IC1, IC2	ILQ74 (2 off)

Miscellaneous

P.c.b.
Vero pins

To enable this to be carried out with the greatest of ease, a simple terminal block can be used as an intermediary between the computer and interface boards. This not only cuts out the cost of sockets, but makes the mixing of applications much quicker and adds to the versatility of the boards by making lines CA1 and CA2 available from the input control board to enable interrupts to be utilised (see last month).

The terminal uses just one socket connected by ribbon cable to a 12 way in-line terminal block. Unterminated ribbon cable is used on the interface boards, which can be connected at will. This not only saves wear and tear on the port, but makes the board available for use on several computers by making up suitable terminals.

A quicker method of mixing applications can be achieved by connecting, shall we say, an input control board and low voltage output control board to the terminal block by way of 8 s.p.d.t. switches, the common going to the terminal and one side of each switch to the corresponding data line on the interface boards.

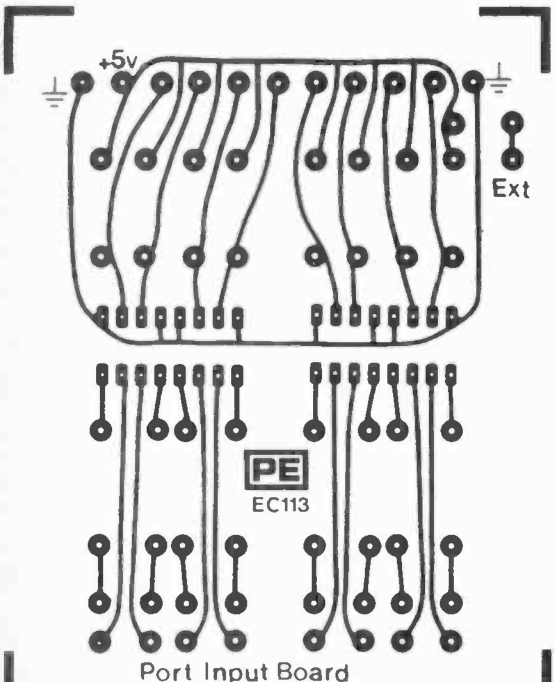


Fig. 4.5. Input control board p.c.b. (actual size)

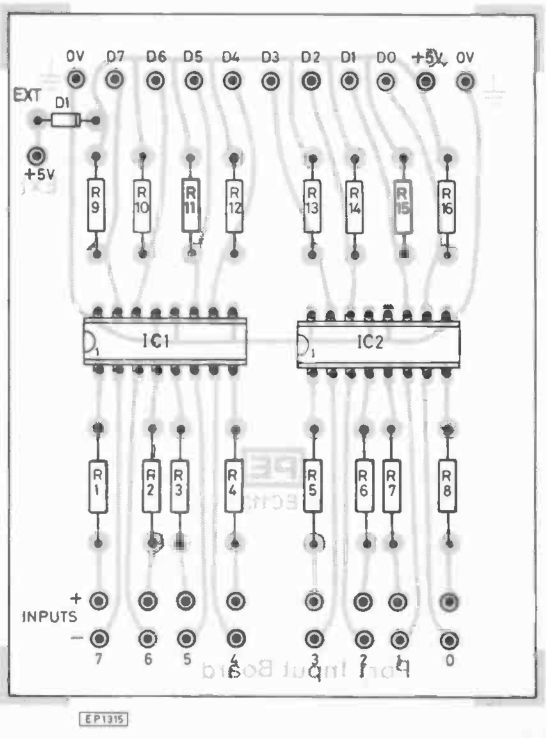


Fig. 4.6. Input control board component layout

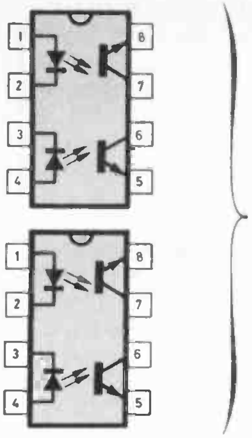


Fig. 4.7. Two juxtaposed dual opto-isolators may be used instead of one quad isolator, if spacing is taken into account. The pin-out configurations are compatible

HARDWARE HINTS

The author often uses Bi-Pak bargain packs to cut costs of resistors, transistors, diodes, l.e.d.s, etc, as well as those offered by many other advertisers. Resistors are often advertised as low as 70p/100 for same value or 90p/100 mixed. Values in common use are 100R, 470R, 1k, 2k2, 4k7, 10k, 15k, 22k, 33k, 47k, 100k, 470k and 1M. Polyester capacitors are available in cheap packs and come in the popular 470n, 330n, 220n, 100n, 47n, 33n, 22n, 10n values. Electrolytic packs are not so good, comprising large quantities of low voltage, physically large types. C.R. Supply Co. give good value and it is good practice to build up a stock, in order to save postage. Useful values of electrolytic and tantalum bead capacitors are 1μ, 2μ, 4μ7, 10μ, 22μ, 33μ, 47μ, 100μ, 220μ, 470μ, 1000μ, 2000μ and 3000μ. Ex-computer boards are a valued source of cheap top quality components, and also provide essential practice in desoldering. Bi-Pak, mentioned earlier, often sell bargain packs of fibreglass p.c.b. and etch resist pens. Greenwald have a current offer on ferric chloride. Midwich are one of the most competitive in prices of logic and memory devices, whilst Watford and Technomatic stock those 'difficult to get' bits and pieces. It is worth studying the market. Have you noticed the difference in prices of prepared p.c.b.s? This is sometimes determined by the quality of the board with regard to thickness of fibreglass and copper laminate. Important with uncased projects and novice constructors, but not so important if projects are cased and constructed by experienced persons.

TOOLS

Essential tools are a small pair of side cutters, snipe nosed pliers, wire strippers and a leak-proof soldering iron—15 watt Antex, or similar. With the help of the car or household tool kit this would be a good start. Next essential is a multimeter. This should have printed on the dial, 20000 ohms per volt, or 50000 ohms per volt. Several versions of the latter type have recently flooded the market as a 'range doubler' meter and have been as low as £15 on special offer. The author is pleased with the one he bought for £20 and finds it has a useful selection of ranges. For making holes in printed circuit boards, before the miniature drills came on the market, the author used a *Black and Decker D500 drill held in the lap* (crikey!). However, a modern miniature drill is recommended, with 0·8mm drills for i.c., transistor, diode and capacitor holes, 1mm for resistors and 4000 series diodes and 1·3mm for presets and pilot holes. Accessories for these drills are a worthwhile addition later on.

PRINTED CIRCUIT BOARDS

Those who wish to make their own circuit boards will require copper laminated fibreglass board, double sided for Part 1 of the series and single sided for the other projects. Also required is an etch resist pen or etchant repellant component pads, and ferric chloride crystals. Those who have facilities for using photo resist methods of board production should be familiar with their own process.

Drawing with etch resist pens is not as difficult as it at first seems. First cut a piece of board to the size of the board being produced and include in it the extension bar shown on the double sided board foil patterns. These extensions are provided for those lucky few who have gold plating facilities, but they can also provide a guide for placing the edge connectors in the correct place. A photo copy of the foil patterns would be useful here, otherwise use tracing paper and mark off with dots, where every hole appears on the component side of the board. Also place a dot at the thin line that joins the bar with the edge connectors. Whichever method is used, tape the dot pattern to the p.c.b. and drill the holes.

After drilling the holes, remove the pattern guide and clean both sides of the board of all drill burrs and other marks with very fine sand paper or fine wire wool. This also gives an edge for the resist to grip. Now either lay out the component side of the board with etch resist pads and lines, or, first draw the pads and then the lines with etch resist pen. Remember, to get the ink flowing in the pen, it is necessary to press the point at intervals. Do not do this on the board as it sometimes makes a large blob. Do not worry if the resist sometimes appears thin. It is complete coverage that matters—not the thickness of the resist. Any errors should be gently scraped off with the rounded part of a craft knife—*not the point*.

The opposite side is generally known as the copper, or track side, even when referring to double sided boards. Great care has to be taken when drawing this side not to scratch the top surface tracks. A holding frame is best, but a slot cut in two lengths of wood should form the basis of a satisfactory holder. This side has the greater number of tracks and also has tracks between the pads. Again, draw your pads and then draw the lines. Should they meet, again scratch away a very thin line to make a division between the pads and the intended track, just enough to expose copper. If you fail first time put on some more etch resist and when set try again. One advantage of the slotted wood is that this also makes provision for holding a ruler over the board to make drawing easier. After completion check both sides, then check again, correcting any errors.

ETCHANT

Ferric chloride crystals should be dissolved in water a day or two before use. The author makes up a solution in a coffee jar and adds crystals to warm—not hot—water, stirring until saturated. Do not add *water to crystals* as this causes a violent chemical reaction.

The benefit of a wide necked jar is that many small p.c.b.'s can be dangled in the jar without using a dish. The author usually threads a piece of sleeved wire through a hole in the board and suspends this over the neck of the jar. This is a good method of examining the boards and also allows air to reach the board surface, enabling quicker chemical reaction. If the board is etched in a dish, it should be floated on the surface of the etchant. Again, the author ties a loose noose of sleeved wire around the board, allowing the board to be examined. By placing the board on the surface of the etchant at an angle, air bubbles are forced out, leaving the whole surface exposed to the etchant. As copper is dissolved away, it falls to the bottom of the dish, leaving a fresh surface of copper exposed. After total etching of both surfaces, which takes about 15 to 20 minutes in fresh solution, the etch resist is removed from the board. Again, the author uses wire wool, which provides a clean surface for soldering.

A 1lb pack would last for several years, each jar described processes several square feet and keeps until exhausted.

SOLDERING

Multicored solder must be used. For the applications in this project, 22 s.w.g. is suitable. When new, soldering irons are normally fitted with a $\frac{1}{8}$ inch bit. The best size for i.c. work is $\frac{1}{16}$ or $\frac{3}{32}$ inch. Most irons come fitted with iron coated tips. These keep cleaner and last much longer than plain copper tips.

It is usual to mount the lowest lying components first. This makes soldering much easier, because after mounting, the board is turned over on a flat surface, so components are held in place by that surface. The usual mounting order is, wire links, resistors and diodes, i.c. sockets, horizontal presets, capacitors and transistors, l.e.d.s etc, soldering taking place at each level.

When soldering, each joint should take around 2 to 3 seconds, with the solder and iron being applied simultaneously.

USE OF THE BOARDS

The author deliberately left out of the article on the RAM, ROM and motherboards, information that is available in the Vic 20 User Manual. Since the author has a copy of The Vic 20 Programmers Manual and *Nick Hampshire's Vic Revealed*, he has not read the one supplied with the Vic 20 as the abovementioned does explain everything much more fully. Not being very conversant with programming, he has found the routines provided in these two references invaluable in compiling small routines for testing the interfaces.

The motherboard permits use of 3 x 8K RAM boards if desired, these being placed in BLKs 1, 2 and 3, at edge connectors 10, 11 and 12 counting from the left-hand side of the board, with the edge connectors towards you and the components facing up. These take positions in memory at 2000Hex, 4000Hex and 6000Hex. On the prototype board copper track, a split disc was provided above each of these edge connector segments and a blob of solder was all that was required to select the memory position. However, in the published article, two sets of parallel pads are provided which require short wire links. These locations can be used for RAM or ROM. Indeed, most games cartridges and Vicmon use BLK3. The Vic system uses BLK4 at 8000Hex and BLK5 at A000Hex is available for ROM only and is normally used by Super Expander. The Commodore 8K package resides at BLK1 and the 16K package resides at BLKs 2 and 3. The author uses BLKs 1 and 2 for his two 8K boards. Having a disc unit, he intends using the Vic 20 for storage of amateur radio callsigns, but after several years of using a Nascom with 32K memory (it once had 64K), recommends that the starter in computing should limit his memory to 8K unless he buys games that require 16K and save his money for more useful equipment. Very few people write programs that take up even 8K. The Vicmon and Super Expander chips are available from some Commodore dealers, but it is not known if these are supplied under licence. Should this be so, details will be supplied in a later section. When fitted to the RAM or ROM boards, they behave exactly the same as on the Commodore boards.

The motherboard will permit the use of any commercial i.c. package and these will have no effect on the RAM residing at the same memory location. ROM takes precedence over RAM and normally replaces any program or random values that were previously stored. Should a program in ROM not be correctly terminated (such as END or RETURN in Basic) the program would then try to continue into the adjacent memory locations, but it is unlikely that this should be the case.

Those readers wanting to make the 3K RAM board, with a 4K ROM (Super Expander), might have difficulty in getting the 4118A RAMs. Should only the 4118N or 4118P type static RAMs be available, these have a latching facility at pin 19. In this case, an additional cut will have to be made in the track at pin 19 of the ROM and on the A10 side of the end RAM. An insulated link is then taken from pin 19 of the ROM, across to A10 and a further link on either side of the board between pins 19 and 24 (+5V) of any one of the RAMs to prevent it floating.

PIGGY-BACKED ROMS

The author 'piggy backs' his ROMs, but did not mention it in the article because this should only be done by experienced constructors. And these readers probably do it in any case. As the method has been requested, this is how it is done. If it is intended to 'piggy back' ROMs, there is no point in using sockets, so the first ROM is soldered into place with pin 20 CE bent out instead of being fitted into the hole. The second ROM is then soldered on to the first, again with pin 20 CE bent out.

There is room for a small SPDT (or DPDT) switch to be mounted on the ROM board between ICs 2 and 3. The switch should be towards the back, track-side, of the board, care being taken not to foul or break any tracks. The common terminal of the switch is taken to the most convenient connection to the ROM pin 20 CE pad. This could be the track to the decoding i.c. The other sides of the switch are taken to pin 20 CE of the individual ROMs. Should 2 x 8K programs be put on the board in this way (2 x (2 x 4K)), care should be taken in connecting the correct pairs to the DPDT switch.

The penalty is extra drain on the Vic 20 power supply, but the 6116 RAMs use so little current that the whole would cause less drain than the Commodore 16K RAM Board, which uses 2114 RAMs.

Once again, for the information of experienced constructors, the 4118 stands up well to soldering direct to the board.

It is hoped that these extra notes are helpful to those who requested them. Should there be further requests for extra information these notes will be updated accordingly and will appear in later parts of this series.

STEPPER MOTOR CONTROL

It was hoped that a number of more useful BASIC I/O routines would be included at the end of this article, but due to lack of space, they have been deferred to Part 5. Next month will also follow on from this with some hardware of interest to the robotics fan.

With a great interest being taken in robotics and the availability of cheap ex-equipment or surplus stepper motors, the next part in this series will cover applications of two separate stepper motor controllers, and modes of operating them to suit different stepper motors.

Space Watch...

SPACELABS

This vital mission catches up on previously laid plans and the hopes of its Commander John Young. John is fond of saying that he is the 'old man' of the team. He has a low pulse rate even when waiting for the final seconds of lift off (50 per minute). He is without doubt the most retiring and calm man I have ever met. This will be his sixth flight and the fulfilment of his fondest hopes. With him will be Owen Garriot who was the civilian who flew in SPACELAB 1. He was the first of the astronauts of the time to talk freely and comfortably about his own thoughts. Service personnel tend to be somewhat reserved when they are alone and talking to a civilian. As he was basically an electrical engineer we quickly found common ground especially on the philosophical aspects of a first experience. The other members of the team are Brewster Shaw who will be co-pilot, Robert Parker, Ulf Merbold of West Germany and Byron Lichtenberg. The latter two members will be known as the payload specialists. They will be in constant touch with the Earthbound specialists who devised and set the scientific experiments. Since there are so many people on board it will be a little cramped. This will provide a useful test of close proximity living. There will be further information in the next issue but the mission will be over before that is available.

The many delays of this mission have arisen because of the joint funding. The first spacelab under this scheme will belong to NASA. On balance a reduced enterprise has produced something, but we are in danger of being left behind by Russia. It is true that there is a special concentration of energy on the ferrying of hostile hardware into space as is shown with the Soyuz/Salyut space missions; it is also true that the Shuttle system is now proven. We must therefore catch up with the co-operation for the advancement of a peaceful mankind, a great future lies before us if our endeavours are maintained as they were planned. Unfortunately the control of funds lies with those who are perhaps not able to realise the importance of the future, that first priority is for our preservation, order and well-being.

JOBS IN HAND

The SPACELAB programme is carefully worked out but it is hoped that there may be additional experiments according to time available and the astronauts' own inclination. The planned tasks are divided among groups of scientists. In this mission some 47 experiments cover the biological and materials field. Attention will again be towards the distress caused by motion sickness which has recently been the subject of some rethinking. This is likely to involve the study of plant cells in weightless conditions. So far no concrete statements have come from the teams who are working on the matter. Nor has there been any results so far published about the effects of the rotational movement of travel, introduced because of the effects of temperature. These experiments are time consuming and are also restricted by the physical space available.

Some of the experiments are quite ingenious such as that devised by Helen Ross, a psychologist at Stirling University. This is in the form of small steel balls. A box of 24 has been supplied to each member of the crew. Each box contains steel balls of the same size but of differing densities. The task is to take a pair of balls and in the weightless conditions of space try to assess the difference in weight. This would add enormously to our knowledge, if a difference of density could be detected. The full programme will be issued from other sources, unfortunately too late to appear here.

RUSSIAN LAUNCH EXPLOSION

The mishap at the launching of the Russian mission to put a mixed crew into space was the second of such ventures to be aborted. The most recent was much more hazardous than the previous one. The attempted launch was made from the pad at Tyuratam on September 28th 1983. Fortunately the cosmonauts were not seriously injured.

The sequence of events is thought to be as follows: Sensors detected a malfunction and immediately a command was made to the escape system which then fired, drawing the SOYUZ away from the area. The escape tower rockets pulled the complete SOYUZ with its shroud and the crew well away from the booster. Then the main section carrying the crew was separated after first jettisoning the instrument section. The parachute opened at a height of several hundred feet and the crew descended to safety.

There is another matter yet to be settled and that is the 'make up' of the crew. It was known that the third member of the crew was to be a Russian woman or an Indian scientist. Perhaps we shall never know.

JUPITER AND OTHERS

Now that Voyager's records are being deciphered it is becoming clear that the giant planets were formed from ice particles. The formation of Jupiter and Saturn was not, it is now suggested, formed by the direct result of gravitational collapse of large gas clouds, but by the accumulation of small bodies made of solid ice. It is suggested that Titan, the largest satellite of Saturn, is a surviving example. Until recently it was thought that the formation of the solar system was such that the Earth was about 4·6 million years old and that the original body is now our Sun, this was the generally understood picture. It follows from this that the Sun and the Planets should be composed of common elements and that they would be in the same proportion. The fact is that the infra-red findings of Voyager disagree with this. Thus the simple view that the solar system came from one source is in grave doubt.

This complicates the matter especially for those who have had doubts that the Sun is the main part of the original mass but rather is a large piece while the rest originally was the main source of material. Without digressing however at this time if the findings of Voyager are confirmed then we are forced to do some considerable rethinking. It would seem indeed that a whole new viewpoint is provided for exploration due entirely to the extending of our knowledge in a very short time, less than a year or so. It will be interesting to hear the reaction of others in this regard. One is tempted to enter the fray at such times.

AMSAT

Oscar 10, the amateur satellite of the International Amateur Organisation, has had only a part of its planned mission fulfilled due to a failure of the ARIANE launch. The satellite failed to reach its planned orbit as a result of a series of problems and consequently it is not working as scheduled. Even so it has been doing quite a useful job.

The orbit is inclined 25·9 degrees instead of the planned 57 degrees. The orbit only covers a little over half of that planned. Frequent off-pointing manoeuvres of the aerials are necessary for the present. The satellite is spin stabilised and stands around 14ft high; it is shaped like a three-pointed star. The objects of the satellite were for relay services for amateur operators and for the study of multiple access techniques using linear transponders.

IRAS AGAIN

The claims made recently for the first planetary find of matter surrounding a star suggesting a new system like our own, have been opposed by ground based astronomers. Ground based astronomers are hinting of other disk systems which exist and are more interesting than those discovered by IRAS. Some of them are already at an advanced stage and are said to be around 100,000 years old. They have about the same mass as the Sun but are younger than the Sun, being under 1,000,000 years old. Their interiors are producing energy by nuclear fission but their outer layers are only now settling down.

Astronomers are pointing out that the matter of other planetary systems has been studied for at least ten years and the stars involved have been the subject of scientific papers. So here we go again with new discoveries and rivalries.

Such is the nature of exploration that we learn more of the Universe. Every new discovery leads us to doubt what we previously thought and what the truth might be.

Frank W. Hyde

INTRODUCTION TO DIGITAL ELECTRONICS

MICHAEL TOOLEY BA   DAVID WHITFIELD MA MSc CEng MIEE

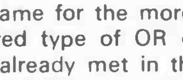
O & A Level   Part Four

THE exclusive-OR gate (usually referred to as the XOR gate) completes the set of basic gates commonly encountered in digital circuits. The XOR gate only occurs in a 2-input form, and its behaviour is such that the output is a logic 1 if *only* one of the inputs is at a logic 1. Thus, if both inputs are at logic 0, or both are at logic 1, then the output of an XOR gate will be a logic 0. The corresponding truth table for the exclusive-OR gate is shown in Table 4.1, and the appropriate logic symbol is shown in Fig. 4.1.

INPUTS		OUTPUT
A	B	$A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

EG1359

Table 4.1. Truth table for the 2-input XOR gate



EG1365

Fig. 4.1. Circuit symbols for the XOR gate

As its name suggests, the exclusive-OR is a variety of the OR gate; the 'proper' name for the more frequently encountered type of OR gate, which we have already met in the series, is the inclusive-OR gate. The inclusive-OR name is, however, only normally used when it is necessary to make the distinction between the two types absolutely clear; it is normally assumed that OR refers to inclusive-OR, and that XOR refers to the exclusive-OR function. The XOR gate, however, arguably performs the 'true' OR function because its output is 1 when one input *or* the other is 1, but not otherwise. The point is of passing interest, however, since the common use of these terms is as described above.

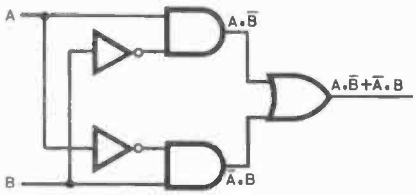
Now that we have seen the function performed by an XOR gate, it is appropriate to look at how such a gate can be built up from the other standard gates, before moving on to look at uses for XOR gates. We can make a first guess at the XOR equivalent circuit by working out the Boolean Expression for the XOR function. As a first step in this process, we will suggest a definition of the behaviour of the XOR gate. The description given above tells us that, if the inputs to the gate are labelled as A and B, and the corresponding output is X, then the gate will function as follows:

If $A = 1$ and $B = 0$ then $X = 1$
or If $A = 0$ and $B = 1$ then $X = 1$

Using the standard Boolean notation, we see that the operation of the XOR gate can therefore be described by the expression:

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

From this expression we can see that an XOR gate can be built up from other standard logic elements as shown in Fig. 4.2. We shall see later that there are other Boolean Expressions which would equally well describe the behaviour of the XOR gate. These in turn would give rise to equivalent circuits that are outwardly different to that in Fig. 4.2, but the point to remember is that these different expressions and circuits are simply *alternative* ways of describing the *same* behaviour. We will need to explore Boolean Algebra a little further, however, before we are able to prove that these alternatives are equivalent, so for the moment we will confine our discussion to the circuit of Fig. 4.2.



EG1366

Fig. 4.2. The XOR gate made up from other functions

We now have a description for the behaviour of the XOR gate in terms of both a truth table and a Boolean Expression. The expression given above, however, is rather cumbersome and, in view of the possibility of alternative forms of the expression, it is not always immediately recognisable. For these reasons, therefore, there is a shorthand notation for XOR in much the same way as we have already seen for AND, OR and NOT. The shorthand for the exclusive-OR function is the $\oplus$ symbol. Thus, from what we have seen above, we can choose to describe the action of a two-input XOR gate by either of the following (equivalent) expressions:

$$X = A \cdot \overline{B} + \overline{A} \cdot B$$
$$\text{or } X = A \oplus B$$

These two expressions are equivalent in every way; the second form, however, makes it easier to recognise where an XOR gate could be used in a practical circuit. Now let us have a look at some examples of uses for real XOR gates.

7486 TTL XOR GATE

The 7486 is a quadruple 2-input XOR gate whose pin configuration and internal layout is shown in Fig. 4.3. The i.c. is in fact pin-compatible with the 7432 inclusive-OR gate, although it is rather unlikely that an exchange of this type will be required very often! The four gates are, as usual, electrically identical, and the power supply connections are quite standard.

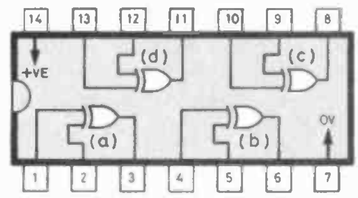


Fig. 4.3. Pin configuration for the 7486 quadruple 2-input XOR

So far, so good, but what about practical uses for this new gate, or is it only a curiosity of rather limited usefulness? In fact, the XOR gate turns out to be unexpectedly versatile. In Fig. 4.4 the gate is shown used as a controllable complementer. If the command signal is a logic 0, the signal will be unaffected by the XOR gate. When the command signal is a 1, however, the output signal is the logical complement of the input signal.

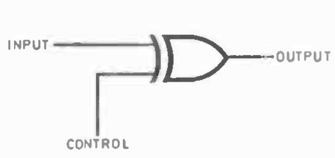


Fig. 4.4. An XOR gate as a controllable complementer

A more interesting use of the XOR gate is as a data scrambler, or coder. The idea is that the data to be protected is mixed with a random-looking (so-called pseudo-random) stream of 0's and 1's from a digital generator. The wanted signal and the scrambling signal are combined by an XOR gate to form a chain of mixed good and bad data. Whenever the random scrambling signal is a 1, the wanted signal is inverted, thereby scrambling the original information. The scrambled signal is then transmitted down a line, or even over a radio link. At the far end, there is another XOR gate driven by a synchronised digital generator providing the same signal as was used to scramble the data originally (it may even be the same one), which allows the scrambled data to be decoded. When the scrambling signal is a 1 at the receiving end, the incoming signal is inverted, thereby undoing the inversion introduced at the sending end; when the scrambling signal is a 0, the incoming signal is unaffected. The point to note is that unscrambling the data in the middle (e.g. by tapping the line) is very difficult since neither the original signal nor the scrambling signal are known. This type of circuitry therefore finds considerable use in cryptography, locks and in all sorts of security systems.

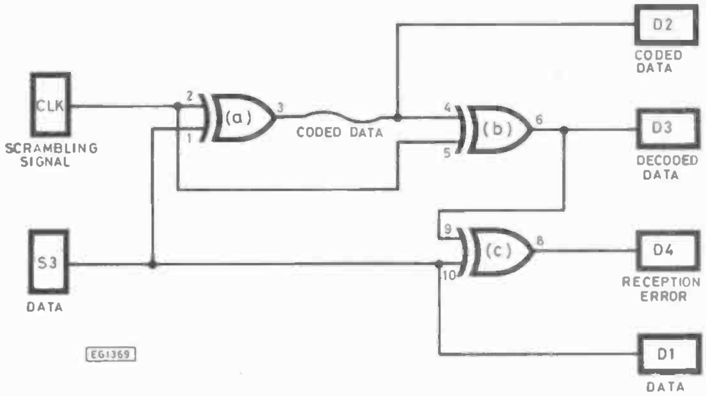


Fig. 4.5. A data scrambling circuit using XOR gates

A simple demonstration of the coding technique just described is provided by the circuit shown in Fig. 4.5. The circuit is set up by inserting a 7486 in socket A, with pin 1 aligned with A1, and then adding the following links.

S3	to	A1	(Original data)
S3	to	D1	
Clock	to	A2	(Coding signal)
Clock	to	A5	(Decoding signal)
A3	to	A4	(Scrambled data)
A3	to	D2	
A6	to	D3	(Received data)
A6	to	A11	(RX data)
S3	to	A12	(TX data)
A10	to	D4	(Data error)
0V	to	A7	(Supply)
+5V	to	A16	(Supply)

In this circuit, S3 provides the signal to be scrambled, and D1 shows the signal level. The Clock signal from the PE Logic Tutor is used as a coding signal, although more complex coding will usually be employed in practice. The scrambled signal is shown by D2, and the unscrambled signal at the receiving end is shown by D3. The third XOR gate is used to compare the sent and received signals. If there is any disagreement between them, D4 will be illuminated to indicate a transmission error.

Pressing S3 should cause D3 to change to indicate the new output state (also shown by D1). The indicator on the scrambled link (D2), however, will show that it is impossible to work out the true state of the coded signal. Remember that in practice the scrambling signal will usually be faster and more random than the Clock used here, and that the link between A3 and A4 could be a telephone or radio link, making the system much more secure.

XOR GATES AS ADDERS

The traditional use for the exclusive-OR is shown in Fig. 4.6. The circuit here is for what is known as a binary half-adder, and is used in building up binary addition circuits. The subject of binary numbers is covered in detail in Part Five, but for the present no such detail is required. The half-adder circuit shown follows the rules of binary addition:

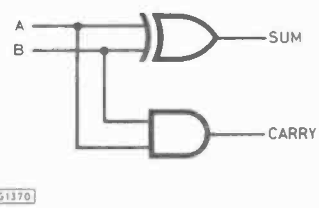


Fig. 4.6. A binary half-adder

$0 + 0 = 0$
$0 + 1 = 1$
$1 + 0 = 1$
$1 + 1 = 0$ plus carry 1

The truth table for the half-adder circuit is shown in Table 4.2. In multi-bit arithmetic applications, we must cascade the carry output from one stage to the carry input of the next

INPUTS		OUTPUTS	
A	B	SUM	CARRY
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

EG1360

Table 4.2. Truth table for a binary half-adder

stage. This type of circuit is known as a full-adder, and it is common to find a single i.c. incorporating many such full-adder stages, having cascaded carry inputs and outputs. Although this subject is a little beyond the scope of the present series, readers may like to investigate the behaviour of the full-adder circuit shown in Fig. 4.7; the truth table is given in Table 4.3.

The full-adder circuit shown below is constructed on the Logic Tutor as follows. Insert a 7486 XOR gate into socket B, and a 7400 NAND gate into socket C, both i.c.s having pin 1 of the appropriate socket. Then add the following links:

S1	to	B4	(Carry input)
B4	to	C4	
S3	to	B1	(A input)
B1	to	C1	
S4	to	B2	(B input)
B2	to	C2	
B3	to	B5	$(A \oplus B)$
B5	to	C5	
B6	to	D1	(Sum output)
C3	to	C12	
C6	to	C11	
C10	to	D2	(Carry output)
B7	to	0V	(Supply)
C7	to	0V	(Supply)
B16	to	+5V	(Supply)
C16	to	+5V	(Supply)

In the circuit as wired above, the two normal inputs (A and B) are provided by S3 and S4, respectively; the carry input is provided by S1 (or fixed logic levels if this is more convenient than a momentary switch). The sum output is displayed by D1, and the carry output by D2. It is then an interesting exercise to verify the truth table given in Table 4.3.

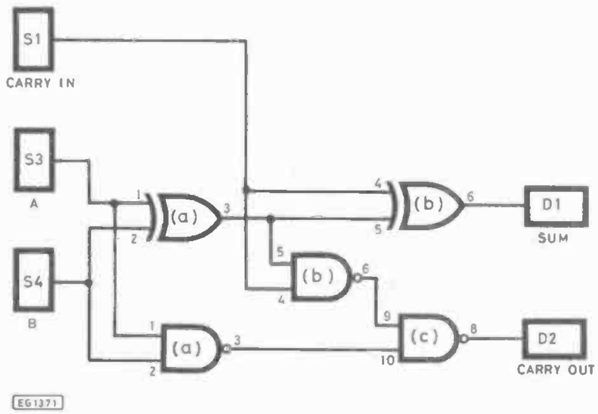


Fig. 4.7. A binary full-adder

INPUTS			OUTPUTS	
Cin	A	B	SUM	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

EG1361

Table 4.3. Truth table for a binary full-adder

Readers may, as a final exercise, like to try constructing a second full-adder stage, using the other two XOR gates from ICB and a further 7400. The carry output of the first stage is simply connected into the carry input of the second. Is its behaviour as you would expect? If not, try again after Part Five!

THE FORGOTTEN POWER SUPPLY

The power supply in any well-designed system is rather taken for granted. It does what is required, with the minimum of fuss, and for the most part can be all but ignored. This can, however, have some amusing effects on the thought processes of designers trying to debug a misbehaving circuit. It is not unknown for the problem to be traced eventually to i.c.s which have been carefully wired up according to the circuit diagram, but with the power supply connections omitted. The problem here is that, if only one i.c. of many (usually one that has been added after the original design was produced!) is without power, the symptoms are not always easy to spot. Strange you may think, but true we assure you! The extreme of this syndrome is usually the basis of a favourite tale in every lab: the story of how "X" spent all afternoon trying to debug a circuit which was not even switched on! All too easy to do when surrounded by masses of test equipment which is all switched on and working, but it does show how much logic power supplies are taken for granted.

The cautionary tales above reflect some possible results of a situation that we are in fact striving to achieve; a logic power supply should provide power for the circuit without producing any adverse effects. The use of a logic family such as the 7400 TTL series greatly simplifies the task of designing a suitable power supply since the supply requirements for the whole family are similar. On the whole, the major difference between the i.c.s in a logic family, as far as the power supply is concerned, is in terms of the load placed on the supply. We shall see later that there are other factors which also affect the way in which the supply is *used*, but this does not affect the supply itself. Once we have designed a suitable TTL supply, therefore, we should be able to use it for any TTL circuit which does not exceed the available load capacity.

POWER SUPPLIES FOR TTL

The 7400 family of TTL i.c.s are all designed to operate from a single +5 volt power supply. There are, however, a number of features of this power supply which we must consider carefully if our TTL circuits are to operate reliably and predictably. The following characteristics summarise the basic requirements for power supplies intended for use with TTL.

The output from the power supply unit (p.s.u.) should be regulated so that, at any time, the voltage is within

250mV of the nominal +5 volts. Ideally the supply should also be stabilised so that any variations in the current drawn by the circuit do not affect the output voltage. The ripple on the supply line (often the result of inadequate smoothing in mains powered circuits) should similarly always be kept to less than 250mV.

Some simple small-scale TTL circuits can be operated from batteries (e.g. three fresh HP2 cells wired in series), or from wider-range unregulated supplies. Many unstabilised supplies are actually suitable for small circuits, provided that the output does not exceed +5·5 volts, but a regulated supply is always to be preferred. The greater the number of i.c.s in a circuit, the greater becomes the need for a tightly regulated supply. In any event, it should be remembered that the absolute maximum voltage at the supply pin of a TTL i.c. is limited to +7 volts. Exceeding this voltage may cause damage to the device; the other (guaranteed) method of doing this is to connect the supply to the i.c. the wrong way round!

So far, we have concentrated on the power supply requirements for TTL circuits in terms of its voltage specifications. The other side of the problem, however, is to work out the load current for the circuit to be supplied. The data books usually quote the supply requirements in terms of either the power (in mW) or the current (in mA) required by each gate in an i.c. package. Power supply design is usually concerned with load current, so any mW figures must first be converted to mA by dividing by 5 (the nominal supply voltage). It should be remembered, however, that this current is drawn *whether or not* a particular gate in an i.c. is being used. Furthermore, whole unused i.c.s will still place a load on the power supply unless they are actually disconnected from the supply rails.

To work out the total load current for a particular circuit, we simply add up the supply currents for each i.c., and then add in the loads for devices other than the i.c.s, e.g. indicator l.e.d.s at 10mA each. We usually then add a safety margin of, say, 20% to this figure to arrive at the minimum current that we should design our power supply to provide. As a guide, supply current figures for a selection of standard TTL gate functions are given in Table 4.5. By way of comparison of the differences between the TTL sub-families discussed in Part Three, Table 4.6 shows typical supply figures for comparable gates in the various sub-families.

GATE TYPE	AVERAGE SUPPLY CURRENT (mA PER IC)
7400	8
7402	11
7404	8
7408	15·6
7414	20·4
7432	19
7486	30

EG1363

Table 4.5. Supply current figures for some standard TTL gates

GATE TYPE	AVERAGE SUPPLY CURRENT (mA PER IC)
7400	8
74H00	17·6
74LS00	1·6
74S00	15·2
74ALS00	1
74L00	0·8

EG1364

Table 4.6. Typical supply figures for various TTL sub-families

A PRACTICAL PSU CIRCUIT

The simplest way to provide power for a TTL circuit is to use a mains transformer, combined with a rectifier/smoothing circuit. This should provide a raw, unregulated d.c. supply in the range +8 to +12 volts. We then add an i.c. voltage regulator stage to stabilise the output from the smoothing circuit to +5 volts. These voltage regulator i.c.s are available in a wide range of current ratings, and they provide excellent performance at relatively low cost. They are very simple to use, usually include internal protection against excess temperature and output current, and are extremely robust and reliable. At higher current ratings a heatsink may be required to cool the regulator; the heat generated (in watts) is equivalent to the product of the load current (in amps) and the voltage by which the unstabilised supply exceeds 5 volts. A typical mains powered TTL power supply circuit is shown in Fig. 4.8.

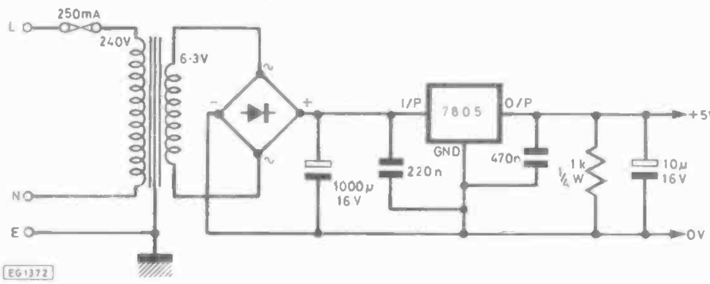


Fig. 4.8. Mains power supply for TTL

Where an unstabilised d.c. supply of around +8 volts is already available, the simplified stabiliser circuit shown in Fig. 4.9 may be used. This circuit is simply placed between the unstabilised supply and the TTL circuit to be powered. No heatsink will be needed unless the supply current exceeds approximately 250mA. The regulator specified is suitable for load currents of up to 1 amp, and others are available for higher/lower load requirements.

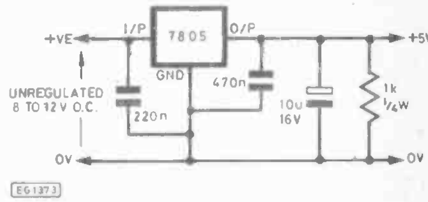


Fig. 4.9. Simple stabiliser circuit

SUPPLY DISTRIBUTION

Producing a good power supply is only part of the story when it comes to dealing with real digital circuits. No matter how good the supply, it is still possible to run into problems if it is not properly distributed to the i.c.s in the circuit. This is another case where we never really notice good supply distribution, until we forget! There are a number of simple rules which, if followed, will assist in producing good supply distribution, and hence avoiding trouble.

The most important characteristic of the interconnections between the supply and the circuit (i.e. the i.c.s, etc.), is that they should have a low impedance at all frequencies below 35MHz (or 125MHz with Schottky TTL). This is essential if a sudden change, or burst of high speed operation in one circuit area is not to affect another area via the supply lines. In this respect it should be remembered that, although the signals being processed by a circuit may be slow, the switching speed of TTL is always high. The impedance of the supply leads is usually most affected by two factors: how the supply is distributed, and how the supply rails are decoupled. We will look first at how to minimise the impedance of the supply by proper distribution of the supply, before going on to look at decoupling.

The power supply wiring runs themselves should have the lowest possible impedance. In practice this means that wide foil tracks are required on printed circuit boards for *both* +5V and 0V rails. Typically, the main ground (0V) rail on the board should be at least 8mm wide, while the main +5V rail should be at least 6mm wide. It is quite a common practice for the main ground rail to run all or most of the way around the edge of the p.c.b. to minimise the impedance of the ground tracks to the individual i.c.s. The general rule here is that the wider the p.c.b. track, the better.

Connecting the supply to the board itself should be via terminals which can carry a heavy current by comparison with the expected load, or through several connector pins wired in parallel. Power supply connections to the board should use heavy gauge wire of minimum length. Again, the general rule is that the shorter and thicker the power supply distribution leads (on and off the p.c.b.), the better.

DECOUPLING CAPACITORS

When the output of a TTL gate changes from 0 to 1, or vice versa, the output transistors conduct heavily. The instantaneous current under these conditions may be as much as ten times the normal supply current. The idea is to speed up the switching performance of the output stage, but a side effect is that a large current 'spike' is drawn from the supply rails. This spike can easily exceed 100mA, and typically lasts around 10 nanoseconds. We must do something, therefore, if this spike is not to cause problems for the other i.c.s in the circuit.

The normal solution is to add small-value capacitors (known as decoupling capacitors) along the supply rails, situated near to the i.c.s. The point is that the current spikes represent very high frequency signals, and we must prevent these from going through the supply system, and upsetting other stages. The decoupling capacitors must therefore be distributed throughout the supply system, and *not* concentrated at the power supply itself. These local capacitors then supply the energy for the supply during the output transitions, and the spikes are prevented from spreading into the system.

The capacitors used for decoupling should be high frequency types (*not* electrolytics), and they should be connected with short lead lengths as close as possible to the i.c. power pins. Small disc ceramic capacitors of 4·7μF to 100nF, and rated at 10 volts working or higher, are recommended for supply decoupling. This type of capacitor can conveniently be mounted adjacent to the appropriate i.c. package, the closer the better.

In general, a useful rule is to use at least one decoupling capacitor for every four or five i.c.s. Add an extra capacitor wherever an i.c. is further than, say, 100mm from its nearest decoupling capacitor. Finally, if in doubt, add some more decoupling; this will then safeguard against the problem that, when a circuit is extended, extra decoupling is often forgotten. Remember: distributed decoupling is *essential* for proper TTL operation.

In addition to the high frequency decoupling described above, it is good practice to use some distributed low frequency decoupling. As a general rule, a single 10μF tantalum electrolytic capacitor rated at 10 volts is sufficient for each printed circuit board. For very large circuits, one such capacitor per 10–20 i.c.s is a useful ratio.

The main rule for supply decoupling is to add what seems to be enough, and then add some more. Never be tempted, however, to think that, because the decoupling capacitors appear to be connected in parallel, they can be replaced by a single capacitor of seemingly equivalent value. This will *not* work. The reason is that the distributed capacitors are not connected in parallel, they are separated by the impedance of the supply leads, and by the transit time of the spikes along the leads. Fig. 4.10 shows a p.c.b. layout which summarises the general principles of supply distribution and decoupling for a medium-sized TTL circuit; all signal leads have been omitted for clarity.

LAWS OF BOOLEAN ALGEBRA

When we introduced Boolean Algebra in Part Three, we mentioned that a set of rules were really necessary in order to be able to manipulate Boolean Expressions. These rules are often called identities because they tell us how to recognise Boolean Expressions which are equivalent to each other, but which are expressed in a different form. We will also be looking at the basic laws of Boolean Algebra in this part of the series, before going on to the more advanced ideas of De Morgan and Karnaugh in future parts. As with all types of algebra, a firm grasp of the basic laws will be an

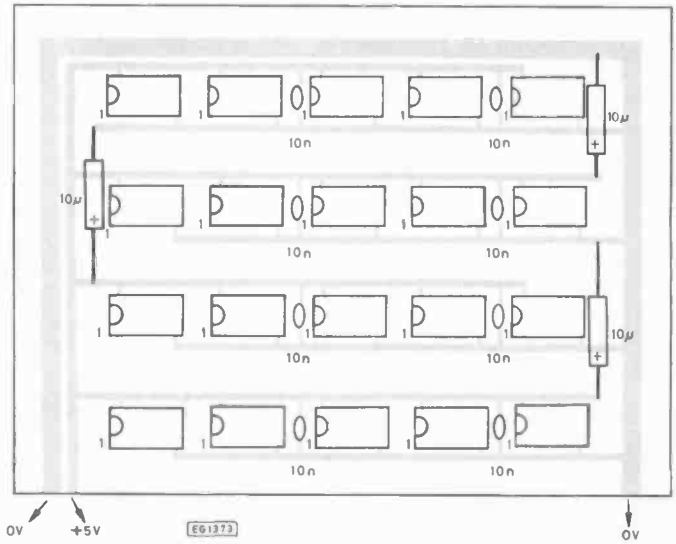


Fig. 4.10. Supply distribution and decoupling rules summarised

invaluable asset when analysing gate circuits.

In looking at the basic Boolean Identities, one useful approach is to use simple switch logic to simulate the actions of logic gates. This analogy was introduced briefly in Part Two, and we will now use it in discussing some of the laws of Boolean Algebra as they relate to two-input gates. To summarise the conventions of switch logic, a closed switch represents a logic 1, and an open switch a logic 0; Fig. 4.11 shows the corresponding representations of AND and OR gates.

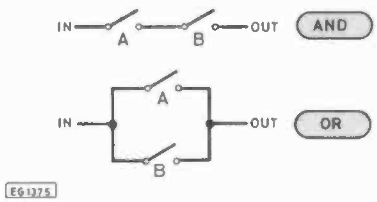


Fig. 4.11. Switch logic representations of AND and OR gates

When we work out the effect of a Boolean Expression, the rules of Boolean Algebra say that we consider the AND functions first, and then the OR functions. Thus we work through expressions from left to right, first with the AND functions, and then again with the OR functions. We can use brackets, however, to over-ride this order; the contents of any brackets are worked out first, before working left to right as before. Brackets also allow us simply to clarify an expression, or to indicate the way in which the circuit which implements the expression will be built.

Commutative Law. This law states that the order in which the terms or variables appear in a Boolean Expression is unimportant. In particular, this means that the following relationships hold true:

$$A + B = B + A$$
$$A \,.\, B = B \,.\, A$$

These are illustrated in switch logic in Fig. 4.12 (a) and (b), respectively.

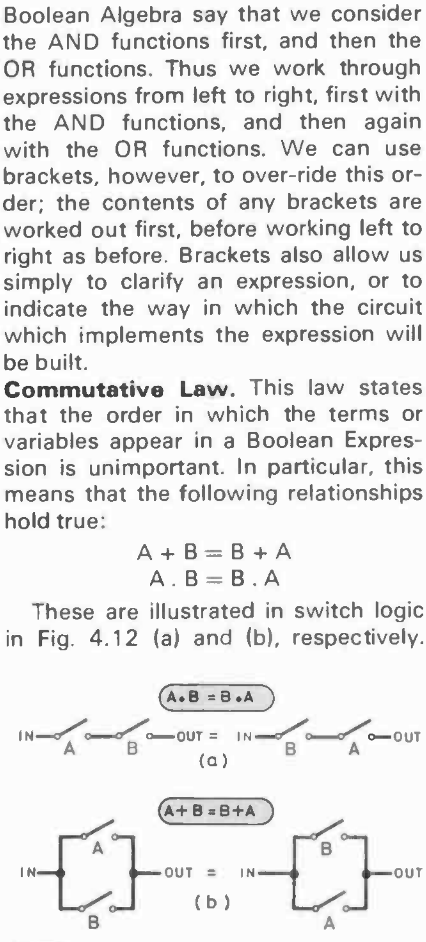


Fig. 4.12. The Commutative Law

The law in essence means that the order in which we write down the input signals when we analyse a gate circuit is unimportant. The order in which the *functions* are written down, however, may be significant, depending on whether or not the Associative Law applies.

Associative Law. This law states that the order in which *identical* functions are performed is not significant. Thus, if we use brackets to show how cascaded gates implement the logical expression, the following relationships hold true:

$$(A + (B + C)) = ((A + B) + C)$$
$$(A \,.\, (B \,.\, C)) = ((A \,.\, B) \,.\, C)$$

These expressions are each illustrated, using standard logic symbols and switch logic, in Fig. 4.13 and Fig. 4.14, respectively. Although the order in which identical functions appear is not significant, the order in which non-identical functions are written down is important; this difference is highlighted by the Distributive Law.

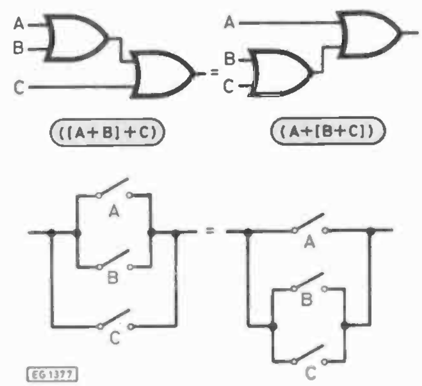


Fig. 4.13. The Associative Law for the OR function

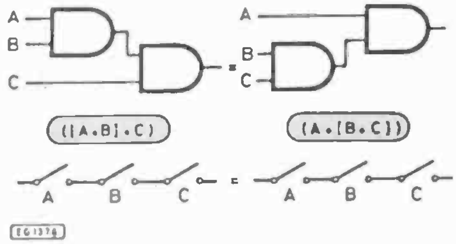


Fig. 4.14. The Associative Law for the AND function

Distributive Law. There are two ways of expressing this law, depending on the type of logical operations involved. The two forms are:

$$A + (B \,.\, C) = (A + B) \,.\, (A + C)$$
$$A \,.\, (B + C) = (A \,.\, B) + (A \,.\, C)$$

The first form is known as the product of sums expression, while the second form is the sum of products result. The logic arrangements corresponding to these two forms of the law are shown in Fig. 4.15 and 4.16, respectively.

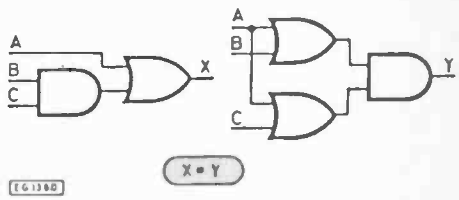


Fig. 4.15. The product of sums form of the Distributive Law

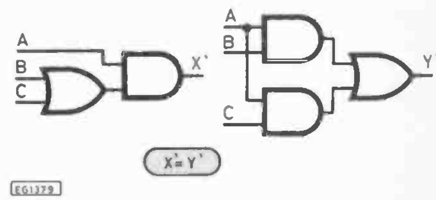


Fig. 4.16. The sum of products form of the Distributive Law

Useful Identities. There are a number of other Boolean Identities which are extremely useful in practical logic design. We have already seen many of these in our discussions of the behaviour of the basic logic gate functions, but it is useful to identify the underlying theorems for future use.

$A + 0 = A$	$A \,.\, 0 = 0$	$A \oplus 0 = A$
$A + 1 = 1$	$A \,.\, 1 = A$	$A \oplus 1 = \overline{A}$
$A + A = A$	$A \,.\, A = A$	$A \oplus A = 0$
$A + \overline{A} = 1$	$A \,.\, \overline{A} = 0$	$A \oplus \overline{A} = 1$
	$\overline{\overline{A}} = A$	

Although at first sight rather simple expressions, these are probably the most widely used and useful of the Boolean Identities.

BOOLEAN MINIMISATION

The most important uses of the laws and identities described above are essentially practical; they allow us to rearrange and simplify logical expressions. When building TTL circuits, the i.c.s we use often have many gates in a single package, and one of our aims is usually to keep the number of these i.c.s to a minimum. Our objective, therefore, is to rearrange the logical expression which describes our circuit so that we make best use of the smallest number of i.c.s.

An example is the best way of illustrating the type of savings which can be made by even simple rearrangements. If we look at the circuit of Fig.

4.17(a), we can see that it involves both OR and NOR gates, and would require two i.c.s to build it in TTL. However, by applying one of the Boolean Identities above, we can rearrange it to make use of only NOR gates, and hence reduce the circuit to a single i.c., as shown in Fig. 4.17(b).

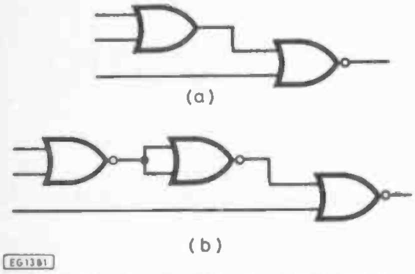


Fig. 4.17. Two ways of building a circuit to perform the same function

This is obviously a rather trivial example, but it is a useful illustration of the effectiveness of the identities in practice. The introduction of De Morgan's Theorem in Part Seven will give us further scope for this type of 'gate swapping', but for the present the laws and Boolean Identities provide us with useful design tools. Let us look now at an example of how to minimise the number and complexity of the terms in a logical expression.

When we design a logic circuit, the most natural approach is to consider each of the input signals in turn, and decide how it will be combined with the other inputs to produce the output signal(s). This gives us a design (and an associated logical expression) which is usually easily understood, but which is not necessarily the most efficient way of building the associated circuit. What we are looking for is the simplest way of expressing our initial design; a so-called minimal solution. Before embarking on this exercise, however, it is as well to remember that there are often a number of minimal solutions. The choice of which one to use is usually a compromise based on the number of i.c.s required, the number of connections, the layout, the types of gates required, cost, etc. In most cases, one of the hidden factors is also that minimising the circuit often reduces the ease with which it can be understood or modified. As in all branches of design engineering, however, solutions to problems invariably represent some form of compromise between the various factors. Now for the example.

Let us assume that we are again involved with the design of the electronically controlled shop introduced in Part Two. A section of the shop's security system is to set off a warning if the following logical expression is true.

$$A.B.C+\bar{B}.A.C+\bar{C}.B.A$$

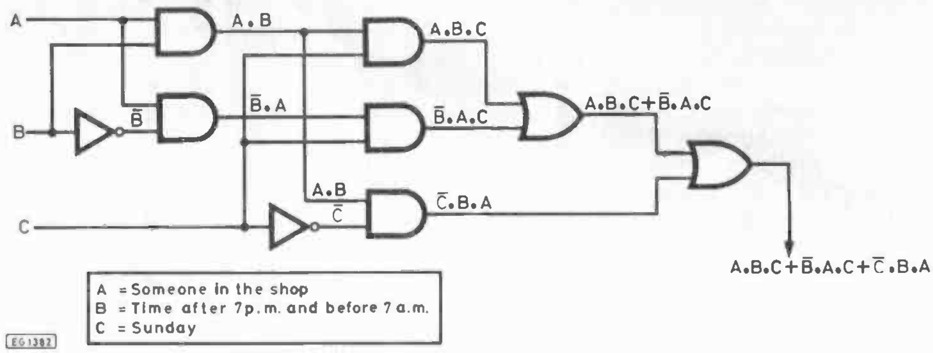


Fig. 4.18. Shop security system before minimisation

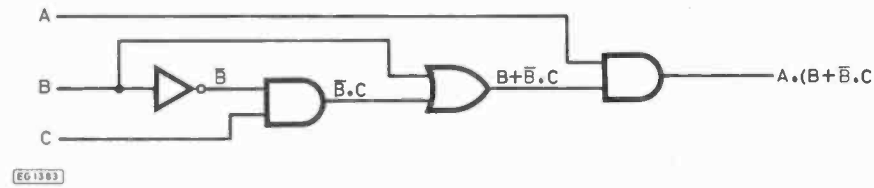


Fig. 4.19. Shop security system after first minimisation

Fig. 4.18 shows how this design could be built directly, but we will try rearranging the expression to see if it can be reduced. Let us first apply the commutative law to rearrange the terms, and then collect them up together:

$$A.B.C+\bar{C}.B.A+\bar{B}.A.C$$
$$C.A.B+\bar{C}.B.A+\bar{B}.A.C$$

Now we apply the distributive law, and use one of the Boolean Identities to simplify the resulting expression:

$$(C+\bar{C}).(B.A)+\bar{B}.A.C$$
$$1.(B.A)+\bar{B}.A.C$$

This can be simplified further by applying another of the Boolean Identities, and then applying the distributive law again:

$$B.A+\bar{B}.A.C$$
$$A.(B+\bar{B}.C)$$

This seems to be about as far as we can go in this direction. The minimised circuit which results from this manipulation is shown in Fig. 4.19, and represents a considerable reduction when compared with Fig. 4.18. A very similar result can be obtained by eliminating B from the first/third terms, rather than eliminating C from the first/second terms:

$$A.(C+\bar{C}.B)$$

As a final exercise we will suggest that there is yet another form of the minimal solution which can be obtained by using the following Boolean Identity:

$$A.B.C=A.B.C+A.B.C$$

This is actually just another form of the identity $A = A + A$. If we put this identity into our original Boolean Expression above, and then re-work the minimisation, it is possible to reduce the final expression to:

$$A.(B+C)$$

If this result seems doubtful, try building the two circuits on the Logic Tutor and comparing their truth tables. The circuit for this solution is shown in Fig. 4.20. The final test, really, is to

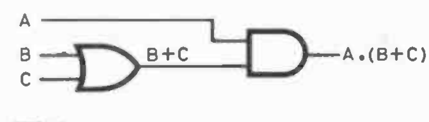


Fig. 4.20. Minimal solution for the shop security system

look at what the original logic expression *means* in terms of the conditions required to set off the alarm, and see whether the minimised expression does the same; it should!

NEXT MONTH: Bistables

'SIMPLE' 'SPEECH'

P. Creighton

Digital Acquisition & Reproduction

Part Two

Experimental Speech System

TWO approaches have been tried for the systematic acquisition of a vocabulary and for selective replay of a specified word. They have both been considered because they have their respective merits. In the first approach the acquisition count routine halts during silences; this has the great advantage of ignoring redundant silence either side of a word as spoken during the period that the Acquisition Enable button is depressed. However, intra-word silences are elided. One solution to this difficulty might have been to make acquisition conditional on the state of the output of an envelope detector; however, this would still be unsatisfactory, because the first few milliseconds of a word would be missed, owing to the response time of the envelope detector. Furthermore, the acquisition procedure would be fooled, since it would be unable to distinguish between such a brief hiatus and the true end of a word.

Yet other approaches might be tried: obviously the problem could be overcome by using a double-precision counter, which would time for long enough to cover the intra-word silences; but it would be wasteful of memory to store two bytes per inter-transition interval, for much of the time the high-order byte would be redundant; it would also (in the case of the 6502) increase the count loop time, so making for poorer resolution of intervals.

The first approach was tried, and was quite successful, apart from the elision of intra-word silences.

In the second approach, for which programs are here presented, provision is made for the acquisition of silences of a limited duration, whose maximum value may be specified before execution of the acquisition program.

The end address of the speech data is automatically recorded in a table when the press button switch is released. This is achieved by means of a routine to which control is transferred by a negative-going transition on the 6502's $\overline{\text{NMI}}$ line.

The replay program regenerates any chosen word, the appropriate speech data being accessed simply by a number, this being the position of the word in the sequence that was originally stored.

Note that 16K of RAM is needed, and that BASIC must be restricted to decimal 5567 bytes. The additional hardware needed has already been given in the lower part of Fig. 1.2 last month, but revised, rationalised circuitry is given in Fig. 2.1.

REVISED ACQUISITION CIRCUITRY

The acquisition circuitry has been modified to avoid the need for a dual power supply, and to incorporate some nominal filtering to restrict the speech bandwidth. If you wish to experiment with different bandwidths, then omit this filtering and use the variable low and high-cut filters described earlier. A further refinement is the provision of an l.e.d. driven by the comparator output; this is helpful in

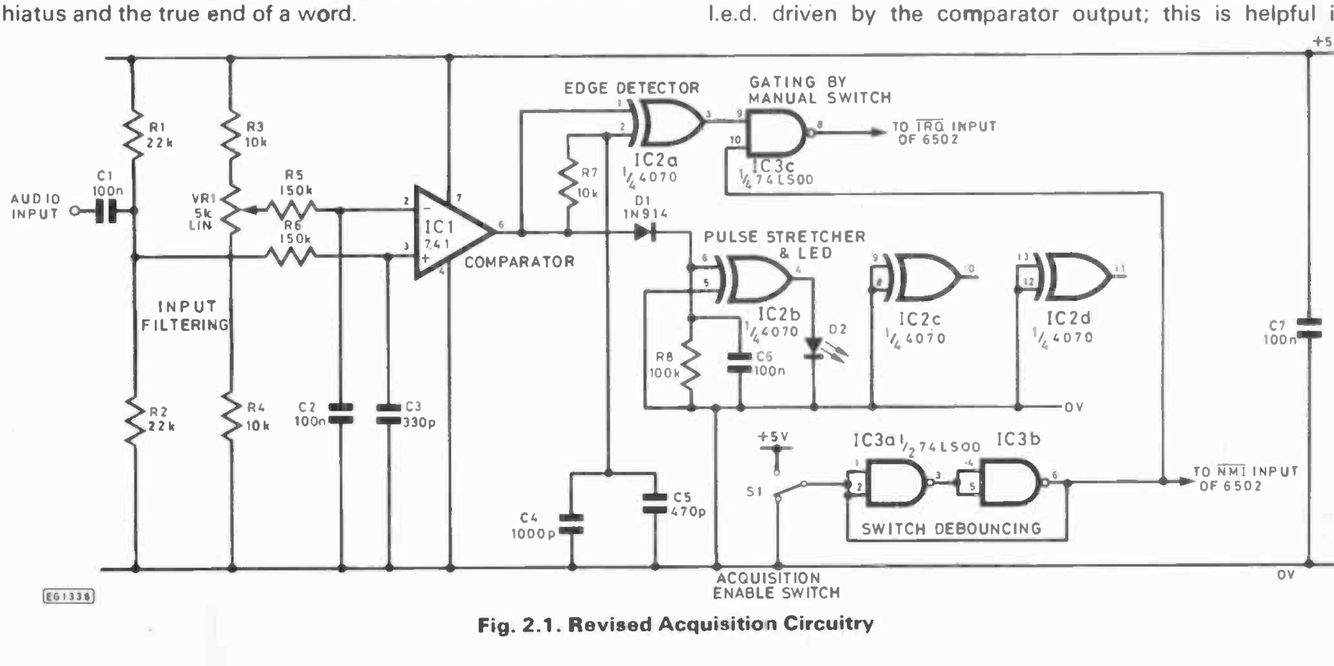


Fig. 2.1. Revised Acquisition Circuitry

setting the comparator threshold just above the noise level: VR1 should be set so that the l.e.d. just stays off at the ambient 'silence' level. (It is important that background noise be reasonably low within the operating bandwidth). A delay interposed between the comparator and the l.e.d. stretches brief threshold crossings enough to visibly light the l.e.d.

REPLAY CIRCUITRY

Quite acceptable speech output can be obtained, without the need for an audio amplifier, by connecting a small loudspeaker to the flip-flop as shown. Placing the loudspeaker cone downwards in a small plastic bowl of suitable tapering diameter was found to provide a beneficial resonance; this is something to experiment with.

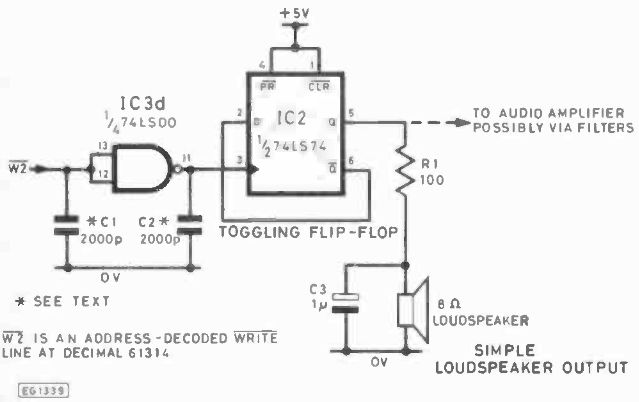


Fig. 2.2. Replay circuitry

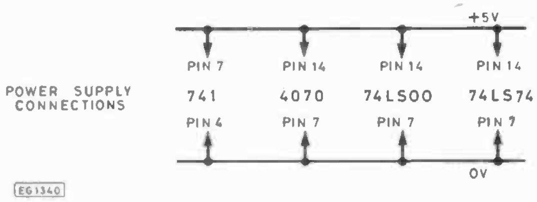


Fig. 2.3. Power supply connections for i.c.s

SETTING UP OF HARDWARE

Setting up the acquisition circuitry involves only adjustment of VR1 as already described. To verify that the D-type flip-flop can toggle correctly, fill up part or all of the word data storage area with some arbitrary interval value (except 255, which is treated as silence), and execute the routine for continuous replay, i.e. RPFF3 given earlier. This should yield a continuous tone of steady pitch; if it sounds ragged or irregular, then try changing the values of the capacitors marked with an asterisk.

CONSTRUCTION

The circuitry is not complicated or critical in layout, and because it is regarded as experimental and open to improvement, a p.c.b. design has not been provided. It can readily be assembled on Veroboard or fitted into space on an existing board.

USING THE PROGRAMS

Having set up the hardware, the programs may now be tried out.

Enter a value into SILMAX, i.e. page zero location 51 hex. This gives the maximum length of continuous silence that can be acquired; a value of 10 hex seems about right. Now execute the acquisition program from 029B hex. No speech data will be stored in memory until the Acquisition Enable button is pressed. Thus the procedure is as follows: decide on the vocabulary sequence you wish to enter; execute the program from the machine code monitor; press the button and hold down, starting to speak the word as soon as the button is depressed, and releasing the button as soon as the word is finished; continue in this fashion until the program returns you to the monitor, which will happen when the memory storage area for either the word data or the end-of-word address table becomes filled up. Depending upon the bandwidth in use, up to 20 average-length words can be stored. If you have more than 16K of memory, then you can modify the programs to increase the vocabulary storage capacity.

Having entered the vocabulary sequence, verify that page zero location 57 hex contains the number of words which you were able to enter; then have a look at the contents of the table of end addresses of words; the two-byte values in low-high order should be in an ascending order.

The replay routine is conveniently tested from BASIC using the test programs given, one of which replays a single specified word, the other replaying the entire vocabulary out in sequence. Clearly the replay routine can be called from any other program of your choice.

It is actually possible to manage without a microphone and preamplifier, because you can store the vocabulary sequence on cassette tape, and then replay the tape recording into the acquisition circuitry at full volume, pressing and releasing the button switch as described above; a particular vocabulary for use with a particular program can be stored on tape along with the program; clearly the vocabulary data could also be stored in its encoded form, in which case the acquisition procedure would not have to be repeated. If you have a disc-based system, then the speech facility becomes much more useful. ★

BASIC Test Programs

```
1000 REM TO TEST SPK7, SWD5
1005 POKE 11,55: POKE 12,22
1010 INPUT "ENTER WORD NO.": WN: POKE 88,WN–1
1015 X = USR(X)
1020 GOTO 1010

1500 REM RUNS THROUGH VOCABULARY
1505 POKE 11,55: POKE 12,22
1510 FOR N = 0 TO (PEEK(87)–1)
1515 POKE 88,N
1520 X = USR(X)
1525 FOR T = 1 TO 400: NEXT T
1530 NEXT N
1535 GOTO 1510
```

Lines 1005 or 1505 set up the USR address; once this is set up any program in BASIC can elicit a specified word by putting the word number in page zero location 58 hex by doing a POKE 88, word number–1, and then doing a USR call.

MEMORY ALLOCATION

Hex Address	Decimal Address	Name	Usage	
$ 3FFF	16383		16K	
				Storage area for speech word data
$ 1800	6144		6K	
$ 17FF	6143			
				Machine code routines
$ 1600	5632			
$ 15FF	5631			Table of addresses of ends of words (up to 32 words, subject to memory space)

$ 15C0	5568	
$ 15BF	5567	BASIC's workspace. I.e. restrict MEMORY SIZE to 5567 when cold-starting
$ 0300	768	
$ 02FF	767	Machine code routines
$ 0250	592	

PAGE ZERO

$ 50	80	BGNWD(L) *	Address of beginning of word to be replayed.
$ 51	81	BGNWD(H) **	
$ 52	82	ENDWD(L)	Address of end of word to be replayed.
$ 53	83	ENDWD(H)	
$ 54	84	TINDEX	Offset or index for table.
$ 55	85	P1(L)	Indirect pointer P1
$ 56	86	P1(H)	
$ 57	87	NWORD	Number of words in vocabulary.
$ 58	88	WCHWD	Specifies which word to play back.

* ALSO USED AS SILENGTH
** ALSO USED AS SILMAX

VOCABULARY ACQUISITION PROGRAM

```
  1                            ; Vocabulary Acquisition
                                 Program.
  5                            ; Before execution enter value
                                 of (SILMAX) into ($ 0051),
                                 e.g. S 10
 10                            ; Assemble from $ 0250.
 15                            ; Execute from $ 029B
 18           ORG 592
 20                            ; Interrupt-driven Count routine
 25  NXT      TXA              ; Come here on IRQ interrupt.
                                 Store last-acquired interval.
 27           STAIY 85
 30  NMI6EP   LDXIM 0          ; Entry point from NMI routine.
                                 Clear interval counter.
 50           CLC              ; Increment indirect pointer to
                                 memory storage area.
 60           LDAZ 85
 70           ADCIM 1
 80           STAZ 85
 90           LDAZ 86
100           ADCIM 0
110           STAZ 86
120           CMPIM 64         ; Exit if end of memory
                                 reached (16 K)
130           BEQ EXIT
140           CLI              ; Enable maskable interrupts
150  CNT      INX              ; and start counting until next
                                 interrupt
160           CPXIM 255        ; Or, if count reaches 255,
163           BEQ SIL
166           JMP CNT
168  SIL      SEI              ; then disable interrupts,
170           INCZ 80          ; and increment (SILENGTH)
                                 (silence counter)
173           LDAZ 80
176           CMPZ 81
180           BNE NXT          ; and branch back to start of
                                 count routine
183           LDAIM 0          ; unless (SILENGTH) equals
                                 (SILMAX) in which case
186           STAZ 80          ; clear (SILENGTH),
187           CLI              ; re-enable interrupts,
188  LIMBO    BEQ LIMBO        ; and wait for next interrupt
190  EXIT     BRK
205                            ; NMI routine. Stores end
                                 address of word in table
220           SEI              ; Disable maskable interrupts
230           LDXZ 84          ; Fetch index to table of
                                 addresses of ends of words
240           CPXIM 64         ; Exit if no. of words has
                                 reached 32.
250           BEQ STOP
260           LDAZ 85          ; Else store end address of
                                 just-acquired word in table.
270           STAX 5568
280           INX
290           LDAZ 86
300           STAX 5568
305           INX              ; Adjust index ready for next
                                 entry
310           STXZ 84          ; and save in (TINDEX)
320           INCZ 87          ; Increment word counter,
                                 (NWORD)
330           JMP NMI6EP
340  STOP     BRK
405                            ; Initialisation routine. Execute
                                 from here, i.e. $ 029B
410           CLD              ; Binary arithmetic mode
420           LDYIM 76         ; Set up IRQ vector to access
                                 count routine.
430           STY 561
440           LDYIM 80
450           STY 562
460           LDYIM 2
470           STY 563
480           LDYIM 76         ; Set up NMI vector to access
                                 routine to store end
                                 addresses of words
490           STY 558
500           LDYIM 128
510           STY 559
520           STY 560
540           LDYIM 0          ; Memory pointer offset
                                 equals zero.
550           LDXIM 255        ; First 'interval' stored will be
                                 255, treated as silence by
                                 replay routine.
555           STYZ 80          ; Clear (SILENGTH)
560           STYZ 85          ; Clear memory pointer low
                                 byte.
565           STYZ 87          ; Clear word counter.
570           LDAIM 24         ; Initialise high byte of
                                 memory pointer to $ 18
575           STAZ 86
580           LDAIM 255        ; Make first entry in table of
                                 end addresses $ 17FF, i.e.
                                 a dummy entry because no
                                 previous word before first.
585           STA 5568
590           LDAIM 23
595           STA 5569
600           LDAIM 2          ; Start off table index
                                 (TINDEX) with value 2 to
                                 bypass dummy entry.
605           STAZ 84
610           CLI              ; Enable maskable interrupts.
615  WAIT     JMP WAIT         ; Wait for first interrupt
```

Note. Above code can be shortened somewhat because some instructions are duplicated. However, for the sake of clarity, this has not been done.

DISASSEMBLED LISTING OF ACQ2

HEX ADDRESS	INSTRUCTION CODE	MNEMONIC	OPERAND (HEX)
0250	8A	TXA	
0251	9155	STAIY	55
0253	A200	LDXIM	0
0255	18	CLC	
0256	A555	LDAZ	55
0258	6901	ADCIM	1
025A	8555	STAZ	55
025C	A556	LDAZ	56
025E	6900	ADCIM	0
0260	8556	STAZ	56
0262	C940	CMPIM	40
0264	F019	BEQ	27F
0266	58	CLI	
0267	E8	INX	
0268	E0FF	CPXIM	FF
026A	F003	BEQ	26F
026C	4C6702	JMP	267
026F	78	SEI	
0270	E650	INCZ	50
0272	A550	LDAZ	50
0274	C551	CMPZ	51
0276	D0D8	BNE	250
0278	A900	LDAIM	0
027A	8550	STAZ	50
027C	58	CLI	
027D	F0FE	BEQ	27D
027F	00	BRK	
0280	78	SEI	
0281	A654	LDXZ	54
0283	E040	CPXIM	40
0285	F013	BEQ	29A
0287	A555	LDAZ	55
0289	9DC015	STAX	15C0
028C	E8	INX	
028D	A556	LDAZ	56
028F	9DC015	STAX	15C0
0292	E8	INX	
0293	8654	STXZ	54
0295	E657	INCZ	57
0297	4C5302	JMP	353
029A	00	BRK	
029B	D8	CLD	
029C	A04C	LDYIM	4C
029E	8C3102	STY	231
02A1	A050	LDYIM	50
02A3	8C3202	STY	232
02A6	A002	LDYIM	2
02A8	8C3302	STY	233
02AB	A04C	LDYIM	4C
02AD	8C2E02	STY	22E
02B0	A080	LDYIM	80
02B2	8C2F02	STY	22F
02B5	A002	LDYIM	2
02B7	8C3002	STY	230
02BA	A000	LDYIM	0
02BC	A2FF	LDXIM	FF
02BE	8450	STYZ	50
02C0	8455	STYZ	55
02C2	8457	STYZ	57
02C4	A918	LDAIM	18
02C6	8556	STAZ	56
02C8	A9FF	LDAIM	FF
02CA	8DC015	STA	15C0
02CD	A917	LDAIM	17
02CF	8DC115	STA	15C1
02D2	A902	LDAIM	2
02D4	8554	STAZ	54
02D6	58	CLI	
02D7	4CD702	JMP	2D7

SINGLE WORD REPLAY PROGRAM

1			; Replays a single word specified by (WCHWD)
5			; Assemble from $ 1600
7			; Execute from $ 1637
10		ORG 5632	
30	SWD6	LDAZ 80	; Set memory pointer to beginning of word.
40		STAZ 85	
50		LDAZ 81	
60		STAZ 86	
70		LDYIM 0	; Pointer offset equals zero.
80	NXTBT	LDAIY 85	; Fetch next byte of interval data.
90		TAX	
100	LOOP	DEX	; Count down for duration corresponding to interval data.
120		BNE LOOP	
130		CMPIM 255	
140		BEQ NOTOG	; Treat an interval of 255 as silence.
150		STA 61314	; Else toggle flip-flop.
160	NOTOG	CLC	; Increment memory pointer.
170		LDAZ 85	
180		ADCIM 1	
190		STAZ 85	
200		LDAZ 86	
210		ADCIM 0	
215		STAZ 86	
220		CMPZ 83	; Return if end of word reached
230		BEQ FORWD	
240		NOP	; Time path adjustment
250		INX	
260		DEX	
270		JMP NXTBT	
280	FORWD	LDAZ 85	; Else jump back to fetch next byte of interval data.
290		CMPZ 82	
300		BNE NXTBT	
310		RTS	
405			; Sets up for replay of specified word.
410		CLD	; Binary arithmetic
420		LDAZ 88	; Get no. of specified word
440		ASLA	; Multiply by 2
450		TAX	; Use to access low byte of end address of preceding word from table.
460		LDAX 5568	
470		CLC	; Increment from start address of specified word, and put in (BGNWDL)
480		ADCIM 1	
490		STAZ 80	
500		INX	
510		LDAX 5568	; Get high byte,
520		ADCIM 0	; Add in Carry bit
530		STAZ 81	; Put in (BGNWDH)
540		INX	
550		LDAX 5568	; Get end address of specified word and put in (ENDWD)
570		INX	
575		LDAX 5568	
580		STAZ 83	
590		JSR SWD6	; Call routine to replay single word
600		RTS	; and return.

DISASSEMBLED LISTING OF RPL2

HEX ADDRESS	INSTRUCTION CODE	MNEMONIC	OPERAND (HEX)
1600	A550	LDAZ	50
1602	8555	STAZ	55
1604	A551	LDAZ	51
1606	8556	STAZ	56
1608	A000	LDYIM	0
160A	B155	LDAIY	55
160C	AA	TAX	
160D	CA	DEX	
160E	E000	CPXIM	0
1610	D0FB	BNE	160D
1612	C9FF	CMPIM	FF
1614	F003	BEQ	1619
1616	8D82EF	STA	EF82
1619	18	CLC	
161A	A555	LDAZ	55
161C	6901	ADCIM	1
161E	8555	STAZ	55
1620	A556	LDAZ	56
1622	6900	ADCIM	0
1624	8556	STAZ	56
1626	C553	CMPZ	53
1628	F006	BEQ	1630
162A	EA	NOP	
162B	E8	INX	
162C	CA	DEX	
162D	4C0A16	JMP	160A
1630	A555	LDAZ	55
1632	C552	CMPZ	52
1634	D0D4	BNE	160A
1636	60	RTS	
1637	D8	CLD	
1638	A558	LDAZ	58
163A	0A	ASLA	
163B	AA	TAX	
163C	BDC015	LDAX	15C0
163F	18	CLC	
1640	6901	ADCIM	1
1642	8550	STAZ	50
1644	E8	INX	
1645	BDC015	LDAX	15C0
1648	6900	ADCIM	0
164A	8551	STAZ	51
164C	E8	INX	
164D	BDC015	LDAX	15C0
1650	8552	STAZ	52
1652	E8	INX	
1653	BDC015	LDAX	15C0
1656	8553	STAZ	53
1658	200016	JSR	1600
165B	60	RTS	

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SEMICONDUCTOR CIRCUITS

TOM GASKELL B.A.(Hons)

STEREO SIGNAL PROCESSOR (TDA 3810)

DESPITE the widespread use of stereo sound in audio systems, there are still many occasions when only mono signals are available, or the stereo sound is presented so poorly that it gives little or no benefit over mono. Many television sets and portable radios fall into these categories; they are either mono only, or their stereo speakers are very close together, giving an unnaturally narrow stereo image. The Mullard TDA 3810 is a brand new 18 pin i.c. designed to overcome some of these problems; it can be fed with either a mono or a stereo signal, which it then processes in various ways.

A stereo signal can be passed through the TDA 3810 normally, or it can be made to sound spatial; the stereo image is widened, or spread further apart. This can considerably enhance the stereo effect when listening on closely spaced loudspeakers, and is also very interesting on headphones! The mono signal, again, can be passed through the i.c. normally, or it can be turned into a pseudo-stereo signal. Circuits which can synthesise stereo sound from a mono source have been known about for a long time, but most of these worked on the principle of 'treble on the left, bass on the right', or similar. The majority of these systems sounded very obvious indeed! The TDA 3810, on the other hand, uses a more sophisticated arrangement which produces a much more convincing effect. Mono recordings are reproduced with a realistic ambience that considerably enhances the sound in many cases, giving it a richer and more spacious feel. Recordings made from a disco console being used for parties really came to life when processed in this way; the system seems to be very good with pop music, crowd noise, and a whole host of other sounds.

PRINCIPLES OF OPERATION

The simplified block diagram of the i.c. with its associated external components is shown in Fig. 2. The stereo mode is the simplest configuration; each signal simply passes through its own set of three amplifiers without modification. In the spatial mode, the left signal is fed to the non-inverting input of a differential amplifier. The inverting input of that amplifier is fed, via R1 and C1, from the left output of the i.c.; this provides feedback for the differential amplifier. However, a proportion of the right output is also fed back into this inverting input via R2, C2 and R3. The amount fed back, and hence the widening of the image, is determined by the ratio of R1 to R3. This portion of signal from the right channel is a deliberately introduced crosstalk signal; furthermore, it is antiphase crosstalk, since it is fed into the inverting input of the left channel's differential amplifier. It is the antiphase nature of this crosstalk which gives the apparent widening of the stereo image. The above description applies equally well to the right channel, of course, as to the left; the two halves of the i.c. are symmetrical in this respect. The capacitors C1 and C2, in conjunction with R1 and R2, ensure stability and slowly roll off the signal amplitudes at the outputs of the i.c. at above a few kilohertz. This is intended to give a subjectively pleasant effect when combined with the stereo widening in the spatial mode. In practice it is largely a matter of personal preference, so experimentation will determine the most appropriate values of C1 and C2 in each application.

The pseudo-stereo mode is a little more complex. The left channel passes directly through the circuit; resistors R4 and R5 are of equal value, so the left output is simply a unity gain inverted version of the left input signal. The right channel, on the other hand, has two filter networks incorporated in its signal and feedback paths. Between the right input amplifier and the inverting amplifier the signal passes through a notch filter. This is not used primarily to provide a notch in the frequency response, however. Its main function is to produce a rapid and wide ranging phase change in the signal, from 0 through to 360° over the low to mid frequency audio band. This phase change, of course, manifests itself as a frequency dependent time delay. Thus, the basic phase and frequency response characteristics of the right pseudo-stereo channel have been determined. R7 is the input resistor to the inverting amplifier, and R6 the feedback resistor. The frequency dependent time delay of the right output, as opposed to the directly fed left output, gives the illusion of

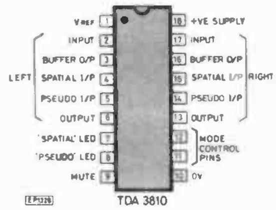


Fig. 1. Pin-out and specification

CHARACTERISTIC	NOTES	MIN	TYPICAL	MAX	UNITS
Supply voltage	All spec's measured at +12V	4·5	12	15	V
Quiescent current	No l.e.d.s driven		7	12	mA
Temperature range		0		70	°C
Voltage reference	V_{ref}	5·3	6	6·7	V
Input resistance	Pins 2 and 17	50	75		k
Maximum input signal	Pins 2 and 17, for 0·5% THD	2			$V_{r.m.s.}$
STEREO MODE					
Voltage gain	Input to output		0		dB
Gain difference	(between channels)			0·5	dB
Distortion (THD)	40Hz–16kHz, output=1$V_{r.m.s.}$		0·1		%
Noise output	Left and right, 20Hz–20kHz			10	$\mu V_{r.m.s.}$
SPATIAL MODE					
Antiphase crosstalk	} With circuit shown (Fig. 3)		50		%
Voltage gain		1·4	2·4	3·4	dB
Control input resistance	Pins 11 and 12	70	120		k
Control input current	Pins 11 and 12		−95	−160	μA
L.e.d. output current	From pins 7 and 8	10	12	15	mA
L.e.d. forward voltage				6	V
Supply ripple rejection			50		dB
Channel separation	Stereo mode		50		dB

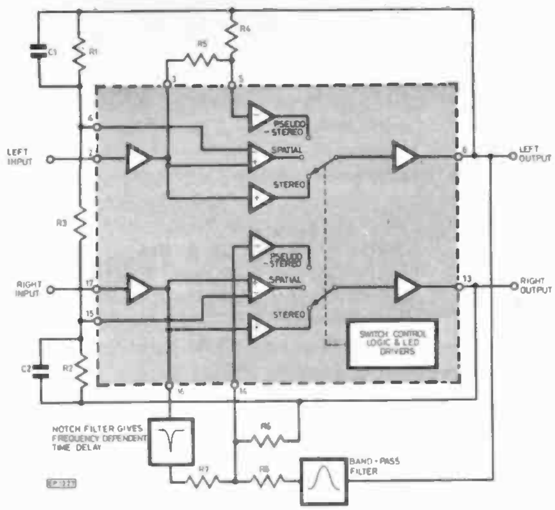


Fig. 2 (top left). Simplified block diagram of i.c. with associated external components

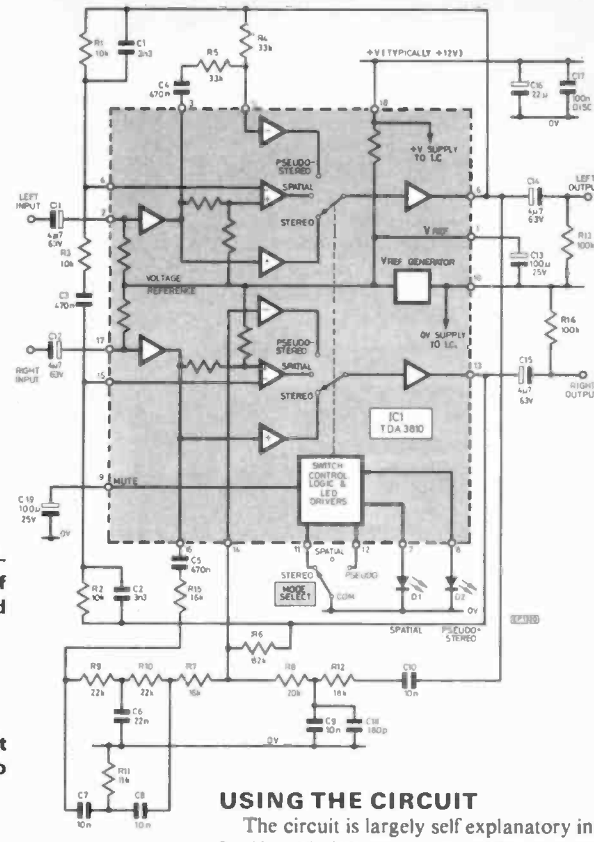


Fig. 3 (right). Full circuit diagram of the stereo signal processor

stereo sound. However, we are left with an unfortunate notch in the frequency response of the right channel. To help alleviate this, the left output (which is inverted with respect to the right input) is fed back to the inverting amplifier of the right channel via a bandpass filter and R8. The full effect of this arrangement is very complex indeed, but basically it helps to fill out the right output signal, making up for the loss in signal energy caused by the notch filter's response. The components used for both filters are provided externally to the i.c. in order that they can be tailored to suit individual tastes or desired characteristics. The quality of the pseudo-stereo effect is very dependent on the performance of these filters.

APPLICATIONS CIRCUIT

Fig. 3 shows the full circuit diagram of the stereo signal processor. A single supply rail is used in this system, with a maximum voltage of +15V, and a typical supply of +12V. To bias the internal amplifiers, a voltage reference V_{ref} is derived internally; this is decoupled to 0V by C13. As a result, input and output decoupling capacitors must be used: C11, C12, C14 and C15. C3, C4 and C5 decouple different sections of the i.c., and help to reduce offset voltages. The notch filter is a passive twin-T network formed by R9, R10, R11, C6, C7 and C8, in conjunction with R7 and R15, while the bandpass filter is a Wien network comprising of R8, R12, C9 in parallel with C18, and C10. Pin 9 is a 'mute' facility which turns the outputs of the i.c. off when pulled down to 0 volts by a resistor of typically a few kilohms. C19 helps to prevent too many clicks when this happens. The mode of operation of the i.c. is controlled by internal analogue switches. These are controlled by pins 11 and 12 of the i.c. as shown below:

Mode	Pin 11	Pin 12
Stereo (or mono)	Logic 0	—
"Spatial"	Logic 1	Logic 1
"Pseudo-stereo"	Logic 1	Logic 0

Logic 1 is a voltage between +2V and the positive supply; if left open circuit, a control input will naturally go to logic 1. Logic 0 is any voltage between 0V and 0·5V. These inputs are compatible with both TTL and CMOS logic. Alternatively, a centre-off 3 position switch, as shown in Fig. 3, can be used. The l.e.d.s show the mode selected; if neither is lit, the mode is "normal", or "stereo". (If a mono signal is used, of course, it will still come out mono).

USING THE CIRCUIT

The circuit is largely self explanatory in use. It should be connected after any pre-amplification, but prior to volume controls, balance controls, etc. if possible. (Using tape output and tape monitor facilities on hi-fi amplifiers is often an easy way to connect it in circuit). The two filters can be experimented with, and values changed. The values shown should be adhered to closely when not experimenting, although making R11 = 10k, and R15, R7 = 15k, and R8 = 22k will not degrade the performance very seriously. They could even be replaced with active filters for more striking effects.

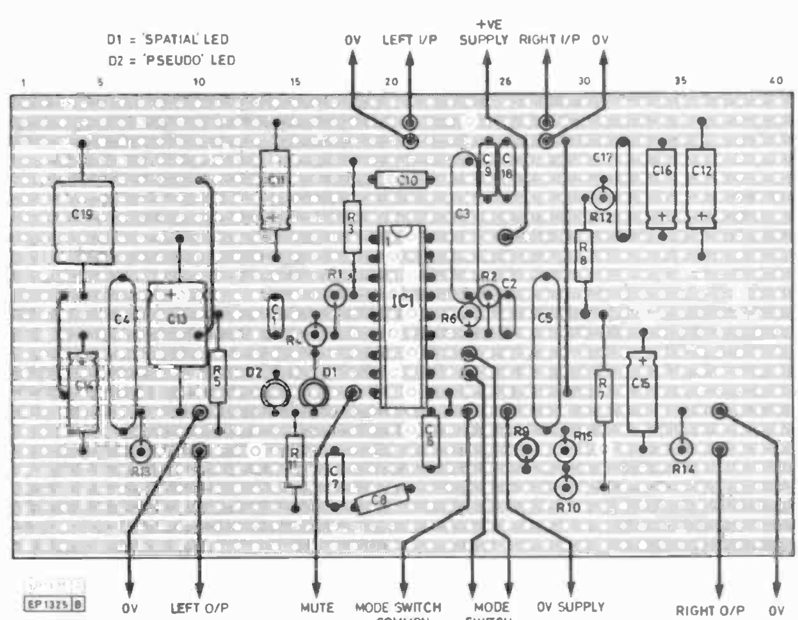


Fig. 4. Board assembly detail

The notch filter shown in Fig. 3 provides a 30dB cut at a centre frequency of 700Hz, and −3dB points at approximately 240Hz and 1·8kHz, while the bandpass filter also peaked at 700Hz, with a gentle slope rolling off to approximately −20dB at 20Hz and 20kHz.

The performance of the i.c. is quite good in purely hi-fi terms, as well as subjectively; Fig. 1 gives the full specifications. In practice the circuit behaved very well; the distortion was well within specification (nearer 0·01%), and the 20Hz to 20kHz bandwidth r.m.s. noise was measured as −97dBu in the stereo mode, −98dBu in the spatial mode, and −88dBu in the pseudo-stereo mode (right output). The mode switching clicks have been reduced by using offset compensated amplifiers, so that the circuit could be controlled, for example, by the stereo pilot tone detection circuitry of an FM tuner; when receiving stereo transmissions it could produce normal or spatial stereo sound, and when receiving mono it could synthesise the stereo effect itself.

Finally, try altering a few component values in the circuit. Changing the values of C1 and C2 will affect the frequency response of the spatial mode, while changing the ratio of R1 and R2 to R3 alters the amount of stereo spread. If R1 and R2 remain at 10k, but R3 is reduced to only a few kilohms, the effect becomes similar to live music being played in a large concert hall; very ambient and raucous! Vocals tend to vanish into the background, because most of the signals from the centre of the stereo 'stage' cancel each other out, leaving only the wider placed signals, expecially ambience, reverberation, etc. Altogether, there seems to be plenty of scope for experimentation with this i.c.!

The TDA 3810 can be obtained from **Ace Mailtronix Ltd., 3a, Commercial Street, Batley, West Yorkshire.**

Readout...

Red Shift

Sir—I was interested to read Frank Hyde's wistful comments on Quasar red-shifts in his *Spacewatch* column. It seems from his words that he feels it unlikely that any definite answer will emerge from current research on the subject. May I suggest that there could be an answer staring him in the face from the work to which he referred, and which is readily understandable by all who have some knowledge of radio propagation.

The question is: are Quasar red-shifts derived from their supposed extremely remote distance or are they relatively "local" objects with an unknown reason for their red-shifts? I believe the local/remote question can be answered through an aspect of the milli-arc-second-scale maps to which he referred. Several Quasars have now been mapped to this scale and these maps are precisely aligned with the optical object in the sky. But is it not true that light rays are unaffected by ionised material on the line-of-sight to the Quasars but radio waves will tend to be dispersed and distorted by such intervening matter.

How is it then that we have such exquisitely aligned radio and optical images of these objects when the radiation has travelled across half the Universe. Are there no ionised clouds in space to speak of? As far as I can judge I would say this point is a dead giveaway, Quasars must be local! However, do not attempt to tell this to any astronomers you may know, I believe facts confuse them.

P. W. Shimmon
Crawley
West Sussex.

F. Hyde comments:

In dealing with the red-shift problem we must be careful about the derivation of parameters. It would seem that Mr. Shimmon is one of those who still adhere to the generally discarded views of very distant bodies. The subject is not that simple.

Leaving aside the various schools of thought on these matters the energy levels involved are not compatible with close objects and we must compare like with like. The small number of the sources involved which have caused so much controversy are open to the varied reactions of different observers. As a solution the local radar effects, local because they are tenable only at local distances, must of course lead us to quote from experience. The distances involved are very great and consequently line-of-sight obstruction cannot be extrapolated in such a straightforward manner no matter what its nature.

In the case of observations where the bodies involved are in fact moving at right angles to the line-of-sight, observable links were verified. The very fact that the required power involved in relation to the power received is so great that normal explanations do not seem to be relevant. The most recent findings of shifts many times the speed of light does not help at all.

The recent work carried out by J. Sulentic does offer proof that some of the observed shift is not due to the expanding Universe. This would seem to settle a part of the argument which has occupied several decades. It would appear that Mr. Shimmon holds very definite views of these various facts and perhaps we are missing something right under our noses. Unfortunately Spacewatch *does not allow the mention of the many different views, which at the moment occupy several erudite volumes, to be put forward. I would however be glad to pursue this matter privately with Mr. Shimmon.*

Chip Chop?

Sir — Regarding your September issue editorial I wish I could have been on a bit of high ground behind you as you wrote it and instigated three hearty cheers, for the situation can be reflected in many other fields.

Back in 1969 I received a ticking-off in your columns for my attempt to curb the spread of the i.c. My unstated fear was that by resorting to special components, one could be in difficulty later if a manufacturer had conveniently discontinued its production and so caused a costly appliance to transform overnight into useless scrap. Another trick is to embody flimsy components and charge tropospheric prices for spares.

In the hobby field my electronics interest is in the organ, and some 10 or so years ago the top-octave divider i.c. (the AY-1-0212 and similar) promised a revolution in that tuning became unnecessary. At the time I had private misgivings about longterm availability. Now, advertisers seem to have dropped the sale of these—the last being Maplin I think, and presumably the trend is to use some of the huge "108's" or "208's" or even something akin to a microprocessor.

I think that the ordinary private user should consider well before sinking large sums in the purchase of appliances using highly sophisticated components lest they overnight assume scrap value. Just imagine what will become of all the home computers if a manufacturer decides to cease production of a vital "chip" for which there is really no compatible substitute.

James W. Robson
Newcastle-Upon-Tyne.

Illogical

Sir—With reference to "Introduction to Digital Electronics".

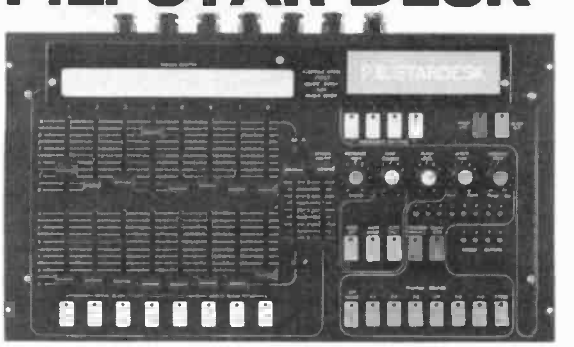
I think the above series of articles is very well conceived and I look forward to those which are yet to come, having built the "Logic Tutor". In this connection, I should be grateful if you would tell me which i.c.s will be dealt with over the series of articles so that I may buy them all at one time from one of your advertisers. The reason being, there is not a suitable shop in this area, and it is uneconomic to buy them by post in ones and twos.

May I point out that there are two R19s on the p.c.b.? I expect that you already have been told that the one adjacent to LK2/LK3 is in fact R15.

E. J. Hatch
Sittingbourne
Kent.

Thank you for your comments. A list of the necessary i.c.s is shown below:—
7400, 7402, 7404, 7408, 7414, 7432, 7473, 7474, 7486, 74107, 74121, 745124.
With regard to the Logic Tutor board you are quite right, the R19 next to link 3 should be R15. There was also a misprint under the "Initial Tests" heading which is covered at the end of Part 3 of Introduction to Digital Electronics (December 1983).

P.E. STAR DESK



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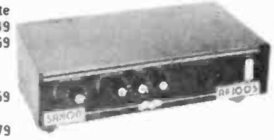

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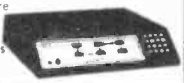

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MINIKEY SERIES KL This is an American made membrane keyboard with silver contacts as used on Prestel to dial into the British Telecom phone system. It is really miniature, only 60mm x 65mm x 5mm thick. It has 16 press buttons, giving standard 0-9 numbers and ABCO facilities. There are two other buttons engraved asterisks. This is an extremely well made board. £4.60.

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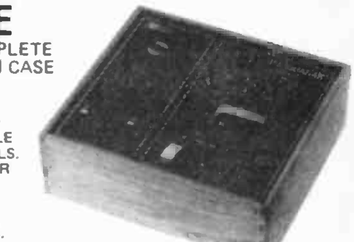

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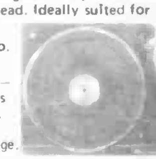

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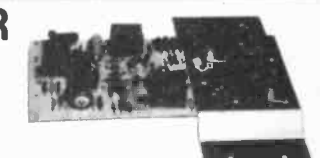

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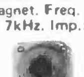

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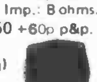

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2N4402 30p
2N4403 30p
2N4409 36p
2N4410 42p
2N4427 1.30
2N4870 80p
2N4871 55p
2N4888 99p
2N4901 1.69
2N4902 1.85
2N4903 1.98
2N4904 2.15
2N4905 2.75
2N4906 2.99
2N4907 3.20
2N4908 3.15
2N4909 2.90
2N4918 65p
2N4919 75p
2N4920 85p
2N4921 55p
2N4922 69p
2N4923 99p
2N5086 36p
2N5087 39p
2N5088 37p
2N5089 37p
2N5190 68p
2N5191 70p
2N5193 90p
2N5194 79p
2N5245 37p
2N5246 40p
2N5247 45p
2N5248 46p
2N5249 48p
2N5266 2.88
2N5293 98p
2N5294 1.28
2N5295 1.37
2N5401 35p
2N5415 1.10
2N5416 1.54
2N5447 16p
2N5448 19p
2N5449 21p
2N5450 23p
2N5451 25p
2N5457 29p
2N5458 29p
2N5459 29p
2N5460 72p
2N5551 37p
2N5884 5.95
2N5886 5.95
2N6083 17.95
2N6121 57p
2N6122 59p
2N6123 65p
2N6124 59p
2N6125 65p
2N6126 75p
2N6129 79p
2N6130 93p
2N6131 98p
2N6132 83p
2N6133 1.14
2N6134 1.35
2N6253 1.45
2N6254 1.55
2SC1306 95p
2SC2078 1.70
2SJ49 3.99
2SJ50 4.50
2SJ82 4.75
2SK134 3.99
2SK135 4.50
2SK226 4.75
3N128 1.12
3N140 1.07
3N200 6.93
3N201 2.98
40360 60p
40361 67p
40362 67p
40363 2.95
40406 1.39
40407 75p
40408 1.58
40410 1.80
40411 3.95
40412 90p
40673 70p
40822 1.80
40871 1.00
40872 1.00
AC125 49p
AC126 32p
AC127 32p
AC128 35p
AC132 68p
AC141K 28p
AC142K 28p
AC151 51p
AC152 45p
AC153 55p
AC153K 64p
AC176 27p
AC176K 37p
AC187 25p
AC187K 28p
AC188 25p
AC188K 40p
AF239 55p
AF240 1.00
BC107 10p
BC107A 10p
BC107B 12p
BC108 12p
BC108A 12p
BC108B 12p
BC108C 14p
BC109 10p
BC109B 12p
BC109C 13p
BC140 29p
BC141 37p
BC142 29p
BC143 30p
BC147 10p
BC147A 10p
BC147B 10p
BC147C 20p
BC148 10p
BC148A 12p
BC148B 13p
BC148C 10p
BC149 10p
BC149B 10p
BC149C 13p
BC152 35p
BC153 23p
BC154 27p
BC157 11p
BC157A 12p
BC157B 12p
BC158 10p
BC158A 12p
BC158B 13p
BC159 11p
BC159A 12p
BC159B 13p
BC159C 18p
BC160 42p
BC161 48p
BC167 10p
BC167A 10p
BC167B 13p
BC168 10p
BC168B 10p
BC168C 10p
BC169 10p
BC169B 10p
BC169C 10p
BC177 16p
BC177A 25p
BC177B 26p
BC178 16p
BC178A 24p
BC178B 25p
BC179 20p
BC179A 25p
BC179B 25p
BC179C 27p
BC182 10p
BC182A 12p
BC182B 13p
BC182L 10p
BC182LA 13p
BC182LB 14p
BC183 10p
BC183A 11p
BC183B 12p
BC183C 13p
BC183L 10p
BC183LA 13p
BC183LB 13p
BC183LC 14p
BC184 10p
BC184B 12p
BC184C 12p
BC184L 10p
BC184LB 12p
BC184LC 12p
BC186 24p
BC187 24p
BC212 10p
BC212A 12p
BC212B 12p
BC212L 10p
BC212LA 12p
BC212LB 12p
BC213 10p
BC213A 12p
BC213B 12p
BC213C 13p
BC213L 10p
BC213LA 12p
BC213LB 12p
BC213LC 13p
BC214 10p
BC214B 12p
BC214C 12p
BC214L 10p
BC214LB 12p
BC214LC 12p
BC237 12p
BC237A 14p
BC237B 14p
BC237C 15p
BC238 13p
BC238A 14p
BC238B 15p
BC238C 15p
BC239 15p
BC239A 17p
BC239B 17p
BC239C 17p
BC300 38p
BC301 37p
BC302 34p
BC303 47p
BC327 14p
BC328 14p
BC337 15p
BC338 15p
BC440 32p
BC441 35p
BC460 40p
BC461 43p
BC516 40p
BC517 40p
BC546B 15p
BC547 13p
BC556B 15p
BC547A 14p
BC547B 14p
BC548 12p
BC548A 13p
BC548B 14p
BC548C 15p
BC549 13p
BC549B 14p
BC549C 15p
BC550 15p
BC550C 25p
BC557 15p
BC557A 16p
BC557B 16p
BC558 14p
BC558A 15p
BC558B 16p
BC558C 17p
BC559 15p
BC559B 16p
BC559C 17p
BC560 25p
BC560C 25p
BC650 45p
BC651 46p
BCY70 16p
BCY71 16p
BCY72 19p
BD131 44p
BD132 44p
BD135 35p
BD136 35p
BD137 37p
BD138 37p
BD139 38p
BD140 38p
BD237 98p
BD238 98p
BD239A 57p
BD239C 64p
BD240A 59p
BD240C 73p
BD241A 61p
BD241C 67p
BD242A 65p
BD242C 70p
BD243A 72p
BD243C 85p
BD244A 82p
BD244C 1.00
BD245A 1.14
BD245C 1.30
BD246A 1.20
BD246C 1.50
BD249A 2.00
BD249C 2.31
BD250A 2.11
BD250C 2.46
BD419 1.29
BD420 1.37
BD437 88p
BD438 88p
BD439 90p
BD440 91p
BD441 91p
BD442 93p
BD529 1.20
BD530 1.30
BD535 75p
BD536 75p
BD537 80p
BD538 80p
BD539 80p
BD539C 1.10
BD540 85p
BD540C 1.20
BD675 72p
BD676 77p
BD677 78p
BD678 83p
BD711 1.32
BD712 1.32
BDX32 3.47
BDX66B 5.95
BDX67B 5.95
BDY54 1.70
BDY55 1.75
BDY56 1.80
BDY57 5.25
BDY58 6.15
BF194 12p
BF195 12p
BF196 12p
BF197 12p
BF198 15p
BF199 15p
BF200 75p
BF224J 32p
BF225J 35p
BF244A 55p
BF244B 55p
BF245A 55p
BF245B 65p
BF246 70p
BF246A 70p
BF246B 70p
BF247A 75p
BF247B 75p
BF254 39p
BF255 42p
BF256A 58p
BF256B 58p
BF256C 65p
BF257 30p
BF258 32p
BF259 35p
BF457 46p
BF458 56p
BF459 62p
BF469 86p
BF470 86p
BFR39 25p
BFR40 25p
BFR41 25p
BFR79 25p
BFR80 25p
BFR81 25p
BFR90 2.11
BFS28 2.95
BFS61 1.00
BFS98 1.10
BFX29 26p
BFX30 27p
BFY50 23p
BFY51 23p
BFY52 23p
BFY53 31p
BSX19 24p
BSX20 24p
BSX21 40p
BU104 2.22
BU105 1.70
BU108 3.95
BU109 3.29
BU126 1.47
BU204 2.25
BU205 1.75
BU206 1.89
BU208 1.98
BU226 3.95
BU326S 2.35
BU406 1.45
BU407 1.45
BU408 1.35
BU500 2.95
BUY18S 3.95
E430 5.95
J300 70p
J310 70p
MJ802 3.99
MJ900 2.90
MJ901 3.10
MJ1000 2.50
MJ1001 3.00
MJ1800 3.60
MJ2500 2.19
MJ2501 2.25
MJ2955 1.00
MJ3000 2.19
MJ3001 2.25
MJ4502 3.99
MJ15003 4.85
MJ14004 5.55
MJ15015 2.45
MJ15016 3.34
MJE340 53p
MJE350 1.50
MJE2955 99p
MJE3055 69p
MPSA05 23p
MPSA06 25p
MPSA10 28p
MPSA12 29p
MPSA13 48p
MPSA14 46p
MPSA16 30p
MPSA18 65p
MPSA20 48p
MPSA42 49p
MPSA43 49p
MPSA55 28p
MPSA56 30p
MPSA65 40p
MPSA66 47p
MPSA70 32p
MPSA92 39p
MPSA93 39p
MPSL01 46p
MPSL51 49p
MPSU01 84p
MPSU04 1.32
MPSU05 55p
MPSU06 56p
MPSU07 75p
MPSU51 88p
MPSU55 58p
MPSU56 59p
MPSU57 1.20

JUST RELEASED NEW ILLUSTRATED CATALOGUE £1.00 inc. p&p

TIP29A 29p
TIP29C 38p
TIP30A 35p
TIP30C 36p
TIP31A 33p
TIP31C 34p
TIP32A 38p
TIP32C 42p
TIP33A 65p
TIP33C 78p
TIP34A 78p
TIP34C 88p
TIP35A 1.09
TIP35C 1.28
TIP36A 1.29
TIP36C 1.39
TIP41A 49p
TIP41C 55p
TIP42A 55p
TIP42C 59p
TIP49 1.20
TIP50 1.40
TIP53 1.57
TIP54 1.95
TIP110 74p
TIP112 90p
TIP115 81p
TIP117 86p
TIP120 80p
TIP122 73p
TIP125 84p
TIP127 84p
TIP130 93p
TIP132 93p
TIP135 99p
TIP137 1.04
TIP140 1.04
TIP142 1.04
TIP145 1.15
TIP147 1.15
TIP162 4.95
TIP2955 77p
TIP3055 70p
TIS43 50p
TIS88A 50p
VN10KM 60p
VN46AF 84p
VN66AF 85p
ZTX107 10p
ZTX108 10p
ZTX109 12p
ZTX300 13p
ZTX301 15p
ZTX302 20p
ZTX303 23p
ZTX304 15p
ZTX310 19p
ZTX311 32p
ZTX312 35p
ZTX313 36p
ZTX314 24p
ZTX320 32p
ZTX330 28p
ZTX341 38p
ZTX450 39p
ZTX500 14p
ZTX501 14p
ZTX502 17p
ZTX503 19p
ZTX504 24p
ZTX510 24p
ZTX530 28p
ZTX531 25p
ZTX650 45p

DIODES

1N34A 30p
1N821 70p
1N823 92p
1N914 4p
1N916 6p
1N4001 4p
1N4002 4½p
1N4003 5p
1N4004 5½p
1N4005 6p
1N4006 6½p
1N4007 7p
1N4009 20p
1N4148 3p
1N4150 18p
1N4448 22p
1N5400 12p
1N5401 13p
1N5402 14p
1N5404 16p
1N5406 18p
1N5407 19p
1N5408 20p
1N5024 52p
IS44 10p
BA102 25p
BA115 25p
BA133 40p
BA138 30p
BA142 20p
BA155 15p
BA156 38p
BA157 25p
BA158 30p
BA150 32p
BA182 40p
BA201 18p
BA202 26p
BA316 25p
BA317 25p
BA318 30p
BAV10 16p
BAV19 15p
BAV20 15p
BAX13 10p
BB109G 65p
BY126 11p
BY127 12p
BY134 52p

SCR's, TRIACS DIACS

THYRISTORS 4, 8 & 12 Amps Texas TO220
Suffix A 100V
B 200V
C 300V
D 400V
M 600V
4A
TIC106A 46p
TIC106B 47p
TIC106C 48p
TIC106D
TIC106M 68p
8A
TIC116A 66p
TIC116B 68p
TIC116C 71p
TIC116D 72p
TIC116M 80p
TIC126A 72p
TIC126B 72p
12A
TIC126C 73p
TIC126D 77p
TIC126M 96p

TRIACS Texas 400V
TO220 Case
TIC206D(4A) 66p
TIC225D(6A) 74p
TIC226D(8A) 88p
TIC236D(12A) 1.16
TIC246D(16A) 1.22
TIC253D(20A) 1.90
TIC263D(25A) 2.11

DIACS
BR100 25p
ST2 25p

ZENER'S

400 500mW E24 Series 2.4-47V 7p
1.3 Watt E24 Series 3.3-82V 14p

BRIDGE

(PIV shown in brackets)
1½ amp type
W01(100) 28p
W02(200) 34p
W04(200) 38p
W08(800) 50p
2 amp type Square with hole
S01(100) 49p
S02(200) 50p
S04(400) 55p
S08(800) 66p
6 amp type Square with hole
PW01(100) 95p
PW02(200) 99p
PW04(400) 1.30
PW06(600) 1.39
25 amp type Metal clad with hole
K01(100) 2.62
K02(200) 2.75
K04(400) 3.25
K06(600) 4.10
BYW64
35A 400V 4.50

OPTO

LED LAMPS
R Red
G Green
Y Yellow
Large Diffused 1 + 50 +
R5D 9p 7p
G5D 15p 12p
Y5D 15p 12p
Small diffused
R2D 8p 6p
G2D 12p 10p
Y2D 12p 10p
Micro 0.1"
R1D 25p 22p
G1D 27p 25p
Y1D 27p 25p
Large clear
R5C 12p 10p
G5C 17p 13p
Y5C 17p 13p
Super bright high efficiency Large (100 times brighter)
R5U 38p 29p
G5U 42p 34p
Y5U 42p 34p
Rectangular Stackables LEDs
R6L 17p
G6L 18p
Y6L 19p

LIN ICS

AY1 5050 95p
AY3 8910 3.66
AY3 8912 4.40
CA3048 2.15
CA3059 2.80
CA3090AQ 3.70
CA3130E 87p
CA3130T 1.80
CA3140E 39p
CA3140T 95p
HA1366W 2.40
HA388 2.54
ICL7106 6.85
ICL7107 9.50
ICL7611 97p
ICL8038 2.99
ICL7555 80p
ICL7556 1.50
LC7120 3.20
LC7130 3.40
LC7137 3.95
LF347 1.50
LF351 47p
LF353 92p
LF355 83p
LF356 92p
LF357 1.09
LF398 4.59
LM335Z 1.60
LM348N 62p
LM349N 1.09
LM350K 4.60
LM379S 5.50
LM380N14 75p
LM380N8 1.50
LM381AN 2.26
LM381N 1.40
LM382N 1.12
LM383T 3.40
LM384N 1.40
LM386 88p
LM388N 2.43
LM391N60 2.10
LM391N80 2.40
LM723CH 95p
LM723CN 35p
LM725CH 3.40
LM725CN 3.19
LM741CH 96p
LM741CN 15p
LM741CN14 80p
LM747CN 69p
LM748CH 1.00
LM748CN 35p
LM1871 3.25
LM1872 4.39
LM1877 3.95
LM1886 7.44
LM1889 3.77
LM2907N 2.75
LM2907N8 2.60
LM2917N 2.40
LM2917N8 2.40
LM3900 48p
LM3911 1.20
LM3914 3.25
LM3915 3.25
LM13600 95p
MF10 3.50
NE531N 1.36
NE543N 2.50
NE544N 1.95
NE555 18p
NE556 65p
NE558 1.89
NE560 3.25
NE565 1.18
NE566 1.49
NE567 1.37
NE570 4.07
NE571 3.99
NE5534A 1.45
TBA500 2.97
TBA500Q 3.11
TBA510 2.95
TBA510Q 3.05
TBA520 2.57
TBA520Q 2.75
TBA530 2.55
TBA530Q 2.76
TBA540 2.72
TBA540Q 2.74
TBA550 3.25
TBA550Q 3.27
TBA560C 2.87
TBA570 2.37
TBA570Q 2.48
TDA1002 3.39
TDA1003 3.94
TDA1004 3.94
TDA1005 3.94
TDA1010A 2.25
TDA1022 4.95
TDA2611A 2.50
TDA7000 3.45
TL061 40p
TL062 60p
TL064 95p
TL071 24p
TL072 45p
TL074 99p
TL081 24p
TL082 45p
TL084 89p
UAA170 2.49
UAA180 2.49
ULN2003 75p
UPC575C2 2.00
UPC1156H 2.75
XR2206 2.92
ZN409 2.25
ZN414 1.00
ZN1034 1.99

74TTL

7400 19p
7401 19p
7402 19p
7403 19p
7404 19p
7405 19p
7408 19p
7409 19p
7410 19p
7411 19p
7412 19p
7413 25p
7414 50p
7416 40p
7417 40p
7420 19p
7421 19p
7422 19p
7423 19p
7425 19p
7426 19p
7427 19p
7428 26p
7430 19p
7432 24p
7433 24p
7437 25p
7438 36p
7440 22p
7441 55p
7442 32p
7443 89p
7444 89p
7445 69p
7446 59p
7447 70p
7448 70p
7450 15p
7451 15p
7453 15p
7454 14p
7460 29p
7470 34p
7472 29p
7473 55p
7474 55p
7475 55p
7476 55p
7480 49p
7481 1.19
7482 90p
7483 38p
7484 90p
7485 90p
7486 30p
7489 1.68
7490 19p
7491 44p
7492 44p
7493 44p
7494 72p
7495 36p
7496 48p
7497 1.19
74100 1.25
74104 49p
74105 55p
74107 26p
74109 30p
74110 35p
74116 90p
74118 90p
74119 75p
74120 99p
74121 30p
74122 40p
74123 40p
74125 35p
74126 34p
74128 35p
74132 39p
74136 39p
74141 55p
74142 1.95
74143 2.08
74144 2.08
74145 70p
74147 88p
74148 75p
74150 1.20
74151 39p
74153 39p
74154 1.20
74155 45p
74156 45p
74157 45p
74159 1.50
74160 59p
74161 59p
74162 49p
74163 49p
74164 56p
74165 76p
74166 99p
74170 1.25
74172 2.49
74173 59p
74174 54p
74175 49p
74176 39p
74177 45p
74178 79p
74180 40p
74181 1.40
74182 80p
74184 89p
74185 69p
74186 4.69
74188 2.48
74190 60p
74191 60p
74192 60p
74193 60p
74194 60p
74195 60p
74196 45p
74197 45p
74198 1.50
74199 1.50
74221 73p

74LS TTL

74LS00 19p
74LS01 19p
74LS02 19p
74LS03 19p
74LS04 19p
74LS05 19p
74LS08 19p
74LS10 19p
74LS11 19p
74LS12 19p
74LS13 39p
74LS14 39p
74LS15 15p
74LS20 19p
74LS21 19p
74LS22 19p
74LS27 19p
74LS28 19p
74LS30 19p
74LS32 19p
74LS33 19p
74LS37 19p
74LS38 19p
74LS40 19p
74LS42 19p
74LS47 35p
74LS51 60p
74LS54 19p
74LS55 19p
74LS73 19p
74LS74 28p
74LS75 28p
74LS76 28p
74LS78 28p
74LS83 35p
74LS85 40p
74LS86 60p
74LS90 22p
74LS92 32p
74LS93 45p
74LS95 24p
74LS96 39p
74LS107 93p
74LS109 35p
74LS112 35p
74LS113 35p
74LS114 35p
74LS122 35p
74LS123 60p
74LS124 1.50
74LS125 24p
74LS126 25p
74LS132 40p
74LS136 29p
74LS138 39p
74LS139 39p
74LS145 99p
74LS147 99p
74LS148 1.19
74LS151 47p
74LS153 49p
74LS154 1.50
74LS155 39p
74LS156 46p
74LS157 40p
74LS158 35p
74LS160 50p
74LS161 50p
74LS162 50p
74LS163 50p
74LS164 50p
74LS165 60p
74LS168 1.40
74LS169 1.09
74LS170 19p
74LS173 90p
74LS174 40p
74LS175 40p
74LS181 1.20
74LS183 1.20
74LS190 60p
74LS191 60p
74LS192 60p
74LS193 60p
74LS194 50p
74LS195 50p
74LS196 59p
74LS197 59p
74LS221 95p
74LS240 1.40
74LS241 1.40
74LS242 1.40
74LS243 1.40
74LS244 1.40
74LS245 1.40
74LS247 1.40
74LS248 1.40
74LS249 1.40
74LS251 45p
74LS253 45p
74LS257 45p
74LS258 45p
74LS259 80p
74LS261 99p
74LS266 25p
74LS273 75p
74LS275 1.25
74LS279 33p
74LS280 1.80
74LS283 49p
74LS289 4.70
74LS290 55p
74LS293 49p
74LS295 74p
74LS298 79p
74LS299 1.95
74LS323 1.95
74LS324 1.95
74LS325 3.50
74LS326 3.50
74LS327 3.50
74LS347 1.35
74LS348 1.40
74LS352 71p
74LS353 71p
74LS362 7.25
74LS365 40p
74LS366 40p
74LS367 40p
74LS368 40p
74LS373 99p
74LS378 99p
74LS386 1.14
74LS390 46p
74LS393 99p
74LS395 89p
74LS396 1.90
74LS398 2.70
74LS399 1.59
74LS445 1.40
74LS490 1.40
74LS540 89p
74LS541 79p
74LS640 2.00
74LS641 2.00

CMOS

4000 16p
4001 16p
4002 16p
4006 49p
4007 19p
4008 32p
4009 24p
4010 24p
4011 16p
4012 19p
4013 19p
4014 46p
4015 39p
4016 19p
4017 32p
4018 45p
4019 24p
4020 42p
4021 39p
4022 39p
4023 19p
4024 32p
4025 19p
4026 79p
4027 28p
4028 39p
4029 43p
4030 19p
4031 1.19
4032 79p
4033 1.19
4034 1.29
4035 44p
4036 2.49
4037 1.13
4038 99p
4039 2.45
4040 39p
4041 39p
4042 39p
4043 39p
4044 39p
4045 99p
4046 44p
4047 39p
4048 39p
4049 22p
4050 23p
4051 44p
4052 58p
4053 49p
4054 79p
4055 83p
4056 83p
4059 4.35
4060 42p
4063 79p
4066 22p
4067 2.39
4068 19p
4069 19p
4070 19p
4071 19p
4072 19p
4073 19p
4075 19p
4076 45p
4077 19p
4078 19p
4081 19p
4082 19p
4085 49p
4086 60p
4089 1.23
4093 19p
4094 69p
4095 71p
4096 69p
4097 2.88
4098 74p
4099 89p
4502 55p
4503 39p
4507 33p
4508 1.26
4510 44p
4511 44p
4512 48p
4514 1.13
4515 1.13
4516 55p
4518 39p
4519 29p
4520 48p
4521 88p
4526 68p
4527 62p
4528 74p
4532 69p
4534 3.96
4536 2.59
4538 78p
4539 89p
4543 68p
4553 2.25
4555 35p
4556 35p
4560 1.49
4566 1.49
4569 1.65
4584 39p
4585 59p

LOGIC

CPUs
1802 6.50
2550A 11.99
6502 3.24
6800 2.10
6802 2.40
6809 6.20
8035 3.49
8080A 2.50
8085A 3.49
Z80A 2.98
Z80B 8.60

MEMORIES
2114(200ns) 99p
2532 2.98
2564 6.25
2708 2.95
2716(5v) 2.50
2764 4.25
4116(200ns) 99p
4118 3 3.25
4164 4.25
5101(450ns) 1.89
5204 7.50
6116P3 3.85
6514 3.30
6810 1.45
7489 1.65
74189 4.00
74LS188 2.25
74LS287 3.05
74LS288 2.25
74LS289 3.25

MISC LOGIC ICs
ADC0804 4.40
ADC0816 14.95
ADC0817 10.39
INS1671 20.00
INS1771 14.50
RO2513LC 6.50
RO2513UC 6.50
SAA5000 3.00
SAA5010 7.10
SAA5012 7.10
SAA5020 5.50
SAA5030 9.00
SAA5040 15.00
SAA5041 15.00
SAA5050 8.50
SAA5052 8.50
SAA5070 16.95
TMS6011 3.65
8T26 95p
8T28 1.20
8T95 85p
8T97 85p
81LS95 80p
81LS96 85p
81LS97 90p
81LS98 85p
6522 3.19
6532 5.70
8154 9.00
8155 3.50
8212 1.70
8216 99p
8224 1.95
8226 2.50
Z80ACTC 2.60
Z80ADART 5.50
Z80ADMA 6.70
Z80APIO 2.70
ZN425E8 3.39

V.REGS

Positive 100mA
78L05A 29p
78L12A 29p
78L15A 29p
78L24A 29p
1 Amp TO220
7805T 39p
7812T 39p
7815T 39p
7824T 39p
Negative 100 mA TO92
79L05 49p
79L12 49p
79L15 49p
1 Amp. TO220
7905T 44p
7912T 44p
7915T 44p
7924T 44p

ZIF SOCKET

24 Pin 4.35

SWITCHES

TOGGLE (MINI)
SPST 49p
SPDT 59p
DPDT 69p
DPDT C OFF 79p
4PDT 2.75